Report of a
National Seminar on

Mini- and Micro-hydropower Development in the Hindu Kush-Himalayan Region - The Nepal Perspective

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and
V.B. Amatya

Jointly Organised by the
Agricultural Development Bank of Nepal and
International Centre for Integrated Mountain Development
Kathmandu, Nepal
1-2 September 1994

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Prepared by
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on behalf of
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Cover photographs:

Background:	Langtang and Ganesh Himal seen from Dhulikhel
Top left:	Hydro plant at Muktinath
Bottom right:	Workshop Participants

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Foreword

This Report of the `National Seminar on Mini- and Micro-Hydropower Development in the Hindu Kush-Himalayan Region : The Nepal Perspective', is a summarised version of the proceedings of the Seminar, including the speeches during the Inaugural Session, the papers presented, the discussions and the conclusions arrived at by the participants. Part A presents the highlights of the seminar and Part B contains the actual papers prepared for the seminar in a somewhat abridged form. The Seminar was held from 1-2 September, 1994, in Kathmandu, as one of the activities under a NORAD-sponsored project on mini- and micro-hydropower (MMHP) development in the HKH Region.

The seminar brought together promoters, planners, financiers, experts, and other interested persons to discuss ideas and concerns. The private/decentralised MMHP programmes in Nepal and elsewhere in the Region are at a critical juncture on many accounts, and the workshop also provided participants with opportunities for establishing contacts and new partnerships in the field of MMHP in Nepal.

ICIMOD is particularly interested in mini- and micro-hydropower development, as it is a mountain-specific source of energy that can be used as a tool for development in remote areas. The technology has been developed to such an extent in Nepal that it can be applied with little or no inputs from outside the country. In general, it is also a highly environmentally-friendly source of energy. Despite all these advantages, MMHP has not been adopted on the scale that was hoped for some 20 years ago when major efforts in Nepal commenced in this field. The analysis of constraints and opportunities which were identified during the seminar will serve as guidance for future interventions.

The seminar was organised in joint collaboration with the Agricultural Development Bank of Nepal (ADB/N), which also provided useful inputs and contributions. I am grateful to Dr Tilak Rawal, the then General Manager ADB/N, Mr. P. P. Lamsal, Division Chief (Loans), and Mr. D. P. Adhikari, In-charge, MHP cell, for their collaboration, and contributions. I would also like to thank Dr. R. D. Joshi, Dean, Institute of Engineering and Mr. V. B. Amatya of the Water and Energy Commission Secretariat (WECS) for preparing this report on behalf of ICIMOD. Thanks are also due to Dr. A. A. Junejo for coordinating the preparation of the Report in addition to his other work in implementing the MMHP Project. The support of the Norwegian government to these endeavours is especially acknowledged.

I hope that the publication and distribution of this Report will be helpful for the promotion and improvement of MMHP programmes in Nepal.

Egbert Pelinck,
Director General

Acronyms

ADB/N	Agricultural Development Bank of Nepal
BEW	Butwal Engineering Works
BYS	Balaju Yantra Shala (P.) Ltd.
BPC	Butwal Power Company
DCS	Development and Consultancy Services
DIN	German Industrial Norm
HKH	Hindu Kush-Himalayas
ICIMOD	International Centre for Integrated Mountain Development
INGO	International Non-Governmental Organisation
ITDG	Intermediate Technology Development Group
I.Rs.	Indian Rupees
KMTNC	King Mahendra Trust for Nature Conservation
KMI	Kathmandu Metal Industries
MMHP	Mini- and Micro-Hydropower
MHP	Micro Hydropower Plants
MPPU	Multipurpose Power Unit
NORAD	Norwegian Agency for Technical Cooperation
NGO	Non-Governmental Organisation
NHE	Nepal Hydro and Electric (P.) Ltd.
NPC	National Planning Commission
N.Rs.	Nepalese Rupees
NEA	Nepal Electricity Authority
P.Rs.	Pakistani Rupees
SHP	Small Hydropower
SCECO	Salleri-Chialsa Electricity Company Ltd.
SDC	Swiss Development Corporation
SELUP	Salleri-Chialsa Electricity Utilisation Project
UMN	United Mission to Nepal

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PART A

1
Introduction

The Hindu Kush-Himalayan (HKH) Region, with a population of about 120 million, extends across Afghanistan, Pakistan, India, Nepal, China, Bhutan, Bangladesh, and Myanmar. The people of the HKH Region, despite their belonging to different countries, live in similar conditions. They face the same types of hardship and developmental constraints. The HKH Region is characterised by a lack of adequate infrastructural development; low agricultural productivity; net deficiency in food products; poor access to health, communications, and education; and a dwindling energy base. This has led to alarming poverty in the HKH Region and, consequently, continuous outmigration.

The heavy reliance of people on fuelwood and marginal farming practices has contributed to deforestation, land degradation, and soil erosion. This has placed an additional burden on the people, especially women, in the context of procuring drinking water and ever decreasing supplies of fuelwood.

The plight of the people can be alleviated only through socioeconomic development of the region. Additional energy inputs are among the many requirements for facilitating this socioeconomic development.

Additional energy requirements can be best met through the development of Mini- and Micro-Hydropower (MMHP) for the following reasons.

- A sizeable MMHP potential exists in all the countries, and it is more or less evenly distributed throughout the region.
- In this region, fossil fuels are not competitive in remote areas because of high transportation costs.
- Grid extension is not competitive due to the remoteness and sparse nature of the settlements.
- Plants of this scale can be manufactured indigenously.
- MMHP, especially MHP (micro-hydropower), could be developed through private initiatives.
- MMHP dissemination can stimulate the national economy.
- Adverse environmental impacts are minimal.
- MMHP is suitable for decentralised development.
- MMHP can be integrated with other rural water utilisation schemes and financial viability can thereby be increased.
- Other renewable energy sources can supplement, but not replace, MMHP.
- MMHP can stimulate the local economy, provided other inputs are carefully planned and implemented.

- Rural people find MMHP attractive because it can use local resources.
- MMHP energy is suitable for agro-industrial development.

Some important breakthroughs have already been made in the HKH Region with respect to the promotion of MMHP. For example, in Nepal, about 1,000 privately-owned commercial Micro-Hydropower Plants (MHP) are operating. They provide mechanical power for agro-processing and electricity for numerous end uses, such as electric lights, agro-processing mills, sawmills, paper mills, driers, bakeries, televisions, and other domestic appliances. In some rural settlements, these plants have succeeded in bringing about modest socioeconomic changes.

At this stage, the critical question is not whether MMHP can alleviate the poverty of the people of the HKH Region but how MMHP can best contribute to this end. It was for this reason that the National Seminar on '***Mini- and Micro-Hydropower Development in the Hindu Kush-Himalayan Region: Achievements, Problems and Prospects***' was organised. The main focus of discussions being private or decentralised MMHP, since this sector is usually ignored by the main utilities of all the regional countries, which concentrate on bigger plants.

The seminar was organised through an ICIMOD-implemented project entitled 'Design and Testing of a `Regional Training Programme on Mini- and Micro-Hydropower for Mountain Development in the Hindu Kush-Himalayan Region'. It was funded by the Norwegian Agency for Development Cooperation (NORAD). This seminar facilitated the exchange of available information by a broad category of participants from government agencies, donors, manufacturers, installers, promoters, and consultants. The material contained in the Nepal Country Report on MMHP and the proceedings of the International Experts' Consultative Meeting on MMHP, both published by the same project, served as a basis for the deliberations of the seminar. In addition, the participants, many of whom have been associated with MMHP for a long time, were able to provide additional information.

Altogether 33 experts participated in the seminar. They represented donors, INGOs, NGOs, government and utility agencies, banks, teaching/training institutes, R&D institutes, manufacturers, entrepreneurs, contractors, consultants, and so on.

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Inaugural Session

Introduction to the Seminar by Dr. Anwar Junejo, Coordinator of the MMHP Project

Dr. Junejo welcomed the participants and outlined the purpose and background of the National Seminar. He said that the seminar was organised jointly by ICIMOD and the Agricultural Development Bank of Nepal (ADB/N) with the principal objective of exchanging information and making it available to as wide an audience as possible, an audience representing government agencies, donors, manufacturers, promoters, and consultants. He also said that the main themes of the seminar were new approaches to the promotion of MMHP in the rural mountain areas, their impact and advantages, and, most importantly, the prevalent problems and their redressal.

Dr. Junejo mentioned that similar seminars were proposed in Bhutan, India, and Pakistan as a mandatory component of the `Design and Testing of a Regional Training Programme on MMHP for Mountain Development in the Hindu Kush-Himalayan Region'; a project sponsored by the Norwegian Agency for Development Cooperation (NORAD) and implemented by ICIMOD. He also said that the seminar had been preceded by a 'Consultative Meeting of International Experts' on MMHP'. The meeting dealt in depth with the issues related to improving the viability and reliability of MMHP.

Keynote Speech by Mr. Srikrishna Upadhyay

Mr. Upadhyay's speech covered the problems and prospects of MHP development in Nepal and highlighted the present status. He said that there were 25,000 *ghatta*(s) in Nepal. Out of these, about 600 had been converted into Multipurpose Power Units (MPPU), each of which can generate up to two kW of electricity. There were over 700 water turbines, out of which about 100 generated electricity; the aggregate total was about one MW.

Mr. Upadhyay further noted that 32 Nepal Electricity Authority (NEA)-owned MHP generated about five MW of power. The total capacity of government-owned small hydropower plants was 10 MW.

Mr. Upadhyay said that most of the MHP units were individually owned. However, recently, some NGOs, such as the King Mahendra Trust for Nature Conservation, were promoting community-owned plants. The Ghandruk and Siklis MHP plants were examples of plants promoted by them.

With regard to the promotion of MHP, Mr. Upadhyay said that the Agricultural Development Bank of Nepal (ADB/N) was playing a key role through liberal financing, arranging training programmes in association with organisations such as the UNDP and the Intermediate Technology Development Group (ITDG), and providing technical support through its Appropriate Technology Units. He further said that the government was helping to promote electrification plants by partially subsidising the cost of electrical equipment and delicensing plants of up to 1,000kW.

Mr. Upadhyay noted that decline in the ADB/N's interest, coupled with the withdrawal of government subsidies from 1989/90 to 1992/93, had had a negative impact on MHP promotion. The government subsidy on MHP was reintroduced subsequently, and it had regained priority at the ADB/N as well. Referring to the viability of MHP, Mr. Upadhyay said that privately-owned MHP gave better performances than the NEA-owned in terms of capital as well as operational costs.

With regard to the state of MHP technology, Mr. Upadhyay mentioned a number of technological achievements such as development/adaption of Pelton turbines, electronic load controllers, induction generators, and peltric units. The ITDG and Kathmandu Metal Industries (KMI) had played important roles in such achievements. The introduction of popular peltric units had had a remarkable impact on the dissemination of MHP.

Mr. Upadhyay noted that a potential for generating approximately 26MW of electricity, using the existing 25,000 *ghatta*(s) and 4,000 sprinklers, existed. The potential for electricity generation from small and MHP for the Eastern Development Region was estimated at 18MW. Thus, there was considerable potential for electricity generation from MMHP.

Mr. Upadhyay also recommended the following strategies for the promotion of MHP.

- Establishment of an Alternative Energy Promotion Centre
- Increasing the subsidy rate
- Setting up a revolving fund to support subsidies
- Expansion of a dealer network and other publicity measures
- Supporting R&D activities
- End-use development
- Strengthening the capacity of manufacturers
- Conversion of *ghatta* to MPPU and dissemination of more Peltric units

Inaugural Speech by Mr. E. Pelinck, Director General, ICIMOD

Mr. Egbert Pelinck highlighted the objectives of ICIMOD and its various programmes. He mentioned *'Rural Energy Planning and Management at District Level in Mountain Areas'* as an example of ICIMOD's earlier original energy-related programmes. This programme identified and assessed the various options that were available and recommended decentralised planning and implementation systems at the district level, including adequate training for the personnel of concerned agencies.

Mr. Pelinck appreciated the generous offer of the Norwegian Government to support the 'Design and Testing of a Regional Training Programme on Mini- and Micro-Hydropower for Mountain Development in the Hindu Kush-Himalayan Region' Project. He noted that the Consultative Meeting of MMHP experts organised previously was the first major outcome of this project. The current seminar was also an important activity in the process of implementing this project.

Mr. Pelinck further stated that the project and the seminar reflected ICIMOD's mandate very well and that is:

- addressing key issues in mountain development through the processes of environmental conservation and poverty alleviation. Mini- and micro-hydropower are particularly designed to reach disadvantaged groups as a means of improving their standards of living through the sustainable management of natural resources;
- examining the mountain-specific opportunities that mountain areas can provide; and
- bringing together experts and experiences from different countries in the region.

Mr. Pelinck said that he was aware how important an appropriate energy initiative can be for rural development. Furthermore, he emphasised the need to seriously consider the advantages and limitations of a particular alternative initiative, such as micro-hydropower, as, more often than not, it is more important to take the limitations rather than the advantages into consideration when promoting usage.

Mr. Pelinck further noted that MMHP entrepreneurs and users were interested in what MMHP could do to alleviate their problems and at what cost. This included not only monetary cost but also the work load involved, the efforts required to deal with ensuing problems, and so on.

Finally, Mr. Pelinck thanked ADB/N for co-sponsoring the seminar and wished the participants a successful outcome.

Concluding the inaugural session, Dr. Junejo thanked the Chairman of the session, Mr. Pelinck, the Guest of Honour, Mr. Upadhyay, the authors of the papers, ADB/N, ITDG, and the participants.

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Working Sessions

Working Session 1: New Approaches and Activities

The first session of the seminar was chaired by **Dr. M. Banskota,** Deputy Director General, ICIMOD. **Mr. B. Pandey,** of ITDG was the rapporteur for this session. The highlights of the session are presented below and the summarised versions of the papers presented are given in Part B.

Dr. A.A. Junejo presented the first paper of the session: ***"Mini- and Micro-Hydropower Development in the Hindu Kush-Himalayan Region: Achievements, Impacts and Future Prospects."*** The paper reviewed MMHP development in Bhutan, China, India, Nepal, and Pakistan in great depth.

Referring to the achievements in the field of MMHP, Dr. Junejo said that China was in the forefront of MMHP development in terms of the number of plants installed, the development of local manufacturing capabilities, and the impact of MMHP on rural development. China began MMHP development in the early fifties. It had so far installed 45,700 MMHP plants of up to 500kW capacity, with a total installed capacity of about 6,000MW. The share of MMHP in the total hydropower harnessed is about 20 per cent.

The development of MMHP in Nepal has followed a unique course. The remarkable features of MMHP development in Nepal were the emergence of a significant number of commercial private sector MHP targetted at electrification of remote rural hill areas; the development of a large number of MHP for mechanical power; remarkable local manufacturing capabilities including R&D activities; interesting experiments in developing innovative systems of private sector MMHP management; and efforts to develop and disseminate end uses. He also said that there were 35 MMHP plants having a total capacity of nine MW, installed by the government in Nepal. There were over 700 micro-hydro units in the private sector. These represented a wide range of technologies such as stand-alone electrification units; 'milling only' plants of various degrees of sophistication from improved traditional water wheels (*ghatta*) to modern turbine units; milling units with add-on electricity generating facilities; and small portable stand-alone electricity generating units in the one kW range called peltric sets.

Dr. Junejo further mentioned that Pakistan had installed approximately two MW of MHP in the private sector, which was comparable to the figure in Nepal. The non-commercial nature of the plants and the dedication of all the plants to electricity generation were distinctive features of private sector MHP development in Pakistan. In the public sector, there were 64 MMHP plants with a total capacity of about 17MW.

Dr. Junejo said that there were 145 MMHP/SHP plants in the public sector in India with a total capacity of about 106 MW. Recently, NGOs had also started to take part in the dissemination of MHP. In Bhutan, there were 19 MMHP with a total capacity of about three MW in the public sector.

Dr. Junejo noted that Nepal had developed the most elaborate policy framework and support for private sector MHP promotion. It had also formulated policies for the promotion of hydropower in general, and these made special reference to mini-hydropower development. China had been developing MMHP under the policy of self-construction, self-management, and self-consumption. China had developed MMHP as one of the components of the rural development package and not as an isolated or independent development endeavour. Bhutan and Pakistan had not formulated policies as such for the promotion of MMHP. However, Pakistan had been supporting MHP promotion because the government was committed to rural electrification. India had announced special incentives for MMHP development in the private sector. It treated private MMHP as a supplement to the government's electrification efforts.

Furthermore, Dr. Junejo said that, generally, the principal public utilities, which were involved in the development of MMHP in the initial stages, were moving away from MMHP to larger plants because of the poor financial performance of utility-owned MMHP. However, from the perspective of the private local entrepreneur, mini- and micro-range plants had proved to be more viable. Therefore, the promotion of MMHP should be continued.

Dr. Junejo said that the cost of indigenous equipment was considerably less than that of imported equipment. But the rise in MMHP costs in Nepal, which were already higher than in Pakistan, India and China, was unsettling.

Dr. Junejo mentioned that, in all the regional countries, private or decentralised MMHP had been receiving financial and other support. Government support to MMHP should continue for some time as it should be regarded as an input to the infrastructural development of remote rural areas. Government support should also be extended to R&D, promotion, training of manpower, and so on.

Mr. Devendra Adhikari from the ADB/N presented the second paper entitled, '***ADB/N's Contribution to the Development of Micro Hydropower - Achievements, Problems and Prospects***'. The presentation gave an extensive review of the efforts of the ADB/N in promoting MHP in Nepal. He said that the ADB/N played a pivotal role in the promotion of MHP in Nepal. However, due to the fact that relatively little weightage was given to MHP programmes in terms of the ADB/N's total investment, it was not able to give this sector the full support it needed. In the context of current bank priorities, he expressed the opinion that a national-level organisation was needed to take the lead in promoting alternative energy technologies, including MMHP.

Mr. Adhikari expressed serious concern about the significant escalation of MHP costs, as they could be detrimental to the promotion of MMHP. Operation and maintenance problems were also serious. He suggested that the agencies involved in MHP should make adequate efforts to train manpower, rehabilitate sick plants, carry out R&D and pay attention to other technical aspects.

Mr. Adhikari was of the opinion that the current level of capital subsidy on electrification plants was not enough to make them financially viable. He suggested that end-use development, as well as subsidies in productive end uses, should be considered as a means of supporting electrification plants.

Discussion. The papers led to lively discussions. Reasons for the high cost of MMHP installations in Nepal compared to the costs in Pakistan and China were sought. It was thought that, due to different hidden subsidies in the cost of raw materials in China, it would be difficult to make a comparison with the costs in Nepal. However, compared to Pakistan, Nepal was thought to have higher transportation costs (up to 40% of the total cost), more sophisticated control systems using load controllers, more expensive raw materials for penstock pipes, and no inexpensive generators, as in China. It was also pointed out that costs of MMHP have been rising over the years as has the reliability of schemes with improved civil works. However, the question was not completely resolved, and it was thought that the monopoly of manufacturers in MMHP equipment and the availability of government subsidies might be contributing to the rising cost of MMHP in Nepal.

The Government of Nepal's commitment to MMHP was questioned in light of the decreasing number of installations every year since 1985 and the uncertain and irregular annual subsidies for electrification. Confusion prevailed over the actual status of government subsidies. Of the 15 million rupees set aside in the national budget the previous year only three million rupees had been spent. However, at the same time, many entrepreneurs were not able to receive subsidies. It was not clear what the bottlenecks in the subsidy process were; this required more study.

The viability of MMHP, the rationale for subsidising MMHP and other renewable energy sources, such as photo-voltaics, and the real cost of MMHP versus diesel were the other questions for which no definite answers could be provided and for which it was agreed that further studies were needed. It was pointed out that the new demand for MMHP was more for electrification than for milling purposes. This was true for both small Peltrics and for larger stand-alone installations.

The actual performance of MMHPs was not well documented. It was not known how many of the over 900 installations were actually still working. It was recommended that a study be conducted to find out the number of operating installations.

A proposal was made that the cost of equipment be reduced by taking advantage of standardisation and mass manufacture of equipment. It was suggested that a mass market could be created by providing lower level subsidies and by widening the support so that installation rates increased considerably.

At the end of the session, the Chairman, **Dr. Banskota**, summarised the proceedings of the session. He said that MMHP had a definite role to play in Nepal and that MMHP development should not be seen in isolation but in the context of rural development as a whole. Further, touching upon the issue of the reduced growth rate in MMHP installations, he pointed out that there may be a need to take the risk of generating demand instead of just waiting for it to materialise. The costs, viability, and subsidies of MMHP were not absolute; it was difficult to put economic values to the savings in terms of forests and rural development. Finally, Dr. Banskota thanked the participants and those who presented papers.

Working Session 2: New Approaches and Activities (Cont'd.)

