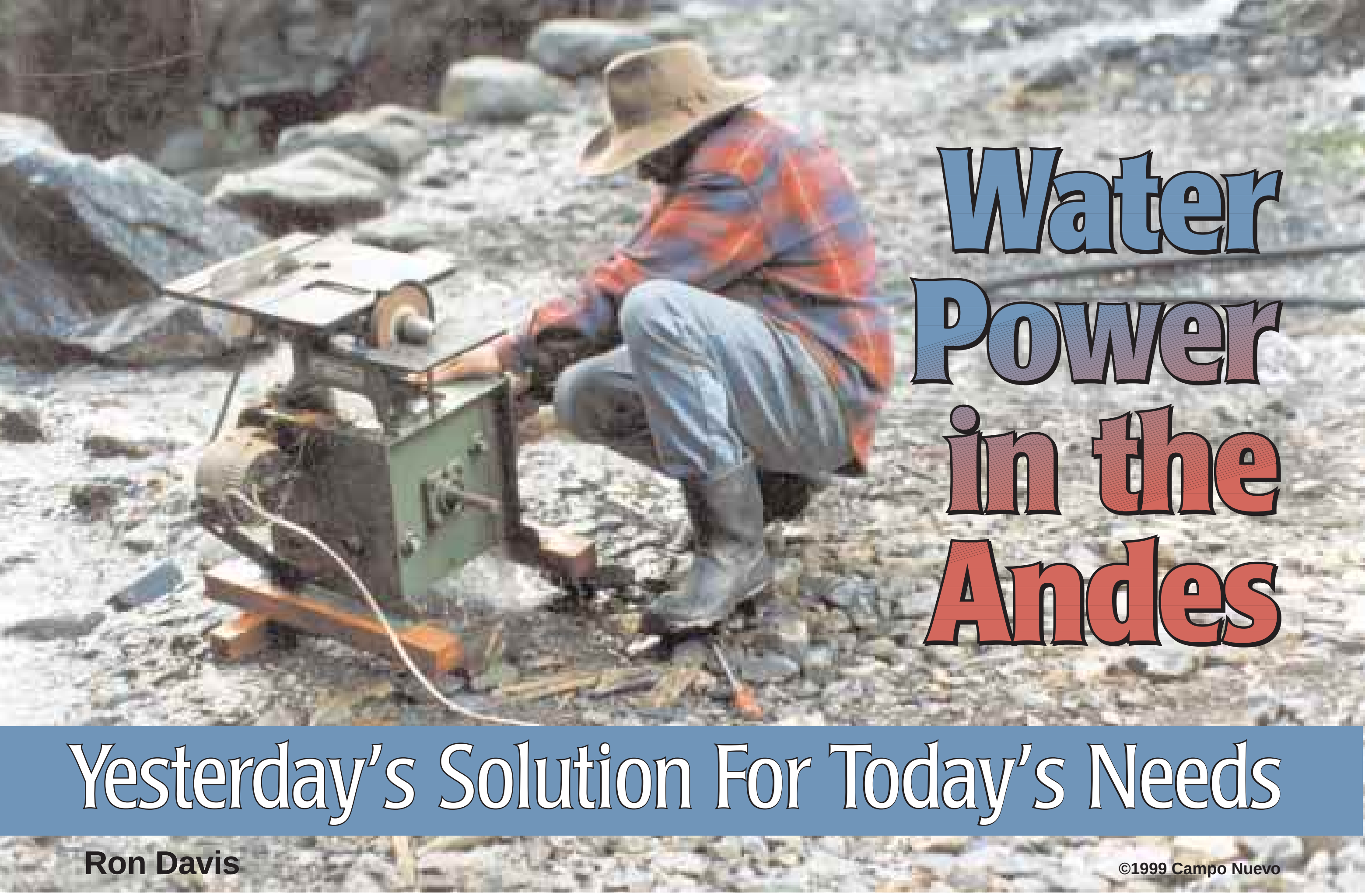
Water Power in the Andes



Yesterday's Solution For Today's Needs

Ron Davis

Ron Davis tests an early Watermotor: falling water powers a saw, grinding wheel, and alternator for electricity.

