Chapter 2
Status of MMHP Programmes

2.1: A Brief History

MMHP plants were introduced into the HKH Region by the electricity departments of the various governments. In Nepal, the first MMHP plant was installed at Pharping in the Kathmandu Valley in 1911. It had a 500kW capacity and went out of operation a few years ago. The first MMHP plant was installed in India in 1897 in Darjeeling and had a 130kW capacity and in Kunming, China, in 1912 (480kW). Most other countries in the Region also had MMHP installations by the 1920s. At that time, there was no particular distinction between larger and smaller plants. The basic equipment was the same and almost always imported. Therefore, MMHP plants tended to be costlier than the larger ones, in terms of both the installed and production costs per kW and the per kWh.

It was during the fifties in China and the sixties and seventies in other countries of the region that a new approach emerged; i.e., indigenous development and decentralised installation of MMHP plants. This new approach reduced the capital costs considerably and introduced informal management and operational practices. Consequently, the rate of installations increased substantially, and some really remote and inaccessible villages witnessed the advent of electricity, unthinkable under a government-planned and managed system. These MMHP plants, mostly in the three to 40kW range, are usually subsidised by some government development agency or an NGO, as in Nepal and Pakistan. In China, similar but larger plants are financed by a combination of government agencies (central, provincial, or local). After installation, the local communities own, operate, maintain, and organise the repair of these plants. In a way, the new approach MMHP plants were considered to be an extension of the traditional *ghatta* or *gharat* (water wheel) technology which was used in the region for many centuries, mostly operating small agro-processing units.

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

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

Private MMHP plants have distinct advantages over the larger public sector versions. Therefore, although the larger government-owned MMHP plants are not excluded from the overall programme, the main focus of this reference work is on MMHP plants installed and managed by the private sector or communities.

2.2: MMHP Installations in the Region

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

At present, there are 19 MMHP plants in **Bhutan** with a total capacity of 3.40MW, all installed by the Royal Government under various aid agreements, mainly with India and Japan. There are only three other hydropower plants in Bhutan, i.e., the Chukha (336MW)[2], Gyetsa (1.5MW), and Gidakom (1.25MW). Whereas the identified and economically feasible hydropower potential is estimated to be 16,000MW. Most of the electro-mechanical equipment has been imported, mainly from India or Japan. Plant design and installation are also undertaken by foreign consultants, and most of the funds (loans or grants) have been provided by foreign agencies. At present, about 20 per cent of the population has access to electricity. Ten MHP plants, varying in capacity between 20kW to 70kW, were handed over to user communities for operation, maintenance, and distribution of electricity recently. The communities also fix tariffs and collect revenues. This experiment has been introduced mainly because the government agencies were finding it very difficult to operate and maintain these plants. Responsibility for their repair, however, still lies with the Department of Power. The government agencies regard MMHP plants to be very expensive, and there is more emphasis on the construction of larger plants which could also bring in revenue from the export of electricity.

In **India**, 153 MMHP/SHP plants (up to 3MW), with a total capacity of about 114MW, have been installed so far by various government agencies, while 178 additional plants, with a cumulative capacity of 220MW, are under construction. Out of the above, about 100 of the existing plants are located in the northern Himalayan range; these have an installed capacity of about 70MW. In addition, 1,344 sites, with a total aggregate capacity of 1,171MW, have been identified and incorporated into a comprehensive database established by the Ministry of Non-Conventional Energy Sources (MNES). All the plants are managed by State Electricity Boards or by the Department of Power (in Arunachal Pradesh). In most cases, the tariff charged is the same as the general government tariff for the grid system, except in the case of Arunachal Pradesh where it is much lower. More recently, approval has been given for installation of some private-sector plants. NGOs in Ladakh and Uttar Pradesh have also started installing MHP plants. One NGO, the Ladakh Ecological Development Group (LEDG), has installed 15 MHP plants so far, and these have been handed over to the communities for operation.

In **Nepal,** 35 MMHP plants, with a total installed capacity of 8.5MW, have been installed and operated by the Nepal Electricity Authority (NEA), and five of them are connected to the grid. During 1993, five of the above plants (at Darchula, Bhojpur, Kandhabari, Jomsom, and Bhajang) were leased out to private commercial companies. The new companies are

[2] About 80 per cent of the electricity generated by the Chukha plant is currently being exported to India.

to be responsible for operation and maintenance of these plants, as well as for the distribution of electricity. They are also authorised to fix tariffs and collect revenues from consumers, but the tariffs fixed by them must not be higher than the prevailing NEA tariffs. This is a new initiative adopted by NEA in order to cut down losses from mini-hydropower plants, and it is expected to continue.

There are other formal but private MMHP plants in Nepal where electricity is distributed, tariffs fixed, and revenue collected by the management. The largest and the most important of these plants is the 400kW Salleri Chialsa Power Plant which was commissioned in 1988. The tariff system is somewhat complex, as it has three main components, designed to promote more uniform use of electricity. The first component is the initial connection fee which increases with the amount of power allowed, from NRs 250 for a 100W connection to NRs 1,500 for loads higher than 4,000W. This connection fee is automatically transformed into company shares. Secondly, there are fixed rates for admissible power, subdivided into eight levels: rates vary from NRs 50/month for the first-level 100W connection to NRs 500/month for the eighth level. Thirdly, apart from for the first two levels, an energy charge per kWh is also made; this ranges between NRs 0.90 to NRs 3.00. Another interesting MHP plant is the 50kW Ghandruk power plant managed by a Users' Committee under the overall patronage of the Annapurna Conservation Area Project (ACAP); here also a similar tariff system based on connected power rather than on energy used has been implemented. A cut-off device is installed in the connections to switch off power if the prescribed limit is exceeded. Other similar plants are also under construction or being planned. These new trends, although not perfect for solving the problem of sharp peaks and non-uniform usage, have come a long way from the energy-(kWh) based tariffs.

In Nepal, there are about 900 MHP turbine units owned and operated by individual entrepreneurs, mostly for powering agro-processing equipment; and about 100 of these units also have add-on generators. In addition, about 200 peltric sets, with an average power output of about one kW, have also been installed for electricity generation in various locations. The number of electricity-only MHP plants is quite small; about 20. Another interesting endeavour is the improvement of *ghatta*(s) or traditional water wheels. So far, about 200 *ghatta*(s) have been improved by replacing the traditional wooden runner with a steel one, with buckets similar to turgo turbines. As a result of this, efficiency is reported to have doubled. The expenditure was nominal at NRs 5,000 (US$ 100). During the 80s, turbines with designs similar to the improved *ghatta*(s), but with components made of steel, were also installed; these were called multipurpose power units (MPPU). The MHP are mostly concentrated around the two manufacturing centres; i.e., Kathmandu and Butwal.

