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ıral power schemes Pakistan

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Although hydropower resources exist in remote, rural areas of many developing countries, high costs and the difficulties of operating micro-hydro schemes in these areas often discourage such efforts. However the Appropriate Technology Development Organization in Pakistan has found that when villagers install, operate, and manage their own schemes, and the turbines are built locally, installations in the 5-15 kW range can cost from US$250 to $400 per installed kilowatt.

TAPPING THE WATER resources in remote, rural areas with micro-hydro plants appears an attractive alternative to the costly extension of the national grid or to transporting increasingly expensive and scarce diesel fuel to those areas which rely on diesel generation of electricity. In addition, the potential contribution which micro-hydro plants make to rural development in these and other areas is out of proportion to the quantity of energy which can be delivered.

Problems

Of all the popular renewable energy technologies for electricity generation, including hydro, solar, biogas, and wind, hydro is the most proven, most reliable and potentially least costly to date. But hopes for using this technology in remote areas can be quickly dashed by the realities generally encountered in such efforts around the world—excessive costs and unwieldy management requirements.

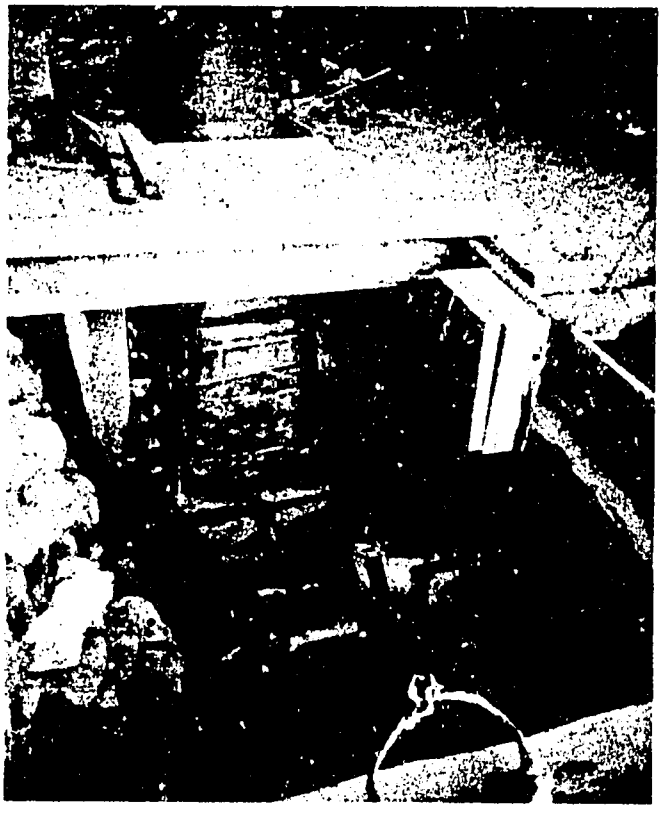
With the exception of some schemes installed by private groups or individuals, implementation of small hydro schemes has often followed the conventional pattern used with large schemes—several levels of feasibility and engineering studies, conventional capital-intensive designs, imported hardware, construction firms and labour from outside the area, and overseas consultants. Working under this premise, economies of (large) scale are inevitable. Small hydropower schemes therefore are bound to be too expensive.

In addition, to have a significant impact on a nation's economy, a large number of these small schemes need to be implemented. But, if this is to be undertaken by a centralized, national utility, the vast logistical and managerial complications in implementing, operating, and maintaining these would be formidable.

Alternative approach

If any of the potential for micro-hydropower is to be developed, these problem areas must be addressed with a new approach. The Appropriate Technology Development Organization (ATDO), under the Pakistan's Ministry of Science and Technology, has been tackling the problem since the mid-1970s. There are already 22 5-15 kW micro-hydro schemes operating in the mountainous regions of northern Pakistan, and it is now being demonstrated that electricity can be generated at low cost and that schemes can be successfully managed and maintained by the local villagers.

