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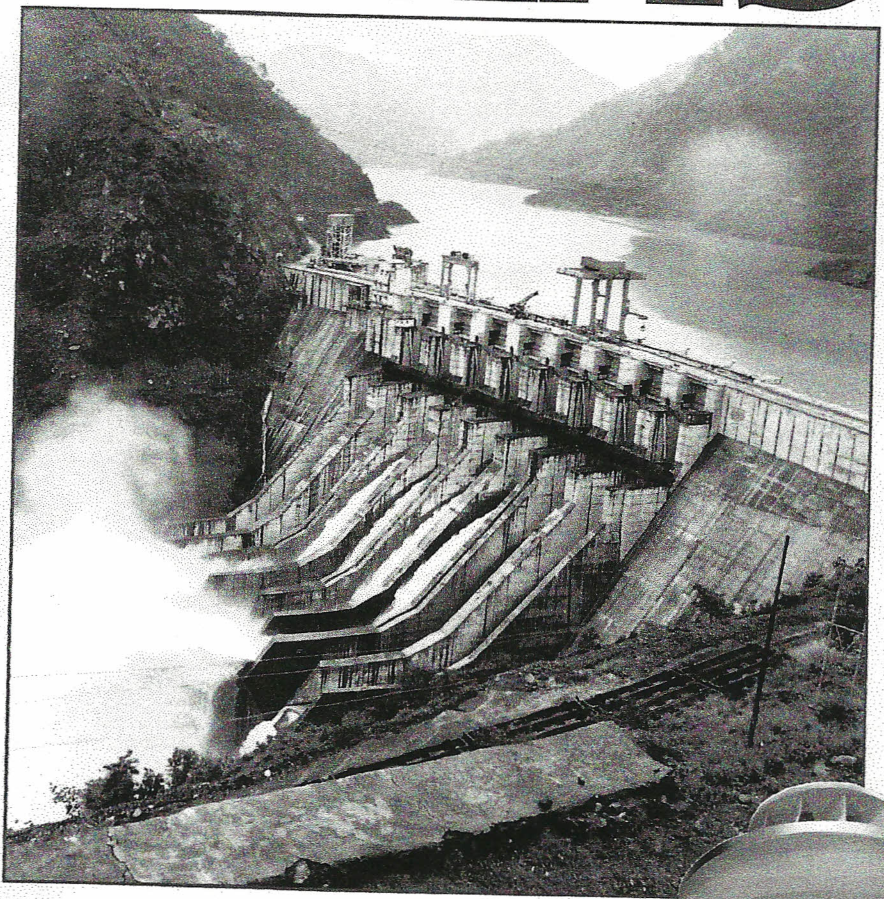

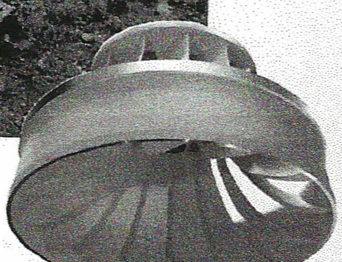

DAM ENGINEERING
HYDROPOWER MACHINERY
WATER RESOURCES MANAGEMENT

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The 'walking excavator' at Croesor.

the results are applicable to future sites.
- What approach could be taken to proposed schemes before the results of the monitoring are available?
- The way forward.

Seminar 2 – Identification of suitable small hydro development

The questions raised in this seminar were:

- What would make a scheme acceptable?
- How can we improve the range of sites that might be acceptable?

It became clear during this seminar that the answers to these questions were polarised. The seminar went a long way to improving trust among the attendees.

Seminar 3 – Best practice guidelines

It was important that all parties were involved in drawing up the guidelines since the developers and the Environment Agency were previously drawing up separate guidelines without any collaboration.

Agreements were made during this seminar about:

- Who should be using the guidelines.
- What should be in the guidelines.
- Who needs to be involved, and how, in producing the guidelines.

Results

It was clear from the literature search and the meetings that small hydro development in fragile environments such as Snowdonia National Park faces a series of barriers and raises a number of conflicts. Three main themes emerged which formed the basis of discussions at the regional seminars:

- The lack of understanding by all parties of the actual effects of small hydro on the riverine environment, and the consequent use of the precautionary principle, particularly for permissible water abstraction levels.
- The various actors have very different ideas of what is an 'acceptable' small hydro site, and there was concern over the lack of any framework for assessing what is a suitable and acceptable site.
- There was agreement that a document of best practice methods would be useful; however, there was an evident need to bring the parties together to discuss requirements and to jointly develop an accepted 'Best Practice'.

