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FIELD REPORT

RECOMMENDATIONS ON THE USE OF MICRO-HYDRO POWER IN RURAL DEVELOPMENT

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1 INTRODUCTION

A recently completed research programme on the "Community micro-hydro in LDCs: adoption, management and poverty impact", funded by DfID, studied the strengths and weaknesses of the micro-hydro programme in Nepal and Sri Lanka in the light of the potential for this technology in Ethiopia and Uganda. The programme in Nepal is regarded as being very successful, especially in the provision of energy in rural areas for food processing. The programme in Sri Lanka has placed much more emphasis on the generation of electricity, but this area is growing steadily. There is a fast developing programme in Ethiopia, which seems to be following a similar pattern to that used in Nepal in the late 1970s, when the programme first started. There is a keen interest in Uganda, but little progress has been made, as yet.

2 BACKGROUND

Lack of energy is often a constraint in rural development, as it holds people back from achieving a better life-style. Many routine jobs that rural people have to do manually, can be done using an external source of energy thus releasing people from drudgery and allowing them to be far more productive in their use of time (NMHDA, 1997). Small turbine technology (Harvey, *et al.*, 1993; Rijal, 1998) has been developed in many countries that can allow both shaft power and electricity to be generated from small streams flowing down hillsides cheaply and efficiently (Joshi, *et al.*, 1994; Shrestha, 1997). Shaft power can be used directly for food processing, such as rice hulling, the flour and the pressing of food oils from seeds.

Water turbines can also be used to generate electricity. The size of turbines and the

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Table 1. Classification of hydro systems

Size	Application	Power	Classification
Very small	family	less than 5 kW	pico-hydro
Small	village-scale	5 to 100 kw	micro-hydro
Medium	number of villages/grid or mini-grid	100 kW to 5 MW	mini-hydro
Full-sized	connected to the grid	greater than 5 MW	full-scale

amount of electricity that can be produced varies over a wide range as shown in Table 1.

The main use of electricity in a rural community is for lighting, as electric light is brighter and much easier to use than kerosene or vegetable oil. Electric light allows productive tasks to be done at night and students to study for much longer. However, it does not directly earn income and is only required for a few hours a day, so it can only use 20 to 30 per cent of the available energy from a hydroelectric plant. Other uses must be found for the rest of the energy.

3 SETTING UP A MICRO-HYDRO PROGRAMME

Purpose

The aim and purposes of a new rural development programme need to be carefully considered to ensure that it does help the people for whom it is intended. One major problem in the past with technology-led programmes, such as micro-hydro, has been that the effects of installing the technology on the people has not been adequately considered, or even studied after the event. A second problem with some past programmes is that certain aspects have been neglected, so that the programmes, as a whole, have been weaker than they could have been.

A common motive in setting up micro-hydro programmes is political: micro-hydro electrification is seen as a short cut to providing electricity for remote areas, but usually results in a project that is poorly planned and executed. A better motive is to recognize the constrains that lack of energy places on people's ability to develop and find ways in which micro-hydro power, in various forms, can assist people to overcome this constraint. This approach requires that local people are involved in the decision-making process and that the end-uses to which the energy is put do help people to improve their life-styles.

Methods

The various aspects of a project that must be considered in the planning process include:

- the technology: its manufacture and installation;
- extension work and publicity: persuading people that they should become involved;
- finance: provision of loan funds or even subsidy;
- follow-up work and maintenance: to ensure the technology continues to work; and
- socio-economic aspects: the study of how people are responding to the new technology and whether it is doing what was expected.

Such projects require the manufacture or supply of a technology, such as water turbines in the case of micro-hydro. Workshops that are capable of making suitable designs must be identified and the managers must have an appropriate commitment to the project. Staff need to be trained and some means of quality control needs to be maintained over the manufacturing process.

If a technology is to be of use to people, they must be willing to own it and use it. Too many technology-based projects have started out as demonstrations, but fail once the demonstration phase is complete, as no one is willing to take over responsibility for the technology from the agency that has installed it. So a second aspect of a rural energy programme is extension, which involves motivating people to use the new technology in a way that will help them improve their life-style. For the extension worker, this might involve setting up a co-operative to run the new venture, as well as establishing a market for the products of the venture, if one does not already exist.