Most private MHP plants were installed during the 1980s when the Government removed the requirement for obtaining licenses for MHP installations of up to 100kW and provided funding facilities through loans and subsidies. Subsidies of up to 50 per cent, 75 per cent, or 80 per cent of the cost of the electrical equipment only is given for accessible locations, more remote areas, or very special cases, respectively. In addition, loans were available for mechanical equipment and civil works as well as for allied agro-processing equipment.

Installation of MMHP/SHP plants in China began in the 1950s. At present, China has 48,300 MMHP/SHP plants (up to 25MW in capacity) with a total generating capacity of about 15,100MW; the energy generated annually being 47.00TWh. Out of these, 45,600 plants are in the mini- / micro-range (up to 500kW). About 35 per cent of the plants are grid connected; however, in terms of capacity, 93.5 per cent of the power from MMHP/ SHP plants is connected either to national or to local grids.

Most of the plants installed in China began, were constructed, and are managed in a decentralised manner, based on the policy of 'self-construction, self-management, and self-consumption'. The plants are managed and operated by local governments, which include village, township, or county administrations. Funding for the plants is obtained from various sources, including the Central Government, provincial governments, and many other administrative systems. About 35 per cent of the funds were also arranged through bank loans on an interest basis. The owners (individuals as well as communities) also contributed about 14 per cent of the costs. The energy charges collected from the consumers are fixed by the administration. However, the rates for sale to the national grid are government rates. At present, these rates vary between 0.05-0.08 *yuan*[3]/kWh (less than US one cent). The other rates are somewhat higher, but not known. Technical assistance for design and installation and training for operation and maintenance are provided by bureaus established for this purpose.

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

Two organisations in **Pakistan** are engaged in the promotion of private sector MMHP; i.e., Pakistan Council of Appropriate Technology (PCAT) and the Aga Khan Rural Support Programme (AKRSP). Both of these organisations install plants in the hilly/mountain areas under a subsidy programme. All the plants installed by these two agencies are electrification schemes which are handed over after installation to the recipient community for operation, maintenance, and distribution of electricity. The PCAT, at present, provides a subsidy of about 40 per cent on the total cost of the plant. The villagers pay for and complete the civil works and the transmission/distribution system and provide all the labour and transport. Of late, the recipients also provide about 50 per cent of the cost of the penstock. In the case of plants installed by the AKRSP, however, the subsidy varies considerably, depending upon the situation. In one case, for example, about 80 per cent of the project cost was arranged by the villagers through contributions. On the other hand, another plant was almost entirely financed through funds provided by the Canadian High Commission.

Since 1975,the PCAT has installed about 160 plants with a total generating capacity of about two MW and an average plant capacity of about 12.8kW. About 90 per cent of the plants are within the five-20kW range. All the plants use an old cross-flow turbine design and supply electricity to a rural mountain population of about 10,000 distributed throughout 160 villages. In about 20 per cent of the cases, add-on agro-processing or similar units also receive power from the plants. Since 1986, the AKRSP has installed 26 MMHP plants with a total installed capacity of 600kW (average plant size 23kW), supplying electricity to about 1,100 households. Unlike the PCAT, the AKRSP has installed various types of turbines for their plants; these include the cross-flow, Tubular (propeller), Pelton, and Francis.

3 There are currently 8.32 *yuan* to the US dollar.

Table: 2.1 shows the number of MMHP installations in the public and private sector in each of five countries in the Region. Since the MMHP plants in China are managed and operated by village or county councils, they have been placed in part B of the Table.

Table 2.1: MMHP Installations in Five Countries of the HKH Region

A. Public Sector Plants (1994)

Country	Micro-Hydropower		Mini-Hydropower		Total	
	No.	Total Capacity MW	No.	Total Capacity MW	No.	Total Capacity MW
Bhutan	11	0.4	8	3.0	19	3.4
India	NA	NA	NA	NA	145	106.6
Nepal	12	0.72	23	7.78	35	8.5
Pakistan	NA	NA	64	17.12	64	17.12

Notes

- Micro-Hydropower plants are up to and including 100kW in capacity in all countries
- The Mini-Hydropower range is up to 1.0MW in capacity in Bhutan, Nepal, and Pakistan and up to 500kW in China and up to 3MW in India.
- All the plants in India and Pakistan have been shown to be in the mini-range, since figures are not available for micro- and mini-ranges separately.

B. Private Sector or Decentralised Plants (1993)

Country	Micro-Hydropower		Mini-Hydropower		Total	
	No.	Total Capacity MW	No.	Total Capacity MW	No.	Total Capacity MW
China	27010	880	18635	5123	45645	6003
India	~20	~0.2	-	-	20	0.2
Nepal	~900	9.00	1	0.4	~900	9.40
Pakistan	~190	~2.6	-	-	190	2.6

Notes

- There are no private MMHP plants in Bhutan; however, ten government-owned MHP plants have been handed over to communities for operation and use
- Plants in China are not privately owned; however they are installed and managed in a decentralised way.
- In China, plants having capacities of between 100kW and 500kW are designated mini-plants.
- The exact data are not available for private MMHP in India.

2.3: Main Features of Private/Decentralised MMHP Installations

Almost all private/decentralised MMHP plants installed in Pakistan, Nepal, and China are indigenously manufactured. In Pakistan, out of 186 turbines installed in the private sector (by PCAT and AKRSP), 177 are cross-flow. Only a few turbines installed by the AKRSP are Pelton or other types. In Nepal also, about 76 per cent of the turbines are cross-flow, followed by 20 per cent MPPU, and 13 per cent Pelton. During the past four years or so, Pelton wheels have also been designed and manufactured locally, especially the smaller version (~1kW) peltric set. These sets are standard designs in which the generator and turbine are mounted on the same vertical shaft. Their advantages are the small size, which can be easily transported, and that ordinary pipes are used as penstocks. In Nepal, the technology for casting Pelton buckets seems to have been mastered reasonably well. However, it is difficult to say whether the requisite quality and precision have been achieved to provide the desirable efficiency and durability. China has a very broad base for manufacturing different turbines (including Francis, Propeller/Tubular, Turgo, and Pelton). China also exports MMHP equipment to other countries within the region, as well as outside. Chinese synchronous generators, for example, have been used in Pakistani MHP programmes from the initial stages and have given a reasonably trouble-free service. Interestingly, the cross-flow turbine does not seem to be very popular in China.

