Practical Action, Peru

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the **Ashden Awards** for sustainable energy

Micro-hydropower bringing services and income to communities in the Eastern Andes

Summary

The Eastern slopes of the Andes in North Peru are among the least developed parts of the country, and the difficult terrain and scattered population mean that few people have grid electricity. However, there is a large potential resource of hydroelectricity in the many rivers and streams. Practical Action, Peru has installed 47 micro-hydro schemes, with average electrical power 33 kW, to provide metered electricity to about 5,000 families. Electricity from the micro-hydro provides good quality lighting, refrigeration and entertainment in homes, and improves education and health care provision through the use of electrical equipment. Surveys suggest that about 25% of households have started or expanded businesses as a result of having electricity, and many people who left the villages because of better employment opportunities in the cities have come back and started local businesses.

About 40% of the cost of the micro-hydro scheme is paid by the community members, partly using a loan from the Inter-American Development bank. Most schemes are run by a local management group which sets a suitable tariff structure so that electricity payments provide for operation and maintenance costs, and loan repayment. A village micro-enterprise of Practical Action-trained technicians is responsible for the day-to-day operation and maintenance of the micro-hydro.

The organisation

Practical Action (formerly known as the Intermediate Technology Development Group) is an NGO founded in 1966 by Dr Fritz Schumacher. It has a headquarters in the UK and eight offices around the world, with a total of 520 staff. 110 staff work in the Latin America regional office in Peru, which was founded in 1985. Practical Action receives funding from government agencies, private foundations and NGOs, and had a turnover of about £1.8 million in 2005/06, of which £12,000 was related to micro-hydro work.

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Context

Statistical information

Population (2004)	27.6 million
Urban population (2004)	72.4%
GDP per capita US$ (2004)	$ 2,490
- at purchasing power parity	$ 5,678
Population living on less than $1 a day (2004)	12.5%
Population living on less than $2 a day (2004)	31.8%
Population with access to grid electricity (2000)	73%
Annual electricity consumption per person (2003)	868 kWh
Annual CO_2 emissions per person (2003)	1 tonne
Population undernourished (2001-03)	12%
Population with access to an improved water supply (2004)	83%

Sources: UNDP, World Resources Institute

The Eastern slopes of the Andes in North Peru have stunning mountain scenery with many streams, fed by the high rainfall from the prevailing wind that blows across the Amazon. The high rainfall supports a range of agricultural activities including growing coffee, rice, maize, potatoes and fruit, and raising cattle. Agriculture and associated service industries are the main economic activity.

However, access to the region is difficult with villages and trading towns connected by un-metalled roads, and the region is one of the most underdeveloped in Peru. In recent times the villagers also suffered greatly at the hands of the *Sendero Luminoso*, or Shining Path guerrillas.

25% of the population of Peru do not have access to grid electricity, and most are in rural areas like the jungle Andes, where 68%, or about 5 million, people are not reached by the grid. Many people leave the un-electrified villages for the wider opportunities in the cities. The use of micro-hydro technology can bring electricity to remote rural villages and promote very effective development.

Technology and use

Hydro power uses the energy of fast-moving or high-pressure water to rotate the blades of a turbine at high speed. The turbine turns an electrical generator, which produces AC electric power. Hydro turbines come in a wide range of sizes: those used by Practical Action range from about 1 kW to 200 kW electrical output, and are classed as micro-hydro. The economic potential for micro-hydro in this region is very substantial: this has been estimated by the World Energy Council to be 260 TWh/yr of which 5% is currently used.

Micro-hydro schemes require civil engineering work to control the flow of water. In the Practical Action schemes a canal is dug to take a proportion of the river flow to a convenient point where the water intake can be constructed. At this point a forebay (small storage dam) is built which diverts the water into a penstock (high-pressure pipe) through which the water flows down a steep gradient. Water leaving the penstock rotates the blades of the hydro turbine, which is connected by a shaft to an induction generator. The electric output from the generator is stepped up to a voltage of 10kV by a transformer, so that the main connection to a small town or village is made with low electrical losses. This power is then stepped down to 220V for delivery to households and businesses.

