Micro-hydroelectric Installations:
A beginner's perspective

Bob Fife is manager of a company that manufactures micro hydro equipment, but until he decided to help out some clients with his colleague Paul Cunningham, he had never taken part in an installation himself. There were some surprises in store when he put theory into practice.

Late in the summer of 1998, we received a call from Valerie, a woman representing Earthaven Ecovillage, an intentional community in Black Mountain, North Carolina, USA, who sought information regarding the hydroelectric potential at their community. This began a learning process unlike that faces me day to day. Usually, my workplace is a modest shop in New Brunswick, Canada, where I control the environment and set the tone; on site, I would be at the mercy of the elements, the geography and those with whom I would be working.

Site Assessment

Planning the system from our shop in New Brunswick, I began with a preliminary site assessment, as I usually do when contacted by a potential client. These are difficult to do at times, depending on the skill level and experience of the individual, but in their simplest form can be reduced to a few elementary concerns that are common at any potential installation:

1.What are the load demands of this potential system? 2.What resources are available to meet this demand? (Accurate head and flow figures are vital if the suppliers are to be of any help to their customer in matching the resources to the most suitable turbine design, and in accurately assessing the power output potential.) 3.What is the transmission distance from the site of generation to the site of use? This will determine the voltage, and therefore amperage of the transmission, in order to gauge potential losses along the lines. Large gauge wire may be necessary, or transformers. 4.What size and length is the pipeline to be? Choosing the proper pipe diameter can deliver the water to the turbine with a minimum loss and a maximum amount of power. Friction losses due to undersizing can reduce a potential site to a pitiful disappointment.

Load demand

Load demand was a minor consideration because the community required all the power that could be generated. They were relying on a few PV panels to provide power to some buildings. At the outset, Valerie sought a system which might equally divide output between four separate structures (she thought perhaps a timer for 6 hours charging per location) but for reasons of cost, simplicity of design, and the pre existing Trace 5548 inverter, it was decided that a centralized system -- using this large inverter to transmit power to its points of use -- was most appropriate and effective. After all, to decentralize a scheme in this manner would require four smaller inverters, four battery banks etc., which would drive the cost of this project up prohibitively, and complicate future maintenance.

Resources

The water resources were described as about 15 metres of static head, and a minimum flow of 750 litres/metre, which showed promise as a power source. Using the formula Hn (net head in metres) x Q (flow litres/metre) / 8, the power potential in this body of water was found to be approximately 1400 W continuous, which is a generous battery charging scenario, to say the least. By cross referencing the head measurements with a RPM chart, we found that our generator could achieve 1300 rpm; since our generator produces approximately 400 W/ l000 rpm, we estimated the output potential from one of our generators (I will be calling the electricity generating component of our system a generator despite its production of AC. It is immediately rectified, in most cases, and transmitted as DC, and it is the generic sense of the term, generator, to which I refer) to be between 520-550 W. This site was indeed viable, and we agreed to explore it with the community.

Transmission distance

The transmission distance was found to be negligible, as the turbine was to be positioned next to the battery shed. This said, we used 10 gauge wire to lead front the turbine to the batteries but in some cases, a turbine may be a considerable distance from the point of use, and high voltage transmission may be necessary, or large gauge wire, in order to minimize line losses {see article entitled Long-distance power transmission for renewable energy systems, REW September 98, page 72). Something to be kept in mind is that one can never possess too many good tools, and in this instance, a simple wire loss table goes a long way, with Ohm's Law, to helping find the most suitable wire for any given transmission distance. A collection of up to date, accurate tables will always be useful.

Pipeline

The pipeline was already installed when we were contacted, and measured 300 metres of 10 cm polyethylene. Once again, the use of a pre-existing chart allowed us to cross-reference the pipe size and type to determine the friction losses for this installation at this head and flow. They were found to be about 3 metres loss at a flow of about 400 litres/metre (this corresponds to a nozzle size of 22 mm) at this site which gave us the net, or 'dynamic' head of 12 metres or so. This completed the picture with regards to information and allowed to determine what the potential was, in this instance, and to proceed to what might be called the 'hands on' stage of the installation.

Packing

It is at this point that the more trying stage of the installation begins. In this, as in most cases, the installers find themselves faced with the most difficult of issues: how, and which equipment, does one pack in order to complete the installation of a system which is usually miles distant and often with limited resources beyond those packed; it is difficult to fashion custom tools from those which are more commonly found, so be prepared, and be flexible. We settled on a list which was thorough, and seemingly complete (even so we found ourselves without a few tools) so before setting out over what may be a long trip, it is a good idea to determine your eventual proximity to the nearest hardware and plumbing supplier. (We were assured that everything would be ready and waiting when we arrived, but in several instances found components missing. This is the nature of the game. However, with willing help and a co-operative effort, these obstacles were overcome and the components found.)

My associate, Paul Cunningham, and I packed an array of tools and resources, including the following: a complete set of sockets and wrenches, a good, reliable multi-tester, pipe wrenches, plumbing tape and cements, literature (manuals for the support components of the system), and a range of screw drivers, wire strippers, and miscellany. There is not room to include the complete list of the tools necessary, but the ones listed above are essential. It is wise to over-pack rather than under-pack, keeping in mind that its better to not need a tool and have it than vice versa.