Small-scale schemes being developed by small, private companies or community groups can be most affected by these barriers, since the cost of assessment, consultation and mitigation is greater in proportion to the number of kWh generated for smaller schemes.

Conclusions

In Snowdonia, the seminars brought together parties who rarely meet unless they are tackling specific schemes, and so they went a long way to improving understanding of the environmental issues and of the knowledge vacuum in which all parties are working. A framework was set up for further collaborative work through a cross-party Steering Group made up from representatives of the seminar participants, together with a member of parliament, to ensure political support. The general remit of the group was to take forward the following:

- A programme of independent, short-term and long-term monitoring of existing sites, new sites and control sites.
- Establishing an 'impact acceptability' framework for assessing what impacts are acceptable and how to decide this in relation to the benefits of the scheme.
- Consider the development of a 'site identification framework' to support the development of 'low risk' sites and protection of 'high risk sites'.
- Initiate a joint development scheme under Objective I funding to illustrate best practice in action and demonstrate innovative technological and environmental mitigation measures.
- Contact and inform members of NASEG (National Assembly Sustainable Energy Group) of the actions being taken forward by the Steering Group. This could extend to other policy makers.
- Contribute to, and be influenced by, existing proposals by the Joint Nature Conservancy Council for producing generic guidelines on the importance of populations in a national and local context.

A model for other areas

The successful methods used in the RAPPIDS project can be replicated in other locations and for other forms of development where there may be an environmental conflict. The advantages are:

- An improved understanding of the market actors, and of the effects of development. This is achieved through improved dialogue and subsequent sharing of information.
- The identification of successful environmental measures for reducing effects of development, through the examination of best practice.
- Raised awareness, for regulators, of the benefits of renewable energy development; and for developers, of the potential effects of hydro schemes on the environment and how these can be measured and overcome. *- R. Stevenson, Dulas Ltd, UK.*

Chitral micro schemes provide more than just electricity

The Aga Khan Rural Support Programme (AKRSP) has completed 145 micro hydro units (MHUs) in the district of Chitral, Pakistan, in the past ten years, providing electricity to 14 000 of the district's 42 492 households. The emphasis on community owned and managed schemes has increased community co-operation and fostered other development activities in water supply and agriculture. This article reviews this experience to highlight some of the key factors in a successful development programme.

The district of Chitral has a limited national electric grid, supplying relatively expensive electricity. It has fast flowing rivers with plentiful water, reasonable transportation infrastructure, and cooperative, peaceful people familiar with irrigation channels, traditional flour milling, carpentry and masonry: an ideal situation for micro hydro.

It is significant to note that all but one of Chitral's installations use crossflow turbines designed and constructed in Pakistan. Nearly 100 per cent of all generators installed are three-phase, brush-type machines, manufactured in China. There have been very few failures, although several have had to be relocated as a result of channel failures across difficult terrain. Approximately 60 more installations have been completed by other development programmes and private individuals. However, as many quietly rusting installations demonstrate, a successful micro hydropower programme involves more than just installing good technical equipment. To maintain a micro hydro system, and get the maximum benefit out of it, good social organization is essential.

Social organization

Successful MHUs are run by properly organized villages, not NGOs or governments. A village must take ownership of the installation, work together, pool financial resources, and cooperate in the management and use of the generated power. This social organization is crucial for successful long-term operation.

AKRSP use a three-dialogue process in working with a village. Briefly, during the First Dialogue, a project is identified and a Voluntary Organization is formed with an elected President and Manager. In the Second Dialogue, the technical feasibility of a project is determined. If the project is feasible and the file and finances are approved, the project is initiated at the Third Dialogue.

Village involvement

AKRSP carefully involves villagers and their representatives in nearly every aspect of the implementation of a scheme. Villagers are encouraged to handle responsibility, give input, ask questions, and take ownership. This transparent approach fosters trust between the agency and the village, which forms a firm foundation on which to build further development activities. It is also an educational process, as villagers not only learn how to assemble various components, but also find out where they come from and how much they cost. If something breaks or needs to be repaired, they learn to arrange for it themselves. These linkages formed with the agency, banks, and urban markets, are major factors in the high survivability of AKRSP schemes.