Dr. R.D. Joshi chaired this session and **Mr. D. Adhikari** was the rapporteur. The highlights of the session are presented here while the summarised versions of the papers are given in Part B.

Mr. R.S. Thapa, from the Salleri-Chialsa Electricity Company Ltd. (SCECO), presented the first paper of the session entitled ***'Salleri-Chialsa Electric Company - An Experience of a New Approach for MMHP Management'***. He illustrated how an innovative management approach had helped to improve the dwindling image of MMHP in Nepal. He said that SCECO, which was a shareholder company of the Nepal Electricity Authority, the Swiss Development Corporation, and consumers (householders) as shareholders, had made a remarkable achievement in the context of making MMHP sustainable through participatory management. This had helped to win the confidence of the local community. Other measures taken had been introduction of an innovative tariff system, which helped to increase the load factor to about 44 per cent; efficient administrative and technical management, which helped to reduce system losses, maintain a high plant availability of about 99 per cent, and relatively low running costs; and allocation of about 40 per cent of the expenditure for depreciation to create a capital replacement fund.

Mr. Thapa stressed the fact that the small personnel numbers in SCECO (only 10) was remarkable in the context of the employment patterns in publicly-owned MMHP. This was achieved through training as well as giving reasonable incentives.

'The Role of the Nepal Hydro and Electric and Butwal Engineering Works' was the second paper presented by **Mr. N.R. Shrestha** from the Nepal Hydro and Electric Company (P) Ltd. (NHE). Mr. Shrestha said that Butwal Engineering Works (BEW) and NHE were two pioneering companies in the field of MMHP with a focus on development and manufacturing of electro-mechanical equipment. NHE was a joint venture company formed with the purpose of getting foreign technical support.

Mr. Shrestha highlighted the joint manufacturing capabilities of the BEW and NHE which included crossflow turbines of up to 100kW capacity, Pelton and Francis turbines of up to five MW capacity, governors, electronic load controllers, control systems, transmission towers, penstocks and accessories, and so on. The list clearly showed that these companies were the front-runners in MMHP in Nepal.

Mr. Shrestha gave a list of the principal NHE/BEW undertakings, which included, among others, the rehabilitation of the Tinau Plant (1,000kW); the rehabilitation of turbine runners for the Sundarijal Plant (640kW); manufacturing/rehabilitation of equipment for the Andhi *Khola* Plant (5.1MW); design/ manufacturing/installation of equipment for the Darchula (250kW) and Jhimruk Plants (12MW); and site welding of the penstock during the rehabilitation of Kulekhani - I (60 MW).

Mr. Shrestha said that the low volume of demand for MMHP and insufficient government commitment to support the development of indigenous manufacturing capabilities were the main difficulties being faced by the MMHP industry.

The third paper, ***'Experiences in End-Use Development and Small Industry Promotion in Salleri'***, was presented by **Mr. H.P. Shrestha** of the Salleri-Chialsa Electricity Company (SCECO). The paper highlighted the importance of institutional support to end-use promotion to make MMHP financially viable.

Mr. Shrestha noted that the Salleri-Chialsa Hydropower Plant, built with the assistance of the Swiss Government, differed from other MMHP plants because the commissioning of the plant was not perceived as the final goal. The final goal was to make maximum use of the plant by promoting appropriate end uses, thus contributing to local development as well as to sustainability of the plant. The Salleri-Chialsa Electricity Utilisation Project (SELUP) was established for this purpose.

Mr. Shrestha said that SELUP introduced a number of domestic end uses, such as rice cookers, electric kettles, mixer-grinders, irons, immersion rods, blower fans, *bijuli dekchi*(s), and so on. It organised demonstrations of end uses and provided repair and maintenance services to the users. As a result of this promotional activity, a stable market for electric appliances developed and private electric shops were opened. These shops have taken over most of the SELUP activities in this field.

Small industry promotion received importance in SELUP, said Mr. Shrestha. SELUP supported entrepreneurs through technical information dissemination, coordination of business ventures, advisory services, feasibility studies, and training on management and book-keeping.

Mr. Shrestha also said that the achievements of SELUP were impressive. Twenty-six small-scale industries had been established. About 35 per cent of the households had started to use electricity for cooking and about 11 per cent for heating. Concluding, Mr. Shrestha said that the Agricultural Development Bank should take responsibility for providing technical and financial services to local entrepreneurs.

Mr. Ajoy Karki from the Butwal Power Company presented the last paper of the session entitled, ***'Development of Mini-Hydropower in Remote Areas - Some Experiences and Challenges'***. Mr. Karki said that mini-hydropower development required more rigorous financial, technological, and socioeconomic analyses than micro-hydro.

Citing the example of the 500kW Jhankre Mini-hydro plant, designed to supply power, together with a diesel plant, during the construction of the 60MW Khimti Hydropower Plant, Mr. Karki said that it resolved the water rights' issue by guaranteeing the existing mode of water withdrawal for irrigation. The reasonably detailed financial analysis of the project helped to select the best water availability for the plant, considering its inclusion in the grid after the commissioning of the Khimti Project. He also said that the concerns of the local people were addressed while developing the national-scale Khimti Project by making provisions for electrification of the surrounding area and providing job opportunities to local people.

Mr. Karki listed a few innovative technical decisions adopted in Jhankre with the aim of reducing costs. These included the use of plum concrete in anchor and thrust blocks, the use of high-grade steel for penstocks, and the use of a desilting basin cum forebay concept. In conclusion, he remarked that preliminary geotechnical investigations might be justifiable in the case of mini-hydro schemes.

Discussion. Regarding the paper presented by **Mr. R.S. Thapa**, the participants unanimously agreed that improved management can improve the sustainability of MMHP to a significant degree. They also appreciated the progress made by SCECO in managing the Salleri-Chialsa Mini-Hydro Plant. However, some participants said that the hidden cost of Swiss support in the management of the plant should be considered before drawing inferences about the sustainability of the plant.

The participants lauded the role of NHE and BEW in MMHP development. They also suggested that these companies should play a greater role in helping other private manufacturers to develop their capabilities. The participants agreed with the conclusion that MMHP could be sustainable only if adequate efforts were made to promote end uses. The reported improvements in the financial situation of the Barpak MHP, due to enhanced end uses, was cited as an example of the positive impact of end uses on the financial viability of MMHP.

The innovative approaches adopted in the Jhankre Mini-hydro Plant sparked the interest of the participants. Some participants expressed doubts about the appropriateness of the low-water availability selected for the plant in view of the lack of adequate water storage facilities.

Working Session 3: Problems and Redressal

Mr. Gerry Kent chaired the session. **Mr. S. Sharma** was the rapporteur. The highlights of the papers presented in the session are outlined below, and the summarised versions of these papers are presented in Part B.

Dr. A.A. Junejo started the session by presenting the paper entitled ***'Problems Associated with the Private/Decentralised MMHP Plants and Some Possible Redressals'***. Dr. Junejo said that the MMHP funding system was most developed in Nepal. However, low and inconsistent funding had discouraged entrepreneurs as well as manufacturers. The poor repayment of loans had further aggravated the situation by discouraging the bank as well.

Dr. Junejo said that poor implementation of some of the existing policies and the lack of policies in other areas had made MMHP investment risky. He emphasised the alarming increase in prices of indigenous equipment. This could not be explained by inflation alone and should be investigated seriously. He mentioned that the economic returns of electrification through MMHP were still poor. Dr. Junejo expressed the opinion that, both in Pakistan and Nepal, frequent plant failures had been reported. The administrative and technical management capabilities of owners/managers and operators were, as a rule, poor. The remoteness of private MHP in Nepal had made these difficulties more serious.

In conclusion, Dr. Junejo recommended some redressals, such as extensive manpower training on MHP, support to R&D activities, development and promotion of end uses, better coordination between agencies involved in MHP, establishment/designation of a suitable institution with the overall responsibility for MMHP promotion, preparation of guidelines for surveys, feasibility studies, design, installation and commissioning, and so on.

Mr. S. Devkota from the Balaju Yantra Shala (BYS) presented the second paper of the session entitled, ***'Balaju Yantra Shala Experiences in MHP Technology Development.'*** He said that BYS was the first industry in Nepal to manufacture MMHP equipment, notably turbines. It started by manufacturing propeller turbines. After a few trials of propeller turbines, this venture was abandoned as it did not meet the local requirements. Subsequently, BYS manufactured cross-flow turbines, which was gradually established as the predominant turbine used in MHP in Nepal. BYS had achieved a great deal in cross-flow turbine type manufacture, developing 13 models altogether. In addition, BYS had been carrying out site surveys and installing and commissioning MHP plants.

Highlighting the difficulties faced by manufacturers, he said that high customs' duties on raw materials and low customs' duties on imported turbines were discouraging local manufacturers. The lack of a hydrological database for MHP sites and the lack of trained mechanics were also mentioned by him as serious constraints to MHP development.

The third paper of the session entitled, ***'State-of-the-Art — Technologies Appropriate for MMHP',*** was presented by **Mr. B. Pandey** from the Intermediate Technology Development Group (ITDG). The paper provided guidelines for selection of MMHP technology. It emphasised that the appropriate choice of technology was crucial for the success of an MMHP. Reliability, local/national manufacturing capabilities, and correspondence with the needs and capabilities of the community for whom it was designed were the parameters determining the appropriateness of a particular technology in a given situation.

Mr. Pandey's presentation covered the following technologies: improved *ghatta*, turbines for milling, add-on schemes, peltric sets, and stand-alone schemes. He said that despite reasonably-matured MHP technology, some bottlenecks still remained in certain areas: civil works, pelton turbines, induction generator controllers, and current cut-outs.

Discussing the example of the Yangar MHP in remote Humla District, Mr. Pandey said that its failure was clearly due to the selection of inappropriate technologies. Further, he recommended the following measures for MHP promotion in remote areas: (a) the role of organising and motivating communities may be better served by NGOs than by ADB/N; (b) MHPs were unlikely to succeed without outside technical support; (c) the current level of financial support to electrification MHPs should be increased; (d) stand-alone electrification schemes were seldom sustainable; and (e) agroprocessing, especially oil expelling powered by MHPs, was most rewarding economically.

The fourth paper of the session entitled ***'Viability and Desirability of Mini- and Micro-Hydropower'*** was presented by **Dr. R.D. Joshi** from the Tribhuvan University. He said that both private and public sector efforts in the electrification of rural hill areas started in the mid-seventies. Private sector efforts had been directed towards the sparsely-populated rural hills, whereas the public sector had been towards the district headquarters. Though the success of private sector electrification in Nepal was encouraging, its growth rate had not been high enough to meet the Eighth Five Year Plan target.

Dr. Joshi was of the opinion that MHP technology, although already workable, was still evolving. Further research and development (R&D) efforts were necessary for a fully matured technology. He also said that add-on MHP might be financially viable, but stand-alone plants became financially viable only when end uses were adequately developed. Popular one kW peltric sets of the stand-alone type were an exception to the above rule.

Dr. Joshi mentioned that community-owned, non-commercial MHP was also emerging in Nepal. This type of plant could be divided into formally-managed and non-formally managed plants. Experiments were being carried out to evolve financially-sustainable models of formally-managed plants. Dr. Joshi said that rural electrification efforts in Nepal, through private MHP, were encouraging from the rural development standpoint, because it was a common practice for MHP entrepreneurs to integrate agro-industrial end uses with MHP.

Concluding the presentation, Dr. Joshi suggested the following measures for MHP promotion: (a) entrepreneur-owned MHP should be the focus for MHP promotion; (b) end-use promotion should receive high priority; (c) stand-alone plants, which could make relatively higher contributions to rural development, should receive higher subsidies than add-on plants; (d) an agency responsible for the overall promotion of MHP should be established or designated; and (e) the subsidy level should be differentiated according to the economic development indicators of the areas being considered.

Mr. G.P. Devkota presented the last paper of the session entitled ***'Development and Dissemination of Mini- and Micro-Hydropower in Nepal: The DCS Experience.'*** He mentioned that the Development and Consulting Services entered the MHP field with the manufacturing and installation of the first turbine — a cross-flow turbine, in Jhare *Khola* in 1976. Since then it had been involved in survey, design, installation, and commissioning of MMHP. Its notable R&D activities were related to automatic voltage regulators, electronic current cut-outs, positive thermal coefficient thermistors, and electronic load controllers.

Mr. Devkota said that 260 MMHP plants, out of the 918 installed by 1993 in Nepal, were installed by DCS alone. Out of the DCS-installed MMHP plants, 54 were electrification schemes. By 1993, it was estimated that the total power generation from DCS installations was 730kW, and approximately 50,000 people benefitted from DCS electrification programmes.

The lack of good testing facilities, the lack of MMHP standards, uncertainty in the provision of subsidies, high initial costs, inadequate users' knowledge, and limited availability of spare parts were mentioned by Mr. Devkota as the main problems facing MMHP promotion. He said that the possible solutions to these problems might be: (a) organising repair and maintenance training for operators; (b) opening local sales' depots; (c) organising consumer education and mobile training programmes; and (d) rewarding the successful owners/promoters/operators.

Concluding the presentation, Mr. Devkota made the following recommendations: (a) standardised equipment should be developed; (b) simpler funding mechanisms should be developed; (c) manufacturers should organise follow-up visits; (d) plant operation manuals should be prepared; (e) R&D activities should be undertaken to develop end uses; and (f) MMHP awareness-raising programmes should be organised.

Discussion. Responding to the question from a participant about the possible ways of dealing with non-repayment of loans, it was suggested that judicial measures to approve as well as recover loans might be helpful. The issue of escalating MMHP costs in Nepal was widely discussed. One of the participants, commenting on this issue, said that the old micro-hydro schemes were cheaper but unreliable, and the new ones were more expensive but reliable.

During the discussions, concerns were raised about the difficulties involved in returning poor quality imported Indian goods. No satisfactory solution was found to that problem. A number of questions was raised about the price and quality of various cross-flow turbine models manufactured by BYS.

One of the participants asked whether the appointment of dealers could help promote MHP. It was agreed that such an approach was feasible only for standardised equipment, such as peltric sets, but not for larger sets that were site-specific.

Regarding the decline of MHP business, it was noted that the MHP turnover had remained more or less stable in BYS, though its share in the company's turnover had always remained below 10 per cent. BYS had been exporting equipment. However, it had not been able to make a profit out of MHP.

Discussions about the of demand for MHP were not conclusive. Some participants felt that the demand for MHP was not sufficient, while others opined that there was too much demand for it and stressed that MHP should be promoted carefully. The scope for introducing Francis turbines in Nepal was also discussed. Participants were of the opinion that it would not be wise to introduce Francis turbines because of the low level of MHP demand.

In the course of discussions on the reliability of load controllers, it was noted that electronic load controllers were fairly reliable, whereas induction generator controllers still had reliability problems. The possibility of introducing subsidies on energy as an alternative to the subsidies on capital costs was discussed. It was agreed that in the current circumstances this was practically impossible.

One of the participants asked if DCS was making a profit from MHP, and it was explained that DCS, a non-profit organisation, had been operating at break-even point. Referring to the low priority accorded to milling type MHP by DCS, it was clarified that DCS was withdrawing from that area because private manufacturers had already developed adequate capabilities in that field.

One of the participants asked whether it would be appropriate for DCS to promote milling MHP in the Mid and Far-Western Development Regions, given the slow dissemination of such MHP in those regions. It was explained that there was not much demand for milling MHP in these regions.

Working Session 4: Direction for the Future

The fourth session was chaired by **Mr. B. Pandey** and **Mr. S. Sharma** was the rapporteur. The highlights of the session are given below. The summaries of the papers presented are given in Part B.

Mr. V.B. Amatya presented the first paper entitled **'Institutional Requirements for MMHP Development in Nepal'**. In the context of dwindling biomass resources and high transportation costs of fossil fuels, Mr. Amatya said that alternative energy sources should be seriously considered for remote rural hills. Among the alternative energy sources, micro-hydro had proven to be capable of being commercialised.

Mr. Amatya also gave a brief review of the institutions involved in the MMHP sector. In the course of the review, he said that the ADB/N played a key role in the successful dissemination of MMHP. He also said that NGOs and INGOs had played important roles in this endeavour. Mr. Amatya said that the Eighth Five Year Plan included policies and programmes for Alternative Energy Technology (AET) promotion, including the institutional set-up.

Referring to the problems faced by MMHP, Mr. Amatya said that most of the problems could be directly linked to the lack of a dedicated institution for MMHP promotion. He suggested that a Central Micro-Hydropower Promotion Centre, which could be a wing of the Alternative Energy Promotion Centre proposed in the Eighth Plan, be formed within the government framework but that it should be made as autonomous as possible. The main responsibilities of such a centre should include: (a) coordination and facilitation of R&D activities; (b) preparation of guidelines and manuals on MHP-related work; (c) quality control; (d) facilitation and coordination of training programmes; and (e) facilitation of financing.

Dr. K. Rijal presented the last paper of the session entitled ***'Perspective on Mini- and Micro-Hydropower Development'.*** He noted that the scattered settlement pattern in the hills and mountains of Nepal had made micro-hydro a preferable option for rural energy supply. The other intangible benefits of MMHP were its potential to: (a) substitute fuelwood for cooking and heating applications in residential, agro-based cottage industries and commercial activities; (b) reduce human drudgery, especially of women; (c) increase income-generating activities and help move towards a modern economy; and (d) reduce carbon emissions and deforestation. With regard to the international experience in rural electrification, he said that rural development could only be achieved if a broader-based development package was designed with energy as the prime mover of rural development. Dr. Rijal also listed the factors impeding the growth of MMHP, which were: (a) market and price distortion; (b) lack of capital resources; (c) low load factor; (d) lack of policies to guide R&D activities; and (e) lack of a coordinating agency. He proposed the following means to promote MMHP: (a) improve the economics of MMHP through end-use diversification; (b) link it to the development of mega-projects; and (c) conduct economic analyses taking market distortion into consideration.

Discussion. One of the participants wondered if the Alternative Energy Promotion Centre (AEPC) was necessary as MMHP was already being subsidised. It was mentioned that many inputs, other than funding, were necessary to promote MMHP. Another participant enquired why alternative energy resources were discussed only during power crises. It was noted that the drive to promote MHP was not associated with the current power crisis because the MHP target area was generally beyond the reach of the grid.

The concept of linking MMHP to mega-projects sparked the interest of the participants. They agreed that MMHP could be used to supply electricity to the areas surrounding the mega-projects.

4
Concluding Session

The Concluding Session was chaired by **Dr. M. Banskota**, Director of Programmes, ICIMOD, and **Mr. S.L. Vaidya** was the rapporteur.

Dr. R.D. Joshi presented the seminar conclusions prepared by a small committee. Members of the committee were Dr. A. Junejo, Mr. B. Pandey, Mr. D. Adhikary, and Dr. R.D. Joshi.

The proposed conclusions, the discussions which followed them, and the conclusions adopted subsequently are presented below.

Conclusions and Discussions

1. Appropriate standards of technological reliability need to be developed and implemented.

The participants made an effort to identify appropriate agencies for the preparation of MMHP standards. However, the participants could not agree on that issue. A conclusion was adopted with the following modification:

> *"Appropriate standards or guidelines for design and manufacture of MMHP need to be developed to improve the performance and reliability of plants."*

2. R&D and allied facilities need to be developed and adequately supported.

The participants felt that the conclusion should be spelt out more precisely, elaborating on the purpose of R&D activities. Some participants were of the opinion that *quasi-*governmental organisations or NGOs might be suitable for developing such facilities. The conclusion was adopted in the following form.

> *"R&D and allied facilities need to be established or incorporated in the existing manufacturing systems to improve performance and quality and also to reduce costs. Additionally, development of more standard equipment, such as peltric sets, would also be helpful in this regard.*

3. End uses need R&D as well as financial support in the same way as MMHP plants.

This issue generated considerable interest among the participants. They stressed the importance of rigorous technical and financial feasibility analyses before the introduction of end uses. As there is a great deal of risk involved in starting end uses before MMHP becomes viable, there is a case for providing financial support to end uses. The conclusion was adopted after the following modifications for clarity were incorporated.

> *"More R&D also needs to be carried out to identify and develop the additional end uses as well as the allied appliances. Financial inputs would also be necessary."*

4. <u>Novel electricity tariffs and adequate management systems are proving to be useful tools for increasing plant use. This work needs to be continued.</u>

The conclusion was adopted in the following form:

> *"Novel electricity tariffs and management systems for the formal electrification plants have contributed significantly towards enhancing the plant factors. These ideas may be pursued further and promoted."*

5. <u>Training of surveyors, installers, owners, managers and operators is very important and has not received adequate attention.</u>

Various agencies that could contribute to the training were identified, but the participants could not recommend a particular organisation that would take care of the training activities. The conclusion was adopted unchanged.

