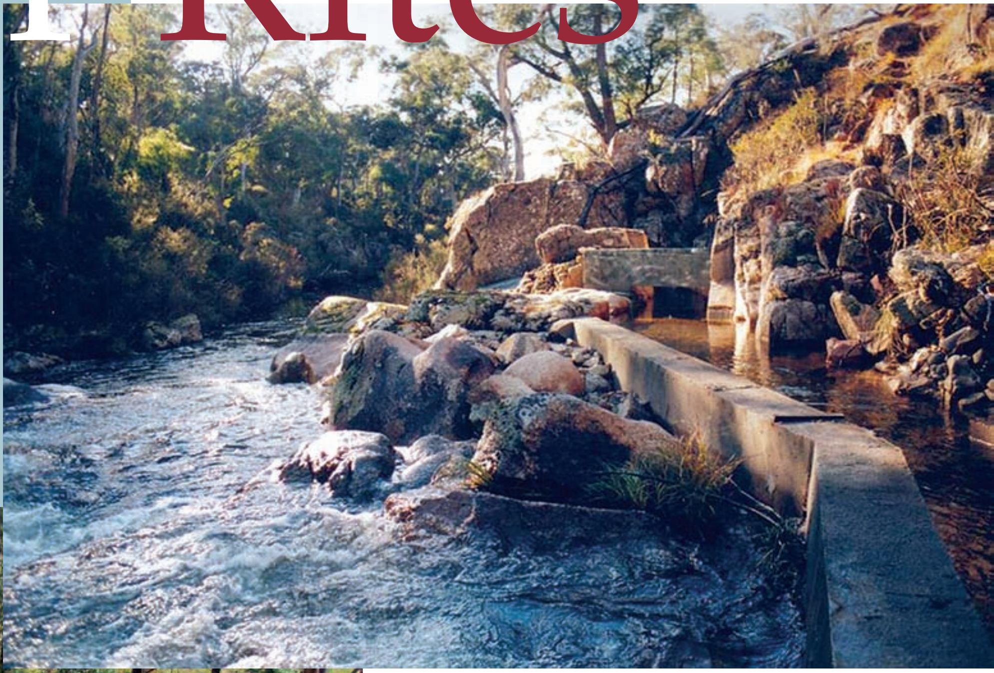
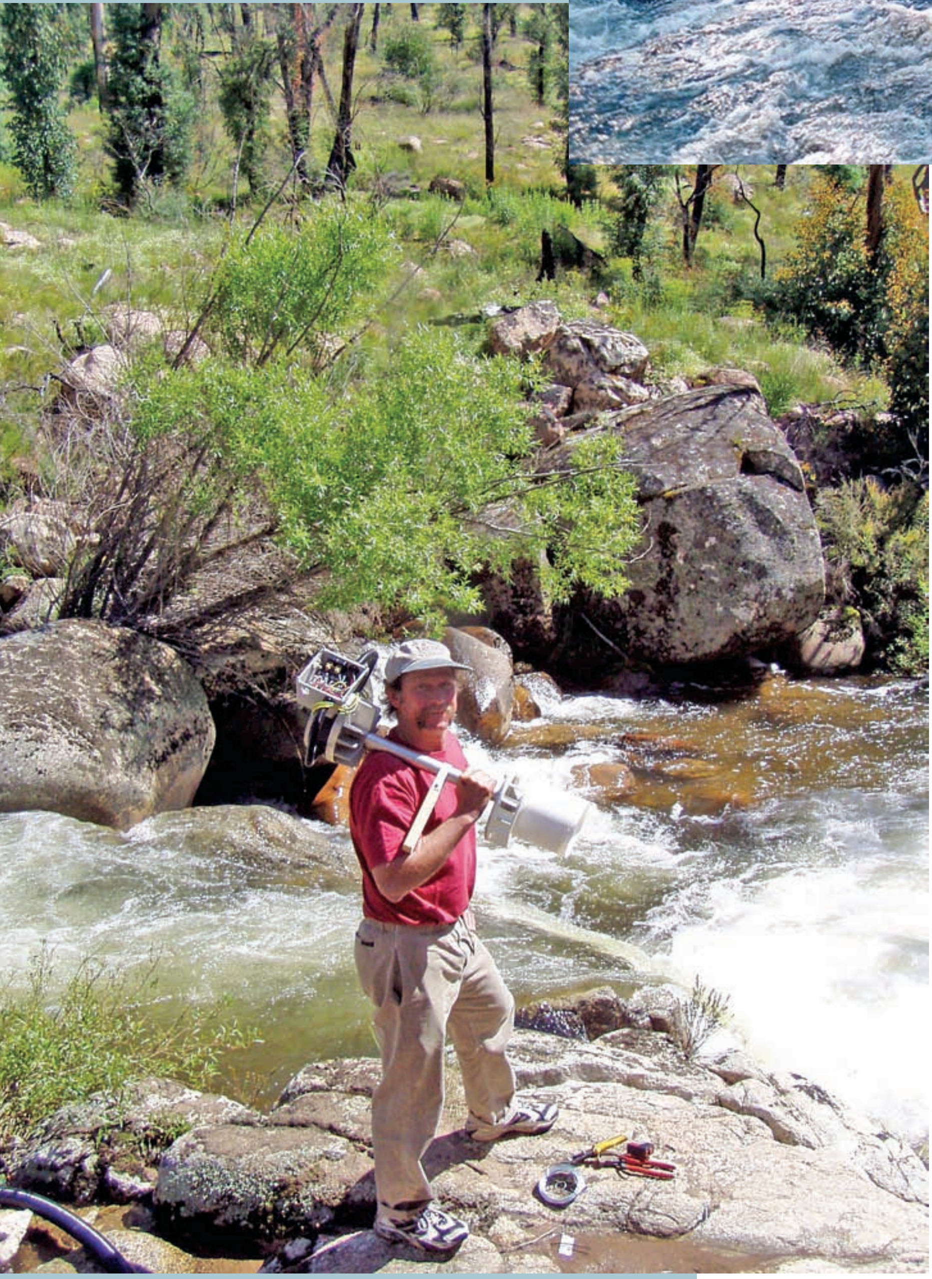
Water Rites