This approach is proving contagious. In Lillonai, the first village to have an ATDO installation five years ago, four plants are now operating. In a small valley around Bishband, only accessible by foot, three plants have been installed. A dozen schemes with outputs of up to 50 kW are under construction at present.



Generating equipment for the Lillonai plant; the penstock is made of oil drums, and the turbine is located under a wooden cover.

With the increasing number of installations around the countryside, there is a growing awareness among villagers of the potential of hydropower. The ATDO is receiving an increasing number of requests for assistance. In each case, if no extension of the national grid is planned for the area in the foreseeable future, one or two individuals from the ATDO micro-hydro team visit the village and assess its potential for hydropower development. The team discusses all aspects of the project with the village leaders to make them aware of their obligations and understand their role. If villagers' interest is widespread and genuine, the project goes ahead.

Construction of the civil works and purchasing the necessary materials are undertaken by the villagers. No engineering drawings are prepared. Small wooden models have been used to convey the design of some of the components. No critical dimensions or designs are included in the overall plan. The villagers are already familiar with the technology since irrigation canals and traditional water-powered flour mills have been used in

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The Bishband powerhouse. Note the dry-rubble masonry forebay structure and wooden penstock.

the area for generations.

During the course of the site work, the ATDO provides technical guidance when necessary, while the turbine is being manufactured in a town. The turbo-generating equipment is installed by the villagers under the guidance of the ATDO. If the villagers apply themselves and no disputes over the land arise, a project can be completed in 3-4 months. Village leaders hire an individual from the village to operate and maintain the scheme. Decisions such as those regarding the tariff structure and the operating hours are made by the villagers.

Designs

For the civil works, designs which minimize cost and maximize villager labour inputs have been adopted. Local materials are used whenever possible.

The intake structure is a replica of the innumerable intakes to small irrigation canals dotting the region. A low stone weir is constructed to deflect the flow into the unlined headrace. An advantage of this type of intake, in addition to low cost, is that it can be washed away in times of floods, letting the water and river-borne debris pass downstream unhindered, and then can be easily replaced.

The penstocks are usually 5-15 m long and, to facilitate manufacture, no bends are included. Conventional steel pipe is used for heads of over about 6 m, and a valve is included just before the nozzle. For lower heads, non-conventional but more readily available materials such as wood or oil drums are used. In this case, flow is

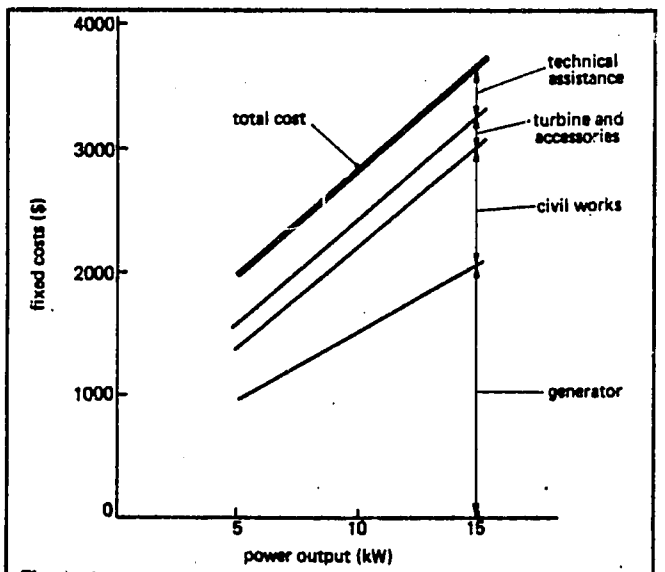

Fig. 1. Cost breakdown and ATDO schemes installed to date.