Renewable energy technologies tend to have a much higher capital cost than competing conventional systems, although the running costs are much lower. Rural people must be able to take out a loan to pay the capital cost, but they can usually recover the money to pay back the loan and interest from the money they save running the system. If there is financial support for the use of the technology, through loans and subsidies, the job of the extension agent will include helping the individual or group of people involved fill in the appropriate forms to obtain the correct finance, as they are often not willing to make the approaches by themselves.

The next step is the installation of the technology, which, in the case of micro-hydro turbines, demands appropriate skills in site surveying and designing the civil works correctly to match the system. Many technical systems have failed because the operators are not taught the best way to run them and to do routine maintenance. Support should be available to assist the operators in case of problems with which they are unable to cope. Follow-up visits to the operators are needed to help to build up contact, provide the opportunity for further training and allow the support staff to assist with routine maintenance work.

If the micro-hydro system is being used to generate income such as selling services, support and training are also required to ensure good accounts are written, so that customers are correctly charged for these services and that the money is used wisely. If a loan has been taken for the purchase of the equipment, then the bank should be able to check that income is available for making loan-repayments. Owners should therefore be training in simple bookkeeping and money management.

Alongside the primary tasks that are involved in running a rural energy programme, there are other tasks that should be done. The extension work is greatly assisted if there is a publicity campaign explaining the use of the new technology in the local media, especially via radio.

4 THE MICRO-HYDRO PROGRAMME IN NEPAL

Manufacturing and Technology

The programme was started in the 1970s through the work of two main agencies: Balaju Yantra Shala (BYS), a Swiss funded project and Development and Consulting Services (DCS), a programme set up by the United Mission to Nepal (UMN). Both groups quickly recognized a need in the hills of Nepal for food processing. Waterpower had been used traditionally in Nepal for several centuries, using a simple vertical-axis water wheel called a *ghatta*, which can provide about 1 kW of mechanical power.

Demands for rice hulling and flour milling had led to the use of Indian diesel mills, which were expensive to run. The availability of 20 to 50 kW of shaft power for water-driven mills from BYS and DCS allowed them to compete with diesel mills on price and many entrepreneurs were keen to respond to this new business opportunity. A typical cross-flow system is also able to drive an oil press to produce cooking oil from the mustard seed grown by many villagers, which has a high value and is much more efficient than hand processing.

Other groups, such as Kathmandu Metal Industries (KMI) developed an improved *ghatta*, a metal water wheel mounted on a vertical axis, and RECAST developed the MPPU, multi-purpose power unit. There are now seven main manufacturers and installers of water turbines in Nepal, who have formed an association Nepal Micro-Hydro Developers Association (NMHDA).

Further Developments

The effective demand for micro-hydro driven milling systems occurred in the mid-1980s, when large numbers of entrepreneurs saw an opportunity to invest in a new technology that was much cheaper to run than diesel driven systems. DCS and BYS began to add small electric generators onto existing milling systems using a simple load controller available from ITDG in the UK and a similar system from Switzerland. The manufacturers also introduced Pelton turbines with the help of ITDG who were able to draw on experience from other countries. This approach included a small Pelton turbine directly coupled to an induction generator to form a small-scale 'pico-hydro' system, which produces about 1 kW of electricity.

His Majesty's Government of Nepal (HMG/N) are involved in establishing large-scale hydro systems through the Nepal Electricity Corporation (NEC). In the 1980s, small-scale electrification was deregulated so some entrepreneurs have taken advantage of this opportunity to build hydroelectric systems (Shrestha and Adhikari, 1998). HMG/N also set up REDP (Rural Energy Development Programme) and RADC (Remote Area Development Committee) to organise a community-based programme for the installation of rural electrification projects.

Electronic Control Systems for Hydro-Electric Systems

The power from micro-hydro-electric generation needs to be controlled but mechanical systems are expensive. The answer was provided by an electronic load controller (ELC) developed in Britain in the early 1980s. A load controller assumes that the electrical output from the generator is constant and diverts the power that is not demanded by the users to a 'dump' load, usually a bank of heaters. Other electronic equipment that has been developed included an induction generator controller (IGC) although their reliability is considered to be lower than ELCs by some users (Joshi and Amatya, 1994). The mountains of Nepal are subject to heavy electrical storms, so all electronic equipment must be well protected against lightning damage.