A Microhydro Evolution

by Jeffe Aronson





Above: The view downstream along the weir.
Left: The author with the new turbine.

Every morning, before brushing teeth or having a look at the weather outside our Victoria, Australia, off-grid home, my wife Carrie or I pad downstairs to the battery room to check the meters that monitor our electrical system. The reading determines whether we use the propane stove or the electric jug to heat water for our tea. Since our microhydro plant upgrade, it's usually the jug.

This ritual has become a part of our daily lives, like making the bed: A quick look at battery voltage and power from our microhydro system. It used to be a stomach-churning moment for us: Our previous microhydro turbine was dysfunctional too often due to its poor design, which meant a trip down to the river to clean the turbine blades—an uncomfortable and sometimes life-endangering task. Since replacing that "experiment" with an Energy Systems & Design (ES&D) LH1000 low-head turbine, complete with a prototype "leaf-mulcher," and new PV modules to back up the hydro, off-grid life's simply blissful.

Off-Grid with Comfort

Living in the most remote part of the Victorian Alps, 15 kilometers (9.3 mi.) from the electric grid, has not reduced my appreciation for flipping a switch rather than filling and lighting kerosene lanterns, using circular saws instead of hand saws, or for using other time-savers like toasters and microwave ovens.

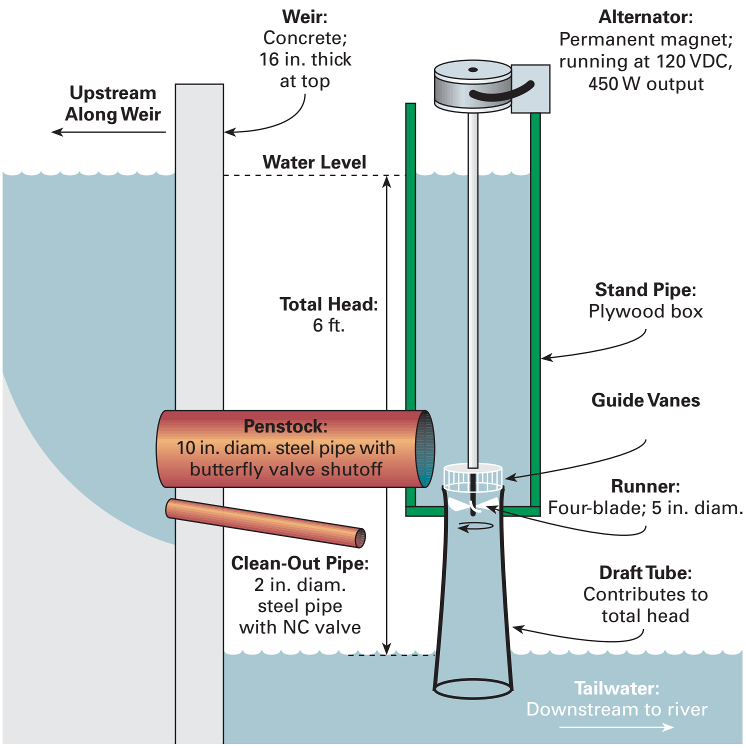
These days, although I'm an active 53 years old, I'm not content to spend my time chopping wood for cooking. Nor do I care to write by lantern light, or pull a coolish beer out of the river. Instead, I want plenty of free time to go trekking, kayaking, and skiing. Plus, I like my beer *ice cold*!

For the first few years, we had big problems with our original, locally engineered hydro plant (see "Choosing Microhydro…" in *HP101*). We feared that we'd made a huge mistake, as our time, money, and energy was sucked into the hydro like leaves. Friends and neighbors shook their heads at our folly. But our recent turbine upgrade has markedly reduced our "power plant management" needs, freeing several daily hours for ourselves, and now our off-grid life is good.

Microhydro Madness

It wasn't until after we installed our first contraption that we discovered it was a manufacturer's experiment in low-head axial turbines. Its many 90-degree angles impeded flow, making it inefficient. Its access port to the blades was too small for an average-sized adult, and usually under water, making debris clearing a freezing-cold, often dangerous nightmare. We kept a cardboard "turbine box" near the back door stocked with a dry suit, goggles, snorkel, life jacket, and safety rope. No kidding.