Going to work these days is always a bit of a thrill for me—often more than I care for. It means crossing a 15,000 foot (4,570 m) pass over the Bolivian Andes and snaking down a muddy one lane road carved into the face of immense cliffs. *The Most Dangerous Road in the World* was the title of an old *National Geographic* article about this spectacular route.

World's Biggest Solar Machine

Actually I'm entering the world's biggest solar energy machine—the Amazon basin. Towering glacier-topped 20,000 foot (6,100 m) peaks are clearly visible from our tropical water power demonstration site. The eastern face of the Andes so thoroughly captures the Amazon moisture that the western side—the Atacama desert—is said to be the driest place in the world. Sometimes rain only falls there a few times during an entire lifetime.

But on this side, it's just the opposite. Uncounted streams and waterfalls abound, some falling hundreds of feet directly onto the roadway! About 80 people die each year on this short section of road, since it is very narrow and slippery. Vehicles that slip off the road can simply disappear into dense vegetation a thousand feet (300 m) below. It's incredible to think that this is the only road into a tropical part of Bolivia the size of Texas.

Leaving the narrow road, it's a relief to arrive in the lovely town of Coroico at 5,500 feet (1,676 m), near our demonstration site. Green hillsides are covered with coffee, citrus, and bananas. This also happens to be the home of Bolivia's traditional coca leaf production, so the area is much affected by the U.S. "war on drugs."

Campo Nuevo—Meeting People's Needs

Over fifteen years ago, Diane Bellomy and I founded Campo Nuevo. We started our family-sized appropriate technology organization to improve lives by bringing simple technology to Bolivia's indigenous people. We teach them how to use their local natural resources for energy. We want to show people how easy it is to employ the abundant small local sources of water power to improve their lives. This can help make it possible for them to remain on their land and in their own communities.

We are working with Aymara-speaking native Americans, one of the largest and most intact indigenous cultures in the Western Hemisphere.

Notable for having withstood the Incan conquest, and later the Spaniards, the Aymaras are now succumbing to the pressures of modern global economics. Like rural people all over the "third world," they are being forced to relocate simply to survive. They usually migrate to a desolate 13,000 foot (3,960 m) suburb of La Paz, in order to compete for unskilled, low paying, and often temporary jobs.

A New-Old Solution

Although they may not realize it, what visitors to our demonstration site see is not really new. It's actually a revival of the nearly forgotten traditional use of water power. For thousands of years before the invention of centrally generated electricity, water power was employed to directly run machines, something it does very well.

What *is* new is the development of a modern low-cost turbine specifically for this purpose—a "motor" driven by water power. We call it the Watermotor. It can provide the energy to drive a variety of machines, replacing the mid-sized electric motors upon which nearly all modern production depends.

Lester Pelton, who invented the Pelton wheel, produced a variety of these water powered motors. They were in use before 1900, powering individual machines. Pelton even used one to run a sewing machine! The direct drive hydro units were replaced by electric motors after centrally produced electricity became the norm.

Few people realize how closely rural poverty is related to the lack of machines necessary for local production and services. In the third world, the power grid is usually confined to cities and large towns. Rural people still use muscle power as everyone did in the past, and they do without electric lights. The need to generate cash to buy anything they don't produce themselves causes a focus on cash crops. This further reduces their self-sufficiency, encouraging a downward spiral towards dependency on a system that cannot be depended upon!

Demo Site

Water power is nature's most concentrated form of solar energy, and by far the easiest to convert into usable mechanical power. At our new Campo Nuevo demonstration site, we are featuring practical machines, directly powered by water. There are woodworking tools, air compressors, and water-powered water pumps. We also run an auto alternator to charge batteries and provide lighting. This can be switched on when mechanical power is not being used, and is driven by the same belt drive that powers the tools.

The main attraction at our site is a Watermotor driving a small multipurpose woodworking unit. The machine is

Campo Nuevo assistant, Iran, rips a board.

suitable for producing doors, window frames, and furniture—necessities usually purchased from the city. It processes locally grown timber instead of wood carried up from the Amazon forest.