The choice of turbine depends on the flow rate and head of water, and Practical Action supplies Pelton turbines (available in 0.5 to 1,000 kW range), axial turbines with fixed blades (5 to 250 kW)

and crossflow turbines (1 to 100 kW) The generators are mainly induction machines, which are up to 60% cheaper than alternators at below 12 kW rating. A simple electronic load controller is used with each induction generator to keep it running smoothly at different electrical loads.

Most of the turbines are manufactured by small companies in Peru to Practical Action designs, with each company making three or four turbines per year. Practical Action sees local manufacture as a key step towards widespread use of renewable energy. Many of the load controllers are imported from the UK or Canada.

47 micro-hydro systems have been or are currently being installed, with a combined capacity of 1568 kW.

How users pay

£1 = 6.4 (Peru Nuevos Soles) [March 2007].

Many of the micro-hydro schemes are owned by the communities that they serve. A key part of the work of Practical Action is to arrange with each community how the capital and operating costs of the scheme will be covered, and how the micro-hydro system will be operated and maintained. The preferred approach is to set up a local management group to handle the allocation of electricity and the finances, and a micro-enterprise of trained local technicians who are given a three to four year contract for operation and maintenance.

The capital cost of the micro-hydro systems averages about £1,700/kW, which is about £500 per household, since household supply averages 300 W capacity. The community provides typically 10-15% of the capital cost as construction labour. The Inter-America development bank has a revolving fund to provide loan finance for about 30% of the cost, and to date there is about 90% success rate with repayments. This loan is repaid over three to six years by the management group that operates the plant. The final 55-60% of the cost is provided as a subsidy from Practical Action.

The running costs are covered by the income from electricity sales, according to a tariff determined by the management group. This pays the micro-enterprise for operation and maintenance, and the loan repayments. The electricity is metered and different tariff structures are used depending on the priorities of the community. A typical tariff structure is shown below; the low rate for consumption above 60 kWh/month is designed to encourage businesses to be set up using spare capacity.

Payment structure of micro hydro plant of Conchan		
Item	**Unit**	**Amount**
Amount per energy consumed		
Until 20 kWh	US$/kWh	0,14
From 20 kWh to 60 kWh	US$/kWh	0,12
More than 60 kWh	US$/kWh	0,02
Other payments		
Connection rights (for new users)	US$	28,50
Street lighting	US$/month	0,28
Power cut and replacements	US$	0,57
Monthly interest rate (% of debt)	%	2,00

Some of the micro-hydro systems are owned and run by private operators or municipalities, but the experience of Practical Action is that the micro-enterprise approach is the most effective.

Training, support and quality control

Practical Action ensures that the equipment is easy to maintain and operate, and trains the plant operators through courses and also 'on the job' during the installation and commissioning phase. The whole management group is also trained in how the technology works and is operated.

Using a local micro-enterprise to run the scheme has proved very successful. Operators carry out planned and corrective maintenance work, such as replacing the brushes on an induction machine every five years or repairing the guide vanes on a Francis turbine. The operators are able to seek help from the local Practical Action engineer when there is a major failure, but as their experience increases they will do most of the repair and maintenance work themselves. In one village, the micro-enterprise has decided to install a second turbine to meet increased demand, and the technicians feel confident to do this without help from Practical Action.

The installed systems have been designed for an average lifetime of 20 years. All serial numbers and system details are recorded so that Practical Action can check back if problems arise.

Benefits

It is estimated that 5,044 families (around 30,000 people) benefit from electricity from the 47 Practical Action micro-hydro schemes in Peru, which generate in total about 40 GWh/year with an availability of about 80%, after allowing for maintenance and repair time. The electricity supply stimulates demand, which has been growing at about 2.5% per year.

Remote villagers of Peru see electricity as essential for the development of their communities. Previously, people moved away to start businesses in places where the infrastructure was better, but the electricity from micro-hydro schemes has brought them back. Some villages have doubled in size: for example connections to the micro-hydro scheme in Tamborapa have increased from 200 to 400 homes, and 90% of this increase was due to people returning to the village and bringing their businesses with them.