6. <u>The question of soft loans and subsidies needs to be studied in depth, in terms of level and various other parameters as well as implementation aspects.</u>

There was general consensus on the issue that the subsidies were not adequate to achieve the desired dissemination MMHP. However, recommendations on the level of subsidies and their mode of implementation could not be made because the issue required rigorous study. The conclusion was adopted in the following form.

> *"The situation regarding the loans and subsidies, including the amounts and percentages and other parameters as well as implementation aspects needs to be studied in depth and a more effective system may be developed."*

7. <u>Customs' and sales' taxes need to be reduced on and consistently applied for raw materials for MMHP.</u>

The participants, especially those representing the manufacturers, stressed that high customs' duties on raw materials and low custom duties on imported finished MMHP products had weakened the MMHP industry in Nepal and raised the MMHP costs. Some participants were of the opinion that providing rebates on the customs duties to MMHP manufacturers might serve the purpose better. The conclusion was adopted after the following modification.

> *"Customs' duties and sales' tax for raw materials and other components needed for indigenous manufacture of MMHP equipment, may be reduced or rebate be provided, whichever can be implemented more judiciously and transparently."*

8. <u>There is a need for an independent institution to oversee the promotion of MMHP and to organise inputs.</u>

The need for an organisation with the overall responsibility for MMHP promotion was recognised by the participants. Some participants felt that it might be better to designate an existing agency for this purpose rather than create a new one. The conclusion was adopted with the following revision.

> *"An independent institution may be established or a coordinating agency may be organised from the existing institutions to oversee the promotion of private MMHP and organise inputs for its proper development and implementation."*

9. <u>The current rates of MMHP growth are not adequate for the sustainable growth of MMHP.</u>

Some participants were of the opinion that the current growth rate was not sufficient to meet the Eighth Five-Year Plan target and, therefore, the National Planning Commission (NPC) should review the situation. Others were worried that the present rate could not sustain the manufacturers and, hence, NPC intervention, in terms of increased support, was needed. After a lively discussion, the conclusion was adopted in the following form.

> *"The current rate of installation of private MMHP is neither sufficient to meet the projected government targets nor to lead to eventual sustainable growth. Consistent and enhanced financial supports may be provided for agro-processing and electrification MMHP plants."*

10. <u>The establishment of more extension centres in locations where MMHP has not made adequate inroads is also required.</u>

There was general consensus on this issue. Many participants felt that urgent action was necessary in this area. The mode of establishment of such centres was also discussed. The conclusion was adopted in the following form.

> *"More extension/promotion centres may be established in remote areas to promote the technology."*

The seminar also recommended that the following studies be undertaken.

1. An assessment of the reasons behind rising MMHP costs so as to identify ways to curb them to the maximum possible extent
2. Identification of bottlenecks in MMHP-financing procedures in order to make them simple and effective
3. An assessment of the operational status of private MMHP
4. A study of the competitiveness of MMHP with diesel plants, with special reference to the repair and maintenance aspects of MMHP

Chairman's Remarks

Dr. M. Banskota, the Chairman of the session, thanked the participants and the co-sponsor of the seminar, ADB/N. He also congratulated Dr. A. Junejo, the Coordinator of the MMHP Programme, and the participants for the very useful outputs of the seminar.

He said that development intervention in the Hindu Kush-Himalayan Region should be based on need assessment. While the need for strengthening the energy base of the region was generally accepted, the need for MMHP and its scope needed to be carefully studied. The parameters/linkages which influenced the performance of MMHP should be studied in depth.

Dr. Banskota also stressed the fact that the development of local entrepreneurship was one of the crucial factors in the success of MMHP. Lastly, he thanked the participants once again for attending the seminar.

PART B

Mini-and Micro-hydropower Development In the Hindu Kush-Himalayan Region Achievements, Impacts and Future Prospects

- Dr. A.A. Junejo[1]

Introduction

Mini- and Micro-Hydropower (MMHP) has been used for milling in the region for many centuries. Although modernisation in water mill technology started around the turn of the century in the West, its progress as an alternative energy source took place only after the oil crisis of 1973, along with that of other renewable technologies. China has been in the forefront of MMHP development since the early 50s and, at present, has 45,700 MMHP plants with a total installed capacity of about 6,000 MW.

Hydropower as such is considered environmentally-benign, and hydropower in the MMHP range is considered even more benign due to its ability to blend with the local environment and traditions. Hydropower in the MMHP range has comparative advantages over large hydropower; its appropriateness in integrating with rural development is an important one. It is possible to develop MMHP as decentralised systems. They are simple in design, can be installed quickly, and are easier to manage and operate. Unfortunately, only a small portion of the MMHP potential is utilised in the Hindu-Kush Himalayan (HKH) Region, where rapid development of a cheap and non-polluting source of energy to meet the challenges of development and a deteriorating environment are warranted.

Summary of the MMHP Installation Programme in the HKH Region

Considerable progress has been made in five countries of the HKH region, in terms of the number of installations in the MMHP range. In India and Pakistan, the share of MMHP is less than one per cent of the total harnessed hydropower, although its potential share could exceed 10 per cent. In China, this share is about 20 per cent.

Bhutan

Most of the electro-mechanical components of the 19 MMHP installations, with a total capacity of 3.40 MW, have been imported from and funded by Japan and India. MMHP plants in Bhutan were designed and installed by foreign consultants. The Royal Government of Bhutan does not have any future expansion plans for MMHP. Government agencies consider MMHP plants to be expensive and economically non-viable. Out of a total of 19, 10 MMHP plants were handed over to user communities for operation, maintenance, and power distribution. The communities were also

1 Project Coordinator, MMHP Project, ICIMOD

empowered to fix the tariffs. Responsibility for repair of these plants, however, lay with the Department of Power.

India

There were reported to be 145 MMHP/SHP[2] plants in India, with a total capacity of 106 MW, which had been installed by various government agencies, while 159 additional plants, with a total capacity of 198MW, were under construction. Out of the 145 existing plants, approximately 100, with a total capacity of 70MW, were located in the northern Himalayan range. These plants are in 10 northern states, starting from Arunachal Pradesh in the east to Jammu and Kashmir in the west. All of these plants were being managed by the State Electricity Boards/Department of Power. In most of the cases, tariffs charged to consumers were the same as those charged to consumers connected to the grid. However, in some states, the tariffs were lower and were charged on a flat rate basis. For example, in Arunachal Pradesh, a fixed sum of IRs 9 per point[3] was charged to the consumers.

More recently, NGOs had also started to take part in the dissemination of MHPs in Ladakh and Uttar Pradesh. One of the NGOs had installed 13 MHPs, with a total capacity of about 200kW. These plants were handed over to the communities for operation.

Nepal

Thirty-five MMHP plants, having a total capacity of nine MW, had been installed by the government in Nepal. These plants were installed and operated by the NEA and five of them were connected to the grid. During 1993, five of these plants were leased to private companies for operation and maintenance so as to cut down NEA's losses from MMHPs. More MMHPs were expected to be leased out in the future. These companies were also empowered to fix tariffs, though not higher than those of NEA, and collect revenue on their own.

Some private MMHP plants were non-commercial and formally managed. These plants represented an effort to arrive at new forms of MMHP management. The effort was being supported by a number of donor agencies.

These plants also used innovative tariffs; one of the distinctive features differentiating them from public sector plants. For example, in the 400kW Salleri Chialsa Plant, the special features of tariffs were introduction of flat tariffs for certain categories of domestic consumer, based on committed/admissible power; relatively high fixed charges for the remaining categories of domestic consumer and all commercial consumers; introduction of cheap off-peak rates for industrial consumers; and differentiation of admissible power during peak and off-peak periods for industrial consumers. These innovative features of the tariff rates helped to reduce costs associated with meter

2 SHP or Small Hydropower includes installations of up to 3.0MW.
3 A point is defined as a bulb/tubelight, or power socket.

reading and, for some categories of domestic consumer, to reduce the peaks and to encourage industries.

The Ghandruk Power Plant, with a capacity of 50kW, has introduced flat tariffs of NRs 0.50/W, NRs 0.75/W and NRs 0.25/W per month for domestic, commercial, and industrial (day time) consumers, respectively. The commercial and industrial consumers of this plant could also choose an alternative tariff of fixed components - NRs 0.25/W/month and NRs 0.08/W/month for commercial and daytime industrial consumers respectively and an energy component of NRs 137/kWh for both types of consumer.

Privately-owned Informal MMHP

This type of plant was owned and operated by private entrepreneurs. There were over 700 turbines in Nepal, of which 13 were stand-alone units for electrification and the rest were installed mainly for agro-processing, 100 of these had add-on units for electricity generation. In addition, about 70 units of the peltric type, having an average power output of one kW, had also been installed for electrification.

The number of improved *ghatta*(s), essentially traditional *ghatta*(s) with improved metal runners, was estimated at 200. Some improved *ghatta*(s) had add-on electrification facilities as well. Multipurpose power units, in the one to four kW range, represented the culmination of the efforts to modernise the traditional *ghatta*. Around 200 units of this type had been installed.

Equipment Development and Manufacture

The first modern turbine — a propeller turbine — was manufactured in 1960 by Balaju Yantra Shala (BYS) with assistance from the Swiss Government. After a few trials with propeller turbines and cross-flow turbines, which were developed subsequently, the cross-flow turbine was accepted for widespread dissemination in Nepal. Eleven companies were manufacturing MHP equipment, including turbines. Nepal was fairly advanced in manufacturing cross-flow turbines.

Manufacturers in Nepal had developed/adapted other MHP equipment and end uses such as pelton turbines, electronic load controllers, *bijuli dekchi*(s), electronic current cutout, and 'air heat storage cookers'.

China

China introduced MMHP/SHP plants in the 50s. It had installed 1,200MW of MMHP/SHP by 1979, which accounted for about 48 per cent of the total harnessed hydropower. Out of the total of 2,300 counties, 1,567 had considerable MMHP/SHP potential and 777 relied mostly on MMHP for electricity. Currently China had 48,284 MMHP/SHP Plants (of up to 25MW in capacity) with a total generating capacity of 15,055MW. Fifty-six per cent of the MMHP/SHP plants were in the micro-range (of up to 100kW), 39 per cent in the mini-range (100-500kW), and the rest were in the SHP range (>500kW).

About eight per cent of the plants were connected to the national grid and 30 per cent were connected to local grids. The remaining 62 per cent of the plants were run on an isolated basis. In terms of capacity, 93.5 per cent of the MMHP/SHP was connected to the grid.

Most of these plants were introduced, constructed, and managed by local governments in a decentralised manner with the help of various funding sources. Funding sources included the Central Government (51%), bank loans (35%), and local contributions (14%). Fifteen per cent of the plants were run by the counties and the rest by village administration.

Pakistan

The main organisation responsible for installing hydropower plants in Pakistan was the public-owned Water and Power Development Authority (WAPDA). There were altogether 64 MMHP plants within the public sector, with a total installed capacity of 17,115kW. The average installed capacities of these plants in the Northern Areas, the North West Frontier Province, and Azad Jammu and Kashmir were about 300, 225, and 95kW, respectively.

Private Sector MMHP

In Pakistan, mainly two organisations, the Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Programme (AKRSP), were engaged in the promotion of MMHP. Both the organisations surveyed, designed, and installed plants. The PCAT provided a subsidy of about 40 per cent of the total cost, and the AKRSP subsidy varied between 20-80 per cent. Since the introduction of the programme in 1975, PCAT had installed 160 plants with a total capacity of two MW. The average capacity of these plants was 12.8kW. The plants were spread over 160 villages and provided electricity to 10,000 people. The cost of the plants ranged between PRs 10,000 to 15,000 per kW (US$ 350-500). AKRSP had installed approximately 25 plants, with a total capacity of 0.6MW.

In Pakistan, MMHP plants which were basically for electricity generation were not commercial entities. The revenues generated were small and usually just sufficient to meet the routine operation and maintenance costs. The usual tariffs were PRs 5-15 per bulb per month for unmetered consumers and PRs 0.40 to 1.50 per kWh for metered consumers.

Main Features of MMHP Technology

In Pakistan and Nepal, the share of cross-flow turbines in private MHP was 97 per cent and 76 per cent, respectively. In Nepal, the other types of turbines in use were the MPPU type (20%), followed by the pelton type (3%)[4] Pelton turbines were gaining in popularity in Nepal especially in stand-alone plants. Micro pelton turbines used in popular one kW peltric sets were widespread in Nepal.

4 Excluding micro pelton turbines.

China manufactured all its own MMHP equipment. In China, MMHP equipment was manufactured in about 100 factories. It also exported MMHP equipment to countries in the HKH region, especially to Pakistan and Nepal. India also had a good capacity for manufacturing MMHP equipment.

Most of the MHP plants in Nepal did not have governors. Electronic load controllers, performing the function of governors, were gaining in popularity in Nepal.

Efficiency and Performance

Breakdowns of MMHP plants were fairly common. One of the surveys undertaken in Pakistan showed that 54 per cent of the plants were not operational. In Nepal, no study had been carried out in this respect. However, there was widespread belief that the plant failure rates were high. The failure rate for plants installed after 1988 in Pakistan was estimated at 10 per cent. The failure rates were declining in Nepal as well.

Civil works' failures were more responsible for MMHP failures than electromechanical equipment failures. There were no adequate facilities to test the efficiency and performance of MMHP equipment in Nepal and Pakistan. There were many MMHP plants that could not develop the rated power at the site.

Plant Cost

The cost of equipment manufactured in China, India, Nepal, and Pakistan was considerably lower than equipment imported from developed countries. Even the relatively better quality equipment from China was two to four times cheaper than European and Japanese equipment. The cost of privately-installed MHPs in Nepal varied between US$ 800-2,000 per kW, whereas, in Pakistan, it was around US$ 300-500 per kW. Chinese and Indian MMHP costs were compatible with those of Pakistan.

Management and Ownership

In publicly-owned plants, the participation of local people was minimal. The operators, in this case, were not sufficiently motivated to operate and maintain the plants successfully. The plants owned by entrepreneurs were relatively small and often operated and maintained by the owners themselves. In these plants, there was greater motivation for proper operation of the plant. In plants owned by communities, the responsibility for operating and maintaining the plant was delegated to an operator or manager to whom payments were made in cash or kind.

Review of Policies Concerning MMHP Programmes

All the countries in the HKH region provided some support to MMHP. The degree of support varied widely. The allocation to the renewable sector, including MMHP/SHP, still remained below one per cent in most cases. Policies of the specific countries are reviewed in this section.

Nepal

On many accounts, Nepal was ahead of the other countries in evolving and adopting policies and plans for the development of new and renewable energy, in general, and MMHP in particular. Bank loans, at priority sector interest rates were had been provided since 1977 for the installation of MMHP by private entrepreneurs. In 1984, plants with a capacity of up to 100kW were delicensed and, in 1985, a subsidy for the electricity component of MHP was introduced. According to the subsidy policy, MHP, in remote and non-remote areas, was entitled to subsidies equal to 75 per cent and 50 per cent of the electrical equipment costs, respectively. In 1992, the Hydropower Development Policy and Water Resources' Act was promulgated. The policy delicensed MMHP of up to 1,000kW. It announced a number of incentives for private sector participation in hydropower development. The private sector was already dominant in the MHP sector in Nepal. The Water Resources' Act, among others, fixed priorities for water use by various sectors. Nepal had been including the targets for MMHP development in its Five-Year Plans. For example, the Eighth Plan (1992/93 - 1996/97) targetted the development of five MW of new MHP capacity.

China

The Government of China was following the policy of self-construction, self-management, and self-consumption for MMHP development. Government subsidies to MMHP installations covered 38 per cent of the capital costs, commercial bank loans contribute 35 per cent, and contributions from people and other sources the rest. China had had remarkable success in the field of MMHP by treating MMHP as one of the components of its rural development package.

India

The Government of India (GOI) accorded special recognition to MMHP/SHP development in its planning and policy documents. The GOI allowed private sector installations and had also announced special incentives, loans, subsidies, and tax relief. The Ministry of Non-conventional Energy had created a new institution — the Indian Renewable Energy Development Agency to channelise World Bank funds for MMHP. India was treating private MMHP/SHP as a supplement to the government electrification efforts. Private MMHP plants supplied energy either to the grid or to isolated areas prioritised by the public sector.

Pakistan

The Government of Pakistan had been supportive of rural electrification. About 40 per cent of the rural areas had been electrified and there were vast rural areas which could be electrified by using MMHP through private initiatives. The government was yet to formulate policies for the promotion of private MMHP. The efforts made by PCAT and AKRSP in MMHP promotion were still to receive due government recognition.

MMHP was being developed in Pakistan, mainly for electrification purposes. The MMHP plants were still non-commercial entities developed with the help of subsidies in the 20 to 80 per cent range.

Bhutan

Bhutan had not formulated policies or plans for private sector participation in the development of MMHP/SHP. However, the establishment of private sector power plants had been declared a desirable option. According to its Master Plan for Development of the Power Sector, MMHP/SHP had not received priority in Bhutan.

Management and Operation of Decentralised Privately-owned Plants

Formally-organised private sector MMHP - such as the Ghandruk and Salleri-Chialsa Plants in Nepal - had demonstrated the viability of operating MMHP in an organised manner. Decentralised MMHP in China was also being formally managed with reasonable success. These MMHP fixed tariffs independently except for the energy supplied to the grid, for which government rates applied.

In Nepal, informally-managed MHP plants were owned mostly by entrepreneurs and a few by communities. The entrepreneur-owned plants were commercial entities, whereas the community-owned ones were non-commercial. The financial and managerial capabilities of owners/managers and operators are generally poor and many MMHP failures were associated with this problem.

In Nepal, add-on MHP seemed to have more outage rates. This is partly explained by the poor returns on investments in add-on plants. Difficulties in the collection of revenues had been reported in Nepal. This was common in cases in which the supply was either not reliable or of poor quality.

In Pakistan, most MHP plants were owned by communities or families. In almost all cases, the owner or a prominent person from the community managed the plant. These community-owned plants, mostly for electrification, were non-profit enterprises. In most of the mountain areas, including Nepal and Pakistan, the organisation of repairs was a difficult and time-consuming endeavour.

Uses of MMHP Energy

Apart from in Nepal, most of the MMHP plants in the region were of the electrification type. In Nepal, many private plants operated agro-processing and other similar equipment directly with water turbines. The load factors of electrification plants were usually low (10-20%), whereas the load factors of agro-processing plants were somewhat better (10-30%). The reasons reported for the low load factors of MMHP plants were: i) use of electricity for lighting only; ii) unreliable or insufficient electricity supply, which hinders industrial and commercial uses; and iii) the installed capacity was higher than demand.

The load factors of formal private sector plants in Nepal, as well as in Pakistan, were found to be higher (up to 42%) and, consequently they were performing better financially than the regional average. The better performance could largely be attributed to end-use promotion activities.

In China, after the replacement of older plants, grid connection, and diversified end-use promotion, load factor improvement was observed in many cases. However, a low load factor was still a problem in isolated systems.

Enhancement and diversification of end uses were considered to be the thrust areas in the context of making MMHP financially more attractive. It is generally observed that electricity, or any other technology for that matter, is adopted more willingly when there are direct economic returns. Therefore, more efforts should be made to promote industrial/commercial uses of electricity.

Some ground-breaking work has already been undertaken in Ghandruk, Salleri-Chialsa, and Andhi *khola* with the aim of improving the load factor. These include promotion of low wattage cookers, introduction of tariffs stimulating daytime industrial activities, and so on.

Plant Economics

Public Sector Plants

Public sector MMHP plants were usually three to five times more expensive than private sector ones, mainly because public sector plants used imported equipment for greater reliability. The cost per kW installed in Pakistan varied from US$ 1,330 to 2,000, whereas, in Nepal, it ranged from US$ 1,550 to US$ 6,000. The financial performance of most of these plants was poor. In Nepal, this kind of plant was able to generate revenue that covered only about 20 per cent of the annual operating costs.

Private Sector Plants

It has been demonstrated that operation and maintenance costs can be lower than revenues in the formal private sector, e.g., Ghandruk and Salleri-Chialsa in Nepal. In Ghandruk, the net income equalled six per cent of the total capital costs and in Salleri, in 1992/93, the net income was equal to 2.4 per cent of the total investment.

Most private sector plants in China, however, were not doing well due to a rise in plant installation and operating costs. With an increase in tariffs, from 0.05-0.08 *yuan*[5] per kWh to 0.20 *yuan*/kWh, it was estimated that plants might need a payback period of about ten years.

In Pakistan, informal plants were non-profit entities. Therefore assessment of financial viability was not easy.

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5 There were eight RMB *yuan* to the US dollar at the end of 1994.

In Nepal, in some cases, the returns on the investments in agro-processing units were high. For example, the return was 90 per cent in one of the case studies carried out by ICIMOD. Among agro-processing units, oil expelling units were most profitable. In other studies reported, the return rates were 20-35 per cent. Generally, the returns on agro-processing units were much higher than those on electrification units. The profits on electrification plants varied from three to 11 per cent.