The first manufacturer of MHP turbines in Nepal was the Balaju Yantra Shala (BYS) which was established in Kathmandu in 1960 with technical and financial assistance from the Swiss Government. After initial experimentation with the axial propeller turbine, the BYS settled for manufacturing cross-flow turbines in the seventies; which is its speciality still today. Soon afterwards, Butwal Technical Institute (BTI), sponsored by the United Mission to Nepal (UMN), also began to manufacture cross-flow turbines. Subsequently, a number of different companies was established to undertake site survey, layout design, plant design, manufacturing, and installations under the overall umbrella of the UMN. At present, there are ten manufacturers based in Butwal and Kathmandu involved in manufacturing and other technical aspects of MHP. They have a production capacity of around 1.00MW per year. However, the generators and instruments are imported (mainly from India). Considerable assistance has also been provided by other international agencies in R&D, promotion, installation, and monitoring and evaluation of private MHP plants in Nepal. Amongst them are SKAT (Swizerland), ITDG (U.K), GATE/GTZ (Germany), and FAKT (Germany).

Reports on the quality and performance of indigenous MMHP plants have been mixed. At present, a proper system for evaluating the quality and performance does not exist in Pakistan or Nepal. At the time of commissioning also, it is not normal practice to measure the power output or to check the maximum or rated power, especially for agro-processing only plants. In one of the surveys undertaken in Pakistan in 1988, it was found that 54 per cent of the plants installed by PCAT were non-operational at the time of the survey. The situation seems to have improved considerably now, and, according to current estimates, about 10 per cent of the plants were non-operational out of the total installed since 1988. PCAT still uses the old cross-flow design, and improvements in the design and manufacturing have been minimal. The failure rates also vary considerably in different areas, both in Nepal as well as in Pakistan. The rates seem to be higher where the number of plants is lower. In the case of Nepal, no study has been undertaken so far to determine the extent of plant failures. There have been some reports of serious breakdowns, e.g., bursting of penstock pipes, breaking of turbine shafts, excessive wearing out of bearings, and serious leakages. However, this situation cannot be avoided completely, since the indigenous manufacturing systems are not so well developed.

Almost all the locally produced equipment in the four countries is considerably cheaper than the equipment imported from abroad. Even the better quality Chinese equipment is cheaper by a factor of from two to four than European or Japanese equipment. The cost of privately-installed plants in Nepal at present varies between NRs 40,000 to 100,000 (US$

800-2,000), whereas, in Pakistan, the cost is around PRs 10,000-15,000 (US$ 300-500). Chinese and Indian equipment also fall within the same cost range.

2.4: Policies and Other Inputs for MMHP Programmes

All the five participating countries have announced some level or form of support for hydropower installations, including MMHP/SHP. They have also declared rural electrification to be a priority area. China, India, and Nepal have also given priority to the installation of MHP/SHP plants for remote and isolated areas. The approaches, however, vary considerably. In India, for example, the recent policy of privatisation aims through various incentives to induce the private sector to start generating electricity as a supplement to government efforts, and then to sell this electricity to the public sector for distribution. It is more likely here that, since private sector entrepreneurs take up installation primarily for profit, they would go for larger installations that could be connected to national/regional grids easily. Thus, the main benefits of such private sector efforts would accrue to the mainstream, mostly the urban/sub-urban consumers. The Government of China, on the other hand, has provided inputs for decentralised plants.

On many accounts, Nepal is ahead of most of the countries in the HKH region in formulating and adopting policies and plans that affect the renewable energy sector, in general, and MMHP/SHP, in particular. Some of the important supporting initiatives are provision of loans on easier terms; subsidies for electrical equipment; and delicensing of plants of up to a 1,000kW in capacity. The extent of subsidies and loans prevalent in Nepal has been enumerated in section 2.6. In spite of such support, however, judicious implementation was reported to be lacking. For example, the availability of funds for loans and subsidies has fluctuated considerably from year to year.

2.5: Planning and Implementation

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

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

2.6: Funding Sources and Procedures

Different types of funding systems have been introduced in China, Pakistan, and Nepal for private/decentralised MMHP installations. These are described here briefly .

- Grants for installations have been provided by donor organisations in some cases. Such grants are not a regular feature and usually do not make much impact on the overall programmes.
- Subsidy funding is the main process in many countries. The level of the subsidy has been gradually reduced from about 70 per cent to the present level of around 40 per cent in Pakistan. The AKRSP, on the other hand, provides varying levels of subsidy. Subsidies are also provided by the ADB/N for the electrical equipment of MHP plants in Nepal. Varying levels of subsidy (up to 90%) are also provided in China for decentralised plants. India also subsidises MMHP/SHP plants at the rate of up to 50 per cent of the total cost.
- Loans for private MMHP installations are provided in Nepal, China, and India. There is an interesting combination of loans and subsidies being implemented in Nepal managed mainly by the ADB/N. The turbine machinery and civil works, as well as the agro-processing units qualify for loans only at slightly cheaper interest rates than commercial loans. However, they are higher than the rates applicable for small-scale industries. Loans of up to 80 per cent of the total cost may be provided. The ADB/N had invested more than NRs 100 million as loans and subsidies in the MHP programme up to 1992. However, the interest rate has varied considerably over the years.

As mentioned earlier also, the Government of India has announced various economic incentives for private sector MMHP/SHP plants of up to 15MW in capacity, including loans and subsidies. Loans of up to 75 per cent of the total plant cost at a simple interest rate of 12.5 per cent have been offered. The maximum amount of the loan varies with the credit ranking and type of security of the borrower; the current maximum limit being IRs 254 million. The MNES also offers 50 per cent subsidies for all MMHP installations, especially in the hill areas, for plants that do not qualify for loans. Some funding facilities are also available for MMHP installations under the GEF-UNDP sponsored hill-hydro project.

2.7: Plant Management, Operation and Repair

The formally-managed private sector plants in Nepal are run quite well by a competent and trained manpower and through occasional backstopping from experts, including expatriates. The Salleri plant has eight employees[4], while the 50kW Ghandruk plant has

4 One General Manager, one Adminstrator and one Accounts' Officer, three operators, and two helpers

three (one manager and two operators). Thus, these plants are doing remarkably well, having net incomes ranging between 2.4 to six per cent of the capital costs. The same size range NEA-managed plants, on the other hand, are losing money, even on a current account basis.