Most systems do not charge customers using meters, but use a flat rate tariff, based on current limiting devices (CLDs). Three types have been used in different schemes in Nepal, but while these devices are much cheaper than meters, they add cost to the installation and are not really reliable. Some customers find ways to bypass these devices, often by connecting directly to power lines, which is very unsafe.

Financial Support

One of the reasons for the fast growth of the use of micro-hydro milling systems in the early 1980s was the support of the Agricultural Development Bank of Nepal (ADB/N). The bank offered loans for the purchase of the technology and also had technical advisers, who acted as extension agents persuading people to take these loans to purchase the technology. Several economic studies of micro-hydro driven milling systems demonstrated that they had a high profitability, so did not need a subsidy. However subsidies were provided for the purchase of the electrical equipment, as this was considered a less profitable service to the community.

The payback from small micro-hydro systems proved poorer than expected, so several studies were done by ITDG and ICIMOD (International Centre for Integrated Mountain Development). These studies concluded that because of poor management many systems were unable to realise their potential. Some owners did not know how to keep accounts and relied on memory to keep track of debtors. Other owners employed illiterate or poorly trained operators to run their mills, so were unable to find out how profitable they were. These owners had set up the mill in order to give themselves political or social prestige in their village, so put a very low priority on repayment of the loan.

Financial Viability of Micro-Hydro Systems

Many calculations on the cost-benefit ratio for mechanical micro-hydro systems (Inversin, 1988; Joshi and Amatya, 1994; Kharel, 1995; Nafziger, 1998) show clearly that a food processing mill driven by water power makes much more money over a project lifetime of 10 years than if driven by a diesel engine. The economic viability of a particular mill depends on the local demand for its services and whether there are other mills in competition. The effect of the apparent high profitability of micro-hydro mills, coupled with the high risks involved, is that it unfortunately sometimes attracts entrepreneurs who want to make a quick profit and who are not committed to maintaining a service to customers.

Analyses of hydroelectric projects show that the load factor is a major parameter. A typical load factor of 20 to 25 per cent means that most systems are not commercially viable. These systems are heavily subsidised by aid groups by between 60 and 80 per cent of the total cost, with the motive that the area is being ‘developed’ by the introduction of electricity. These plants could become much more financially viable, if the load factor were increased, so new uses for the electricity in rural areas need to be sought.

Quality Control

In general, the quality of micro-hydro systems made in Nepal at present seems high, although this has not always been true. The manufacturers seem to pride themselves on quality systems, using more expensive bearings to extend the lifetime of the turbines, if necessary.

The design of the civil works is less good in some cases and surveyors can be influenced by a customer to place a mill in an inappropriate position. Evaluation teams have reported cases of very long supply canals (up to several kilometres), often made across unstable sections of hills. Water supply measurement for the mill is often done during the initial survey for one day in the year, when conditions can vary widely with time. In some cases, turbines and other items have failed because of poor installation.

The sizing of micro-hydro electrification schemes appears to be another weakness and voltages are often low. People steal electricity, making unauthorised connections to the distribution lines. However, even allowing for losses, most systems appear to produce between 60 and 75 per cent of their rated value.

Follow-up, Repair and Maintenance

One major weakness of the Nepal micro-hydro programme seems to have been the lack of good repair and maintenance facilities for customers in remote locations. If a micro-hydro system fails, the operators often lack the training and experience to do very much for themselves. Often the turbine will need to be removed and transported to Kathmandu or Butwal, where the original manufacturer or another workshop can make repairs. This can take several days, if the turbine is sited in a remote area away from a road.

Extension and Motivation

The installation of a hydroelectric generation system often involves a whole community so that the community needs to be mobilized. This involves setting up management systems, so that people can be held responsible for running the system. Usually a hydroelectric scheme is subsidised from outside, but the local people contribute labour for the civil works that need to be done. A distribution system based on poles taking wires around the village is usually part of the infrastructure of the scheme, but people usually have to pay for the connection between the nearest pole and their house. This can be fairly expensive for poorer villagers, so the take-up for connections can be slow.