In a few cases in Nepal, diesel-driven agro-processing units were found to be competitive with agro-processing micro-hydro units.

Future Trends and Prospects for MMHP

The indigenous and decentralised development of MMHP technology had been continuing for more than four decades in China and about two decades in the other countries of the region. More than a third of the counties in China relied on MMHP/SHP for domestic as well as industrial use. Most of these MMHP/SHP plants were also connected to main or local grids. Pakistan and Nepal had also experienced significant achievements in spite of limited inputs and efforts.

At the same time, a number of serious problems urgently in need of redressal had surfaced. One of the problems was the lack of firm commitments at government level due to the belief that "small may be beautiful but large is cheap." Hence, it was likely that future MMHP development would take place mainly in the private sector in a decentralised manner.

The high demand for MMHP in Pakistan and progress in the industrial applications of MMHP in Nepal and China were indications of the future scope for MMHP. There was a lot of scope for further progress in MMHP development in all countries of the region, apart from in China.

Based on the experiences so far, it was reasonable to conclude that some level of financial support would be necessary in the foreseeable future for the desired level of MMHP proliferation in the HKH region and to gain a strong foothold in the overall energy scene in the rural mountain areas. The support needed was mainly in the fields of promotion, R&D, and training.

Based on the conclusions of the Consultative Meeting of MMHP experts, as well as on other experiences, the following factors should be considered in promoting MMHP.

- Electricity supply from MMHP needs to become more reliable quantitatively and qualitatively, to encourage industrial applications.
- Use of electricity from MMHP should be diversified into existing traditional uses, e.g., irrigation.
- Cottage industries could consume sizeable amounts of MMHP power for process heat and motive power. Efforts should be made to identify and promote new industrial end uses.

- China has reported significant achievements in cooking with electricity whereas Nepal is yet to pick up in this area. It is desirable that difficulties associated with electric cookers, such as unreliable supplies, lack of adequate cooking devices, and high capital and energy costs, be carefully studied before making further efforts in this direction.
- Developed countries have witnessed the shift from small isolated plants towards grid-connected larger plants. This trend should not be copied in the HKH region without adequate research.
- Performance and reliability, which are the primary concerns of promoters and entrepreneurs, need to be enhanced through R&D efforts and promotion and distribution of appropriate design and manufacturing manuals.

Agricultural Development Bank Contribution to the Development of Micro-Hydropower Achievements, Problems and Prospects

- *Devendra Prasad Adhikari*[6]

Introduction

The Agricultural Development Bank of Nepal (ADB/N) started financing *ghatta*(s) — traditional water mills used for agroprocessing — and their improved versions from 1968, and modern water turbine installations from the mid-seventies as a way of meeting the increased agro-processing needs of the rural population. Since 1981, the ADB/N has provided financial support for water turbine installations with electrification components.

The ADB/N's policies on micro-hydropower are guided by the following objectives.

(a) Increasing agricultural productivity
(b) Improving the standards of living of the population
(c) Reducing the drudgery of women
(d) Substitution of imported fuel and fuelwood

The ADB/N supports micro-hydropower development through the following measures.

(a) Providing loans, technology, and information
(b) Channelising subsidies (applicable to electrification components) from government or donor agencies
(c) Research and development activities
(d) Organising training programmes

Terms and Conditions for Financing

(a) Technical and financial viability
(b) Sound management capabilities of the entrepreneur
(c) Social acceptability
(d) Environmental sustainability
(e) Entrepreneur's ownership of plant site
(f) Equity participation of about 20 per cent
(g) Loan repayment period of 5 to 10 years

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6 Loan Officer, ADB/N

The Micro Hydropower Project and Project Cycle

The ADB/N finances private sector micro-hydropower plants and these private plants are either entrepreneur-owned or community-owned.

The main components of the project cycle are described below.

(a) *Project Identification:* The projects are identified by the local people with external help.
(b) *Project Preparation:* Project preparation consists of site surveys by a manufacturing company, a loan request by the entrepreneur, and a feasibility study by the ADB/N.
(c) *Project Appraisal:* The Bank appraises the project implementation.
(d) *Implementation:* This phase consists of the bank placing an equipment supply order with the manufacturer transportation of equipment by the client, construction of a canal and powerhouse by the client, and equipment installation by the manufacturer.
(e) *Evaluation/Followup:*This is carried out mainly by the ADB/N and, occasionally, by the manufacturer.

Achievements in the Field of Micro-Hydropower

Until 1992, the ADB/N had invested over NRs 85 million[7] in 685 micro-hydropower installations, which included improved *ghatta*(s) (traditional water mills), multipurpose power units, and water turbines. The ADB/N, until 1993/94, had invested about NRs 23 million on 187 micro-hydroelectric installations with a total capacity of about 1,600kW. The subsidies channelised through the ADB/N for these plants amounted to 22 million rupees. Of the above micro-hydroelectric plants, 13 plants,[8] with a total capacity of 302kW, are dedicated to electricity generation.

A Strategic Development Approach to the Strengths, Weaknesses, Opportunities of Micro-hydropower, and the Threats to the Project

A widespread network of offices throughout the country, availability of staff experienced in micro-hydropower, focus on rural development, and provision of credit to industrial and agricultural sectors are the strengths of the ADB/N. The goodwill of clients earned by the bank, channelisation of subsidies through the bank, and the position of ADB/N as the sole agency promoting micro-hydropower are the opportunities for the bank.

The micro-hydropower programme has limited significance to the Bank in terms of loan flow, deficiency in technical manpower, inadequate resources for research and development, over-enthusiastic nature of the programme, and poor coordination and communication between offices; these are the weak features of the programme. The significant cost escalation of plants, low rate of return on investments, low rate of loan

7 1 US$ = 50 Nepalese Rupees.
8 Does not include plants below a 6kW range.

repayment, low load factor, and poor state of plant operation and maintenance are the problems faced by micro- hydropower development.

Conclusions/Recommendations

1. The organisations concerned in the micro-hydro programmes should seriously take into consideration the price hikes in electro-mechanical equipment.
2. The technical problems being faced by entrepreneurs should be taken into account by manufacturers and other development agencies. INGOs and donors associated with the micro-hydro programmes should put their efforts on training, maintenance, and rehabilitation of sick plants.
3. Capital subsidies alone cannot make the programme economically viable. Therefore, the provision of subsidies in end-use development must be taken into consideration.
4. Generation of power above 25kW and below 100kW might not be economical unless it is used by cottage industries.
5. Tea processing and cardamom drying could be two important end uses for micro-hydropower plants.

Salleri-Chialsa Electric Company - Experience of a New Approach to MMHP Management

- *Rajendra Singh Thapa*[9]

Introduction

This paper highlights the approaches to and activities of the Salleri-Chialsa Mini-Hydroelectric Project in making MMHP viable through participatory management. The Salleri-Chialsa hydropower station and its supply area are located in the Salleri and the Garma Village Development Committees in the Solukhumbu district of eastern Nepal. This power plant was commissioned in 1985 through the Swiss Aid Project. Subsequently, the governments of Nepal and Switzerland decided to manage the Salleri-Chialsa Plant in a non-traditional manner in order to address the problems of high operating costs, poor availability of plant and supply systems, inefficient management, unproductive use of electric power, and the low socioeconomic benefits derived from isolated mini-hydropower systems in Nepal. The ultimate outcome was the establishment of a shareholder public limited company under the name of Salleri Chialsa Electric Company (SCECO).

The Company

SCECO was registered with the Ministry of Industry in February 1991 as a shareholder company with preference (investment) shares held by the Nepal Electricity Authority (NEA) — 31.5 per cent and the Swiss Development Cooperation (SDC) — 31.5 per cent and ordinary shares held by householders (consumers only) — 37 per cent. The Board of Directors has three members; one each from NEA, SDC, and the local community. The company is run by a total of ten employees only.

The Plant and Electrical System

The power plant is a 400kW run-of-the-river scheme housed with two cross-flow turbines. The electrical supply system consists of 20km of 11kV overhead transmission line, 50km of 220V underground distribution cable and 1,150kW of total installed transformer capacity. From each transformer, a distribution line is connected to the Main Distribution Box (MDB) and then to the Sub-Distribution Box (SDB). At each SDB, Load Controlling Switches (LCS) are installed. With the help of the LCS and the Miniature Circuit Breaker, the load to each customer is controlled. In case of an overload or a short circuit, the LCS of the corresponding customer is tripped and the customer is temporarily disconnected.

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9 Rajendra Singh Thapa works for the Salleri-Chialsa Electricity Company Ltd.

Management Aspects

Tariff: The SCECO tariff system for 1994/95 is presented in Table 1. Introduction of peak power limits for industrial consumers and two levels of unmetered domestic consumers distinguish this tariff structure from the NEA tariff structure.

Table 1 : SCECO Tariff for 1994/95

Consumer Type	Level	Admitted Maximum Power, kW	Minimum Charge NRs/ Month	Exempted, KWh	Additional consumption		
					First Slab		Second Slab
					Limit kWh	Rate NRs/kWh	Rate NRs/kWh
Domestic Sector	1	0.1	70	all	-	-	-
	2	0.5	250	all	-	-	-
	3	2.0	300	70	90	4.2	2.0
Service Sector	4/1	4.0	550	75	90	4.2	2.0
	4/2	8.0	945	75	95	4.2	2.0
Industrial Sector		Off Peak / Peak					
	5/1	> 10.0 / 0.1	300	50	85	2.0	1.5
	5/2	> 10.0 / 0.5	405	75	85	2.0	1.5
	5/3	> 10.0 / 2.0	700	120	90	2.0	1.5

Billing is computerised, which has made billing quick, efficient, and error-free.

Other Indicators

Some indicators that show the overall plant performance are presented in Table 2.

Table 2 : Plant Performance Indicators, 1993/94

Losses (%)	Plant Availability (%)	Station Factor (%)	Load Factor (%)	Specific Revenue NRs/kWh
8.1	98.7	30.0	43.8	2.07

The above indicators show that the performance of this plant is the best among all the MMHP plants in Nepal. Therefore, there is much to be learned from this plant in terms of management.

Operation and Maintenance

The technical officer has been trained by the equipment manufacturers, and, therefore, is competent in operating the plant. He has the capability of conducting fault analyses, of replacing faulty parts, and of ordering spare parts with exact and correct specifications. The damaged parts are replaced and not repaired. Lubrication, oil replacement, and inspection of equipment are carried out regularly as per the recommendations of the manufacturers. Annual maintenance is also carried out, for which the plant is shut down for a week. During this period, necessary refurbishment work is completed. To avoid accidents and damage to the equipment, safety measures are constantly taken.

People's Participation and Customer Information

For smooth information flow between the people and SCECO, *ad hoc* committees have been formed in all the supply areas. In these committees, effective use of electricity, company standards and policies, safety measures, and other matters are discussed. This sort of close and open relationship has made implementation of new decisions more easily acceptable. Each customer is privy to information on technical and financial matters.

Within SCECO

Weekly meetings at the executive level and fortnightly meetings at the technical level are held for information exchange, decision-making on new plans, identification/ improvement of work and review of progress, preparation of weekly plans of action, and so on. A weekly work schedule for the operators is also formulated at the meeting. This prepares the operators psychologically for the work to be performed in the coming week. A communication set (walkie-talkie) with each of the operators and the installation of a Local Area Network (LAN) in all the computers at the headquarters have made quick exchange of information between plant personnel possible. It is interesting to note that in 1993/94, 40 per cent of the total expenditure was allocated for depreciation.

Conclusions

Innovative management approaches have helped SCECO achieve the highest standard of plant performance in the mini range. This experience is worth analysing in depth.

The Role of Nepal Hydro and Electric Company and Butwal Engineering Works in Developing Hydropower Equipment

- Nawa Raj Shrestha[10]

Introduction

The Butwal Engineering Works (BEW) and the Nepal Hydro and Electric Company (NHE) are pioneering companies in the field of design, manufacturing, and installation of electro-mechanical equipment for mini- and micro-hydropower. Their focus is on equipment development. BEW and NHE were established in 1977 and 1985 respectively, both being under the same management. These companies were established with the aim of reducing Nepal's dependence on foreign equipment and technology for harnessing its vast hydropower potential. This paper highlights the experiences of these two companies.

Engineering and Production Capabilities

BEW was started with the help of expatriate engineers. Recognising its limitations in developing and producing a wide range of products, it established a joint venture company, the Nepal Hydro and Electric Co. (NHE).

After completion of work on the Tinau Plant and the establishment of a number of micro- hydropower projects, the company committed itself to the following strategic goals.

- To establish a new company in technical collaboration with foreign companies
- To build workshops capable of producing water turbines, governors, control panels, transformers, transmission line towers/poles, and related structures for the 10 to 500kW range
- To develop technical manpower capable of manufacturing the above equipment

The NHE shareholders represent three national companies: BEW, the Butwal Power Company (BPC), the Himal Hydro and General Construction Co (HH), and two Norwegian companies — Kvaerner Energy a.s. (KEN) and ABB National Transformer AS (ABBNT). KEN provides technical support for manufacturing water turbines, governors, and ABBNT supports the manufacture of control panels and the repair of distribution transformers. These two Norwegian partners have been providing on-the-job training to Nepali engineers and technicians. BEW and NHE together have the following capabilities.

[10] Chief of the Electrical Division in Nepal Hydro and Electric Company (P) Ltd.

(i) Design and manufacture of:

- cross-flow turbines up to 100kW
- Pelton and Francis turbines up to 5,000kW
- Governors
- Electronic load controller
- Penstock pipes, gates, draft tubes, trash racks, and other heavy structures
- Control system panels
- Transmission towers (two- or three-legged lattice) up to 132kV and poles (tubular) up to 33kV.

(ii) Repair of valves and distribution of transformers with a capacity of up to 100kVA

(iii) Reconditioning and rewinding of AC and DC motors with a capacity of up to 300kW and generators of up to 500kW

(iv) Overhauling, refurbishing, and installing micro- and small hydropower plants.

Production Facilities

The production facilities of BEW and NHE include a mechanical division consisting of turbine and governor plants (including penstock pipes, gates, etc), a transmission tower section, a specialised plant for fabricating light-weight, tubular steel poles, a galvanising plant, and an electrical division (includes transformer, motor/generator, and control panel sections). These divisions/sections are equipped with: (i) heavy-duty vertical and horizontal lathes, (ii) a horizontal boring machine, (iii) milling and drilling machines, (iv) precision tools and control instruments, and (v) a modern repair workshop with test facilities for breakdown voltage tests of oil, insulation resistance, voltage ratio and polarity, winding resistance, no-load loss and no-load current, load loss and impedance voltage, separate voltage withstand, induced potential test at 100 HZ, and impulse (lightning) voltage test.

Quality Control

To ensure good quality, the finished goods are subjected to continuous quality control checks at every stage of the manufacturing process. Both companies strive to follow International Standard Organisation (ISO) standards in manufacturing, especially project equipment packages of above 100kW capacity. The companies also adhere to the specifications of KEN and ABBNT. For small project equipment packages of below 100kW capacity, a combination of ISO and Indian Standard Institute (ISI) is followed. For cross-flow turbines, the DIN(German [*Deutsche*] Industrial Norm) system is used. For quality control, non-destructive testing (NDT), including X-ray, magnaflux, ultrasound, and dye penetration are available.

Principal Experiences

Rehabilitation of the Tinau Hydropower Plant (1,000kW)

This included (i) overhauling and reconditioning three Francis turbines, spiral casings, governors; (ii) rewinding and replacing coils for rotor, reinsulating stator windings, rewinding DC exciters; and (iii) manufacturing new control system panels.

Sundarijal Hydropower Plant (640kW)

This included rehabilitation of two units of broken and worn out Pelton turbine runners.

Andhi Khola Hydropower Plant (3 x 1,700kW)

This included reconditioning powerhouse equipment imported second-hand from Norway. The principal tasks undertaken were: (i) manufacturing penstock pipes, manifolds, and branch tubes for 250 metre head, control panels, transmission towers/poles; (ii) overhauling Pelton runners, governors, alternators, and switchgears; and (iii) site erection of complete mechanical and electrical equipment.

Darchula Small Hydropower Project (250kW)

Work here included manufacturing a Francis turbine, governor, and control system panel. Design, installation, and commissioning of the plant.

Sikles (100kW) and Ghandruk (50kW) Micro-Hydro Projects

Work included manufacturing Pelton turbines, electronic load controllers, steel penstock pipes, and related structures.

Trishuli Hydropower Plant

Work included (i) fitting a 3,500kW Francis turbine runner to the shaft with new dwell pins, (ii) rewinding a 200kW AC motor, and (iii) removing old bearing metal and rebuilding it by depositing new metal for unit No. 7.

Panauti Hydropower Plant (3 x 800kW)

Work included overhauling and repairing two sluice valves and a DC exciter.

Jhimruk Hydropower Project (3 x 4000kW)

Work carried out included designing and manufacturing: (i) radial gates, slide gates, and trash racks; (ii) penstock lining, manifold and branch tubes; (iii) Francis turbines, excluding runners; (iv) electronic hydraulic governors, excluding electronic head; (v) draft tubes and auxiliary equipment; (vi) control panels for 6.6, 33, and 132kV systems; (vii) galvanised lattice towers for 45km of 132kV; and (viii) galvanised steel tubular poles 155km in length. In addition, the installation and commissioning of complete mechanical and electrical equipment packages were undertaken for the project.

Kulekhani Hydropower Plant (60,000kW)

The company participated in the site welding of steel penstock pipes damaged by the 1993 flood. The welding was carried out on high tensile steel plate according to DIN 17102 STE 460 and was confirmed by a 100 per cent X-ray.

Jhankre Mini-Hydropower Project (450kW)

Three units of 150kW Pelton turbines and control system panels are being manufactured.

Production Problems

To improve capability and quality, the introduction of larger and more sophisticated machines is necessary, but the availability of high quality work within the country is limited. Hence, it is difficult to keep these machines busy throughout the year, and, consequently, overhead expenses increase. Except for micro-hydro, the customers for hydroelectric projects in Nepal are mainly government and government-owned utilities. Since the government has a tendency to develop larger projects this leads to a fair amount of uncertainty concerning plan implementation, as well as adding difficulties because the government has to comply with terms and conditions laid down by financing institutions as well as donors. There is no assured market inducing companies to invest in the creation of facilities capable of manufacturing larger-sized products. On the other hand, local-level private entrepreneurs of micro-scale hydroelectric projects have a tendency to minimise initial investment costs and, therefore, it is difficult for the companies to compete with other local engineering workshops in terms of price.

The other factor is the difficulty in competing with Indian and other overseas' products because of high transportation costs on the import of raw materials and supplies and lower productivity per employee. In addition, strong government commitment to developing indigenous capabilities is lacking.

Conclusion

The formulation of a long-term policy by the government, aimed at encouraging the indigenous private sector to develop and uplift equipment manufacturing and design capabilities, will pave the way for harnessing the hydropower potential of the country at a reasonably low cost.

Experiences in End-use Development and Small Industry Promotion In Salleri

- H.P. Shrestha

Mini Hydropower Development in Salleri

The Salleri-Chialsa Hydropower Project with a capacity of 400kW, was constructed in the Salleri Valley, the headquarters of Solukhumbu district, under Swiss grant assistance. His Majesty's Government of Nepal (HMG/N) and the Swiss Development Cooperation (SDC) agreed to manage the plant under the Salleri Electricity Utilisation Project (SELUP), which was operational from 1987 to 1994, with the ultimate objective of establishing a public shareholding company, the Salleri Chialsa Electricity Company (SCECO), for operation and management. SCECO is now in-charge of the plant's operation and management and aims to achieve operational and financial sustainability. Self-sustainability of the plant calls for maximum use of the installed capacity by increasing the daytime load (load factor). For this purpose, SELUP had maintained a business and industrial promotion unit at Salleri-Chialsa.

Initial Problems of End-Use and Industrial Development

Industrial Development

Before SELUP started its activities, the area faced various problems which deterred end use and industrial development.

In addition to supplying electricity, SELUP provided inputs to the local entrepreneurs in the form of technical information dissemination, coordination of business ventures, and advisory services. The SELUP/SCECO efforts in this area also included assistance in preparing schemes for industrial and business ventures, preparing and acquiring technical designs and quotations for equipment, and assistance in bank loan processes.

Transportation and Communication

The valley is inaccessible by road and takes about four to five days' walk from the nearest road. A scheduled but irregular air service connects Salleri to Kathmandu. Similarly, communication facilities were very poor.

Institutional Support to the Entrepreneurs

There were two financial institutions, the Agricultural Development Bank of Nepal (ADB/N) and the Rashtriya Banijya Bank (RBB), in Salleri. The former finances the agricultural sector and the agro-based industries, and the latter is a commercial bank which does not invest in cottage industries. Slow decision-making in the banking system and high interest rates on available financial assistance did not encourage end use and small industry development.