In the case of informally-managed plants, the owner, or a prominent person from the community, looks after the plants just like an owner/manager, overseeing the operation, and maintenance and handling financial matters. Generally, the owner/managers are not well educated, some may even be illiterate. Also, they may have almost no training, either technical or managerial. In many cases, they may not even have commercial instincts. Therefore, it is not surprising that poor management has been cited as one of the main reasons for the financial troubles of the mills in Nepal. In some districts of Pakistan, MHP plants are more successful than in other areas. These areas also happen to have a large concentration of plants. The general feeling is that, in these areas, the owners/managers and the technicians have learned enough through trial and error. Therefore, they are able to organise and carry out the maintenance and repair on their own without much difficulty. In some districts of Nepal also (e.g., Dhading District), where plant concentration is higher and they happen to be nearer and more accessible to the industrial centres, the plants tend to be more successful than in the more remote parts of the country. Here also, the managers seem to have improved their capabilities over the years.

Many studies, including some of ICIMOD's case studies, have generally pointed out the inadequacy of the capabilities of the owners/managers and operators. In Nepal, book-keeping of any kind was lacking, management of cash was also inadequate, and no amount was being put aside for loan repayment or routine maintenance. Similarly, the operators were not trained well enough to notice signs of impending trouble and take appropriate action to avoid a severe breakdown. Usually, the salaries of the operators were quite low; which could have prompted them to leave the job. These reasons, at least partly, might be responsible for more frequent and severe breakdowns. In some cases, the owners or their relatives were reported to be operating the mills as a secondary occupation. In such cases, the service was unlikely to be reliable, since these operators had to perform other duties also. This would affect consumer confidence, and they might be reluctant to bring their business there.

Almost all the plants in Pakistan are operated and managed as non-profit making enterprises. Therefore, the revenue generated is small and usually just about enough to meet the routine operation and maintenance costs; the normal charges being PRs five to 15 per bulb per month. In case of a serious breakdown, the principal person in charge spends from his own pocket to get the repairs done. He/they may, however, organise a collection for this purpose before or after the repairs have been completed. No serious attempts have been made, so far, to increase and/or diversify the end uses, mainly because profit-making is not the objective and the manager/in-charge does not benefit directly from increased power generation and additional working hours.

In most of the mountain areas, including those of Nepal and Pakistan, organisation of repairs is a difficult and time-consuming endeavour, which could aggravate due to incapable management. Sometimes, the damaged part has to be identified, disassembled, and transported to an appropriate repair centre. Alternatively, a mechanic has to be brought from the repairing establishment to undertake repairs or assembly/disassembly. All this necessitates a considerable level of organisational capability.

In Nepal, it has also been noticed that the add-on electrical equipment goes out of operation more often and the repairs and recommissioning take much longer. This might have something to do with much lower returns from the electricity, or there might be problems with repairs that require more sophisticated equipment or manpower. In this case also, adequate data are not available. Some problems have been reported concerning the collection of electricity revenues from consumers.

2.8: Plant Capacity Utilisation and End Uses

Plant capacity utilisation and the plant factors tend to be quite low for both public and private sector MMHP plants. Plant factors ranging between 10 per cent and 20 per cent are quite common for the electrification schemes. Reliable data about the plant factors of agro-processing units are not available. However, the values are anticipated to be quite low, approximately between 10 to 30 per cent. Since all the plants are run-of-the-river types, having negligible water storage capabilities, the available unutilised energy simply goes to waste. Therefore, low load factors for MMHP plants are a serious drawback.

As discussed earlier, the private/decentralised, formal electrification plants are doing relatively better in Nepal, in the sense that their incomes are higher than their yearly expenditure. The current plant factors are quite satisfactory, and chances of further improvement are high, as a result of innovative tariff systems and promotion of other end uses, including cooking during off-peak periods. Prior to the installation of the new turbine at the Salleri Chialsa Plant, the plant (station) factor was about 41 per cent, whereas the plant factor for the Ghandruk Plant was about 42 per cent.

Many reasons have been reported for the low level of utilisation for private informal plants. For example, the areas were usually remote and undeveloped and the people were poor. Therefore they used electricity for lighting only for three to four hours. Secondly, the supply might not have been so reliable or sufficient for industrial use during the day. In the case of MMHP plants powering agro-processing units, the reasons for low plant factors may be insufficient business, the inadequacy of the capabilities or skills of the operators to connect various units simultaneously, or poor plant performance due to a serious defect or improper maintenance/repair. Generally speaking, many plants have been observed to be running at much lower levels than the rated power.

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

Enhancement and diversification of end uses are considered important in order to make MMHP financially more attractive for private entrepreneurs. Some of the areas identified for other end uses are domestic cooking and heating, commercial uses in shops and lodges, and some small-scale industrial applications. Obviously, commercial and industrial applications of electricity are likely to be more attractive for consumers than domestic applications, since the former are likely to be more financially rewarding.

Some ground-breaking work has already been carried out by the management of Ghandruk, Salleri Chialsa, and Andhikhola Power Plants by introducing novel tariff systems to promote more uniform utilisation of the connected power. Some work has also been undertaken to develop and promote low power (wattage) devices such as cooking utensils and stoves. One example, the *bijuli dekchi*, is an efficient low wattage cooking pot heated by an electrical element and incorporating a thermostat. Wattage ranges may vary between 200W to 500W for pot sizes ranging between 2.5 to 20 litres. In air-heat storage cookers, a bank of packed pebbles is heated through a 250W element and the heat is stored at about 500°C. For use, air is circulated through the pebbles and supplied to the cooking chamber where it heats the pan. The *bijuli dekchi* is currently being distributed in some areas under a subsidy programme, and the storage cooker is undergoing field trials. Electronic load controllers (ELCs) automatically divert the excess power unused by the consumers to ballast heaters. Thus, they maintain a predetermined constant (maximum) load on the turbines and keep the supply voltage as well as frequency constant. ELCs, originally developed in the U.K. and elsewhere, are being assembled locally in Nepal. However, the main components, including the circuit board, are being imported.

The *bijuli dekchi* promoted in some rural areas in Nepal, through various subsidies, does not seem to have made a real impact on users as yet, in the sense that the demand has not increased. The cost of these low power devices tends to be a prohibitive factor; a five-litre *bijuli dekchi*, for example, costs NRs 1,326 and the air-heat storage cooker costs around NRs 6,000. AKRSP has also made efforts to use MHP electricity for drying fruit and vegetables. However, the achievements and impacts have not reached a significant level as yet.

