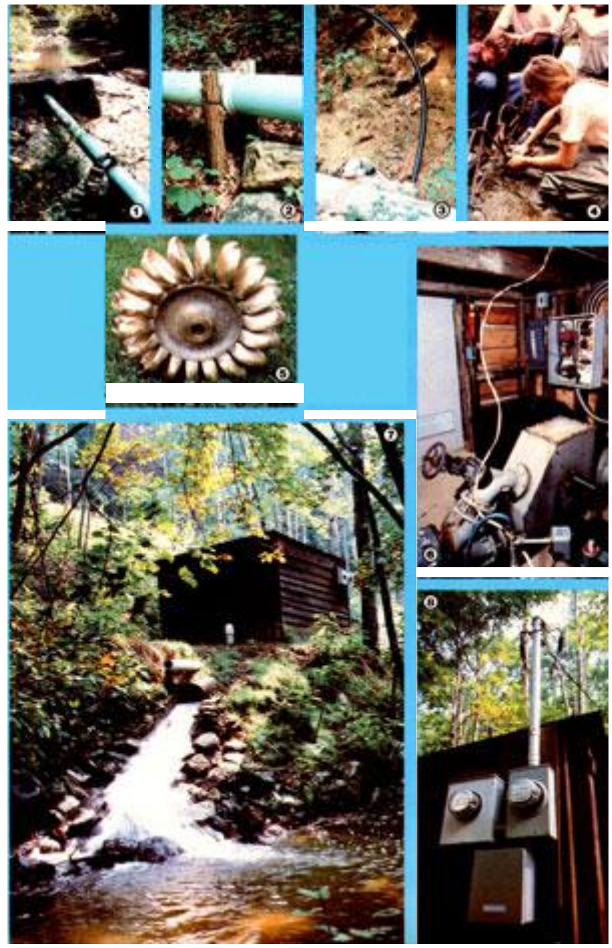
A PROFITABLE PRIVATE MICROHYDROELECTRIC PLANT



It would be easy to get the impression, in the face of the controversy and publicity that have been generated by nuclear energy of late, that fission-derived electricity is the main source of generated power in the United States. Therefore, you might be surprised to learn that only about 10% of this country's electrical needs are actually provided by reactors . . . and that a renewable resource, hydroelectricity, actually outstrips the atom in terms of total watts produced.

Unfortunately, most major rivers were dammed decades ago, and little hydropower capacity has been added in recent years. And that's a real pity, because water power has consistently proved to be the least expensive way to generate electricity and is—many authorities believe—the most environmentally benign method, as well. However, there is significant untapped hydropower potential in small streams, and this source of energy may be particularly appealing to enterprising individuals with an eye to the future.

Microhydropower is the Department of Energy's term for any installation with less than 100 kilowatts (KW) of capacity. (To put that number in perspective, consider that most households use an average of about 1 KW per hour, while a nuclear plant might generate about 1,500,000 KW per reactor.) In the past, the expense of building these very small hydropower plants couldn't often be justified by the value of the power generated . . . but, as most of us are painfully aware, the cost of electricity isn't what it used to be. Today, a resourceful person with access to some capital can put together a microhydro site for a price that makes sense as a long-term investment.

DO IT ON PURPA

One of the main factors making it possible for a small hydro site to become a moneymaking proposition is a federal regulation: Section 210 of the Public Utilities Regulatory Policy Act of 1978 (PURPA). Among other things, the edict specifies that power companies must purchase power from independent producers at what is called "avoided cost". This means, very briefly, that the utility is forced to buy the power (which wasn't the case previously) and that the producers should be paid what it would cost the power company to generate the same amount of electricity. [EDITOR'S NOTE: This is all a great deal more complicated than it sounds . . . so much so, in fact, that the regulation has been challenged in the Supreme Court. Nonetheless, nearly all utilities do buy electricity at this time.]

Of course, few companies are paying as much for power as they're charging for it. (After all, the utilities have such additional expenses as supplying the lines, customer service, billing, etc.) But PURPA has made it possible for small producers to receive at least some payment for the electricity they're capable of generating. And with buy-back rates (the price paid by utilities to small-scale power producers) running between 2¢ and 10¢ per kilowatt-hour (KWH) across the country, microhydropower is capable of becoming a paying proposition.

LAUREL CREEK HYDROELECTRIC

Perhaps the best way to understand the potential of microhydropower is to examine a successful example. Several of MOTHER's staff members have been keeping an eye on one such project since its beginnings, and recently paid a visit to the finished site to see it in full production.

The Laurel Creek microhydropower installation was started back in 1980, when a group of individuals—working under the auspices of the Blue Ridge Group Sierra Club and Appalachian State University (both of which have their headquarters in Boone, North Carolina), and cosponsored by the Blue Ridge Electrical Membership Corporation (BREMCO)—got a $21,416 Department of Energy Appropriate Technology grant to study the microhydropower potential in Watauga County, North Carolina and build a demonstration site.