Hydro System Setup



Microhydro turbine manufacturer Paul Cunningham measures the penstock.

The author works on attaching the penstock to the stand box.

Up and running—the first power output test.

The turbine's poorly designed blades often came loose and rotated to the wrong angle, either jamming the unit or causing the turbine to lose a lot of power. The complete turbine weighed in excess of 200 kilograms (441 lbs.), making its removal a time-consuming process that required a winch.

Another unfortunate problem was that we weren't informed to build the intake with debris screening in mind. All hydro plants have to contend with leaves, sticks, and other detritus. Because of the turbine and intake's design, we had to fiddle and mess with the turbine often, sometimes as much as three times a day. In contrast, a well-designed turbine intake should require a screen- or blade-cleaning perhaps once a week or, during summer low flows, once every few weeks. Unfortunately, when

Above: The new and improved clean-out procedure.

Right: The old, cold clean-out procedure.

Far right: A close-up of the custom leaf mulcher.

Hydro & PV Tech Specs

Overview

System type: Off-grid, battery-based microhydro-electric with PV

System location: Victoria, Australia

Site head: 1.8 m (6 ft.)

Hydro resource: 125 liters/second (30 gal./second), dry season; 190 liters/second (50 gal./second), wet season

Hydro production: 252 KWH per month ave., dry season; 291 KWH per month ave., wet season

Solar resource: 4.7 ave. daily peak sun-hours

PV system production: 45 KWH per month ave.

Hydro Turbine

Turbine: Energy Systems & Design LH1000, low-head propeller

Runner diameter: 5 in.

Alternator: Brushless permanent magnet

Rated peak power output: 1 KW

Hydro Balance of System

Hydro turbine controller: AERL Maximizer

Dump load: Two 400 W heat coils (resistors)

Inverter: Solar Energy Australia 2500, 24 VDC nominal input, 220 VAC, 50 Hz sine wave output

Circuit protection: 30 A breaker

System performance metering: Plasmatronics PL20

Photovoltaics

Modules: Sharp, ND-L3EJE, 123 W STC, 17.2 Vmp, 12 VDC nominal

Array: Two, two-module series strings, 492 W STC total, 34.4 Vmp, 24 VDC nominal

Array disconnect: 40 A breaker

Array installation: Homemade steel mount installed on north-facing roof, 48-degree tilt

