Low-Head Microhydro
Thai Style

Above: The author and his family in Doi Inthanon, Chiang Mai Province, Thailand.

Left: This AC-direct microhydro system provides a source of renewable electricity for a community training center.

For the past several years, Chris Greacen has been living in Bangkok, Thailand, with his wife Chom and their two children, 5-year-old Ty and 3-year-old Isara. He and Chom run a small, nonprofit organization called Palang Thai. ("Palang" means energy or empowerment. "Thai" means freedom or independence.) Through policy and hands-on activities, the organization works to improve governance in the region's energy sector, and to increase the use of renewable energy in Thailand and the Mekong region of Southeast Asia. They've enjoyed several victories in their tenure: drafting Thailand's net metering regulations, helping to shape legislation that establishes an independent energy regulator, and installing solar-electric systems for medical clinics in war-torn areas of Burma (see "Solar Lights for a Dark Time in Burma" in *HP113*). Here Chris writes about one of their most recent projects: the installation of a low-head microhydro system in northern Thailand.

Story & photos by Chris Greacen

Last summer, while my family and I were visiting Doi Inthanon National Park in northern Thailand, we spent some time in Mae Klang Luang—a hill-tribe village about 12 miles inside the park. Though the 200-year-old village only recently opened its doors to tourists, it has quickly become a sought-after destination for its cultural and ecological allure. The village sits in the shadow of Doi Inthanon, Thailand's tallest mountain—among the easternmost beginnings of the Himalayas. The villagers are members of the Karen ethnic minority who migrated to the Thai/Burma area centuries ago from Mongolia. Though the village is very traditional in most ways—the people still harvest and thresh rice by hand—the electric grid was brought into Mae Klang Luang in 2007. Even with utility electricity on hand, some of the villagers still prefer energy independence—tapping the watershed's abundant streams and rivers to generate their own electricity.

Below: Local lumber, rocks, sandbags, and bamboo were used to construct the weir and waterway.

Above: The 6.5-foot-long draft tube is attached to the trough.

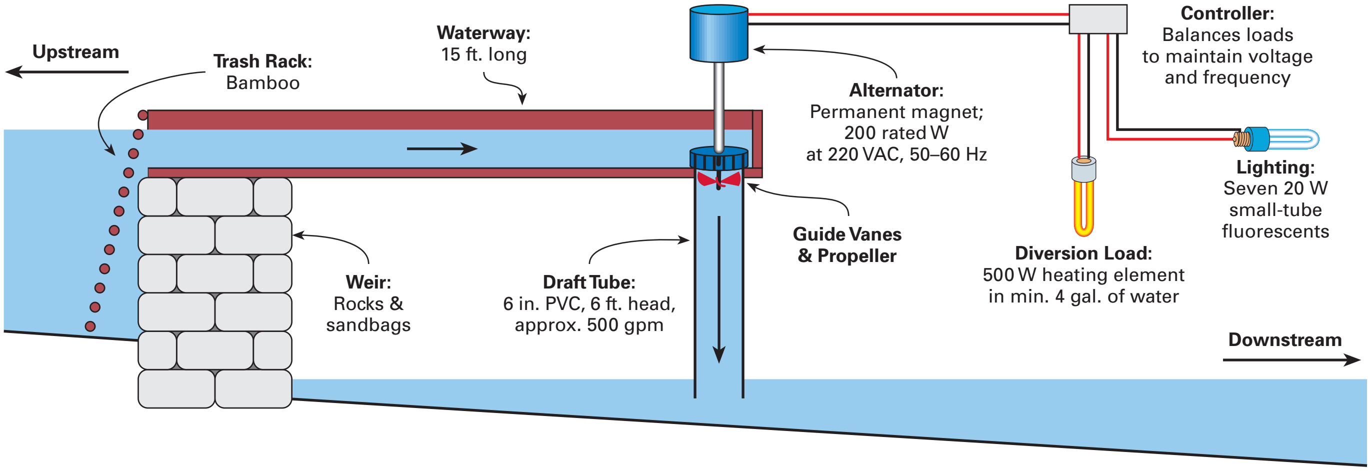
We ended up in Mae Klang Luang after a friend told me about a homestay program that would allow us to live with a local family for a few days. Chom and I liked the idea of supporting the community while exposing our children to the Karen way of life. When we finally arrived in the village, after a two-hour car ride along winding roads, we were surprised to find a film production crew, complete with police barricades, setting up to film a documentary that involved a member of the Thai royal family. An overzealous policeman told us that we could not stay in the village and we would have to turn back. Luckily, a local man, admittedly upset by the policeman's readiness to turn away tourism dollars, overheard the conversation and intervened. Our new friend introduced himself as Somsak Khiriphumthong and directed us down the road to a host home.