Laurel Creek, the waterway they chose, is a cascading mountain stream in the western part of the county. The group erected a tiny (two-foot-high) dam, which diverts water into a penstock . . . and from that point, 1,640 feet of 8"-diameter plastic sewer pipe stretches down the mountainside next to the creek, for a total drop of 178 feet.

The crew had several good reasons for deciding not to build a more typical tall dam. First and foremost, they were able to avoid the primary disadvantage—in the environmentally oriented minds of the developers—of large hydropower installations: the need for flooding the land behind the dam. Second, from a practical standpoint, the diversion and pipe arrangement allow much more drop (or "head", in hydro terminology). Third, getting permission for their project—which required only a verbal OK from local wildlife agencies—was less complicated than it would have been if construction of a larger installation had been planned. And finally, the expense—even though the pipe alone cost more than $5,300—was a small fraction of the investment that's necessary to build a big dam.

Of course, before any work was done, the rate of water flow in Laurel Creek was measured on a regular basis and its profile compared with that of other streams in the area (as gauged by the U.S. Geological Survey). Once all the data were analyzed, Dr. Harvard Ayers (the program director) and builders Andy Feimster and Bob Powell decided to take no more than 2.5 cubic feet per second (CFS) of water—or 1,125 gallons per minute—from the creek. That amount equals about one-third the mean flow in the stream . . . and will leave sufficient water for aquatic life, while allowing the plant to operate about 90% of the time. (Should a severe drought occur, a partial or complete shutdown of the system would be required in order to maintain flow in the creek.)

Once friction losses in the 8"-diameter pipe were calculated, the designers found that they had 145 feet of head to work with. And since any figure over 60 feet is considered to be within the efficient range of a Pelton wheel, that popular and widely available turbine was the obvious choice. The 15 "-hydraulic-diameter runner (which was supplied by Canyon Industries in Deming, Washington) looks much like a thick plate with a number of oddly shaped spoons attached to its periphery. Water shoots at the buckets from two 2"-diameter nozzles to spin the manganese bronze casting. The shape of the cups splits the jets and ushers the water out to the sides of the housing . . . where it falls (having given up its energy) and exits through a drain in the floor.

This rather primitive-sounding device spins at 720 revolutions per minute (RPM)—under the force of the roughly 156 pounds per second of H_20, moving at just short of 65 MPH, that strikes it—and the net result of all this action is the generation of about 30 horsepower at the 1-5/8" shaft. The turbine is linked to the generator by a pair of V-belts that run on adjustable pulleys sized to provide a speed increase of 2.54:1.

The generator itself is actually a 50-HP, three-phase induction motor that—since only two of its "legs" are used—is run as a 30-HP, single-phase generator. It was purchased used, but entirely rebuilt, for only $500 . . . a price that represents a saving of about a thousand dollars when compared with that of a new synchronous generator.

Besides its low cost, the induction generator has another very useful property. When operated as a motor, it receives power from the grid and spins somewhat slower than the standard synchronous speed of 1,800 RPM (this difference is known as its slip speed). But if the induction motor is driven to the slip speed above 1,800 RPM, it begins to generate power. Furthermore, at that point the utility line's signal still regulates the voltage and frequency of the power being delivered (a process called grid excitation), so no complicated and expensive speed control is needed to insure that generator and utility stay in phase.

There are, however, a number of protective circuits needed to make the two-way hydro/utility hookup safe. The Laurel Creek control panel—the design for which was donated by an electrical engineer, Richard Suhre—includes over—and undervoltage relays, a frequency relay, and a starter used for getting the system up to speed. In addition, because the generator depends on the power company's grid for voltage and frequency regulation, it was necessary to devise a way to shut down the plant in the event of utility failure. (This also protects any power company workers from being shocked by water-generated electricity when they're repairing defective utility wires.)

The arrangement the team developed consists of a simple, fail-safe bypass that diverts water from the turbine in the event of a power failure. During normal operation, a valve in the diverter pipe is held closed by compressed air and a solenoid. But if grid power is lost, the solenoid automatically kicks open . . . releasing the air, opening the valve, and thus allowing the water to go around the turbine. When it's time to start up again, the diverter valve is closed, with the help of either a footoperated pump or a small compressor.

Two meters monitor Laurel Creek Hydro's performance. One unit registers the amount of power consumed at the site for lighting, compressor operation, etc., and the other measures the current going back into the grid. Of course, the former reading indicates the electricity charged out at BREMCO's retail rate, and the latter refers to that paid back at the contract price of about 3¢ per KWH. (This two-meter method is the most common utility-accepted arrangement.)