Technical Skills and Awareness

The entrepreneurs lacked the capabilities for preparing schemes, proposals, and feasibility studies, and they also lacked general management and book-keeping skills. Due to the low level of education and inadequate technical know-how, local entrepreneurship was lacking. Moreover, there were no institutions in the vicinity engaged in supporting local entrepreneurs.

Local Resources and Market

The lack of necessary infrastructure (energy, water, transport, communications, etc.) for industrialisation and limited availability of raw materials (available raw materials were mainly based on forests and agriculture) also adversely affected industrial development.

Small Industry Promotion

A Handicraft Centre was the only industrial establishment prior to SELUP. In collaboration with the Small Business Promotion Project (SBPP)/GTZ, SELUP organised several training programmes for entrepreneurs on management, book-keeping, and so on. SBPP prepared the feasibility study reports for a printing press, bakery, and dry fruit industry at the request of SELUP. However, acquiring bank loans remained one of the main hurdles in industrial and end-use development.

End-use Development

In the initial stages of electrification in the area, except for some households with contacts in Kathmandu and abroad, most of the people were unaware of the versatility of electricity. Therefore, SELUP started a programme to promote electrical appliances, and other potential industrial uses. The programme introduced numerous appliances, such as rice cookers, electrical kettles, mixer-grinders, irons, immersion rod water heaters, blower fans, and so on.

Bijuli Dekchi

In 1990, to reduce the high power consumption of rice cookers and clay heaters and to reduce fuelwood consumption, low-wattage cookers — *Bijuli Dekchi* (450 watts) — were introduced in collaboration with the Butwal Bijuli Dekchi Company. A 50 per cent subsidy was provided from time to time for this appliance. A training programme on *Bijuli Dekchi* maintenance was conducted by the manufacturer who also provided free after-sales' services for a period of one year. This service is now provided by SCECO.

Demonstration, Repair and Maintenance Services

A showroom for demonstration of and instruction on electrical appliances was established in Salleri by SELUP/SCECO, and electrical appliance repair and maintenance services were also provided.

Private Electric Shop

With an increase in the demand for electrical appliances, local shopkeepers have started to market electrical appliances. This development has provided the intended relief to SELUP's activity in the promotion of electrical appliances. SCECO has now stopped marketing electrical appliances, except for the Bijuli Dekchi.

Results and Processes of Development

As a result of the efforts of SELUP/SCECO, government offices, businessmen and economically-sound families started to use electricity for heating and other applications. People have started to cook meals with electricity, albeit the process of fuel switching was slow. The energy consumption pattern in 90 surveyed households is given in Table 1. The table shows that electricity has completely replaced kerosene and, to some extent, fuelwood. Consumption of dry cells, which was about 3.7 cells per household per month, has decreased drastically and evening working hours have been extended.

Table 1: Energy Consumption Pattern of Sampled Households (% of households using various forms of energy)

Energy	Lighting	Cooking	Heating	Electrical Appliances
Fuelwood	2.2	95.6	13.3	-
Kerosene	0	0	0	-
Electricity	100	35.5	11.1	82.2

Another SELUP study shows a rapid growth in installed consumer load capacity estimated at 25.6 per cent per annum, on an average between 1989 and 1994.

The following commercial and industrial units were established during the project period (December 1987 - June 1994), which is very encouraging.

Flour Mills	11	Nepali Paper Industry	3
Bakery	1	Noodles	1
Printing Press	1	Photocopy Service	2
Colour Lab Service	1	Radio and Watch Repair Services	4
Sauna	1	Public Bath	1

The distribution of the connected load in 1993 between various appliances is presented in Table 2.

Table 2: Structure of Connected Load

Appli-ances	Lighting	Cook-ing	Heating/ Cooling	Water Heating	House-hold Applia-nces	Electro-nic Applia-nces	Tools Machi-nes	Others	Total
Load, kW	166· (17.0)	151 (15.5)	337 (34.5)	42 (4.3)	35 (3.6)	60 (6.1)	182 (18.7)	3 (0.3)	976 (100)

* Figures inside parentheses are in percentages.

Similarly, in order to reduce the fuelwood consumption of the Tibetan Refugee Camp in raw wool processing, the SDC has constructed a small hydel. Since then, two electric vats are being used for wool processing.

Conclusions

i) From June 1994, the efforts undertaken by SELUP have come to an end. The SCECO efforts should be continued.

ii) Cooperation among local government agencies, financial institutions, and entrepreneurs is vital for small industry development.

iii) The ADB/N, as a development bank, should take the responsibility for providing technical and financial services to local entrepreneurs in small industry development.

Development of Mini-hydropower in Remote Areas - Some experiences and Challenges

- *Ajoy Karki*[11]

Introduction

The Hydropower Act of 1993 has delicensed hydropower schemes of up to 1,000kW and liberalised investment in this sector. As a result of this act, private sector companies have begun to show an interest in investing in hydropower and four new private mini-hydro power companies were established in 1993.

Although mini-hydro schemes can be commercially profitable, the financial, technological, and socioeconomic risks associated with these schemes are greater than those of micro-hydropower plants. Therefore, during the feasibility stage, careful consideration must be given to these aspects and more attention must be paid to the engineering design of these schemes. This paper describes the experiences of and challenges faced by the mini-hydro sector, using the Jhankre mini-hydro project as an example.

Introduction to the Jhankre Mini-hydro

The Jhankre Mini-Hydro Project, a 500kW scheme in Ramechhap district, is being built by Development and Consulting Services (DCS). The source of the Jhankre Plant is the Jhankre river which is one of the tributaries of the Khimti river. The design head and flow of the plant are 180m and 455 l/s respectively. It will have three Pelton turbines with two nozzles in each unit. The penstock length and diameter are 550m and 450mm respectively.

The Jhankre mini-hydro scheme, together with a diesel plant, will supply power for the construction of the 60MW Khimti Project being developed by the Butwal Power Company (BPC). This project aims to save fuel costs and reduce the pollution associated with the construction. After the completion of the Khimti Project, BPC using the Jhankre Scheme, will commence a rural electrification programme, to make electricity available to most of the households in the nearby areas and also to involve the local community in plant management and operation.

This scheme is designed to operate at full capacity four months a year during the monsoon. During the dry season, the available flow is just enough to operate one turbine with a single nozzle. Such a design is feasible because the scheme will operate

11 Civil Engineer, BPC Hydroconsultant

initially in conjunction with diesel generators and later supply power to the national grid.

Water Rights and Socioeconomic Aspects

The Jhankre mini-hydro plant shares the river water that is also used for irrigation purposes. The proposed mini-hydro site is being used by the farmers of Jhankre as an irrigation intake. The current use of water for irrigation is illustrated in the hydrograph (see Fig. 1). The hydrograph shows that 75 per cent of the river flow has been assumed to be available for irrigation and power generation. The remaining 25 per cent of the flow accounts for downstream seepage as well as some flow release to meet environmental requirements.

The agreement between the Khimti project and the local community about sharing the Khimti water stipulates that the villagers will retain the water use rights for irrigation as practised presently (shown in Fig. 1). The above example indicates one of the ways in which water rights' issues can be resolved.

Employment is given to the villagers of Jhankre on a priority basis and is an incentive for the villagers to sign the agreement for water sharing with the Khimti Project. Income-generating opportunities have also been provided to women by buying gravel from them for the project at a guaranteed rate. Some of the villagers will be trained to operate and manage the mini-hydro scheme. The area surrounding the project will be electrified, and this is yet another incentive for the villagers.

Mini-hydro can help conserve resources, such as forests and imported fossil fuel, and reduce environmental pollution. For example, due to mini-hydro, the use of diesel during the construction of the Khimti Project will be reduced. Similarly, the 400kW Salleri-Chialsa Mini-hydro Scheme has been providing the power required for a wool dying industry — the Chialsa Handicraft Centre — thus substituting fuelwood, which is the traditional fuel used in the dyeing industry.

The Salleri-Chialsa Mini-hydro has promoted industries prior to the arrival of the national grid. As of 1992, besides supplying electricity to more than 400 houses, this scheme has been supplying electricity to the Chialsa Handicraft Centre, the Sagarmatha Water Turbine Enterprise (wood-work, paper production, and cereal milling), a bakery, and a 25kW paper mill.

Technological Aspects

The engineering design in mini-hydro schemes is more critical than in micro-hydro schemes. Due to the high capital costs, design errors can be expensive. Thumb rules in civil design are either risky or too conservative. On the other hand, detailed design will make the scheme economically more viable as well as help in quality control. Some innovative technological approaches used in mini-hydro schemes are discussed below.

At the Jhankre Mini-hydro plant, high grade steel (conforming to IS 2062) was used for the penstock in order to decrease the transportation/portering costs by decreasing the weight. This has also decreased the weld thickness. The use of plum concrete in anchor and thrust blocks has reduced the transportation and overall costs without compromising the quality. These blocks are constructed out of Plain Cement Concrete (1:3:6) with 40 per cent plum (boulder content). Nominal reinforcement is provided to resist tensile forces. The mass needed primarily to resist the hydrostatic forces on bends can be partially provided by the use of plums. In order to facilitate penstock movement caused by thermal expansion, steel slide plates and tar paper have been incorporated into the design of support blocks. To hold the base plates firmly on the support piers, anchor rods are welded into them. The top 500mm depth of the support piers is made of PCC for anchorage.

The proposed intake of the Jhankre mini-hydro is on the left bank of the river, downstream from a waterfall. Due to the waterfall and a drystone dam downstream, there is a wide pool at the intake area which decreases the sediment load. A suitable site for the desilting basin and forebay could not be found close to the intake, and placing them further away meant losing head. Therefore, a combined desilting/forebay structure has been designed at the intake. This has made silt and gravel-flushing activities simpler as well. Gravel and silt can be flushed back into the river.

The headrace canal of the Salleri Chialsa plant was torn away several times by landslides. Slope stabilisation and afforestation programmes were initiated in 1983, after which the construction work continued. Similarly, a landslide occurred above the powerhouse area of the Jhankre Mini-hydro plant during monsoon during excavation and blasting. There was also a rockslide which landed 220 cubic metres of boulders at the intake area. Therefore, the cost of a preliminary geotechnical survey in mini-hydro schemes is justifiable.

Fig. 1

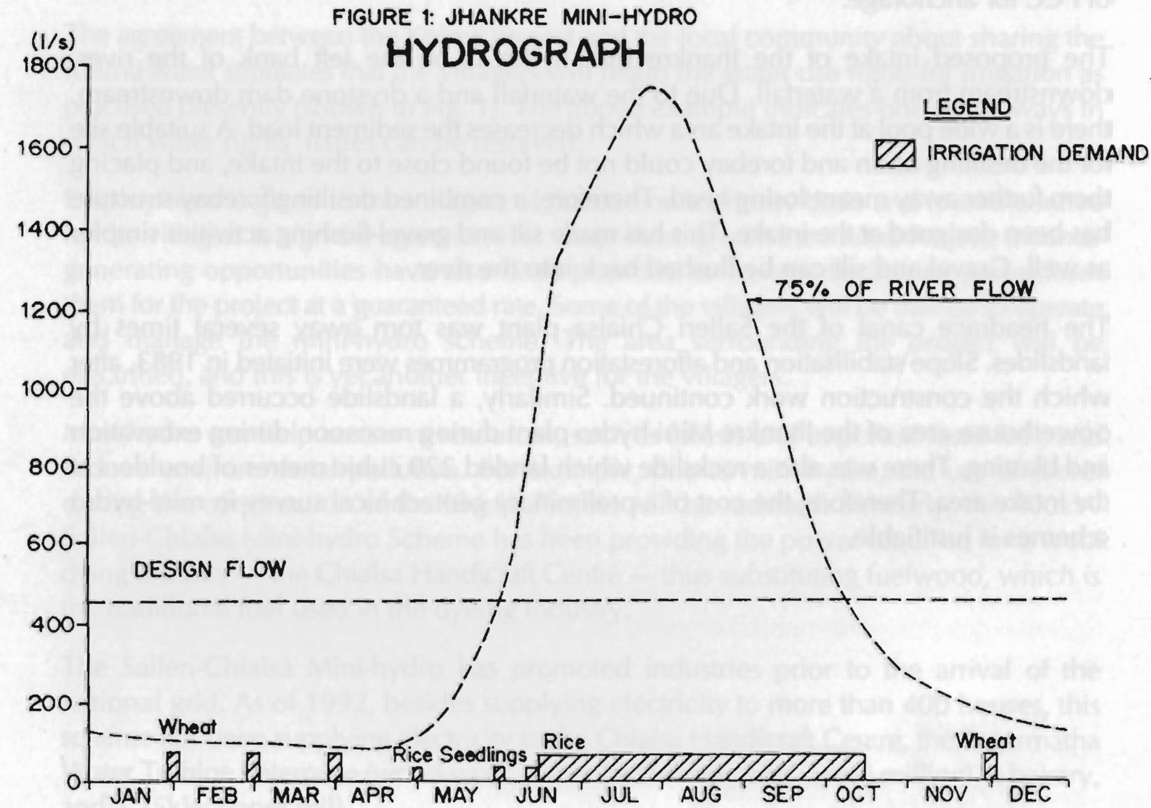
FIGURE 1: JHANKRE MINI-HYDRO
HYDROGRAPH
(l/s)
1800
1600
1400
1200
1000
800
600
400
200
0
LEGEND
IRRIGATION DEMAND
75% OF RIVER FLOW
DESIGN FLOW
Wheat
Rice Seedlings
Rice
Wheat
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Problems Associated with Private/ Decentralised MMHP Plants and Possible Redressal

- Dr. A.A. Junejo[12]

Introduction

Considerable progress has been made in China, Nepal, and Pakistan in developing and implementing mini-and micro-hydropower (MMHP). In spite of this progress, a number of serious problems related to MMHP still exist. These problems and, to some extent, their causes and remedies are discussed below.

Problems of Private Plants

Funding

In Nepal, the funding available for MMHP projects has been rather low and inconsistent. The inconsistency and the recent decline in funds compelled some manufacturers to quit the MMHP business and divert their production capacities to other items. This seems to have increased the MMHP costs. The financing of MMHP through the Agricultural Development Bank of Nepal (ADB/N) has been vital for the success of the MMHP programme in Nepal. The lack of compatible financial arrangements in some other countries has proved to be a serious handicap. Poor repayment of bank loans for MMHP has also become a serious concern in Nepal. The fluctuation of interest rates in Nepal, within a range of from 15 to 19 per cent, is said to have had negative impacts on the confidence of entrepreneurs. The underlying reason for the fluctuating funds seems to be the low priority accorded to renewable resources in the region.

Policies and Implementation Procedures

The main problem in the planning and installation of MMHP plants is the lack of coordination between the various agencies concerned. The 1992 Hydropower Development Policy of Nepal requires the Nepal Electricity Authority (NEA) to buy those Micro-hydropower Plants (MHP) which are affected by its grid extension. However, in practice, problems have emerged in the implementation of this policy. This may discourage investors from investing in MHP.

The ADB/N has a policy of not financing turbine mills within a four-mile radius of an existing turbine mill, because of possible financial difficulties for the plants. But this policy does not seem to have been strictly adhered to. A number of plants failed due to

[12] Project Coordinator of the MMHP Project, ICIMOD.

poor screening of entrepreneurs in terms of their managerial and technical abilities. Over-estimation of harnessable power and revenues has also been reported as one of the causes of MMHP failure. The current situation is partly due to the heavy reliance on manufacturers of MHP in all aspects of MHP development. There is no system for evaluating plant performance after the plant is commissioned. Such a system could help the owners to improve plant performance. Water rights' regulations are detailed in Nepal. However, there are still some ambiguities related to water rights' guarantees for MHP. At present, there is no integration of MMHP, private or government, with other development endeavours in any of the countries of the region, except for China, and the government agencies responsible for rural electrification are yet to realise the importance of private MMHP installations.

Costs

The costs of the indigenously-developed electrification MMHP plants have been rising in Nepal at a much higher rate than could be explained by inflation alone. At present, the plant costs (below 25kW) are approaching US$ 2,000 /kW. The capital costs of MMHP plants are also 10 times higher than those of diesel engine systems (prime movers only).

The costs of indigenous MHP plants are much lower than those of equipment imported from developed countries. The rising costs of MHP plants may partly be explained by the increasing costs of raw materials, fluctuation in the volume of business, and improvements in technology, including introduction of new components such as electronic load controllers and lightning arresters.

Profitability

Many MHP plants have reported inadequate profits. The reasons for the poor performance of MHP are severe competition; abject poverty of the people in some areas; frequent plant breakdowns; low plant factors, especially for electrification schemes; less water available than expected; poor management; and difficulties in repair and maintenance due to the remoteness of plants.

In general MHP plants used for agro-processing operations are commercially viable (more than 20 per cent profit on the original investment), whereas MHP plants used for electricity generation are much less viable.

Technology

Both in Pakistan and Nepal, there have been many reports of plant failures and other technological breakdowns. Similar failures were reported from earlier Chinese installations. The common problems reported are :

- damage to power channels and other civil structures;
- damage to turbine bearings as well as shafts;
- water leakages from joints and so on;
- damage to turbine runners;

- frequent damage to the water regulating vanes or valves;
- frequent damage to generators and control equipment;
- excessive voltage fluctuations causing bulb damage; and
- frequent damage to transmission lines.

Overall, the quality, performance, and life of indigenously manufactured equipment are relatively lower than for imported ones. However, the cost of equipment and spare parts is much higher for imported equipment. With the exception of China, R&D activities and facilities in the region are poor. A few NGOs, such as DCS and ITDG in Nepal, are involved in R&D. The reasons for plant breakdowns include the low quality of equipment installed, improper installation, operation by untrained personnel, and inadequate maintenance.

The overall situation in terms of breakdowns of indigenous plants has improved in China, Pakistan, and Nepal. However, actual improvement of the technology may vary considerably from country to country.

Management of MMHP Plants

The low management capabilities of plant owners are a matter of great concern. Poor management of plants may be attributed to the following factors: negligible attention in terms of plant management; lack of understanding of financial management; poor technical know-how; and owners' low level education.

Operation, Maintenance, and Repair

The level of expertise of operators is very low in Nepal and Pakistan. The turnover in plant operators is high. Many serious breakdowns could have been avoided if the operators had been competent. Delays in repair are common, due to the remoteness of the plant location.

Training

The training facilities for MMHP-related personnel in the region are inadequate, except in the case of China. Limited training is arranged in Nepal on an intermittent basis. Training needs have been identified in the following areas.

(a) For decision-makers: project economics, technological awareness, funding systems, project implementation, etc
(b) For communities and their leaders: benefits and limitations of MMHP, role of communities and leadership, end uses
(c) For surveyors: flow and head measurement, plant layout, geology, hydrology, and so on
(d) For designers: design, construction, and supervision
(e) For mechanical/electrical engineers: electro-mechanical equipment, governing/control systems, instrumentation, installation, testing, commissioning, transmission distribution systems, etc

(f) For manufacturers: manufacturing technology, quality control, dimensional accuracy, etc
(g) For owners/managers: plant operation, load management, speed/frequency control, book-keeping, organisation and scheduling of maintenance and repair, and public relations
(h) For operators: operation and maintenance
(i) For mechanics/technicians: operation, repair, and maintenance procedures
(j) For bank personnel: technical and financial performance of plants

Plant Capacity Utilisation

There are many cases of poor plant capacity utilisation. These cases are either due to inflated projections of local demand for various services or due to the inability of managers to create the potential demands and end uses. Efforts to increase end uses of MMHP, directed mainly towards electric cooking and water heating, are still to gather momentum. R&D efforts in promoting industrial end uses are inadequate.

Social Problems

The plants serving non-cohesive communities have suffered from pilferage of electricity, difficulties in revenue collection, and difficulties in repair and maintenance. Clan conflicts have proved to result in serious difficulties in plant operation. The problems stemming from such conflicts are water rights' problems, boycott of plants, etc. Difficulties experienced in collecting electricity revenues are common. These can be aggravated by poor quality electricity and frequent interruptions in supply.

Redressal of the Problems: Measures Identified

Measures identified to redress the problems associated with MMHP dissemination based mainly on the findings of the Country Reports are listed below.[13] However, some of the measures listed have been formulated during or after the Consultative Meeting.

Funding

- Adequate funds should be made available on a regular and consistent basis.
- The prevalent interest rates should be lowered.

Policies and Implementation

- Governments should clearly declare support policies for private, decentralised, and indigenous MMHP installations. Remote and inaccessible areas where extension of grid electricity is not economical, could be earmarked for preferential propagation of MMHP plants.
- Loans and subsidies should be implemented judiciously.

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13 Reports prepared for ICIMOD.