The Watermotor at our demonstration site is provided with power from a water source located 65 feet (19.8 m) above the machine by four 170 foot long (52 m) 1 1/2 inch (38 mm) polyethylene pipes. At the heart of our turbine are two Energy Systems & Design plastic mini-Pelton wheels, mounted on a single shaft and driven by two water jets each. With a flow of 82 gallons (310 l) per minute, we get power similar to a 3/4 HP electric

The first Watermotor—the start of a revolution.

Plumbed to the power and ready to rip.

motor, at about 1,450 rpm. Unlike an electric motor, the Watermotor costs nothing to operate and can't be burned out by hard use.

It's Not Easy

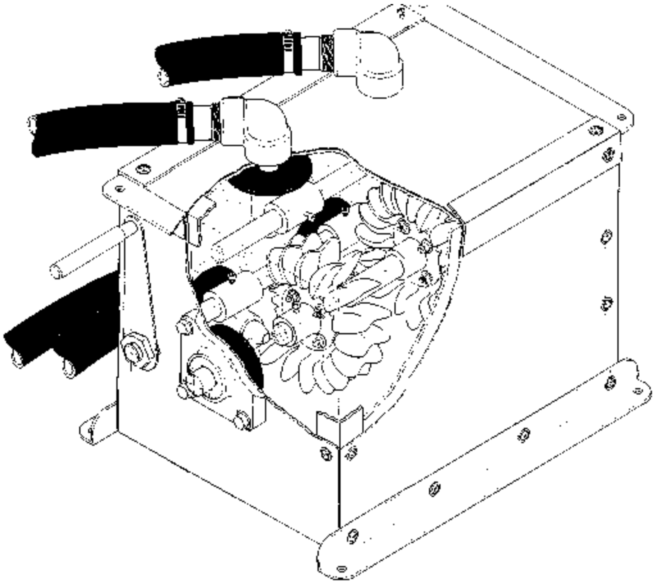
Not much of this area is served by roads or the power grid. The U.S. owned (and U.S. priced) power generating system has little incentive to provide long distance lines to a widely scattered and typically impoverished rural population. Water power is the sole available practical source of energy to run machines. There is not a good wind resource in the mountain valleys and PV is just not economical, compared to the abundant water power here.

There are major obstacles to the introduction of unfamiliar technology to an indigenous population that has traditionally used no machines of any kind. These people have little money to invest in anything that does not promise a practical return. In addition, the Aymaras are unlikely to be reached by advertising in the city newspapers. This is why we felt that a local demonstration site was necessary.

The Watermotor on its side with twin turbines exposed.

Other problems are encountered when machines, however useful, need to be professionally installed, maintained, or repaired. Outside the city, such services are frequently unreliable, hard to come by, and expensive when available.

Cutaway View of the Watermotor



Keep It Simple

In order to overcome these obstacles, we designed the Watermotor to be user installed, maintained, and repaired. Because it is locally produced from common materials, all parts can be easily replaced. Only the Pelton wheels need to be obtained from other than local sources. A Watermotor can be made with hand tools and a drill press, though some welding is required. Most builders will find it convenient to have the hubs which connect the Pelton wheels to the shaft made by a local machine shop.

The efficiency of direct drive water power is a big advantage. A surprisingly small amount of water falling a short distance can produce the 0.5 to 3.5 HP of mechanical power required by most common machines. This means that many potential water power sites are available, and a minimum of civil engineering is required. Water is carried to the turbine by low cost, easily transportable plastic pipes. Rigid large diameter penstocks which require skilled installation are not necessary.

Other projects by Campo Nuevo include ferro-cement water storage tanks, ram pumps, hand powered water pumps, electric and treadle spinning machines, and adobe brick and plastic greenhouses.

The Watermotor itself is very simple to build, operate, and maintain. It functions efficiently in a variety of water power situations. By merely experimenting with easily changed water jets of different sizes, it is possible to vary maximum power output. This also allows the turbine to maintain efficient output over seasonal water flow variations. Control handles connected to the jets are used to divert water flow away from the Pelton wheels, cutting power.

Power Output

Regarding output and efficiency, you can determine how much energy you could get from a particular water power source by using this formula:

$$HP = H \times F \times E \times 0.18 \div 746$$

where HP is horsepower, H is total head (fall) in feet, F is flow in gallons per minute, and E is efficiency in percent. For the metric equivalent to this formula, see pages 42 and 43 in this issue.