THE DO-IT-YOURSELF CONTINGENT

Thousands of hours of volunteer labor went into the construction of Laurel Creek Hydroelectric, and this "sweat equity" was vital to the project's maintaining an attractive "bottom line". However, careful selection of materials and equipment also played a big part in keeping costs down.

For example, Andy and Bob built the powerhouse from recycled timbers and roughcut siding in order to save on lumber costs. They also made such components as the equipment lifts, the turbine housing, the belt guards, and the control box . . . instead of purchasing them. At the intake end, no more ready-mix concrete than necessary was used. The dam was tied to bedrock with rebar . . . poured . . . then covered with hand-laid rock.

The group also showed considerable ingenuity in dealing with the often tricky problems of pipe mounting. The top three supports are made of reinforced concrete and rock, but those down the remainder of the run consist of hand-split locust poles. The posts were pounded into the ground with'a wooden sledge, and the pipe was lashed to them with cable. At one point, where the penstock had to span a small ravine at a height of 7 feet, several pairs of thick locust poles were set in concrete to support the needed bridge.

The secure mounting of the pipe is particularly important in a high-head hydro site because of a potential problem called "pipe hammer". This disturbance can occur if a valve is inadvertently shut off too quickly . . . it's akin to the banging that sometimes takes place when a tap is closed in a poorly plumbed house. However, whereas "faucet rattle" is merely annoying, even minor pipe hammer in a hydropower penstock can easily destroy a poorly mounted system.

Another disaster that had to be guarded against was pipe implosion, which can be caused by the vacuum created behind water flowing from a pipe with its intake closed. To prevent such a calamity, Andy and Bob installed an air bleed near the top of the penstock. A 3"-diameter polybutyl pipe is connected to the 8"-diameter plastic and runs uphill to a point 10 feet above the intake. Thus no water can escape through the tube, but air can be drawn in if necessary.

FINANCES

Dr. Ayers estimates that, if the group hadn't saved money through the use of donated labor and careful equipment selection, the finished price for the site could have totaled more than $50,000. He hastens to add that one cannot, today, hire an engineering firm to develop a plant of this size and expect to make a profit.

As it stands, though, the ratio of dollars invested to KW capacity is quite favorable at Laurel Creek. With just short of $22,000 spent and a delivered output of 17.5 KW, the price per KW is well under the widely accepted guideline of $1,500. In fact, as a point of reference, Laurel Creek Hydroelectric was put on line for less money per KW than it costs a utility company to build a coal-powered plant.

In purely economic terms, the generator will deliver an average of about 132,000 KWH to BREMCO each year, bringing in a gross income of about $4,000 annually. (This figure will, of course, rise as electric rates go up.) Maintenance should be minimal—including bearing lubrication, belt dressing, trash rack cleaning, and inspection—so the major expense to be considered is capital. If the money used for Laurel Creek's construction had been borrowed at prevailing rates (which, of course, it was not . . . being a grant), the system would net about $200 each year (and more as rates rise) for ten years, at which point it would be paid off: From that time until the end of equipment life—a minimum of ten years more—the income produced by the site would be largely profit.

Still, the most difficult aspect of developing a microhydropower site—beyond acquiring or getting access to the necessary expertise—is raising the money. Grants similar to that which provided Laurel Creek Hydroelectric's source of capital have dried up with the "new austerity", and the possibility of federally backed loans is doubtful (the mechanism is there but no funding has yet been provided). And since the costs will run at least $1,000 per KW of capacity, the total sum would add up to more than most folks' savings accounts. Furthermore, banks are likely to be reluctant to make loans, simply because the concept of a profitable small—scale power—generating facility is so unfamiliar. For now, sites such as Laurel Creek offer the best references you can provide to lenders.

Finally, unless you're lucky enough to find one of those increasingly rare "small hydro" sites (the DOE's designation for those between 100 and 3,000 KW), you're not likely to be able to retire on your miniutility's income. Yet there are tens of thousands of locations along small streams in the U.S. that could be developed profitably, and their net power production might well eliminate the need for several nuclear plants. (For example, in a 24-county area of western North Carolina alone, it's been estimated that there may be as much as 10,000,000 watts of potential . . . enough to supply several thousand households.)

A few years ago, experts interested in very small hydroelectric site development were concerned with the question of whether developers could afford to build such installations. The question that's more frequently heard today is, "Can we afford not to build them?"

COST BREAKDOWN FOR
LAUREL CREEK HYDROELECTRIC

Dam	$ 763.68
Pipe	5,338.63
Powerhouse	1,948.36
Turbine	6,716.85
Electrical equipment	2,934.15
Drive	876.98
Other hardware	1,749.87
Utility connection	1,550.00
	$21,878.52