Obviously, more R&D and promotional efforts are needed to make such alternative applications attractive and viable. A system for maintenance and repair of the plants and appliances, such as workshops in remote rural areas, would also be helpful. However, adequate efforts are not forthcoming in this respect.

2.9: Impact, Benefits, Acceptance and Demand

Decentralised public sector MMHP electrification plants have provided considerable benefits to the remote mountain areas in some countries. For example, decentralised MMHP installations in Gilgit (Pakistan) operated by a government agency seem to be more economically viable than the earlier efforts made by a centralised agency such as WAPDA. Here, the generating costs as well as the tariffs are lower than the mainstream rates. The operational costs are higher than the revenues in this case also, but not as bad as the NEA-managed plants; in this instance it is reported that, on average, only about 20 per cent of the recurrent expenditure is covered by the income.

The main benefit of electrification schemes is a better method of lighting one's house or place of work. However, the level of impact varies from country to country. In China, electrification through MMHP and SHP has progressed quite well (with an installed capacity of 15,000MW, which is about 37.2 per cent of the total hydropower installed capacity). Electricity is now available to about 87 per cent of the population. China has exploited the largest proportion of the MMHP potential in the country, and the pace of additional installations and replacement of small, less efficient and unreliable plants have been increasing steadily. About 977 counties (out of a total of 2,300) now predominantly rely on electricity from MMHP-SHP. On both accounts (% of potential exploited and % of people benefitted) the impact is remarkable. Surplus electricity is being used for lift irrigation as well as industrial applications such as agricultural production and processing (including tea and tobacco drying), with the result that in about 100 counties earmarked for prioritised exploitation of MMHP, the agricultural output has more than doubled, while the industrial output has more than quadrupled. In many cases, the electricity is also sold to the national or regional grid, thus earning an additional income. In the case of Dehua county, Fujian Province, the share of electricity generated from MMHP-SHP has risen from 7.7 to 68.5 per cent of the total energy used during the past decade or so, while the share of fuelwood decreased from 66.5 to 12.5 per cent. The level of income per capita has also doubled at least. The study and adoption of the Chinese experience and achievement in the promotion of MMHP in a decentralised way could be very beneficial for the whole region and even beyond.

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

In the case of Pakistan, the total amount spent by the Government on installation of 160 private MHP plants is around PRs 15 million. An additional amount of PRs five million has been spent by the AKRSP for installation of 26 of their plants. The communities benefitting have also contributed about PRs five million, mostly in kind. As a result, electricity has been provided to about 11,000 households, and about 200 jobs have been created in the most remote and inaccessible areas. Some business was generated for the manufacturers and installers; they also benefitted technically since they were able to undertake the manufacturing indigenously. Additionally, business was generated for milling units and other small industries. There have been significant benefits for the environment in the sense that the kerosene used for lighting has been replaced by electricity. Therefore, the benefits, although very small in terms of percentage of population affected or energy used, are quite considerable for the actual beneficiaries. Above all, the potential for substantive improvements in living conditions, including reduction of drudgery and improvement of earning opportunities, is sizeable. The people are by now quite familiar with the technology and have gained enough confidence to manage and operate these plants. The main impact, however, is the increasing demand from the people and their willingness to make large contributions, both in cash and in kind.

In the case of Nepal also, the overall impact of private sector MMHP plants is comparatively small in terms of electrification. However, there have been many other benefits and their impact is quite significant. For example, a number of new industries had been established to develop/manufacture MMHP plants between the 1960s and 1980s. Considering the fact that Nepal, at that time, was far behind in engineering and technology, especially indigenous manufacturing, this is an important contribution. Many of these industries have diversified their businesses, created new jobs, and enhanced their capabilities in the manufacturing sector. Another important aspect of private sector MMHP in Nepal is that the plants are meant to be installed and operated as commercial ventures. Many such agro-processing plants have exhibited that financial returns on investments can be quite lucrative; even though the problems facing these plants have not been overcome as yet. The electrification schemes are admittedly not performing well financially; even then, they are a better alternative to the government installed and operated plants which are losing money on a current account basis. There are also good prospects for improving the plant factors of private plants, thus improving the economic returns, and significant novel approaches are already being tested, including some innovative tariff systems.

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

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

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

The situation in Nepal, however, is a bit more complicated. Although the electrification of rural areas has also increased considerably, through public as well private sector installations, so has the demand; the rate of micro-hydropower installations has declined. It has been suggested that the main reason for this decline is non-availability of funds for loans and subsidies. It seems that there are some other problems as well, e.g., non- repayment of loans, financial difficulties faced by some owners, and lack of business in some areas. These problems are discussed in subsequent sections.

2.10: Current Training Arrangements and Needs

The data and analysis presented above indicate that, in spite of many achievements, some aspects of private MMHP are not functioning properly and need external interventions, including training. For example, managers and operators of private informal plants have been reported to be incapable of running the plants properly. This deficiency can be corrected through appropriate training programmes. The training aspects and requirements are covered in more detail elsewhere in this document.

2.11: Major Problems of Private MMHP and Some Redressals

Problems being faced by private MMHP installation programmes have been identified through various studies, especially in Nepal and Pakistan. The more serious problems and some redressals are discussed below.

- The present funding level is low and inconsistent. It is recognised that private MMHPs need funding support for the foreseeable future. Adequate amounts of funding are needed for implementation, R & D to improve MHP equipment/civil works, end-use appliance development, evaluation/monitoring, and so on.