The businesses which have started as a result of the micro-hydro electricity include restaurants and bars, bakeries, furniture makers, welders and internet cafes. A new milk cooler in Cochin collects milk from local farmers and sends it to a processing plant in Cajamarca. This generates additional income for farmers. An ice-cream factory now operates in Cochin during the hot season.

An external survey carried out for Practical Action in 2005 found that in nine villages with hydro-electricity, 216 businesses had either been started or had grown. On average, 26% of the families benefiting from hydro-power had started or expanded a business. Extrapolating this across all areas with access to micro-hydro systems, suggests that 1,000 businesses have started or grown. 60% of people said that their incomes have increased as a result of electricity coming to their village, and for 23% of people the increase in income was more than 50%. Even people who do not have a personal financial benefit think that the micro-hydro scheme has brought development to their community.

The availability of electricity has many educational benefits. Schools can use computers, photocopiers, audio-visual facilities and amplifiers to enhance their bands. Children are now able to study at home in the evenings with electric light. Teachers are more likely to live in the communities where they work if electricity is available, and contribute more to community life: some also set up enterprises such as internet cafes in their spare time.

The electricity from micro-hydro systems provides many health benefits. Health centres can operate vaccine refrigerators, maintain records on computer, and use radio links for communication, as well as offering a generally improved service through use of electric lights. Dental services have started. A health laboratory can now use equipment such as iceboxes, fridges, centrifuges, humidifiers, sterilisers and electric boilers.

Most of the system components are manufactured by small, local companies. On average, three to four systems are produced each year, creating around 250 person-days of work.

Electric lighting replaces kerosene lamps in homes, which improves indoor air quality and reduces the risk of fires from spilt fuel or lamps. Women and children are most affected by the fumes, which cause breathing problems and eye irritation. Families save between £20 and £60 per year on kerosene and batteries, an average of 70% of their energy costs. Electricity makes it possible to use kitchen appliances such as fridges and food processors, and brings the possibility of radio, TV and DVD players for home entertainment

Potential for growth and replication

Practical Action schemes have been successful because of their technical quality, local management and maintenance, and tariff schemes that encourage the productive use of electricity. They offer excellent examples for replication, which is now recognised by the government of Peru as one of the best approach for providing rural energy services. Less than 5% of the economic hydro potential in the Eastern Andes has been used, so there is significant potential to do more, and this is supported by clear local demand. Electricity from micro-hydro schemes is considered to be a very good alternative to grid power, and many villages approach Practical Action for installations.

The Ministry of Mines and Energy has a ten-year plan that includes providing 58 more micro-hydro schemes. Discussions are underway concerning Japan funding 50 of these schemes.

Several groups in this region share technologies and management approaches through the Hidrored network (Latin American Micro Hydro Energy Network).

The work of Practical Action extends beyond Peru, supported by the applied training centre near Cajamarca, which Practical Action runs in conjunction with the NGO Engineers without Borders. Universities in Peru and Spain help to design and run the courses. During 2006, Practical Action organised two international symposia on micro-hydro technology for 140 participants, including the Directors of the International Network on Small Hydropower and the Hydropower programme of the Idaho National Laboratory, and the Peruvian Vice Minister of Energy. Four books on aspects of the work will be published shortly and Information is also disseminated via the Practical Action, Peru website. Technology developed by Practical Action is used in many countries, including Bolivia, Guatemala, Sri Lanka and Nepal.

Management, finance and partnerships

Practical Action, Peru has 140 staff, 10 of whom work full-time on the micro-hydro programme. The programme is managed by Javier Coello, with day to day project co-ordination by Celso Davilla, field work by Gilberto Villanueva and training by Rafael Escobar. The main role of Practical Action is to respond to requests from rural communities for micro-hydro schemes and help the community to implement them. Practical Action helps communities to apply for funding and approval from the local authority, trains managers and operators, designs systems and identifies suitable equipment and helps manage the construction and installation.

This report is based on information provided to the Ashden Awards judges by Practical Action, Peru and findings from a visit by one of the judges to see their work in Peru.

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