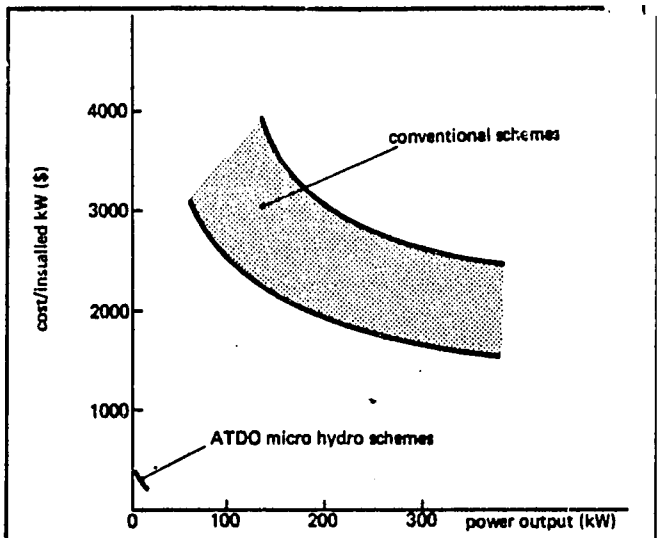

Fig. 2. Comparison of costs of conventional schemes with those installed with ATDO assistance.

controlled by placing boards across the inlet to the penstock. The penstock ends with a rectangular nozzle. To minimize penstock length and avoid bends, the forebay, often built of dry-rubble masonry lined with concrete, is built as close as possible to the point directly above the turbine.

The turbine is a cross-flow type, made of vanes shaped to the proper curvature by hammering strips of steel. With some units, vanes cut from suitably sized pipe have been used. These are then welded to circular end-plates mounted on the shaft. Turbine efficiencies of 50-60 per cent have been measured in the laboratory as well as in the field. Shaft bearings are secured on concrete below the floor level of the powerhouse. The nozzle is fixed independently of the turbine, with clearances of up to about 2 centimeters between the two. No governor is included in the design. Instead, the power input is manually controlled with a gate or valve along the length of the penstock.

The generators commonly used are made in the People's Republic of China, generating 220/380 V, three phase at 1500 rev/min, and are the most costly item. The University of Engineering and Technology at Lahore, under a grant from the ATDO, is at present designing and testing generators for local manufacture in an attempt to reduce costs, and savings of about 25 per cent are now anticipated.

Electrical power distribution is at the generating voltage. Most of the electrical load is for lighting, with three or four 40-60 W incandescent bulbs in most homes. A monthly tariff of about US$0.40/bulb is charged. At

The forebay at the Alpuri plant, leading to the penstock made of oil drums.

one site, an arc-welding unit is used; at another, an electrically driven wheat thresher/corn sheller is operated in the fields. It is moved to convenient locations around the village and electricity is tapped from a nearby distribution pole. Besides the generation of electricity, cottage industries have been established which use direct mechanical power from the turbine to drive a variety of tools. These include flour mills, rice hullers, band saws, wood lathes, cotton gins, corn shellers, and workshop grinders.

Costs

A breakdown of costs for micro-hydro schemes installed to date is given in Fig. 1. The unusually low cost per installed kilowatt (Fig. 2), ranging from US$250-$400, arises from several factors:

- low administrative costs;
- contribution by the villagers of most of the labour;
- maximizing the use of local materials;
- local fabrication of some of the equipment;
- appropriate system design (that is, no attempt to maximize system efficiency, no governor, no full-time operating staff); and,
- minimal use of costly technical expertise and supervision.

At present, the ATDO and provincial governments share the cost of the ATDO's technical services and turbogenerating equipment. The ATDO is working with the provincial department of cooperatives so that loans can eventually be advanced to village groups. Based on a plant life of 25 years, interest at 13 per cent, a plant factor of 30 per cent and distribution losses of 5 per cent, costs/kWh delivered range from 20-40 mill. Consequently, with the tariff structure now in general use, it is possible that schemes could be installed with virtually no government subsidy if loans could be arranged. This would be a break with the prevailing worldwide trend of cumbersome and costly government management. □