- More effective methodologies have to be evolved to work out the appropriate level of subsidies and loans, as well as their judicious administration, on a long-term and consistent basis, in order to avoid problems such as non-repayment, declining rates of installation, and so on.
- Proper feasibility studies to evaluate demand and business in a given area must be undertaken based on wisely-developed methodologies, so that underestimations/ over-estimations are avoided.
- The cost of indigenous MHP plants in Nepal has been going up. Studies should be undertaken to find out why and efforts to reduce/stabilise costs should be introduced, including R & D.
- Economic returns from MHP plants, in general, and electrification schemes, in particular, are very low. Adequate steps should be taken to increase end uses and economic returns.
- Frequent breakdowns are a very severe drawback of indigenous MHP plants, giving the technology a bad name and causing serious problems for the owners. While this problem may be caused by many factors, including lower quality equipment and the incompetence of the managers/operators, adequate measures have to be developed and implemented to improve quality and performance.
- The problems of water availability and usage are becoming increasingly serious due to local conflicts and to other preferred uses such as irrigation. Some policy decisions and legislative measures are needed to deal with this problem.
- Lack of coordination among the agencies implementing electrification in rural areas has been variously reported. Some government implementing agencies also do not recognise the private MHP as a viable option. Coordination needs to be improved in this respect.
- A system of competent assessment of applicants for MHP should be evolved and implemented, since it has been reported that many owners were simply not in a position to manage the plants well.
- Delicensing of MHP plants (say of up to a 100kW) should be introduced in other countries, such as India and Pakistan, also, since this seems to be the single-most important policy decision made by HMG/Nepal which contributed to the proliferation of MHP in remote rural areas.
- In order to improve implementation, management, and performance of MMHP plants, proper training of the concerned personnel should be organised and necessary training materials developed.
- The level of plant capacity utilisation is unsatisfactory for MHP plants. Strategies should be developed and implemented to improve plant factors and enhance end uses.
- It has generally been felt that an independent institution is necessary to organise the development and promotion of private MMHP (including provision of inputs such as training, guidelines, plant performance evaluation, and overall coordination).
- The need to establish such a centre has been emphasised, especially in Nepal. In other countries, existing institutions should be strengthened to carry out these functions.
- Guidelines/standards need to be developed for assessors, surveyors, manufacturers and installers, and supervisors of civil works.
- The quality of indigenous equipment and associated instrumentation and controls needs to be reviewed at this stage; for example, how reliable should the equipment be for a given site? and so on. Some countries are still continuing with rudimentary equipment without any automatic controls. This situation is obviously not helpful in the long run and needs to be reviewed.

- Similarly, the philosophy of charging minimum tariffs, barely enough to cover operational costs, also needs to be reviewed, so that the plants have some net income for major repairs for example, or to cover depreciation, and so on.

2.12: A Case Example of Barpak MHP Plant

This example illustrates the efforts and success of an entrepreneur in the installation of an MHP plant in a remote Nepali village. One feature of this example is the absence of direct involvement by development agencies specialising in energy; both local and foreign. The most significant feature of this case is not that local institutions (banks, manufacturers, surveyors) have functioned well to promote development in a village, but rather that they have apparently functioned in a haphazard way that might have actually inhibited development of this sort in another village. The determination of a young entrepreneur with a vision strong enough to move him to sell all his land in Kathmandu to invest in MHP in his village seems to be the most salient feature, and this perhaps tells us a lot about the ingredients needed for village development.

This case history is also notable in demonstrating the potential for development of economically productive activities directly associated with MHP installation. It demonstrates very clearly how end-use developments and MHP developments are progressive and interactive, moving from stage to stage and, therefore, requiring a considerable local capability for planning and business management and long-term committment to (or motivation for) local development. The case history also opens up questions concerning legislation and the role of local committees representing the public interest.

2.12.1: The Village of Barpak and Advent of Hydropower

Barpak is one-and-a-half day's walk north of Gorkha, a roadhead town close to the Kathmandu-Pokhara highway. The village has around 600 houses. Cash incomes are above average for rural Nepal because the village has traditionally provided recruits for the British Gurkha regiments.

In 1989, Bir Bahadur Ghale, a 21-year old villager living in Barpak, visited an appropriate technology exhibition in Kathmandu organised by ADB/N. It also included stands displaying MHP equipment. He was able to discuss hydropower with a Kathmandu manufacturer (BYS) who referred him to the ADB/N office to seek information on loans. From this point on, it appears that Bir Bahadur experienced a very long and repetitive process involving numerous visits to different ADB/N offices and to various surveyors and manufacturers. This took almost a year, because the local ADB/N office felt that the project was too large. Eventually, Bir Bahadur approached the ADB/N Head Office where the Director, who was pro-MHP, decided in his favour. Finally, Bir Bahadur obtained authorisation for a loan of NRs 11.5 *lakh*[5](s), and obtained a subsidy of NRs 4.9 *lakh* (s), representing almost 50 per cent of the estimated cost of electrical equipment held to a 10-*lakh* ceiling.

The interest rate was 15 per cent and the loan was to be repaid over seven years (the ADB/N had later reset the rate to 19 per cent and reduced it again to 17 per cent). Bir Bahadur sold his private land in Kathmandu in order to personally contribute NRs 3.8 *lakh*(s), and he later channelled further funds to the tune of NRs 4.5 *lakh*(s) into the scheme, for instance, those needed for purchasing land for the channel and powerhouse. The total

[5] A *lakh* is a 100,000. There are currently 56.75 Nepalese rupees to the U.S. dollar.

capital cost is estimated at NRs 24.8 *lakh*(s). In early 1990, Kathmandu Metal Industry (KMI) and Bir Bahadur completed installation of the scheme which had a rated power of 45kW.

In the first year or so of operation, the scheme produced power continuously. Fourteen kW were devoted to domestic lighting and three kW to an electric grain mill owned by Bir Bahadur and situated at his house. A *ghatta* that had operated an hour's walk from the village now stopped milling services. The domestic lighting load rose quickly to 24kW and stayed at this level for more than a year, as the generator was unable to deliver more power due to technical difficulties. The original generator was finally replaced (after a number of false starts with inadequate equipment and periods of severe lightning damage) with one capable of delivering the full scheme capacity of 45kW. By 1994, the domestic lighting load had risen to 41kW. Bir Bahadur had started on this venture with almost no technical knowledge, but, after four years of operation, he had learned a great deal about electricity generation.

In addition to village lighting and grain-milling, Bir Bahadur installed a television in his own house in a position which allowed viewing from outside. This attracted crowds as large as 150 people and has led to complications with respect to laws related to private and public viewing of television.

During late 1993 and 1994, Bir Bahadur planned and established, or assisted others with, a number of further businesses that depended on electricity from the MHP plant. The first to become operational, in addition to the grain mill, was a furniture workshop using electric tools. Subsequently, a paper-making business, owned by Bir Bahadur, using *lokta* bark collected in the neighbouring regions, was established as well as a bakery using an electric oven. The bakery and furniture workshop are owned by other villagers but have been established with help from Bir Bahadur. In early 1995, Bir Bahadur was exploring the possibility of a local metalwork shop, with a welding facility and an incense-making facility, since it is thought that raw materials can be found locally.