On site

Feeling as though we were prepared, and familiar enough with the site, we set out to Earthaven to undertake the installation. The community was a collection of 35 or so members who had carved a niche in the beautiful southern Appalachians. They lived in everything from straw bale and wood-frame houses to a collection of tents, tarpaulins, and yurts which housed the semipermanent members, and the newly arrived. Paul and I were glad to discover that we were to be lodged in a beautiful wood-frame cottage, with a lovely deck overlooking the stream, and a small garden plot that accompanied the dwelling. It was a beautiful home base from which we would operate for most of the next week. As soon as we settled in, a preliminary survey was in order, and we set off into the lush North Carolina forest.

The community had constructed the supporting infrastructure for their micro hydro system at the tailrace of their pipeline, and to our surprise, we found they had constructed a small wood-frame outbuilding (of scrap wood they had milled themselves), which was to house the electrical components, along with a cinder block battery storage compartment with a separate turbine compartment - all in the shape of a boat so to survive the eventuality of a seasonal flood! Not only were the type and design of the buildings unusual, but we had also advised against any permanent concrete work before seeing the turbine (I had seen too many construction sites in other trades gone wrong to wish this upon these people, and knew how far astray the eager and inexperienced can go in a desire to be helpful). Our first appraisal was therefore a critical one, as their concrete work was not only insufficient, but the bolt pattern for the turbine had been incorrectly installed and the turbine support was undersized in the interior dimensions. A judicious blow or two with a sledge hammer, and a few hours of reconstruction, left this section in fine order. The wood frame building was in need of some elementary carpentry, and was still in the works when we left.

These deficiencies are pointed out in order to demonstrate two points. The first is that you never know what you'll find when you arrive on site, so be ready to react to circumstances constructively and with an eye to the clock. And secondly, the system you are about to install is an investment of several thousand dollars, mountains of research, and something that will be depended upon for years to come, so make the supporting structures first class and budget for good, sturdy buildings to protect and maintain these vital pieces of equipment.

Plumbing

Installation of the final plumbing was to be a bit trying, despite the already installed pipeline. It is here that I learned a valuable lesson as a foreman/group leader: be sure to 'take the bull by the horns': give clear, unmistakable directions and ensure that they are followed to the letter when necessary. Despite the clearest of instructions, including a list, a few 'free thinkers' can really cause chaos when they decide to interpret where no interpretation is wanted. (We required a wide array of plumbing fittings and supplies, and it took several trips by one of the group leaders before he finally fathomed that we really did want what was on the list rather than what he thought we needed! Next time I will take charge in an unmistakable fashion so as to meet time constraints and budgets. However, despite these difficulties, the plumbing was secured and we proceeded.)

We split the 10 cm (4 inch) pipe with a Y and from this ran two 5 cm (2 inch) adapters. These were coupled again to 38 mm (1½ inch) adapters which were joined to flex hose leading to the nozzles on the turbine. It is important to bring the large diameter pipe up as close as possible to the turbine before reducing its size to minimize friction losses (see photo in 'Micro HydroElectric Evolution' REW July 98, page 60). Then, by using flex hose, the friction losses are minimized further as the water is sent around a slow curve, rather than a series of sharp bends. If these friction losses are kept minimal you can really draw a lot of power from surprisingly little water.

Electrics

Paul and I proceeded to install the Trace 5548 inverter, the Trace C40 charge controller, and the load centre. Needless to say, this was a real eye opener for me. 1 have never been gifted when it comes to electrical matters, but I soon found out that the manufacturers of these products have people like me in mind. The products are very user friendly as long as no assumptions are made, and homework is done. The process went rather smoothly, and the community had a couple of residents who were rather competent in these matters; they made a great tithe of this work as we all explored the technology, and relied on one another to do a good job. Aside from these things, the actual installation of these components is a real delight. It is sometimes amazing to behold what it is we humans can do when we think it out. The 16 batteries were placed into a 48 V configuration, and placed into their compartment. Then all of the components were linked together, and the turbine inspected to see that all looked all right. A good visual inspection is usually an excellent way to begin start-up; if something looks wrong, it may well be, so take a close look around, and follow your instincts.

Turning on

As we opened the valve to the turbine, we found the machine began to 'freewheel', or run in operation without a load on it. This is indeed a serious situation so we immediately closed the valve and investigated further. When a generator is run without a load,

voltage can rise to very high levels, and can cause damage to the unit itself. With this in mind we quickly found a breaker to be tripped, and reset it. We opened the valve again. Same results, and again, another secondary breaker in need of attention. But, third time lucky, and when the valve was reopened, the generator wound up under a load, and the ammeter began to register. It seemed I had completed my first installation with neither damage nor death to my credit. That spelled success to me. The community had still not used their consensus style decision making process to decide upon a diversion load, but the two women who worked with me during the installation, Ellen, and Adeha, reassured me it could be handled, and the batteries still had a while to go until they were charged anyway. Besides, they weren't exactly sure what they would do with all the power.

The final results were tremendously encouraging. With the 48 V battery bank at about 50 V, the amperage hovered around 12 A. This gave a final output of 600 W, thereby more than doubling the community's generating capacity. Paul and I were delighted, and the rest of the community concurred.

This was the ultimate in renewable energy schemes in many ways, from our perspective. Not only was a water powered generator installed, which would sustainably provide power to this community for years to come, but the community itself was renewed to an extent. In their search for a way of life that was friendly to the planet, and each other, this new power source would allow development and continuation of their ambitious agenda. The permaculture with which they experimented, their forays into alternative construction methodology, and the collective governing that they employed all benefited from this development of reliable power. As in many developing countries, the stability inherent in reliable infrastructure has given a little more freedom to the individuals to pursue higher goals than mere survival, and has attracted new members to their society whose ideas and energies will carry them into the future.