Poorer villagers are often very keen to become involved in setting up such a scheme, even if their houses cannot be connected immediately. They expect to benefit from increased services within the village, including lighting of public areas and the introduction of TV and videos in local teashops and hotels, which they can frequent. One indirect benefit of electricity is that tourists are more likely to visit the village, so creating an increased market for perishable crops, such as fruit.

End Uses of Electricity

A major weakness encountered by most micro-hydro electric schemes in Nepal has been a very low load factor, often less than 25 per cent. The major demand for electric power is for lighting, but this accounts for only one or two hours in the morning and three or four hours at night. The overall load on the generator for this period often exceeds its capacity, but the demand for power for the other 18 hours a day is very small. Systems using an electronic load controller have an even greater problem, since the ballast load needs to absorb almost all the output from the generator for a large proportion of the time. One application for a ballast load is for heating water for showers on a trekking route. DCS, with the help of ITDG, spent many years developing electric cookers that could act as a ballast load (Joshi and Amatya, 1994). An alternative approach was to use a 'slow' cooker, in which the food is cooked at low heat for several hours (Bell, 1994). However, people have not been keen to accept these ideas.

There are innovative entrepreneurs in Nepal. One mill owner built his own refrigeration plant, using a compressor driven directly from the turbine. Other schemes have made ropeways to move goods from one place to another driven by motors powered by hydroelectricity. Another suggestion is the processing of fruit, herbs or spices to give them higher value and make them easier to transport. The weak area in this approach, at present, is the marketing of such produce in the main cities.

5 SUGGESTED MODEL FOR THE EXTENSION OF MICRO-HYDRO TECHNOLOGY

Demonstration units for publicizing a new technology have gained a bad reputation, but the problems are cased by poor management and follow-up of projects, rather than the concept of demonstration itself. An effective demonstration must consider ownership, management and use of the technology as well as the technology itself.

Service Centre Approach

An effective demonstration of micro-hydro technology could be a small workshop in a rural centre set up to manufacture and supply turbines to the area around. Such a centre could act as a service and repair centre for a rural area in which a micro-hydro programme was being developed, as well as a base for training technicians and operators in the use and maintenance of micro-hydro systems.

Such a centre could also act as a place in which research could be done to develop uses for the power that were appropriate to the local area. It could act as an agent to market products from the processing of local products, such as fruit juices. It would also be a base for community mobilisers who would help village communities install their own schemes.

Technical Extension

Such demonstration schemes are often set up under the direction of NGOs, such as BTI and BYS in Nepal and the Selam Technical Training Centre in Ethiopia. However the manufacturing and installation side should be run as commercial enterprises as soon as possible. The commercial sector imposes certain disciplines that encourage a focused approach. There may be a need for another organization that can supervise quality control and supervise the wider development issues, such as community mobilization.

Another task of the supervisory organization is to find the best ways of using micro-hydro technology to encourage economic and life-style development for the people who are using the technology. This may also require the management of subsidy and loan finances that may be available to the programme.

Financing of a Micro-Hydro Programme

Subsidies may be provided on the provision of energy to the rural sector. Renewable energy technologies have a high capital cost, but very low running costs, so loan finance on reasonable terms should be available to enable people to take advantage of the opportunities it offers.

The best organizations to handle money for both loans and subsidies are banks as they are already geared to the handling of money. One of the tasks of a supervising organization is to act as an intermediary between the banks and the local people, even acting as a guarantor against some of the loans offered by banks.

Training

People need to be trained to manufacture, install and use technologies that are new to them. This training also needs to involve organization and management of the use of the technology. It may also include basic business and book-keeping skills, so operators can keep track of their income and expenditure. Training may also cover skills in the selling of the services that micro-hydro power can provide.

6 CONCLUSIONS

Micro-hydro power has proved very successful as a tool to help rural people develop their economic position and improve their life-style. It provides extra energy in a rural area to reduce the drudgery of food processing and it can offer a means of generating electric power in areas well away from the grid. The success of any programme using such a technology depends on a wide range of factors that must all be considered and covered effectively. These include the manufacture and installation of the technology itself, but also making sure the technology is used for purposes for which people have a felt need and which are economically viable. The financing of the installation of the technology through loans and subsidies is another area that needs careful planning over a term of several years.

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