PV Balance of System

Charge controller: Plasmatronics PL40, 40 A, PWM, 12–48 VDC nominal input and output voltage

Inverter: Solar Energy Australia 2500, 2.5 KW, 24 VDC nominal input, 240 VAC, 50 Hz output

System performance metering: Plasmatronics PL20

Energy Storage

Batteries: Lucent 1AVR 2/85-75L, 2 V nominal, 1,200 AH, sealed, valve-regulated lead acid (used telephone co. batteries)

Battery bank: One, 12-battery string, 24 VDC nominal, 1,200 AH total we first built the weir, we did not understand the importance of a debris-screening strategy. Proper design greatly minimizes, or can even eliminate, manual debris removal. Including screening in the original design would have been easy, but now such an addition would be more difficult.

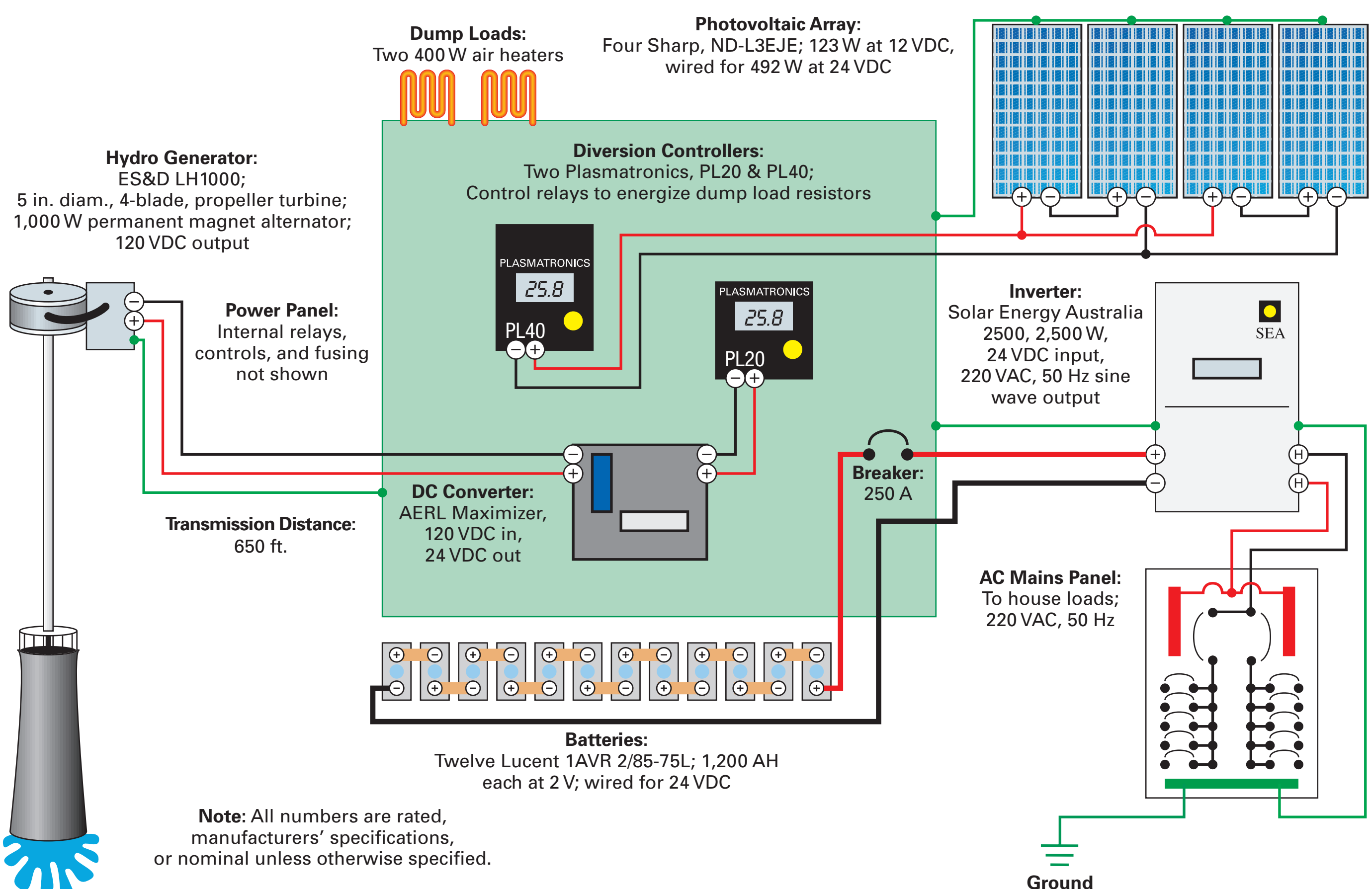
Our original turbine's 350-watt maximum output usually lasted only an hour or so after debris was cleared. After that, frequent checks of our Plasmatronics PL20 display would show the power declining steadily until we'd take our next forced march down the steep hill to reclean the turbine blades and intake screens. I dreaded the next flood or power drop, and dreamed of just going back to loving whatever mood the river was in. That cranky turbine cost us AU$6,000—three times more than the new ES&D LH1000 we replaced it with. Our naïveté and rush to build the hydro system cost us dearly—in money, time, and energy. On the plus side, we learned heaps about microhydro systems and renewable energy, and had in place all the other balance of system equipment—wiring, batteries, inverter, and regulator—for a new turbine. But we'd finally had enough—after five years of struggle, our patience and nerves were at an end, so we decided to replace the flawed turbine.