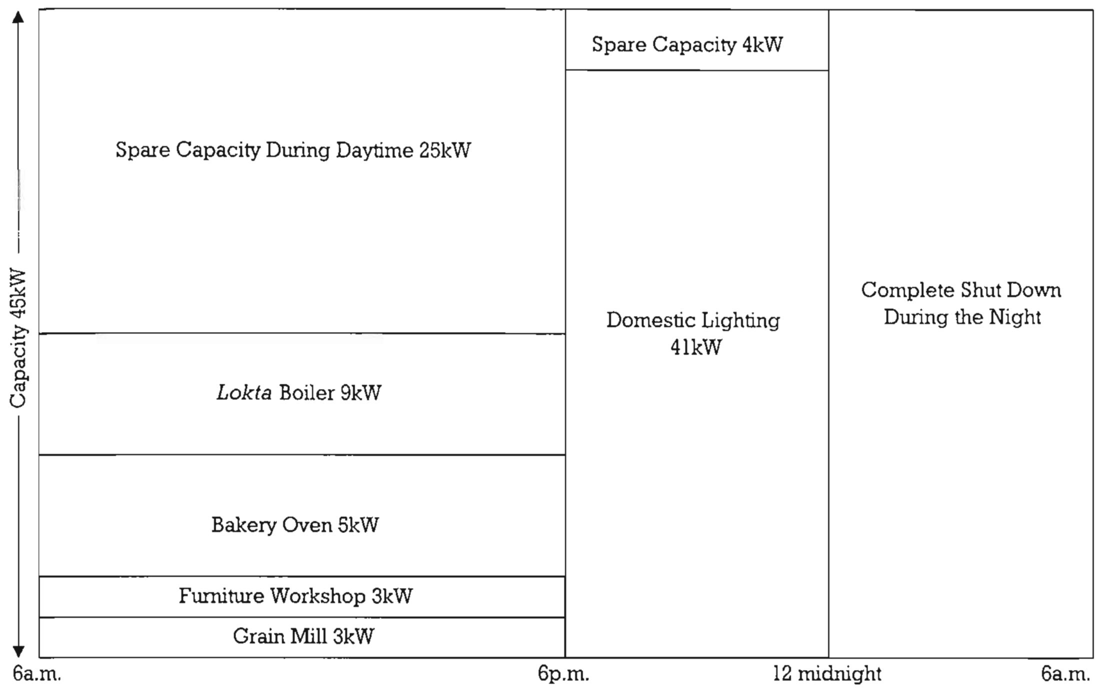
The distribution of electricity use is presented in Figure 2.1. Domestic lighting supply is only available in the evening, from 6 p.m. to 12 a.m. At night the turbine is shut down since constant supervision of the transmission poles is needed, and they are of inadequate quality for the local climate. During the day, the electricity is divided between a nine kW *lokta* boiler for paper-making, the five kW bakery oven, the three kW furniture workshop, and the three kW grain mill.

2.12.2: End Uses of Electricity

Domestic Lighting

Most domestic lighting in Barpak is fitted without meters in order to keep costs to affordable levels. Instead of meters, the householders choose how many bulbs they want and pay a fixed monthly tariff accordingly. If they choose to pay a tariff for 50 watts, for instance, they are dissuaded from fitting bulbs or other appliances that consume more than 50 watts by a special fuse which cuts off the supply when consumption goes above the designated amount. During this blackout, the householder must turn the main switch off, reduce consumption again to the correct level, and wait one or two minutes until the fuse resets and switches the power back on. The fuse, known as a Positive Thermal Coefficient (PTC) switch, costs NRs 200 to 400. Apart from buying bulbs and appliances the house-

Figure 2.1: Load Distribution for Barpak Plant



holder must also pay for wiring in the house, usually between NRs 400 and 1,000, and a small connection fee of about NRs 10. These consumers are allowed to use electricity in the evening hours only between 6 p.m. and 12 a.m. The rules and tariff levels are decided by means of negotiations between the plant owner and consumers, rather than by outside guidance.

There are already some wealthier households in Barpak that have electricity supplies identical to supplies in a town house, with energy (kWh) meters allowing larger amounts of electricity to be used all day and paid for according to the number of kWhs consumed. The businesses that use electricity, such as the furniture workshop and bakery, pay for electricity in this way.

Revenue from the 41kW of evening lighting is estimated at Rs 23,000/month. Costs include Rs 4,000/month for operators' wages (these include, 1 powerhouse operator; 1 administrative officer for collecting tariffs, keeping accounts, and reading meters; and 1 transmission line attendant and repair man). The surplus of Rs 19,000 is spent partly on replacing equipment and maintenance and partly on repaying the loan installment of Rs 18,000/month. The sale of electricity to the external businesses and the profits from paper-making and grain-milling also serve to recoup investment and pay for the operation of the plant.

<u>Paper-making Business</u>

Bir Bahadur attended a government training course in paper making using the Japanese method which involves moisture removal by pressing the paper. This produces a smooth quality product which can be used by offices. At present, a price is being negotiated for purchase of this paper by local government and bank offices. An export market for Nepali paper also exists. In recent years, this has grown rapidly since quality graphics and dyeing techniques have been introduced. Revenues are around Rs 70,000/month at present. There are 32 employees working part time. Electricity costs are insignificant, since in the day the electricity supply is under-utilised, and the power plant and paper factory are both owned by Bir Bahadur. The investment in equipment is in the order of Rs 170,000 (total investment including land and buildings is around Rs 500,000); so profits are used at present to recoup the investment. The long-term economics of paper making look very promising. Bir Bahadur is confident that the business will prove to be a more viable end use than lighting.

Furniture Workshop

This workshop practises a number of different processes, such as planing, which are novel introductions to the village. Production levels are not known but the machinery is used consistently; the MHP plant benefits from an income of Rs 700/month from sale of electricity at a rate of Rs 7/kWh.

Electric Bakery Oven

This business is still in the trial stages. It produces bread made with local flour which is not quite the import substitute product which is in great demand in the village. It does not make any profit and cannot yet pay for the investment costs incurred in installing the oven. Baking takes place in two shifts every other day, and revenues only just cover operational costs. The MHP plant receives an income of Rs 1,000/month from sale of electricity, at a rate of three rupees per kWh.

Grain Milling

This service is very popular in the village, attracting customers from considerable distances. It serves as a social focal point as well as a release to many women from long hours of hard physical drudgery. The revenue is in the order of Rs 7,000/month, and costs are mainly the wages of an operator at Rs 1,100/month and maintenance costs of Rs 500/ month.