Training

AKRSP has conducted, and is setting up, the following courses:

- *Operator Training*: For individuals responsible for running and maintaining their village's MHU.
- *Electrical Safety Training*: This is designed to instruct entire villages about the hazards of electricity.
- *Supervisor Training*: AKRSP employs local men to supervise construction in their region. When winter time slows down construction, classroom training is also carried out to emphasize theoretical aspects of MHP. The goal of this training is to prepare these individuals to carry on the work once the programme officially terminates at some point in the future.

Support services

A sustainable micro hydro programme must encourage the development of support structures servicing the new technology in a region. This is achieved locally by encouraging businesses to stock spare parts, and sending local technicians to take courses such as motor and generator rewinding. Nationally, turbine manufacturers are encouraged to develop designs and production capabilities.

Funding, sustainability, survivability and growth

One basic difference in programmes that has a profound effect on their implementation is whether or not the construction of a scheme is subsidized.

Unsubsidized programmes favour sound economic investments by private entrepreneurs and united villages. These programmes usually develop slowly, but can maintain steady growth whether or not the initial supporting agency is still active, if local individuals have been properly trained to 'carry the torch'. However, there is less chance of controlling the quality of the programme. As a result, unsubsidized programmes may have a low survivability rate of installations.

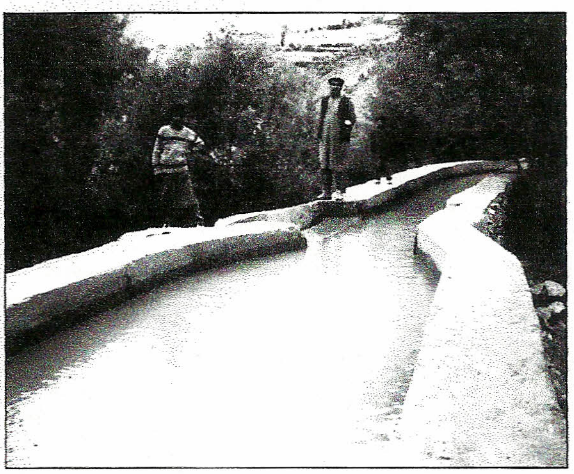
Subsidized programmes can grow explosively. However, to develop a high quality programme with properly trained individuals, it is best to grow slowly and steadily with experience and training until a level is reached that can be sustained over the expected life of the programme. Objective project selection criteria must be developed to avoid favouritism and the danger of making more jealous enemies than grateful friends. Technical quality and social organization can be monitored and controlled because the purse strings are held. This should ensure that installations have a high survivability rate. A subsidized programme also encourages a wide variety of villages to become involved, not just the best ones.

When considering subsidized programmes, the question arises of what will happen to new micro hydro construction once the programme ends. The most important factor is the level of subsidy that has been given. If subsidies have been heavy (more than 75 per cent of the total costs), the project area is likely to develop an entitlement mentality. Villages are inadvertently trained to expect considerable help in any new endeavour. When the development programme ends, there is likely to be a long period of shock before fresh local initiative is taken. Lower subsidies, say 50 per cent of only capital costs, guard against this problem.

Another problem that can arise from subsidies is less village ownership in an MHU, and resulting neglect. In Chitral, however, this has not been a problem as a result of the high value placed on electricity, and the requirement of villages to establish a maintenance fund before a project is initiated. By doing so, villagers realize upfront that maintaining a hydro scheme is a financial commitment.

A very real difficulty in subsidizing only capital costs, and not labour, is that invariably the poor of the village will be expected to do all the labour. One solution to this problem is to keep a daily roster of workers. Those that do not work should be required to pay an agreed or daily wage periodically into a micro hydro fund. If anyone refuses to pay, an electrical connection should not be given. Cultural factors need to be carefully considered in negotiating these agreements, and they should be done before a project is initiated. Such agreements form important precedents for future projects.

To allow for changes in policy as a programme develops, it is best to make it clear when 'Phase I' is done and 'Phase II' begins. Careless management can cause an otherwise ben-



The headrace at the Chitral project in Pakistan.

eficial programme to divide a region more than unite it.