Through a microhydro e-mail list-server group (see Access), we received advice from several folks. Paul Cunningham, of ES&D in Canada, read my *Home Power* article from 2004, and felt that one of his turbines would work for us. The LH1000 turbine he recommended was a fraction of the size of our original turbine, weighing about 20 kilograms (44 lbs.). It has a strong, cast bronze runner/propeller, and could be made to offer blissfully easy access for unclogging.

We decided to give it a try and ordered one. Though Paul offered excellent support and advice over the phone and Internet, we invited him to visit us in Australia and help with the installation, and he accepted.

The power wall.

Aronson Hydro & PV System



Here, the stand box is coated with silt from a flood, but the turbine itself is easily removed if the river is approaching flood stage.

New Nuts & Bolts

With water flows of at least 125 liters per second (1,981 gpm), even during extended drought, and an average 1.8-meter (5.9 ft.) head, the new turbine was projected to provide at least 450 watts. Compared to the old machine, the new turbine required about 50 liters per second (800 gpm), so there was enough water to install two of the ES&D machines if need be.

It took half a day to remove the old turbine, and six people and a truck winch to drag the behemoth up the hill, where it remains lying in the long grass like a carcass. I've since sold its generator—a washing machine motor—for a couple hundred bucks, assuaging my need to recoup at least something from the beast.

It took just another day and a half to nut things out at the river with Paul. We built the plywood box that channels the water to the turbine and carried it down to the river, where we bolted it to the intake pipe. After making some adjustments, we slipped in the draft tube, clamped the new turbine to it, and opened the butterfly valve at the inlet. Just like that, we were up and running, and everything worked great on the first try! What a relief!

Sticks & Stones

We let our new turbine run for the first summer as-is, experimenting and observing. It worked well, regularly putting out about 450 watts. The debris problem remained, but was greatly diminished. With the old turbine, sticks, stones, and leaves worked their way to the blades. These would either clog the blades, or a stone or stick might even break one. Removing the clog meant the water torture of shutting down the turbine, opening the intake, which was often below water level, reaching and contorting to get an arm down to the blades, and grabbing out the glop bit by bit—all the while kneeling chest-deep in freezing water. Not fun.

But the ES&D turbine needs only minor cleaning. The new and improved muck-out process simply involved shutting the intake butterfly valve, removing one wall of the box, and sticking a finger or two through the vanes to wipe the tiny leaves and algae off the blades—all at eye level, high and dry above the water line. The shape of the inlet vanes prevents sticks from reaching the blades. Although stones can still get drawn into the box, they drop safely to the bottom, awaiting removal the next time the access port is opened. The concern became small leaves and algae, which drape themselves over the blades, slowing the turbine and reducing power.

Through the microhydro list server, I communicated with Michael Lawley of Eco Innovation in New Zealand. He'd been having similar debris problems with his Vietnamese-made, low-head unit, which he'd solved by inventing a simple "leaf-mulcher." Paul and I decided to adapt this great idea to our turbine.