2.12.3: Future of the MHP at Barpak

The demand for electric lighting already outstrips the supply capacity. The terrain offers many sites for further MHP installation; for instance, the tailrace of the present plant drops 90 metres to the river below. This means that the MHP is potentially providing an irrigation system for the hillside (at present not cultivated), or that a second power plant could be built below the first one. Bir Bahadur is considering the installation of another power plant, but first he is concentrating on securing revenue from the existing plant by increasing the daytime use of power. This will mean finding secure markets for the paper produced, encouraging other daytime uses of electricity (such as welding and metal working services), and possibly starting a business in incense making.

An important role for the MHP at Barpak is to act as a technical support centre for smaller schemes in the neighbouring area. An effective institutional framework for MHP might seek to build on local initiative of this sort in this way; certainly one way in which a return can be made on public investment in schemes like the Barpak plant is to make use of the technical and management capabilities established there to support further initiatives in the area.

2.13: The MHP Plant in Pida Village

The MHP plant in Pida village near Gajuri in Dhading District is situated along the Prithvi Highway, about 100km from Kathmandu. The plant, owned by Mr. Thir Bikram Basnet, is located about 100m from the main road. The rated capacity of the plant is 18kW, and it is coupled to a 12.5kVA generator. The original agro-processing plant was established in 1984, while the electrical generator was added in 1993. The prime mover is a multipurpose power unit (MPPU); a vertical axis, locally-evolved design, similar in some respects to the turgo turbine. The plant produces and supplies electricity to about 150 houses in the evenings for about five hours. In addition, some agro-processing units are mechanically coupled to the turbine; i.e., flour grinder, rice huller, and oil expeller. The owner has also installed a small ice or ice-cream making plant recently which he operates during summer. Both Mr. Basnet and his son, who has a diploma in engineering, manage, maintain, and repair the plant and sometimes even lend a hand to the two operator employees. The plant is well maintained and seems to be managed and operated properly. It provides a useful service to about 150 households through electricity supply and to another 500 through agro-processing. According to the owner, the net income from the plant is about NRs 150,000 (US$ 3,000) per annum, and this is a very good return on the investment of about NRs 600,000 (total). The owner is also planning to add other commercial units such as paper-making, saw milling, etc. He also intends to expand the water reservoir to increase the storage capacity and to establish a fish farm.

The owner, no doubt, has been working very hard and had faced considerable difficulties when the canal was washed away in 1993 due to heavy floods. He had to spend about NRs 200,000 to reconstruct it. However, in spite of these problems, he seemed to be quite happy with his endeavours and returns.

The MHP plant of Mr. Basnet is not typical; most other such plants were not so successful and were having considerable problems, both in terms of breakdowns as well as economic returns. However, plants such as these clearly demonstrate that MHP plants can be viable in some situations, and proper management seems to play a very important role. Since the capital costs of MHP plants are quite high, financial inputs, such as loans, subsidies, and reasonably low-cost technical support/advice and training services, will be necessary for quite some time to come.

2.14: Some Case Examples from Industrialised Countries

The Norwegian Example

The Norwegian programme for electrification of remote and sparsely populated areas should be of particular interest to the developing countries. Electrification started around the turn of the century in cities, townships, and at industrial sites. In 1930, there were 1,452 hydropower stations in operation, aggregating to 1,701MW; of which about five per cent was used directly as shaft power in operating grain mills, paper mills, sawmills, and mechanical workshops. One thousand and eight plants were less than 100kW in size, and only 35 were larger than one MW.

By 1938, it had become a hot political issue that the remote parts of the country did not enjoy the benefit of electricity, in spite of the fact that there was ample potential for hydropower development in those areas. The government electricity administration then proposed the implementation of a support scheme which was adopted by Parliament. The means required for the support was established through a levy applied on every unit of electricity consumed, collected by the existing supply utilities, and paid to a fund for rural electrification. The idea was that every electricity consumer should contribute towards the provision of electricity to people living in areas without electricity. The support schemes were managed by the electricity administration, in close cooperation with each supply unit, based on the policy guidelines approved by the Government. These are discussed in Chapter 3.

The financing of the projects was based on the revenues anticipated from the new customers. If the local government (municipality) or the county government was the formal owner of the installations, or if they provided guarantees, loans were obtainable from a state bank on favourable conditions. The estimated revenues were based on a relatively high tariff level, but comparable to the other similar counties. Part of the capital was also provided by the local governments and consumers.

The electrification of Norway went on efficiently, thanks to a number of favourable conditions: e.g., substantial hydropower potential on sites of various types; strong local initiative and involvement which enabled rural electrification to proceed in a decentralised framework; and adequate government involvement in the development of the main transmission network as well as other facilities. Emphasis was placed on creating a mechanism that encouraged the local population to involve themselves in the establishment of electricity supply schemes. The support programme greatly helped to ensure that the whole of Norway was receiving electricity by 1965. Today, the country supply is interconnected across rough mountains, fjords, and straits.

During a recent review of two counties of Norway (out of a total of 18), namely, Sogn and Fjordane, 29 private MHP plants ranging in size from 1.5kW to 100kW, and owned by individual households, cooperatives, industries, municipalities, and even hospitals, were still found to be working. The oldest plant was installed in 1899 and the most recent one in 1954. Many of the plants were later rehabilitated, some as late as 1983.

Recently, by revision of the legal framework, the system and the structure have been transformed to a state-owned main transmission grid; but still many regional and local monopoly networks exist. Approximately 60 independent owners of power plants are competing on a free power market, based on common use of the transmission network.

The MMHP Situation in the United Kingdom

Britain is one of the very few developed countries where installation of MMHP/SHP plants is being revived through deregulation and various incentives to induce the private sector. About 70 private MMHP and small-scale hydros, representing about 50MW in capacity, are presently in an advanced state of assessment in Britain. The incentives are given in order to reach the estimated untapped potential in MMHP-SHP of 300MW[6].

An important deregulation feature of the privatised industry is that power can be generated for on-site consumers, consumers can buy from any supplier, and any supplier can buy from any generator. This feature is being realised in stages: up to 1994 only consumers of above one MW could freely negotiate with any supplier, and only in 1998 will consumers of below 100kW have this freedom. In terms of diffusion of energy supply in the HKH Region, this approach would promote a least-cost consumer choice of type of electricity generation. This has the implication that consumers may choose diesel stations over renewable stations because of low start-up costs; and, therefore, that subsidy policies for

[6] The target for all new, renewable generating capacity in the UK is 1,500MW by the year 2000; this is 2.5 per cent of the present overall generating capacity of 58,000MW, of which large hydro installations contribute 83MW.

renewables, or access to loan finance, will be the key to development of hydro and will require facilitation by a regulatory or promotional body. Additional details of policies, including deregulation, are given in Chapter 3.