Conclusion

Micro hydropower technology, coupled with successful social organization, support structures, and training programmes, can act as a motivational catalyst for sustainable change in appropriate mountainous regions. Once a community has been organized around implementing and maintaining a hydro project, they are likely to be much more open to subsequent development activities. Over the years, as improvements take place in lifestyle, health, and education, the community will learn to manage its own resources, mobilize its own people, and sponsor its own initiatives. That is successful development. - *Brad Friesen, MHP Consultant, AKRSP, Chitral, Pakistan. Email: bnfrozen@brain.net.pk.*

Adaptive water management at Casoja

Like many other old small hydro plants in the alpine region of Switzerland, Casoja was built to attract tourists. In the 1900s, having a hotel with lighting was a major business advantage in the developing ski resort of Lenzerheide. Casoja is fed by several perennial mountain springs, through a large storage pond, and incorporates a 90 kW Pelton turbine and generator, based on a design flow of 70 l/s with a 160 m head.

After the interconnection of even the remotest areas with the main grid during the 1950s, many old small hydro plants were abandoned. Casoja was gradually declining and went out of operation a few years ago. The decision to reactivate the plant was dependent on the ability to modify the operating regime to adapt to the changes in water resource and load demand which had occurred since the scheme was originally commissioned. The key changes were:

- the water was also in demand for drinking water supply and artificial snow machines, both of which are high priority uses;
- the plant is now grid connected; and,
- the generated energy is deducted from the energy consumption of the hotel.

To accommodate the above changes, a fully automated setup, including a water and load management system combined with a very compact electro-mechanical design was installed.

Adaptive management

A key element for efficient operation is adaptive water management. During winter the discharge of the springs declines considerably and most or all of the water is diverted for domestic use and snow guns. Thus the discharge varies greatly, but the brief fluctuations can be buffered in the daily storage pond. The task was to determine the optimal operation strategy, without the need for operator intervention, and with very limited information about water availability.

The control system is designed to switch between three different operation strategies, so as to optimize the use of the available water reliably:

- normal operation;
- flushing (intermittent) operation; and,
- anti-freeze (intermittent) operation.

Normal operation

The control system starts the plant automatically, if there are no pending faults and the water level in the reservoir has reached the 'full' level. A level controller is activated as soon as the generator is connected to the grid. The spear valve opening is adjusted to reach and maintain a pre-set water level. Hence, the plant uses all available water at the highest possible head, producing the maximum possible generated output.

Flushing operation

If the discharge into the reservoir declines below a certain amount, the normal operation (level control) becomes uneconomical because of the reduced plant efficiency. In this case, it is better to make use of the storage, by opening the spear valve to the most efficient operating point, thus emptying the reservoir. As soon as a pre-set 'minimum' level is reached, the control system shuts down the plant completely, and waits until the reservoir refills. During this flushing operation, an opening controller is used to maintain the optimal needle position. The control system measures the time for refilling the reservoir and deduces the average water inflow. If this inflow exceeds a pre-set value (the economic minimum turbine discharge), operation is switched back to normal operation.

Anti-freeze operation

If the refilling time exceeds 24 h, so that the plant would not operate for more than a day, the water in the penstock risks freezing. In that case, the control system switches to a third mode, an anti-freeze operation. The plant starts up and discharges the total volume of the penstock, once or twice a day. To achieve this, a power controller in combination with a timer is activated. This allows generation of a defined amount of energy, which is pre-set and is equivalent to the volume of water contained in the penstock. This strategy guarantees a complete replacement of the idle water in the penstock prior to any freezing. This operation can continue for at least ten days before the storage is depleted. An alarm is sent to the operator well before this event occurs. As soon as the 'full' level is regained, operation is switched back to flushing operation.

Operation

The operator has access to the control system through a simple text interface. The operator can adjust key parameters used to optimize the operation such as:

- Optimal opening: spear valve opening for maximum efficiency.
- Minimal opening: spear valve opening at which operation becomes uneconomical.
- Minimum level: reservoir level at which a sufficient volume remains for the anti-freeze operation.
- Timing for refill: storage pond refilling duration, above which the plant remains in the flushing operation.
- Timing for anti-freeze operation: at what time of day (normally morning and evening during peak hours) and for how long the plant should run.

Conclusion

The use of an Entec DTC15 digital control system allowed for a simple, robust and reliable adaptive water management system. All management functions were realized as customized control blocks in the otherwise standard control application, avoiding the need for additional hardware. Applying this concept also avoided the installation of any communication hardware/software to connect the plant with the public water supply authority. They could use water at any time without disturbing the operation of the plant. The plant owner is thus able to verify that the contractually fixed minimum supply is maintained. This proved to be a cost-effective way to re-commission the scheme. - *Rolf Widmer, ENTEC AG, St. Gallen, Switzerland. rolf.widmer@entec.ch*

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