- Working relationships should be established between agencies such as NEA, ADB/N, and others, in order to avoid overlapping and wastage.
- A suitable institution should be established to oversee the overall development of MMHP, arrange various inputs, and establish liaisons with various agencies.
- Guidelines should be prepared and implemented to evaluate the capabilities of the recipient entrepreneurs, as well as to enquire about potential conflicts within the locality or service area of the proposed MMHP plant.
- Some legislation or guidelines are necessary for sorting out water rights' issues.

Costs

R&D efforts are necessary for reducing the costs of indigenous equipment, as well as other efforts which may include inquiries into cost escalation, evaluating possibilities of importing some of the equipment from neighbouring countries (e.g., India, China), and so on.

Economic Return on Investments

- Adequate feasibility studies should be carried out by an independent organisation to evaluate the business opportunities for a proposed plant.
- Proximity regulations, such as the four-mile limit, should be implemented strictly.
- Plant managers and operators should be adequately trained to manage the business properly.

Technology

- R&D should be enhanced to improve the quality of indigenously manufactured equipment.
- Adequate training should be organised for plant designers, surveyors, manufacturers, installers, and so on.
- Manuals/guidelines should be prepared for designers, manufacturers, surveyors, and installers.

Plant Management

- Adequate training should be organised for the plant owners/managers.
- A system of post-installation evaluation of MMHP plants should be introduced.

Operation Maintenance and Repair

- Adequate training should be organised for the operators.
- Optimal systems of repair should be studied for a given area and the owners should be advised to follow these procedures.

Plant Capacity Utilisation

- Adequate R&D efforts should be made to develop appropriate end uses.
- Training for the community and its leaders should be organised to motivate them to introduce various end uses.

Balaju Yantra Shala's Experience in MHP Technology Development

- *Sridhar Devkota*[14]

Introduction

About 95 per cent of the total energy needs of the country are met by traditional sources, such as fuelwood, agricultural residues, and dung. The substitution of traditional energy by kerosene/coal in hill and mountain areas is a difficult task because of the high transportation costs involved. Therefore, the emphasis in these regions must be on renewable energy, e.g., hydropower on different scales.

Early Use of Hydropower in Nepal

The first hydropower plant in Nepal, the 500kW Pharping Plant, was commissioned in 1911. However, the pace of hydroelectricity development in Nepal has been very slow. Before the establishment of the first mechanical workshop, the Balaju Yantra Shala (BYS), in 1960, only four hydroelectric plants existed in Nepal, with a total capacity of less than five MW. The real growth of the power sector began in the sixties.

The Balaju Yantra Shala in MHP

Manufacturing

Nepal did not have welding technology until 1960, and there was almost no technical manpower available in the country. It was in 1960 that BYS was established as a joint venture project of the Nepal Industrial Development Corporation and Helvetas (then SATA - Swiss Association for Technical Assistance). In 1962, BYS built and installed its first propeller turbine to drive a five kW generator at the Godavari Fish Farm. It was the first Micro-Hydropower Plant (MHP) in Nepal.

Traditional water mills, powered by timber water wheels and used for grinding cereals in the hills, were not powerful enough to drive rice-husking machines. Thus, the farmers had to install diesel engines that ran on imported fuel for rice huskers and flour mills. Subsequently, BYS came up with the idea of producing water driven turbine mills. The technical drawings necessary for a propeller turbine were obtained from a Swiss turbine manufacturer. As there was no machine foundry in Nepal, the design was adapted to suit local manufacturing capabilities. Several propeller turbines were manufactured and installed for direct power drives. After some years, an assessment of the performance of these machines was carried out which led to the conclusion that more versatile turbines were needed in terms of output capacity and head range. Consequently, it was also realised that the new turbines should fulfill the following criteria.

14 General Manager of BYS.

i) The machine must be manufactured and based on welding alone as foundry technology is not available. The machine should be such that it can be locally produced.

ii) The weight of a single component should be less than 60kg so that it could be carried by a porter.

iii) The adaptation of turbine sizes to different heads and flows should be simple.

iv) The machine should incorporate a flow-regulating device so that the output can be adjusted to the consumer load.

Since none of the foreign manufacturers were ready to be involved, BYS had to carry on its own. After exploring all types of turbines, BYS selected the cross-flow type for adaption, especially because of its simplicity from the manufacturing point of view. The important features of the cross-flow model are: a) the whole machine can be constructed by welding; b) the runner blades can be produced through plate bending; and c) the machine can be adapted to various head and flow conditions by simply varying the runner blade.

The first model T1 produced was a hand-regulated straightforward design to mechanically drive a flat belt transmission for operating agro-processing machinery, such as rice huskers and oil expellers. BYS has gone through different phases to reach its present stage, with some improvements made at each phase. The models produced until now amount to 13 from the T1 to the T12 including the T3M model. Of these models, the T2, T5, and T7 models have become obsolete. The T4 model was the first turbine with an automatic governor control to be used in a village electrification project. The T12 model is based on experience with models in the past. It uses a new concept to ventilate the jet (free jet approach) and is especially suited for flow control.

Survey, Civil Works, and Installation

Besides manufacturing turbines, BYS has also taken the responsibility of undertaking site surveys and installing and commissioning MHP which are normally the low and medium head run-of-the-river types. The method adopted for choosing the site is basically visual investigation. Only one or two sites that best satisfy the requirements are surveyed in detail. The main components included for the survey are the canal, penstock, and powerhouse.

Constraints

Manufacturing: Since the turbines are to be designed to suit the site conditions and the requirements of that particular area, they cannot be mass produced. Special consideration must also be given to transportation by porters. The individual turbine parts are bolted together and kept in position by taper pins. The role of trained mechanics is very important because many tasks are performed by hand. It is not easy, however, to find such mechanics.

Marketing: Government support for indigenous MHP is not adequate and, therefore, BYS has to promote its product itself. BYS has been able to export its turbines to various countries, but these orders have been commissioned only through personal contacts. BYS has not yet been able to go in for expensive advertisements.

Hydrological Data: Data on small rivers/rivulets, on which MHP is to be developed, are not collected by the Department of Hydrology and Meteorology (DHM). Hence, MHP installation can be based only on a few flow measurements. This leads not only to under or over design, but also increases the risk of damage to the powerhouses by floods.

Raw Materials: All the raw materials required to manufacture the turbines are imported. The customs' regulations of the government do not encourage the manufacturers; the customs' duty on raw materials is 20 per cent, whereas it is only five per cent on imported turbines.

Summary

BYS contributes to national development by manufacturing turbines and installing them. It is committed to MHP development, especially through research into and development of cross-flow turbines. It has come a long way in this field and hopes to contribute further.

State-of-the-Art Technologies Appropriate for MMHP

- *Bikash Pandey*[15]

Introduction

Micro- and mini-hydro plants represent an 'intermediate technology' appropriate for the rural areas of Nepal. There is a broad spectrum of competing MMHP technologies. In addition to the basic requirements that technologies be reliable, locally-manufactured, and maintainable, an additional requirement is that the technology be properly suited to the needs and capabilities of the target communities.

Variety of MMHP Technologies

There is a variety of technologies already available or being developed which come under the MMHP category. The question for many remote districts in the country is not so much whether MMHP has a role to play in the district's sustainable development, but what kinds of MMHP technology are most suitable at the district's present stage of development and what policies should be followed to best implement MMHP.

The 'Improved Ghatta'

The 'Improved *Ghatta*' is an innovation on the traditional *ghatta*[16] which uses a metal runner to increase efficiency. The 'improved *ghatta*' has an average grinding capacity 2.7 times higher than that of a traditional *ghatta*. It also has the additional advantage of allowing power take off with a pulley for rice hulling and electricity generation.

<u>The situations in which the 'improved *ghatta*' may be suitable are as follow.</u>

1. The 'improved ghatta' is appropriate for densely-populated communities where the existing *ghatta* does not process quickly enough and where there is no convenient site in the vicinity to put a second or third *ghatta*.
2. The 'improved *ghatta*' can be used where there is a demand for rice hulling and a small amount of power.

<u>The situations in which the 'improved *ghatta*' would not be appropriate are as follow.</u>

1. In cases where additional traditional *ghatta*(s) can be installed, an 'improved *ghatta*' would not be justified simply on account of the improved speed of processing.

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15 Programme Manager, Intermediate Technology Development Group (ITDG).

16 A traditional water mill which uses a timber runner. The capacity of the *ghatta* is around 0.5kW.

2. The existing *ghatta* can be built and maintained with no metal parts and this is an advantage in an area where the closest welding shop is a faraway town many days walk from the mill.
3. The 'improved *ghatta*' would not be suitable in cases where there is demand for an oil expeller, a saw mill or for electricity beyond half a kilowatt.

Turbines for Milling

Turbine-run milling schemes account for over 80 per cent of the existing micro-hydro schemes in Nepal at present. These schemes generally range from 5 to 15kW and are used to run a range of agro-processing machines, such as grinders, rice hullers, oil expellers, *chiura* beaters, saw mills, and so on.

The situations in which a turbine mill would be suitable are as follow.

1. The turbine mill is suitable for a region that grows a lot of mustard seed or other oil producing seeds or grows large amounts of paddy.
2. It is also suitable when the flow of water is too small to run a *ghatta* but where a large drop is present.
3. If there is interest in the community for add-on electric lighting, a turbine is appropriate.

The situations in which a turbine mill would not be suitable are as follow.

1. If the amount of grain grown in the area is small or if there is already another turbine mill in the area, an 'improved *ghatta*' is the better choice for an entrepreneur.
2. If the need of the community is for a large stand-alone electric scheme, a turbine mill is not suitable.

Add-on Electrification

A small generator can be added to an existing turbine mill to provide electric lighting in the evening to the community situated close to the powerhouse.

The Peltric Unit

A Peltric unit consists of an induction generator with the runner of a Pelton turbine hanging from its shaft. The standard unit manufactured by Kathmandu Metal Industries is designed to operate under a head of 50 m, and its outputs are as follow.

Head	Flow	Power Output	Number of Houses Served
50m	2 lps[17]	500W	5 to 10
	4 lps	1000W	10 to 20
	8 lps	2000W	20 to 40

17 Litres per second

The peltric unit is suitable for providing a few houses with electric lighting. In an area where grinding needs are adequately met by the *ghatta* and where oil processing is not needed, a peltric unit can provide cost-effective electricity to a community that can afford it. The Peltric cannot be used to run an oil expeller, a rice huller, a grinder or a saw mill. Hence, if there is a strong likelihood of interest in the community for these services in the future, the option of a turbine mill should be considered.

Stand-Alone Electricity

A turbine installation which is established primarily to produce electricity and to serve agro-processing activities only as a secondary function is called a stand-alone MMHP. In this system, it is normal for the agro-processing or saw-milling equipment to be situated away from the powerhouse and for it to be run by a motor powered by the electricity produced from the power plant. Where there is a large community that needs to be serviced by an MMHP for electrification in the range of 25kW or more, a stand-alone system can be installed. The stand-alone system would not be appropriate if the community is poor, there are no promising end uses, and the community has no prior experience with electricity.

Technology Bottlenecks

Even though the MMHP industry is relatively mature in Nepal, a number of problem areas remain in terms of technology development.

Civil Works

The area that has received the least research and development interest so far is the civil works aspect of MMHP. ITDG is at present working on Civil Works' Guidelines. The main areas of activity will be intakes, silt control, channels/spillways, slope stabilisation/retaining structures, crossings, penstock/corrosion protection, anchor and support blocks, and powerhouse construction. The project will also be identifying appropriate materials for civil construction, such as concrete/ferro cement, cement, masonry, pipes, and timber.

Pelton Turbines

After the cross-flow turbine, Peltons are the turbines that are most easily available and which are especially suitable for the generation of electricity. However, the locally-built runners suffer from low efficiency. A lot of work is needed to increase the efficiency of and local casting capability for Peltons.

Synchronous Alternators

The majority of synchronous alternators used in MMHP in Nepal are imported from India or Britain. The large alternators available in India have problems with the Automatic Voltage Regulators (AVR). They have been found to be unreliable and often produce oscillating voltages when used with an Electronic Load Controller. Work is being carried out by DCS and Nepal Power Producer to develop both static wound and electronic AVR which can be used for a wide range of alternators.

Induction Generator Controller (IGC)

The IGC was first developed for Nepal, and over a dozen of these controllers are being used with single phase induction generators in the country. However, the technology has yet to acquire the reputation for reliability which the ELC enjoys.

Current Cut-outs

Positive Thermal Coefficient Thermistors (PTC) have been found to be cost-effective with a current cut-out of up to 100W. For higher capacities, both the miniature circuit breakers (MCB) and the locally-designed and built Electronic Current Cut-outs (ECC) are being used. The reliability of the ECC also needs to be improved.

Grid Connection Technology

With the willingness (in principle) of the national grid to purchase energy from small producers, there is now a need to develop the technology for connecting MMHP schemes to the grid.

Appropriateness of the Technology

MMHP for Extremely Remote Communities

The study on 'Micro Hydropower in Humla with Special Reference to the Yangar Project' arrived at the following conclusions for MMHP adaption in remote districts such as Humla.

1. An appropriate choice of size and kind of MMHP technologies should be made in keeping with the needs and capabilities of the communities.
2. MMHP plants installed to provide lighting are not economically sustainable or affordable for most communities, even with a large subsidy.
3. MMHP plants installed for agro-processing, especially oil expelling, can make a positive contribution by saving labour, especially of women, and increasing income.
4. The current financial support provided to MMHP by HMG/N, via ADB/N, in extremely remote districts, such as Humla, is insufficient for them to be financially viable.
5. Community organisation is inadequate and there is a scarcity of skilled technical and managerial personnel in the communities in Humla for organising MMHP on their own. The schemes are unlikely to succeed without technical back-stopping and managerial support.
6. The role of motivating and organising the community should be carried out by an organisation such as the Karnali Local Development Project/Trail Bridge Building

Project, as it is in a position to develop a close relationship with the community, and not by the ADB/N or DCS which are not suited to fulfill this role.

Conclusions

A range of MMHP technologies exist for the entrepreneur or rural community to choose from. From the 'improved *ghatta*' to the grid-connected MMHP systems, there exists a broad spectrum of technologies developed to various levels. The challenge for manufacturers and technology development organisations is to achieve further reliability and better efficiency. At the same time, for rural development organisations, the challenge lies in selecting the proper MMHP technologies to meet their development goals and the needs and capabilities of the community.

Viability and Desirability of Mini-and Micro-hydropower

- Dr. R.D. Joshi[18]

Introduction

Public sector efforts to introduce electrification in the rural hills began in 1975 with the establishment of the Small Hydropower Development Board. This initiative was directed mainly towards electrification of district headquarters. Thirty hydropower plants in a micro range of up to 100kW and a mini range from 100kW up to 1,000kW, with a total capacity of 5,400kW, have been completed under this initiative. These plants, however, proved to be a financial burden.

Private sector efforts in electrification of the rural hills began in the mid-seventies with the addition of electricity-generating facilities to turbine mills. These plants are designed for the electrification of sparse settlements in the rural hills. The delicensing of micro-hydropower plants (MHP) in 1984, the introduction of subsidies on the electrification components of MHP in 1985, bank financing at priority sector interest rates, development of local manufacturing capabilities, and promotional efforts by a number of agencies facilitated the phenomenal growth of MHP in the private sector. The total capacity of the MHP plants installed and being constructed is now approaching 1,900kW.

In spite of the unique promotion of MHP in Nepal, its growth is too slow to meet the government's goal of developing 5,000kW MHP capacity within the Eighth Five Year Plan period (1992/93 - 1996/97). It is in this context that the viability of MHP and the approaches for its dissemination are examined.

Viability of Micro-Hydropower Plants

Technical Viability

MHP technology is still evolving. Technological innovations introduced in MHP are recent and have not passed the test phase. The variety of poorly matured technologies used in the field may often mean that MHP looks as if it lacks credibility. However, in reality, the main innovations introduced into MHP, such as load controllers and current cut-outs, are fairly reliable. The large number of MHP installations in North America, using non-conventional hydropower technology similar to that of Nepal, bear testimony to the technical viability of MHP technology.

The current development and trials of MHP technology are geared not towards proving the possibility of alternatives to conventional hydropower technology but towards

[18] Reader, Institute of Engineering.

technically-acceptable low-cost solutions. Technical failures of MHP have been reported. In many cases these failures are due to the excessive efforts to cut down the plant cost. In order to discourage such efforts, electrical and mechanical guidelines for MHP design and installation have been prepared. *Ad hoc* designs or rural technology still dominate civil works. A sizeable portion of the MHP failures are associated with civil works. To accelerate the promotion of MHP, the following measures are recommended: (a) support to R&D activities; (b) establishment of equipment testing facilities; and (c) preparation of mandatory design manuals.

Financial Viability

Entrepreneur-owned Unsubsidised MHP

The stand-alone[19], one kW Bhadaure MHP in Kaski district is an example of this type of MHP. A case study of this MHP indicated the attractiveness of this MHP with a payback period of four years. This case illustrates that there are settlements in Nepal where MHP can be financially viable without subsidies.

Entrepreneur-owned Subsidised MHP

This type of MHP is predominant in Nepal. All the MHP in the non-remote areas of Nepal are entitled to a subsidy equivalent to 50 per cent of the electrical equipment costs, whereas those in the remote areas are entitled to 75 per cent of the electrical equipment cost. A financial analysis of the add-on type, three kW Angaha MHP in Palpa district indicates the attractiveness of the project with a payback period of five years. A moderate tariff of NRs 0.75/W/month on this plant allows us to generalise on the outcome of the analysis. Add-on MHP plants are, as a rule, more financially viable than stand-alone MHP. Relatively rapid dissemination of the one kW range peltric type stand-alone[20] plants is an exception to this rule. Relatively low per kW cost, negligible construction time, relatively higher cost subsidies, and the ability of peltric sets to command a relatively high tariff explain the financial attractiveness of peltric sets. A financial analysis of a typical peltric set indicates that a tariff of NRs 1.45/W/month can give an attractive payback period of five years. The financial performance of large stand-alone installations very much depend upon end-use development. For example, the 27kW Tamghas MHP plant, which is the second largest plant in this category, is performing well due to its well developed end use, whereas the 50kW Barpak MHP is not performing well due to the relatively poor end-use development. The financial analysis of a typical large MHP (50kW) plant shows that a regular tariff of NRs 1.92/W/month yields a payback period of five years. This clearly illustrates the relatively poorer performance of stand-alone plants.

Informal Community-owned Plants

This type of plant, which has emerged mainly in Mustang, is non-commercial and community-owned. Such projects are financed by government subsidies, additional

19 MHP used solely for electricity generation.

20 Easy to install, low-cost generating set consisting of a micro peltric turbine and an induction generator. These sets are available off-the-shelf and can be carried by a porter.

subsidies from donors, which vary widely in range, contributions from community members, and bank loans, normally small. In spite of the informal nature of management, the plants are running relatively well. The success of this type of plant is attributed to the homogeneity, cohesive nature, and relative affluence of the community which is characteristic of Mustang.

With these plants, once the loan is repayed, the tariff is fixed so as to cover the salaries and the day- to- day maintenance costs. Whenever the need for costly repairs arises, the funds required are raised from the community. The sustainability of this type of plant depends, to a large extent, upon the viability of the community structure itself. More experience and analyses are required to arrive at a firm conclusion regarding the wider applicability of this type of approach.

Formal Community-owned MHP

The Ghandruk MHP plant, commissioned in 1992, is the first plant of this type. Recently, a second plant of this type - a 100kW Siklis plant - has been commissioned. The Ghandruk plant was financed through contributions from donors (CIDA and ACAP, the promoters, 57.5%; government subsidy, 12.5%; cash and labour contributions from the community, 17.5%; and bank loans, 12.5%).

The Ghandruk plant plans to raise seven per cent of the plant cost annually from tariffs. The revenue will cover the salaries - 2.5 per cent, maintenance fund - 1.5 per cent, and the loan repayment/capital replacement fund - 3.0 per cent.

At present, the tariff is NRs 0.50/W/month for domestic consumers, NRs 0.75/w/month for hotels, and NRs 0.25/W/month for daytime industrial loads. The plant is expected to remain sustainable if the tariff increment is kept in tune with inflation. The plant is formally managed by an Electrification Committee. This type of MHP requires relatively large subsidies, and the institutional viability of such MHP plants is still to be tested.

Desirability of Micro-hydropower Plant Promotion

Affordable energy is an important prerequisite for economic development. In the rural hills, 99 per cent of the energy requirements continue to be met from biomass, the supply of which is not sustainable. Therefore, energy scarcity is regarded as one of the constraints to rural development. For the remote hills, MHP is the best alternative for supplying energy for rural development, and the reasons for this are given below.

- Biomass is not convenient for providing motive power.
- Solar and wind power are not competitive.
- Fossil fuels are not competitive due to the high transportation costs.
- The supply from the grid is not competitive due to dispersed and small loads.