Later that evening, I met up with Somsak at a bamboo shed where community members gather to roast, grind, and drink locally produced organic coffee. I came to learn that Somsak runs a training center that teaches local people about the importance of organic farming, environmental preservation, and watershed management. His mission, as he explained, is to promote ecologically sound microenterprise while still preserving the cultural traditions of his people. Somewhere between our first and second cups of coffee, the topic shifted to renewable energy and my work with Palang Thai.

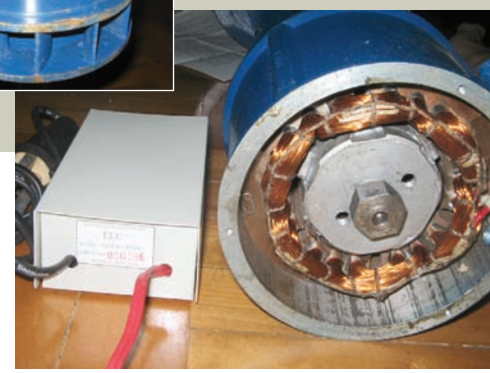
Somsak admitted that he had reluctantly brought grid electricity to the training center from the Provincial Electricity Authority (PEA), Thailand's rural distribution company. Initially he had resisted using PEA because of his concern for the environment. "Trees have to be cut down to get the power poles in, and PEA electricity comes from Thailand's mineral resources, like coal," says Somsak. "When they take coal from the mountains, they destroy them, and the air too. Plus, PEA power means paying a bill every month."

Even with grid electricity now on site, Somsak was still interested in using a nearby stream to generate electricity to power some of the center's loads. Somsak said that he had tried his hand at hydro-electricity several years ago, and rehashed one failed attempt that involved a makeshift Pelton turbine he made from a bicycle wheel and an automotive alternator. After talking some more about the water resource at the center, I said, "Well, I know of a turbine that I can bring up. Let's do it."

AC-Direct $100 Microhydro System



Above: Somsak puts the final touches on the trough.



A close-up of the turbine's propeller and guide vanes (left), and controller and turbine windings (below).

Back for the Installation

In November, I made my way back to Mae Klang Luang with a $90 Vietnamese-manufactured, low-head hydro turbine in hand. While the use of these turbines is still fairly uncommon in this region, they are popular with the few locals who already use them, primarily due to the units' low cost. The fact that the technology is pretty straightforward is attractive too. There are few parts, worn-out bearings can be easily replaced, and the weir and waterway that deliver water to the turbine can be inexpensively built using local lumber, rocks, sandbags, and bamboo.

The turbine I purchased for Somsak's installation came equipped with a guide vane and propeller assembly, a 2-foot-long enclosed shaft, and a permanent-magnet, 220-volt (nominal) AC alternator. The $90 price tag also included a small voltage controller. The turbine/controller combination is designed to power AC loads directly, without any kind of battery storage in the system. If the combined household electric load is insufficient, the controller's simple transistor circuit drives a silicon-controlled rectifier (SCR) to maintain a constant load on the turbine by diverting excess electricity to a resistive submersible heating element. This control method regulates the turbine's AC voltage.

Prior to my arrival, Somsak and his friends had built a small support for the turbine's trough (waterway) from scrap wood and bamboo. The support, which needed to be strong enough to support the weight of the trough, turbine, and several hundred pounds of water, was positioned near a small stream that runs year-round by the training center. At this location, the streambed dropped about 6 feet over a 15-foot span.

When I arrived in Mae Klang Luang, we immediately got to work building a 15-foot-long waterway in two sections, using lumber and bamboo that was on hand. Much of the work was done with a multitool and a machete—though we grabbed hammers, wire cutters, and screwdrivers as needed. We cut a 6-inch-diameter hole for the turbine in the bottom of one end of the trough and wrapped the end with a rounded section of galvanized sheet metal.

Microhydro for $100?

On your next visit to Southeast Asia, you may want to forego the traditional souvenirs, and take home one or two $100 microhydro units instead. Southeast Asia's best-kept secret weighs about 44 pounds (usually below airline baggage-weight limits), packs into a small box, fits into carry-on luggage, and can be found at markets in most major cities. In the Laos capital of Vietiane, for example, you'll have your pick of $100 microhydro units at the metal market. (Tip: Ask for directions to *talart lek*.)

When shopping for a system to bring back to the United States, be mindful of the voltage. If it is impossible to find a 120-volt turbine, you can still make the system work in the United States by using a 120/240 VAC transformer—also widely available in Southeast Asia. If transmission distance is significant, install the transformer close to the load and benefit from reduced resistive losses from high voltage transmission. The frequency produced by the turbine depends on the load and the water flow, and the turbine seems to have no problem operating at 60 Hz as well as 50 Hz.

If you're not heading to Asia anytime soon, you can order Vietnamese-manufactured turbines via PowerPal, a Canadian importer. For a more local product, check out the turbines manufactured by the crew at Energy Systems and Design in New Brunswick, Canada. Their low-head turbines feature a mechanical design similar to the Vietnamese turbines, but they are built for battery charging stations.