The mulcher is a little piece of plastic with its end shaped to mirror the blade tops. It extends down below the inlet vanes about 1 millimeter (0.04 in.). Centrifugal force keeps the leaves at the outside edge of the blades, so the mulcher does not need to stick out very far. As the four blades spin, each passes by the mulcher 1,500 times a minute, which knocks or slices off the buildup. We had the mulcher in place all last summer and never once had to clean the blades! Plus, instead of reducing the turbine's power, its output actually increased!

Now, our cue to clean the new turbine kicks into gear when the meter shows the turbine output dropping to between 10 and 11 amps (from 13 to 15 amps normally), which, in summer or winter, can occur after several weeks, or, in autumn, after several days, instead of just a few hours. One of us strolls down to the falls and turns off the intake butterfly valve to drain the chamber. Then the valve is reopened a crack to direct a high-powered water jet onto one side of the inlet vanes, which washes the leaves and algae from the blades. Once that's finished, we open the valve fully to fill the box and restart the turbine.

RE Reliability

With a few lights and the stereo going, our household loads vary between 100 and 150 watts, depending on whether the fridge and/or freezer are running. If we use the microwave, toaster, or electric tea jug, the load can briefly increase to 1,200 watts. With our microhydro system, these loads are no problem at all, and, within a few minutes, we're back to dumping the excess energy from the hydro plant. Unlike off-grid homes that rely solely on small PV systems, where "phantom" loads from TVs, stereos, computers, and microwave clocks must be scrutinized, our hydro's continuous output means that we can just ignore them.

We recently added 492 watts of rooftop PV modules to our off-grid system. It's a cleaner, quieter backup to the microhydro system than an engine generator and has turned out to be a wonderful complement. During instances of flooding or, more rarely, when the turbine has to be shut down for maintenance, we still have enough energy to run most of our common household loads.

When the sun shines fully, the modules produce up to 450 watts. At the same time, the hydro is producing as much as 450 watts. When everything's humming, the systems produce as much as 13 kilowatt-hours (KWH) daily! This is much more energy than we normally need, but having the two separate energy sources means that when the river is flooding or we're doing maintenance on the hydro, or conversely when the sun's been behind clouds for weeks, we still have plenty of energy.

With solar-made electricity, when the batteries are full, a charge controller cuts back the energy from the modules. But with microhydro, energy production does not stop—as long as water is flowing through the turbine. Switching off the electricity between the turbine and the battery will cause the turbine voltage to go too high. This scenario can create big problems, so those electrons have to go somewhere. When our batteries are full, a diversion controller shunts the excess hydro power to an air-heating resistance "dump load," dispersing it as waste heat, and keeps the turbine electrically loaded and running at the proper rpm.

Have a Cold One

We are quite pleased with the way the systems are working. No longer slaves to our turbine, we can leave for days without worrying about food in the freezer thawing. During floods or long bouts of clouds and rain, we don't have to hassle with a backup generator. Even in rare instances when the river is in flood and there are also several days of heavy cloud cover, we employ energy-conscious practices to make the energy stored in our battery last for two or three days.

There are still some projects ahead. We'll install a more permanent, metal turbine box, with a discreet cover to protect the turbine from flood debris and to hide the equipment from hikers, anglers, and our view. We'll be using some of our newfound time to plan a better pre-screening system to prevent debris or fish from working their way to the turbine box. Finally, we have a water heater coil awaiting installation in a hot water tank, so the excess energy our system makes can be put to good use. After these upgrades, we'll take a long break and have that ice-cold beer, compliments of our fully functional RE system!

Access

Jeffe Aronson (jeffe@tpg.com.au) is a 33-year veteran river guide, having rowed and paddled in South America, Australia, Africa, and the United States. He's owned a natural foods store, pioneered river trips in the Grand Canyon for disabled persons, and directed the historic restoration of downtown Flagstaff, Arizona.

Turbine Manufacturer:
Energy Systems & Design • 506-433-3151 • www.microhydropower.com

Information & Help with Microhydro Systems:
Microhydro Listserv • microhydro-subscribe@yahoogroups.com • www.groups.yahoo.com/group/microhydro