Rural electrification efforts with private MHP in Nepal have been encouraging from the rural economic development perspective, because it has become a common practice for MHP entrepreneurs to integrate end uses with the plant. Nepalese MHP owners, with access to electricity, are gradually becoming the driving force behind rural development. It is indeed an attractive proposition to pursue rural electrification as a means of rural development, because of the immense interest of the rural population in rural electrification and mobilisation of considerable local resources for this purpose.

Approaches to Micro-hydropower Plant Promotion

Ownership

Compared to community ownership, ownership by entrepreneurs is a more efficient and sustainable mode of MHP operation because community-owned MHP requires higher subsidies than entrepreneur-owned MHP. The government's subsidy policy does not differentiate between entrepreneur- and community-owned MHP. The development of community-owned MHP is a result of the efforts of the non-government sector. A workable and sustainable form of community-owned MHP is still to evolve. In this respect, the existing community-owned MHP plants are valuable and should be closely monitored.

Plant Type

Stand-alone plants, compared to add-on plants, are capable of making a greater contribution to rural development by providing energy for productive activities. These plants, as indicated earlier, need greater financial support than add-on plants. Therefore, stand-alone plants should be promoted by providing additional financial support.

End Uses

The development of end uses is crucial to the sustainability of stand-alone plants. End use promotion should receive the same priority as MHP promotion. Wherever feasible, MHP entrepreneurs should also own end uses. As a rule, the capacity of the plant should be compatible with the end-use load.

Promoting Agency

Until recently, the ADB/N assumed the overall responsibility for MHP promotion. Now, it is limiting its role to banking, and no other agency has taken over the overall responsibility from the bank. Thus, MHPs have suffered from a lack of patronage. The designation of an appropriate agency to assume the overall responsibility for MHP promotion is vital for its proper dissemination.

Subsidy

Financial viability is site-specific. The existing subsidy policy divides Nepal into two zones - remote and non-remote. This division, however, is too broad to make the subsidy policy effective. It would be more desirable to divide Nepal into territorial units, according to economic development; this could have a decisive impact on the financial viability of MHP. 'A Study on Economic Viability of Micro-Hydropower Plants' (WECS, 1994) recommends that 50 per cent of the electrical components' cost be financed through a revolving fund throughout Nepal and, for remote areas, an additional support of 25 per cent of the mechanical components' cost should be financed through the fund.

Other Support

For the desired dissemination of MHP, an increase in financial support should be complemented by infrastructural support such as service centres to support MHP technically, manpower training, consumer education, research and development activities, and equipment testing facilities.

Viability and Dissemination of Mini- and Micro-Hydropower in Nepal: Development Consulting Services' Experiences

- *Govinda Prasad Devkota*[21]

Introduction

This paper highlights the development and dissemination of mini- and micro-hydropower (MMHP) in Nepal, with special reference to the experience of the Development and Consulting Services (DCS). DCS is a joint venture organisation of His Majesty's Government of Nepal (HMG/N) and the United Mission to Nepal (UMN), dedicated to technology development and transfer activities. There are two divisions in the organisation to perform these activities, namely, the Research and Development (R&D) Division and the Promotion and Transfer (P&T) Division. The first cross-flow turbine manufactured by the DCS was installed in Jhare *Khola*, Arghakhanchi district, in 1976. This turbine was tested on the Tinau River before installation. A second DCS turbine was installed in Kathe *Khola*, Baglung district, in 1977. Similarly, with the testing of the first Nepali-made, three-phase load controllers, the rural electrification programme started in Turture in Tanahu district. The continuing research activities of DCS are dedicated to the Automatic Voltage Regulator (AVR), Electronic Current Cut-out (ECC), Positive Thermal Co-efficient (PTC) Thermistors' switch, and Electronic Load Controller (ELC).

Installation Process

The micro-hydropower installation process consists of five steps which are described below.

Survey

On the customer's request, a survey is conducted by the installer. This involves flow and head measurements, power and cost calculations, and preparation of a report.

Project Proposal and Quotation

The DCS has developed a standard format for the MMHP project proposal which includes all project data, cost of equipment and material, installation and services, and the terms and conditions required by the Agricultural Development Bank of Nepal (ADB/N) to give loans to customers.

Loan Approval

After receiving the loan application for a given project proposal, based on the ADB/N loan officer's assessment of the economic viability of the proposal and the availability

[21] Divisional Manager of the P&T Division of DCS.

of adequate collateral, the loan is approved. Most of the fund is channelled through the installer.

Installation

The design of the whole scheme and its installation are the responsibility of the installer, while the civil works at the site are the responsibility of the customer.

Testing, Operation, Training, and Handing Over

After installation, the plant is run and tested, the operators are trained, and the project is handed over to the customer who will then sign the bill for final payment by the bank to the installer.

Development and Dissemination

Nine indigenous companies/firms are presently involved in manufacturing and disseminating MMHP in Nepal. They are DCS, Butwal Engineering Works and Nepal Hydro Electric Co. (BEW/NHE), Balaju Yantra Shala (BYS), Nepal Yantra Shala (NYS), Kathmandu Metal Industries (KMI), Thapa Engineering Industries (TEI), National Structure and Engineering Co. (NSE), Nepal Machine and Steel Structure (NMSS), and Nepal Power Producer (NPP). The other two companies, namely, Agro-Engineering Works (AEW) and Inter Tech (ITC) have installed 16 and six MMHP plants respectively in the past, but they are not involved in the MMHP field currently.

Most of the technical personnel in these companies worked for and were trained at the BYS or Butwal Technical Institute (BTI) before moving out to establish their own workshops for manufacturing and installing MMHP units. The total number of MMHP plants installed by these companies until 1993 was 918, of which 260 MMHPs (the largest number) were installed by DCS. Out of these 260 MMHP installed by DCS, 54 schemes are electrification schemes. The largest unit installed so far is the 100kW plant at Siklis, and a 500kW Jhankre mini-hydro scheme is under construction. The turbine is designed by DCS and manufactured by BEW/NHE. DCS-installed MMHPs are spread throughout the hills and mountains of Nepal, covering twelve zones out of the fourteen zones of the country. Over 80 per cent of all the installations are concentrated in the Western Region, and Lumbini Zone alone has about 30 per cent of the MMHP. The flow and head ranges of DCS-installed MMHPs lie respectively within three to 107/sec and 17 to 122 metres. The total power generation from DCS installations is estimated to be 730kW, and about 50,000 people have benefitted from the DCS electrification programme alone. In 1994, a further 492kW of power will be generated by DCS installations.

Promotion and Application of MMHP in Nepal

In addition to private companies, a number of government, semi-government, and non-government organistions are involved in the promotion of, development of, manufacturing of, research into, and policy-making for MMHP. At the central level, the

National Planning Commission (NPC) and the Water and Energy Commission Secretariat (WECS) play their respective roles in planning and policy formulation, while the Research Centre for Applied Science and Technology (RECAST) and the Royal Nepal Academy of Science and Technology (RONAST) are involved in technology development. ADB/N has played a leading role in the financing aspect. Government subsidies of 50 to 75 per cent of the electrical equipment costs are being channelled to developers through this bank. The other organisations involved are the International Centre for Integrated Mountain Development (ICIMOD), the Intermediate Technology Group (ITDG), the German Technical Cooperation (GTZ), and the Swiss Association for Technical Assistance (SATA)-Helvetas, at present.

The applications of MMHP in Nepal are primarily in the agro-processing activities of rural areas. Electricity-generating MMHPs were introduced in 1984. Low-wattage cookers (*Bijuli Dekchi*) and oil expellers are the end-use devices developed and promoted by DCS.

Issues and Possible Solutions

The problems encountered during the promotion of MMHP technology are many. Lack of good testing facilities, lack of MMHP standards, uncertainty about the provision of subsidies, high initial costs, inadequacy of users' knowledge, and unavailability of spare parts are a few of these problems.

The possible solutions to them could be: (i) imparting repair and maintenance training to the operators/users; (ii) opening either a local sales' depot or selecting a local commission agent for selling or making available the accessories/spare parts in the field; (iii) providing a fixed amount of subsidy for a fixed time period; (iv) conducting consumer education and mobile training programmes; and (v) rewarding the successful owner/promoter/operator periodically.

Conclusions and Recommendations

The MMHP sector has made remarkable progress; it installed more than 918 units by 1993. Twenty-eight per cent of these installations were commissioned by DCS. About 50,000 people have benefitted from DCS plants alone. DCS is shifting its emphasis from agro-processing mills to MMHP for electrification. The experience of DCS shows that: (i) the success of MMHP development and dissemination depends on the ability to cater to the needs of the people and on making MMHP affordable for users and (ii) the technology could be transferred only to those areas where a minimum conducive physical environment prevails for development and uses of MMHP.

The following are recommendations that will help the development and dissemination of MMHP technology in Nepal.

1. The equipment to be distributed should be fully developed in keeping with standard specifications.

2. A desirable training package should be provided to users/operators, as well as installers, on a regular basis.
3. A simple mechanism for loans and subsidies should be developed.
4. Follow-up visits by the manufacturers should be undertaken.
5. An evaluative study should be carried out in order to see the performance of the MMHP units. Quality control and standardisation of the product should receive focus.
6. There is a need for better coordination among agencies involved in MMHP.
7. An active Micro-Hydropower Development Association is needed. Otherwise an institution needs to be set-up to organise meetings, seminars, training and coordinating, promoting, monitoring, and evaluating the MMHP programme.
8. End uses suitable for hill communities should be developed.
9. Programmes aimed at increasing the awareness of the rural population about MMHP should be organised.
10. R&D need to be undertaken to improve the performance of the existing end-use appliances.
11. An operational manual should be prepared and distributed to the owners for the successful operation and maintenance of each plant.
12. An MMHP newsletter should be published and distributed widely.

Micro-hydro: Institutional Issues

- Vishwa, B. Amatya[22]

Present Energy Scenario in Nepal

The energy situation in Nepal is characterised by a very low per capita energy consumption of about 14 GJ. Since economic development and the standards of living of the people are directly proportional to the per capita energy consumption, significant increase in energy consumption is necessary to meet the national goals.

The total energy consumption in the year 1992/93 was estimated at about 270 million GJ. The energy consumption growth in the past decade has been about 2.4 per cent per annum. The residential sector consumes 91 per cent of the total energy. About 91 per cent of the energy demand is met by traditional sources — fuelwood, 68 per cent, agricultural by-products, 15 per cent, and animal waste, eight per cent. The share of petroleum fuel, coal, and electricity in the total consumption are estimated 7.2, 1.0, and 0.9 per cent respectively.

A Case for Alternative Energy

Nepal's electricity demand is steadily rising, at the rate of 14-15 per cent per annum but the electricity supply is lagging behind the demand. The deficit is likely to continue to increase until additional supplies from new projects are realised.

Nepal spent about 24 per cent of its earnings from merchandise export in 1992/93 in the import of fossil fuel. This indicates the limitations of substituting traditional fuel sources by fossil fuels. High transportation costs and poor affordability in the rural hills and mountains are additional limitations to substituting traditional sources with fossil fuels.

Heavy reliance on fuelwood has caused irreversible environmental damage in the country. It has also increased the work burden on 78 per cent of the rural women and a greater number of children have to now allot 20 per cent of their time to fuel collection. Moreover, the dwindling supplies of fuelwood have forced people to burn larger quantities of dung and agricultural residues for fuel, thereby depriving the soil of valuable nutrients and organic conditioning materials. As a result, soil fertility has declined drastically.

The present energy situation must be improved to allow the country to achieve its development targets. There is an urgent need to gradually move away from forest-based energy sources so as to maintain the ecological balance and make energy resources

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[22] Energy Consultant, Water and Energy Commission Secretariat (WECS)

sustainable. One viable option, among many others, would be to resort to alternative energy technologies (AETs) which have the ability to perform effectively under arduous conditions. Micro-hydro, an alternative energy source, has proven to be a viable source of electricity and shaft-power in the rural areas of Nepal.

General State of AET Development and HMG Policy

There has been a number of efforts to develop AETs, particularly in the private sector. Several of donor agencies have been supporting various AET projects. Also, an appreciable infrastructure for R&D, fabrication, promotion, and dissemination has been developed, especially in the field of micro-hydro and biogas. In addition, positive developments in solar energy cannot be ignored.

In the past, HMG/N's policies on AET development have been criticised for inconsistency and irregularity. Lately, the importance of alternative energy has been felt at the policy- and decision-making levels, as reflected by the Eighth Five-Year Plan. This plan contains policies and programmes, including provisions for an institutional set-up for MMHP. The Eighth Plan anticipates the investment of NRs 1.61 billion for AETs, of which HMG/N will contribute NRs 0.33 billion. The highest share of the government budget for AETs is for biogas (NRs 250 million), followed by micro-hydro (NRs 50 million).

Main Institutions Involved in Micro-Hydro Development

Government Agencies

The ministries directly involved in the MHP programme are the Ministry of Water Resources (MOWR) and the Ministry of Finance (MOF). Institutions such as the National Planning Commission and the Water and Energy Commission Secretariat are responsible for policy-making and planning related to the development of the energy sector, including micro-hydro.

Semi-government Agencies

Agricultural Development Bank (ADB/N)

Among the semi-government institutions, the ADB/N, with its 238 field offices, 395 Small Farmer Development Projects (SFDP), five training centres, and two Appropriate Technology Units (ATU), stands as a principal development and financial institution. Although its activities are mainly in the agricultural and rural credit sector, it is an established and active promoter of AET. It has already invested more than 80 million rupees to install more than 80 per cent of the total number of micro-hydro installations for agro-processing and rural electrification in the country. The government subsidy on micro-hydro-based rural electrification is also channelled through the ADB/N. Until recently, the ADB/N played a key role in the promotion of MHP. However, it has withdrawn its overall support for MHP and limited its role to financing only.

Nepal Electricity Authority (NEA)

NEA, the only public utility responsible for generating and distributing electric power throughout the country, also supplies electricity to isolated areas, through a number of small hydropower plants. It was established in 1985 after merging the Nepal Electricity Corporation and the Electricity Department of the HMG/N. The Small Hydropower Department of the NEA is responsible for promoting MMHP. NEA previously supported the use of locally-manufactured equipment. However, due to low efficiency, this approach has been abandoned.

Non-government Organisations (NGO)

Among the numerous NGOs in the country, the Annapurna Conservation Area Project (ACAP) and the Association of Micro-Hydro Manufacturers (AMHM) are actively involved in the development of micro-hydro in Nepal. ACAP is a project of the King Mahendra Trust for Nature Conservation (KMTNC), a leading non-government environmental organisation. ACAP has successfully implemented a number of MHPs in the country. They include the 2.5kW Khuldhighar MHP plant, the 50kW Ghandruk MHP plant, and the 100kW Sikles MHP plant.

International Non-government and Donor Organisations

As emphasised in the previous sections of this report, part of the credit for the present state of MMHP development in Nepal goes to various international donor agencies and international non-government agencies. These agencies are listed below.

1. United Mission to Nepal (UMN)
2. Swiss Federal Institute of Technology
3. German Technical Cooperation (GTZ)
4. Association for Context Appropriate Technology (FAKT)
5. Swiss Association for Technical Assistance (SATA)
6. United States Agency for International Development (USAID)
7. Intermediate Technology Development Group (ITDG)

Private Companies

Much of the development in the field of MMHP in Nepal is a result of entrepreneurship of private sector organisations. They were able to develop MMHP because of the support of ADB/N and international donor communities. They were also able to generate support from local entrepreneurs who showed a keen interest in installing MHP. A list of the main private sector institutions involved in MMHP is given below.

- Balaju Yantra Shala
- Nepal Yantra Shala
- Kathmandu Metal Industries
- National Structure and Engineering Company

- National Power Producer
- Thapa Engineering Industries
- Agro-Engineering Works
- Nepal Machine and Steel Structure
- Butwal Engineering Works
- Development and Consulting Services
- Nepal Hydro and Electric Private Limited
- Centre for Rural Technology

Research Institutes

Research Centre for Applied Science and Technology (RECAST)

RECAST has been involved in the improvement of traditional water wheels, the development of MPPU and low lift water pumps, the replacement of cross-flow turbine blades with high density polyethylene (HDP) material to lower the cost of turbines, and so on.

Royal Nepal Academy of Science and Technology (RONAST)

RONAST is involved in the improvement and promotion of appropriate indigenous technologies. It has, so far, not played a significant role in mini- and micro-hydro technology dissemination. It is presently associated with the Information Network on New and Renewable Energy Resources and Technologies for Asia and the Pacific (INNERTAP) to provide information on renewable energy in Nepal.

Institutional Issues in the Development of AETS

Implementation Aspects

At present, all the surveys and design work for MHP development are being carried out by the manufacturers. An outcome of this approach is reduced installation costs. In the drive to achieve lower per unit costs with little or no involvement of professionals, undesirable compromises in survey and design are often made which affect the overall output, reliability, and safety as well as the environment. Furthermore, there is no institutional set-up to regulate equipment quality standards. There is also lack of proper documentation on designs, equipment specifications, and operation and maintenance guidelines.

Management

The financial management, plant operation, and maintenance capabilities of local entrepreneurs are very poor. Proper book-keeping is practically non-existent. The plant owners' perceptions of the value of training and motivation of their employees are limited. The educational backgrounds and level of training provided by the manufacturers to the plant operators vary considerably. In this respect, private utility

MHP differs strongly from NEA-owned MHP. All NEA-owned MHP plants have at least a formally educated and trained technician supported by a large number of foremen, helpers, and electricians, whereas local MHP entrepreneurs act as, or depend on, a single operator who is also responsible for maintenance as well as administrative matters.

Water Rights

Water management is a burning issue in MHP plants. Several MHP plants have failed due to water rights' problems. For example, eight per cent of the turbine mills have failed due to riparian conflicts alone. *Ghatta(s)*, in general, do not interfere with irrigation. Turbine water mills, which have longer canals and longer duration of operation, seem to interfere with the use of water to some extent. Conflicts about turbine mills have surfaced in this respect. MHP plants normally have long canals and the possibility of water-use conflicts between MHP and irrigation is greater than between turbine mills and irrigation. Water rights' conflicts are often exacerbated when the irrigation water users and electricity users are different.

Ownership

Three types of ownership have emerged in MHP – individual, community, and formal company. Individual ownership is predominant by far. In this type of ownership, the sense of purpose is clear. Therefore, in general, such plants are relatively better-managed in terms of operation and maintenance. The only effort to form a company with private participation was made by SCECO (Salleri-Chialsa Electrification Company).

Promotional Activities

In order to improve the economic viability of MHP, it is necessary to integrate promotion of end uses along with promotion of MHP, at least during the initial stages of development. This fact was well recognised right from the initial stages of MHP promotion. However, there are no institutional arrangements to cater to the promotional activities required for MHP development, apart from a few scattered efforts by private entrepreneurs and NGOs.

Financing

Subsidies from the government and assistance from international donor agencies are important inputs to MHP development. Loan assistance from commercial and development banks has played a critical role in achieving the present state of MMHP development in Nepal. However, lack of coordinated efforts on the part of donors, bureaucratic delays, and inconsistent government support have made achievement of the desired target, of making MMHP financially sustainable, difficult.

Technical Support

The lack of adequate technical support, in the form of training, research, information dissemination, and quality assurance, has posed impediments to MMHP development. The absence of an institution to deal specifically with alternative energy development was felt for a long time. Consequently, a coordinating body consisting of representatives from various institutions involved in AETs, was formed under the Water and Energy Commission Secretariat (WECS). However, it has remained practically ineffective due to various reasons. The existing training programmes are confined to building equipment related to MHP units. In these training programmes marketing aspects have not been dealt with. Most manufacturers train their clients during the MHP installation process. Instructions and the training imparted to ensure the smooth operation of the plants seemed to be inadequate .

Institutional Efforts

The ADB/N played a pivotal role as an executing agency translating government plans and policies relating to MHP into action. Unfortunately, in recent years, it has limited itself financing only to MHP. On the technology development side, RECAST, Development Consulting Services (DCS), Intermediate Technology Development Group (ITDG), Kathmandu Metal Industry, and some manufacturers are active from time to time. The development of the Peltric Set, *Bijuli Dekchi*, and so on are some of the important recent developments. The proposal to establish an Alternative Energy Promotion Centre in the Eighth Five Year Plan is a positive indicator in this respect.

Recommendations

MHP, by virtue of its various characteristics, should develop rapidly in Nepal. However, there are a series of constraints that obstruct its rapid development. Most of the problems can be directly linked to the lack of an institution dedicated to its development. A Central Micro-hydropower Promotion Centre (or a separate wing in the envisaged Alternative Energy Promotion Centre) within the government organisation, but as autonomous as possible, should be formed to coordinate the development of MHP. The main responsibilities of such an institution should include:

i) coordination and facilitation of research and development,
ii) preparation of guidelines and manuals for all MHP-related work,
iii) quality control,
iv) facilitation and coordination of training programmes, and
v) facilitation of financing mechanisms.