Several things need to be considered along with this formula. Pelton wheels are usually about 75 percent efficient. There will always be some pressure loss due to friction in the water supply pipes. Your local supplier should be able to help calculate this for different products. Tables for pressure loss in pipes of various sizes can also be found in alternative energy catalogues.

The power output of the Watermotor depends on the fall and the amount of water used to run it. Here are some examples of other possible installations and the energy output that they would produce:

- A 100 foot (30 m) fall and 110 gallons (416 l) per minute would produce 2 HP at 2,050 rpm.
- A 150 foot (46 m) fall and 184 gallons (697 l) per minute would produce 5 HP at 2,550 rpm.

The Basics

The Watermotor can be used to drive most stationary machines normally driven by an externally-mounted electric motor or small gasoline engine in the 0.5 to 3.5 horsepower range. Power output can also be increased by simply lengthening the housing to accommodate more Pelton wheels, without basic design change.

Machines are driven by standard belts and mounted directly on or beside the turbine housing. The shaft between the Watermotor and the tool is 7/8 inch (22 mm), and the housing is about 12 by 12 by 14 inches (30 x 30 x 36 cm). The turbine must be mounted to accommodate the outflow without having water back up. We use a cement box as a tailrace, with a 4 inch (10 cm) drain pipe which returns the water to the stream.

Make the Comparison

How does the Watermotor stack up against the competition? I asked a couple of RE experts to give me the rough cost of a wind or PV system capable of producing 2 1/2 HP of mechanical energy 24 hours a day, including installation in rural Bolivia and technical expertise for maintenance and repair.

Richard Perez of *Home Power* said, “Well, the PVs alone will cost about US$35,000. And the requirement for 24 hour power at that level means a very large battery bank which will bring the system cost up to around US$70,000. And we still need to add small stuff like racks, inverter, and controls. Overall, I’d say about US$80,000. It really points out how cheap hydro is.”

North American wind power guru Mick Sagrillo said, “My guess, using off the shelf equipment, would be that you’d need a 10 KW Bergey Excel. While it’s larger than what’s needed, it’s cheaper than putting up several smaller turbines. The cost for both genny and controls is about US$20,000, less tower, wiring, batteries, and balance of systems components. Total system cost would be roughly US$35,000. The one message I always deliver at my wind power workshops is that if anyone has a good hydro site, they’re in the wrong workshop. While wind is cheaper than PV, it’s no comparison for a hydro site with a 100 percent capacity factor.”

Now, this is not a scientific comparison, and these are admittedly rough figures. But the Watermotor can produce 2 1/2 HP continuously—with a system cost of less than US$2,000. It’s user installable and maintainable (two lubrication points), and easily repairable. It has only one moving part, can be locally produced in a small shop, and is immune to damage from hard use. Also consider that PV and wind equipment are imported, and that there’s a good chance of damage from misuse or poor maintenance.

Watermotor type designs were abandoned about l00 years ago in the developed world in favor of electric motors. To the best of my knowledge, there are no machines equivalent to the Watermotor being produced today. Generally, very few products, no matter how useful, are produced with the aim of promoting self-sufficiency among the world’s rural poor.

Water Power to the People

The best advertisement for our water driven machines is for them to be seen hard at work by the many people passing the demo site daily. Woodworking machines in particular have a substantial per-hour cash value. Because the Watermotor is immune to damage from hard use, it is suitable to rent or lease. At current rates, the entire cost of a Watermotor installation should be recovered in only a few months.

We expect visitors to our demonstration site to have their own ideas about how they can use the Watermotor. The experience gained at this site will provide us with knowledge and incentive to build similar sites in other parts of Bolivia. Plans are available—contact us for more information about building and using the Watermotor.

While Bolivia is especially rich in water power resources, many other parts of the world have similar conditions, and similar needs. We would like to see this clean, self-renewing, easy to use natural resource made available to all.

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Author: Ron Davis, Campo Nuevo, Casilla 4365
La Paz, Bolivia • Phone/Fax: (59l)(2)350409
cnsorata@ceibo.entelnet.bo
www.zuper.net/camponuevo/