The Lowdown on Low-Head Hydro

Most of the microhydro turbines used in home-scale installations in the United States use either a Pelton- or Turgo-style runner coupled to an AC permanent-magnet alternator. These types of turbines are typically used at sites where the vertical drop is more than 15 feet. Water enters a screened intake at the top of a pipeline that runs downhill along the stream's course. There is 1 psi of pressure for every 2.31 feet of drop in the penstock's elevation. The resulting column of pressurized water above the turbine is routed through one or more nozzles inside the turbine's housing, creating strong jets of water that are directed at the turbine's runner to spin the alternator, which generates electricity.

In the Vietnamese low-head hydro unit that I purchased for Somsak's installation, the physics is reversed. There is no penstock. Water is diverted from a stream and channeled through an open-top, elevated waterway that delivers water to the turbine. Instead of the penstock, a pipe called a draft tube is installed *below* the turbine. The draft tube sucks water through the propeller, which in turn spins the alternator. This particular turbine design can generate electricity at sites with as little as 5 feet of head so long as a sufficient flow rate is available. Because of this low head requirement, these turbines are frequently installed between terraces in the rice fields in Southeast Asia.

Unlike the output in many other systems, which either charge batteries or are grid-connected, the voltage of the Vietnamese turbines' AC output is regulated and fed directly to AC loads, most commonly lighting. The inexpensive turbine's AC output is not designed to be synchronized with the utility grid. While the power quality regulation is pretty sloppy—probably not something you'd want to subject your home entertainment system to—it's definitely sufficient to power lighting and other simple appliances typically used in remote parts of Asia.

Once the waterway was fastened to the bamboo support structure, we secured the bottom of the turbine in the trough and then fit the draft tube—6.5 feet of 6-inch PVC pipe—to the base of the trough. We positioned the pipe slightly above the streambed but still submersed in the pool below so that the water discharge from the draft tube was unobstructed.

The wiring of the project was pretty simple. We ran 150 feet of cable from the turbine to the controller, which we mounted inside one of the center's buildings. We installed the diversion-heating element in a 20-gallon bucket of water located under the building to keep it away from the village children. I made sure Somsak understood it was imperative to keep the diversion load submerged to prevent it from burning out.

Up & Running

After everything was installed, we went over the hydro setup one last time, double-checking the wiring and installation details. Once we determined that everything was good to go, we opened the intake in the stream, watched the trough fill with water, and listened as the hydro turbine spun.

Along with the turbine's whirring, a loud sucking sound caught our attention. Through trial and error, we discovered that a bad seal between the draft tube and the trough was affecting the turbine's output. Somsak disappeared for a bit and miraculously, considering our remote location, came back with a sheet of firm synthetic sponge material used to make the soles of sandals, the locals' preferred footwear. We cut a gasket from the material, fit it between the trough and draft tube, and just like that, the turbine's output jumped to 0.7 amps at 220 VAC—154 watts—from about 500 gallons per minute of water falling only 6 feet.

I did a little more geeking with my digital multimeter and noticed that the turbine's voltage controller seemed to produce a waveform with considerable harmonics. At one point, my meter, obviously reading the third harmonic, indicated a frequency of 155 hertz. This "dirty" waveform really wasn't very surprising. The control unit operates by slicing part of the alternator's sine wave to send to the diversion load, which means that only a sliced portion of the waveform is going to the appliances. For lighting, fluorescent bulbs with the old-fashioned magnetic ballasts seem to be more tolerant of the turbine's low power quality than compact fluorescents (CFs) with electronic ballasts.

Power quality aside, our hydro installation was both fun and successful, and Somsak was delighted to have a functioning hydro system at the education center. The turbine powers fluorescent lights in several buildings and the occasional small appliance, like a radio or CD player.

Chris and Somsak assemble the waterway.

The completed installation: weir, waterway, and turbine.

Low Head & Low Cost

Reportedly, 100,000 low-head hydro turbines have been installed in rural Vietnam. And every one of these turbines creates more interest in utilizing local hydro resources to generate renewable electricity at remote sites beyond the reach of the utility grid. In Somsak's case, even though utility power was available, he opted to produce his own electricity, independently—further proving that the call for clean, independent energy is not only heard across the United States, but also in the remote villages in Thailand, and everywhere in between.

Access

Chris Greacen (chris@palangthai.org; www.palangthai.org) and his family will move stateside this spring. Thanks to a long-term lease from the Lopez Community Land Trust, the family will build a net zero energy, solar-powered home on Lopez Island in Washington's Puget Sound.

Web Extra: Video of this project can be viewed at: www.youtube.com/profile_videos?user=cgreacen

Center for Water Resources Conservation & Development • info@warecod.org • www.warecod.org • Vietnamese low-head turbines

Energy Systems & Design • www.microhydropower.com • Canadian low-head turbine manufacturer

PowerPal • www.powerpal.com • Canadian importer of Vietnamese low-head turbines