Perspective on Mini- and Micro-Hydropower Development

- *Kamal Rijal*[23]

Background

Nepal has a long history of hydropower use. The first effort to modernise the *ghatta* - the traditional water mill - began in the sixties. There is immense potential for the development of mini-and micro-hydropower in Nepal with 6,000 rivers and streams criss-crossing its mountainous terrain.

Mini-and Micro Hydropower (MMHP) schemes combine the advantages of large hydro plants, on the one hand, and decentralised power supply, as with diesel sets, on the other. They do not have many of the disadvantages, such as costly transmission and environmental problems, of large hydro plants, and dependence on imported fuel and need for highly-skilled maintenance personnel, as in the case of diesel plants. Moreover, harnessing small hydro resources, being decentralised, leads to decentralised use and local implementation and management, thereby making rural development possible through self reliance and the use of local natural resources.

The energy of micro-hydro plants is best used when the larger part is consumed on the spot as mechanical energy, without the intermediary of electricity generation and transmission. This is applicable to decentralised agro-processing, sawing, and water lifting. Micro-hydro units solely for electricity generation are often not economical because of the high unit costs. MMHP installation does not require elaborate construction work in reinforced concrete or expensive powerhouses and highly-optimised electro-mechanical equipment. Feasibility studies and the planning of installations can be simple. High standards of safety in construction works are often not necessary, as even the rupture of a small diversion weir would not usually threaten human life, and the risks are smaller anyway if the initial costs of construction work are kept down. For electricity generation, standards for voltage, frequency fluctuations, and the reliability of supply can usually be modest, involving considerable savings, without substantially reducing the overall benefits of a scheme.

Needs and Rationale

The scattered settlement patterns in the hills and mountains of Nepal make electricity grid extension to most of these areas unfeasible. One viable option for providing energy to the rural hill areas could be decentralised energy systems, such as MMHP, which exploit the indigenous energy resource base and knowledge system by appropriately integrating local management skills.

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23 Currently the energy specialist, Mountain Enterprise and Infrastructure Division, ICIMOD.

The provision of mechanical and/or electrical energy from MHP schemes will help to increase the living standards of the rural people as well as help to rectify the ecological imbalance. For example, MMHP schemes could contribute to the following.

i) The substitution of fuelwood for cooking and heating in the commercial and residential sector and agro-based rural cottage industries
ii) The reduction of human drudgery, especially of women, by substituting manual agro-processing
iii) The increase in income-generating activities
(iv) The reduction of emission of oxides of carbon as well as the rate of deforestation.

Observations and Lessons Learned

The overall experience in rural electrification is not promising. The report - *The Socioeconomic Impact of Rural Electrification in Developing Countries* - written by the International Labour Organisation (ILO) concludes after reviewing over 150 documents-

> *".... the extension of electricity grids absorbs a considerable share of the development funds.... the benefits of extending grids to rural areas often tend to be overestimated and the costs underestimated. There is not much evidence to suggest that electricity .... had any major beneficial impact on the employment/income situation of the rural poor. On the contrary, there is some evidence of net job losses and worsening income distribution as a result of rural electrification."*

The Linking Rural Electrification with Rural Development in Asia report by ESCAP, after reviewing over 85 documents, has concluded that -

> *".... electrification does not seem to induce economic development unless it is treated as one element in a coordinated rural development effort. .... Electricity shortages can act as an important constraint to industrial growth. ...Irrigation pumping increases agricultural output and yield but dispersed pumps are expensive to electrify and grid electricity may often not be the lowest cost choice. ....the impact of rural electrification per se on the establishment of new industries and business has generally been modest."*

The Report of the Task Force on Rural Electrification Impacts in Nepal by the Water and Energy Commission Secretariat (WECS) concluded that -

> *"... in the past the impacts of rural electrification have been minimal....It does not mean there is no future for rural electrification. Rather it means that development of rural grid must proceed in a planned, reasoned way that accounts in a systematic way for the broader development goals..."*

Impending Issues

Market and Price Distortion

As long as price distortion prevails in the energy market, there is little scope for economically-justifiable energy options such as MMHP. Although the economic fuelwood price perceived by the nation is about NRs 2.5-3.5 per kg, 'free' fuelwood perception of the users will remain a major impediment in the development of MMHP in Nepal.

Lack of Capital Resources

Due to the lack of capital, cheaper traditional energy, which requires very little capital cost, is preferred in the rural areas to MMHP which requires much higher capital costs.

Low Load Factor

The average load factor of the rural electrification schemes in Nepal range between 19-23 per cent, and this does not generate enough revenue to cover the operational costs. The inability of MMHPs to serve the industrial sector, the fact that few in the rural population can afford them or their services, and other socioeconomic factors are the main reasons for the low load factor.

Technology R&D

The lack of policies to guide R&D activities in MMHP development has left R&D activities to the whims of organisations and donor agencies involved in their promotion. In order to use scarce resources sustainably, in a country like Nepal, R&D should be focussed on adaptive research rather than on fundamental research.

Private Sector Initiatives/Commercialisation

The role of private entrepreneurs is pivotal and needs to be further strengthened. The private sector needs to be promoted by the establishment of appropriate norms, standards, and support by the government.

Coordination and Promotion

In the absence of a coordinating agency solely devoted to activities related to renewable energy, either manufacturers or credit-funding agencies are carrying out the development and promotion-related activities in the MMHP arena. Integration is lacking, and most of the projects are formulated on an *ad hoc* basis.

Vision for MMHP

A three-pronged strategy is conceptualised to enhance the effectiveness of MMHP promotion.

Measuring Costs and Benefits

The existing distortions in the economic and market prices of energy must be internalised in carrying out the economic and financial analyses of MMHP so as to promote healthy competition, based on economic merit rather than on hidden subsidies. Additionally, the following measures have the potential for improving the viability of MMHP.

i) Improved rural development linkages
ii) Optimising design standards, costs, and reliability
iii) Encouraging local participation

Linking Mega-Project Development with Decentralised Energy Systems

Mega-power projects do not often envisage electrification of the project area. In such cases, the development activities associated with the project, which require additional energy inputs, may place tremendous pressure on forests for fuelwood. In addition to this, these projects can also lead to widespread resentment among the local people, along with negative socioeconomic and political impacts. Therefore, sufficient energy supplies must be made available in rural areas where large-scale hydropower projects are being considered for implementation. Additional energy supplies for the project areas could be made available through various decentralised energy programmes such as MMHP.

Enhancing the Economics of MMHP

For the reasons mentioned previously, it is unlikely that people will replace fuelwood with electricity without external intervention. These interventions could be in the form of education and awareness, reduced electricity tariffs, increased employment opportunities, and diversified use of electricity.

Electricity has the potential for substituting fuelwood in agro-and forest-based cottage industries as well as replacing human labour in agroprocessing activities and other income-generating activities.

End-use diversification, together with appropriate energy pricing, will also help to improve the load factor of the MMHP system and thereby reduce the cost of electricity. The following cases illustrate the implications of such diversification activities.

Case 1: Five kg of green cardamoms can be processed by a one kW electric furnace operating seven hours a day (0.025 GJ) and replaces 6.26kg of fuelwood (0.105 GJ). In other words, a 20kW capacity micro-hydro unit can process six tons of cardamom in two months and save 7.5 tons of fuelwood.

Case 2: A 10kW micro-hydro unit can reduce the human toil of 100 households in agroprocessing substantially and, thereby, increase the labour available for other activities.

Promoting the Role of the Private Sector

The credit for developing micro-hydro in Nepal goes to the active leadership and sustained promotional activities of the Agricultural Development Bank of Nepal (ADB/N). Need-based development of micro-hydro technology is due to the efforts of private manufacturers and entrepreneurs. The issues that must be dealt with in order to make private sector participation more attractive can be outlined as follow: (i) provision of management, financing, and training; (ii) identification of the role of the private sector; (iii) standardisation of technology; and (iv) an appropriate incentive package for manufacturers.

Concluding Remarks

The provision of mechanical/electrical energy can act as the catalytic agent for rural development if 'other' development inputs and needs are coordinated. Provision of electricity is not enough to facilitate rural development but need-oriented approaches to rural development, linked with the provision of energy, could provide opportunities for local initiatives. The absence of either component will decrease the potential of long-term sustainable growth, although marginal economic benefits from local electricity may be realised initially.

Annex 1
Programme of the Seminar

Day One

1 September, 1994

9:30 to 9:55 : Registration
10:00 : Inauguration
Introduction to the Seminar and Project, ***Dr. A.A. Junejo***
Keynote Speech, ***Mr. Sri Krishna Upadhyay***
Chairman's Remarks, ***Mr. E. Pelinck***
Vote of Thanks, ***Dr. A.A. Junejo***

11:00 : Tea

11:30 to 13:15 : **Working Session 1** *(New Approaches and Activities)*

Chairman : *Dr. M. Banskota*
Rapporteur : *B. Pandey*

Mini- and Micro-Hydropower Development in the Hindu Kush-Himalayan Region: Achievements, Impacts and Future Prospects, ***Dr. A.A. Junejo*** (ICIMOD)

Agricultural Development Bank Contribution to Development of Micro-Hydropower Achievements, Problem and Prospects, ***Mr. D. Adhikari*** (Agricultural Development Bank)

13:15 : Lunch

14:30 to 17:30 : **Working Session 2** *(New Approaches and Activities)*

Chairman : *Dr. R.D. Joshi*
Rapporteur : *D. Adhikari*

Salleri-Chialsa Electric Company - New Approaches and Activities (Viability and Desirability of MMHP), ***Mr. R.S. Thapa*** (Salleri-Chialsa Electricity Co. Ltd.)

The Role of Nepal Hydro and Electric Company and Butwal Engineering Works in Developing Hydropower Equipment, ***Mr. N.R. Shrestha*** (Nepal Hydro & Electric P. Ltd.)

15:40 : Tea

Experiences in End-Use Development and Small Industry Promotion in Salleri, ***Mr. H.P. Shrestha*** (ITECO Nepal P. Ltd.)

Development of Mini-Hydropower in the Remote Areas - Some Experiences and Challenges, ***Mr. A. Karki*** (Butwal Power Company)

Day Two

2 September, 1994

9:00 to 13:00 : **Working Session 3** *(Problems and Redressals)*:

Chairman : *Mr. G. Kent*
Rapporteur : *S. Sharma*

Problems Associated with the Private/Decentralised MMHP Plants and Some Possible Redressals, ***Dr. A.A. Junejo*** (ICIMOD)

Balaju Yantra Shala's Experience in MHP Technology Development, ***Mr. S. Devkota*** (Balaju Yantra Shala)

State-of-the-Art Technologies Appropriate for MHP, ***Mr. B. Panday*** (ITDG/Nepal)

10:45 : Tea

Viability and Desirability of Mini- and Macro-Hydropower, ***Dr. R.D. Joshi*** (T.U. Engineering Campus)

Viability and Dissemination of Mini- and Micro-Hydropower in Nepal : Development and Consulting Services' Experience, ***Mr. G.P. Devkota*** (Development and Consulting Services)

13:00 : Lunch

14:00 to 15:30 : **Working Session 4** *(Directions for the Future)*

Micro-Hydro: Institutional Issues, ***Mr. V.B. Amatya*** (Water & Energy Commission Secretariat)

Perspective on Mini- and Micro-Hydropower Development, ***Dr. K. Rijal*** (HMG National Planning Commission)

15:30 : Tea

16:00 to 17:30 : **Concluding Session**:

Presentation of Summary Conclusions
Discussions
Adoption of Conclusions
Remarks by the Chairman
Closure

Annex 2
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Bibliography

Aitken J.M., Cromwell, G. And Wishart, G., 1991. *Mini- and Micro-Hydropower in Nepal*, Occasional Paper No.16. ICIMOD: Kathmandu.

Bajracharya D., Nakarmi A.M., and Singh K.M., 1991. *Development of Micro-Hydro Systems in Nepal: Problems and Prospects*, MIT Series No.10. ICIMOD: Kathmandu.

Cecelski, E. and Glatt. S, 1982. *The Role of Rural Electrification in Development, Resource for the Future*. Washington D.C.

Devkota, G.P., 1993. *Micro-Hydropower in Nepal.* An example of successful transfer and dissemination of a technology. Butwal:DCS.

East Consult, 1990. *Socio-Economic Evaluation of Micro-Hydro Schemes in Rural Communities of Nepal.* Kathmandu, Nepal:ITGD.

ESCAP, 1990. *Linking Rural Electrification with Rural Development in Asia*. New York:United Nations.

Fluitman, F., 1983. *The Socio-economic Impact of Rural Electrification in Developing Countries: A Review of Evidence*. Geneva: World Employment Programme Research ILO.

HMG/N, 1992. *Hydro Power Development Policy*. Kathmandu:Ministry of Water Resources Singh Durbar.

IREDA, 1993. *Manual for Small Hydro Developers*. New Delhi, India: Indian Renewable Energy Development Agency Ltd.

ITDG, 1991. `Electric Guidelines for Micro-Hydro-Electric Installations', Compiled by Waltham M., UK.

Jantzen, D. and Koirala, K., 1989. *Micro-Hydropower in Nepal.* Kathmandu, Nepal:Bikash Enterprises Inc.

Junejo, A.A., 1988. *Detailed Survey Report on Micro-Hydropower Plants in Northern Areas and NWFP*. Pakistan:Pakistan Council of Appropriate Technology.

Junejo, A.A., 1993. *Micro-Hydropower Programmes in Pakistan - A Brief Review.* Presented at the Training Programme on Micro-Hydropower, Organised by ITDG in Pokhara, Nepal.

Junejo, A.A., 1994. *Mini & Micro Hydro Power Development in the HKH Region.* ICIMOD: Kathmandu.

Joshi, C.B., 1992. *Alternative Energy Technology in Rural Nepal : Problems and Prospects*. NEGAAS Lecture Series No. 3. Kathmandu: NEGAAS.

Lama, P., 1994. *Subsidies and SCECO Tariff Policy, Experiences of Salleri-Chialsa Electric Co*. Presented at the Seminar on Rural Electric Cooking, ITDG/Nepal.

MNES., 1993. *Urja Bharti Special Issue on Small Hydrypower Development*. Ministry of Non-Conventional Energy Sources. New Delhi, India:MNES.

McCawley, P., 1978. *Rural Electrification : Is It Time ?* In Bulletin of Indonesian Economic Studies, Vol. 14, No. 2.

Molinari, P., 1979. *The Need for an Integrated Approach for Rural Electrification in Nepal*. HMG/N:Electricity Department.

New ERA, 1993. *The Techno Economic Performance of Water Turbines in Rural Communities in Nepal*. Kathmandu, Nepal: International Technology Development Group.

New ERA, 1993. *Loan Repayment Status of Turbine Mills*. Kathmandu, Sponsored by ADB/N and ITDG. Kathmandu, Nepal:International Technology Development Group.

NRECA, 1991. *Ten-Year Rural Electrification Study, NRECA/NEPECON*, Kathmandu:NEA.

Panesar, P.S., 1994. *Private Communication*, Alternate Hydro Energy Centre. Roorkee, India: University of Roorkee.

Rijal, K., 1991. *Alternative Energy Proposals, Environmental Management and Sustainable Development in the Arun Basin*. Vol. 11. Kathmandu:King Mahendra Trust for Nature Conservation.

Rijal, K., 1993. `Energy Market Situation, Small Hydropower Master Plan': *Nepal - Chapter 4, Small Hydropower Department and PPL, Final Report Phase - I, Vol. 1-3*. KathmanduLNEA.

Shrestha, G.P. and Upadhaya, S.K., 1991. *Environmentally Friendly Micro Hydro Scheme*. Kathmandu:DCS.

Shrestha, N.R., 1990. *Micro Hydro Scenario of Nepal. Souvenire Issue*, Bulletin of Association of Nepal Engineers'. Lumbini, Butwal.

Tamang, B., 1993. *Hydropower Development in Bhutan*. A background paper for Bhutan's National Environmental Strategy. Bhutan: National Environmental Commission, Royal Government of Bhutan.

Thapa, R.K., 1993. *Ghandruk Micro-Hydropower Project - A Case Study*. Paper Presented at Seminar on Private Sector Investment in Small Hydropower Development. Organised by HMG/NEA/GTZ, Kathmandu, Nepal.

WECS/UNDP, 1994. *A Study on Improvement of Economic Viability of Micro-Hydropower Plants.* HMG, Nepal:Water and Energy Commission Secretariat, Ministry of Water Resources.

WECS, 1988. *Report of the Task Force on Rural Electrification Impacts in Nepal*, Kathmandu.

WECS, 1988. *An Evaluation of Alternative Technologies in Nepal*, Kathmandu.

World Bank, 1975. *Rural Electrification*, Washington D.C.

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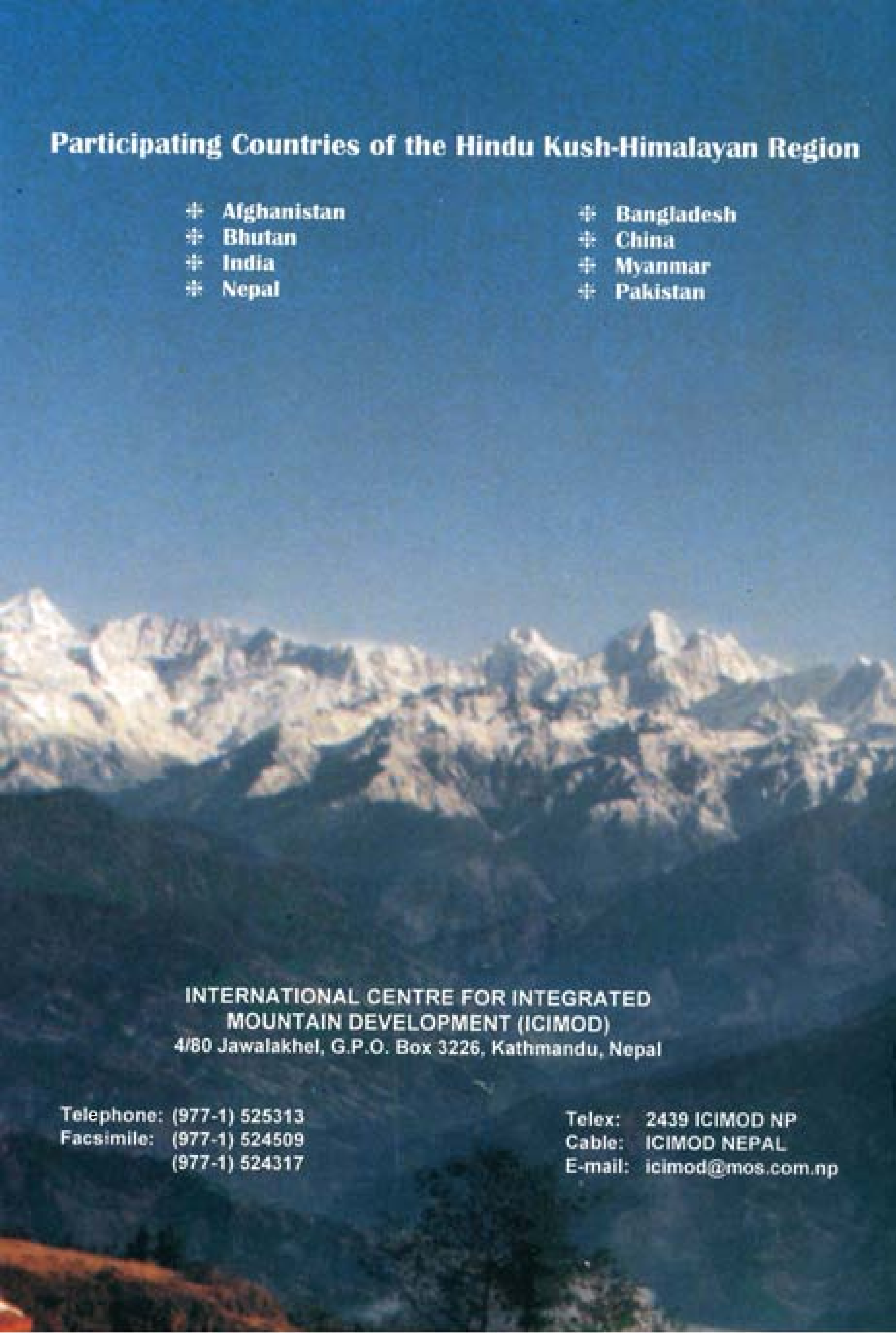

Participating Countries of the Hindu Kush-Himalayan Region

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- Bhutan
- India
- Nepal
- Bangladesh
- China
- Myanmar
- Pakistan

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