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ECHO Asia Notes

Edited by Rick and Ellen Burnette

Reviewed by Dawn Berkelaar and Tim Motis

ECHO is a Christian non-profit organization whose vision is to bring glory to God and a blessing to mankind by using science and technology to help the poor.

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Micro-Hydro in Myanmar and Thailand

By Rick Burnette
Director, ECHO Asia Regional Office

Rugged northeastern Myanmar is home to the Lahu, Shan, Akha, Palaung and various other ethnic groups. With few paved roads and only a small percentage of the Shan State's population connected to the electrical grid, infrastructure serving the locals is still very limited.

Approximately 10 years ago, traders from neighboring China capitalized on the lack of access to electricity by introducing micro-hydro generators. Roughly the size of a 20-liter container, the Chinese-made turbines typically generate between 1-3 kilowatts with larger models producing 5 kw or more. While energy within this range is not enough to power larger appliances (e.g., refrigerators, washing machines), a few light bulbs and very small household appliances such as fans, televisions and radios can be operated.

Relatively inexpensive (selling between $70-450 US, depending on electrical capacity), these generators are also fairly simple to install. However, for a generator's turbine to rotate adequately, the main requirement is access to a sufficient volume of water moving at a necessary rate of speed.

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Contact Us

ECHO Asia Regional Office

P.O. Box 64
Chiang Mai 50000
Thailand

echoasia@echonet.org

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According to experts, micro-hydro systems need a combination of head (hydraulic gradient between two or more points) and flow (volume of fluid which passes through a given surface per unit time) somewhere between these extremes: 2 feet (0.6 m) of drop and 500 gallons (1,892.7 l) per minute, or 2 gallons (7.5 l) of water per minute and 500 feet (152.4 m) of drop. Fortunately, the eastern Shan State is rich in sites that meet such criteria.

Local Micro-Hydro Options

Rev. Lazarus Pa, director of the Christian Social Service and Development Department (CSSDD) of the Keng Tung-based Lahu Baptist Convention, also oversees the work of the Rural Integrated Development Program (RIDP). Besides assisting area Lahu hilltribe communities to access clean water, the RIDP team promotes improved agricultural production and extends microcredit opportunities.

Soon after micro-hydro generators were introduced to the region, RIDP's director purchased a 3 kw unit to try out. With the generator proving affordable, easy to install and reliable, Rev. Lazarus became convinced that micro-hydro technology would be an ideal way of providing electricity to off-grid communities.

Since evaluating the first unit, the RIDP team has assisted over 30 communities to install two basic types of Chinese-made micro-hydro generators:

1. Pipe-fed units with **internal turbines**.
2. Units containing **external turbines** mounted onto long shafts (having an appearance similar to an outboard motor).

Regionally, available micro-hydro technology is not limited to simple internal and external turbine models. According to Dr. Thanad Katpradit,managing director of ENGINEO, Ltd., a renewable energy business based in Chiang Mai, Thailand, a more versatile hybrid model that can be powered by either water or an engine is also on the market. However, the simple micro-hydro units are both reliable and more affordable, and remain the generators of choice in the Shan State.

The Installation of Pipe-Fed Units

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According to Rev. Lazarus, the pipe-fed units are easiest to install. The main requirement is an adequate supply of falling water which can enter a 3-inch intake pipe at a 45-degree angle (although he says, from experience, angles as low as 20 degrees are still usable).

To enable the internal turbine of a 1 kw micro-hydro unit to operate at an adequate generating speed, Rev. Lazarus' estimation is that a minimum 25 ft. (7.6 m) vertical drop is needed. A 50 ft. (15.2 m) and 75 ft. (22.9 m) drop are required for 2 kw and 3 kw generators, respectively.

The following table offers example specifications related to the drop and volume of water needed to operate certain types of micro-hydro units (ENGINEO, Ltd.):

Water Requirements for Select Pipe-Fed Micro-Hydro Units*

Model (kw)	Drop (meters)	Water Volume (l/second)	Intake Pipe Size (in.)
0.6	5	5-8	3
1.0	5	5-8	3
1.5	8	10-12	3
2.0	10	15-20	3.5
3.0	15	15-30	3.5

*Water requirements (e.g., drop, volume) may vary among products. Generators should be installed and maintained according to material requirements as stated by the manufacturer.

Therefore, to make use of pipe-fed units with internal turbines, households or communities that are candidates for such technology must be located fairly close to water sources, such as mountain streams or irrigation channels, which can provide adequate drop to generator installation sites.

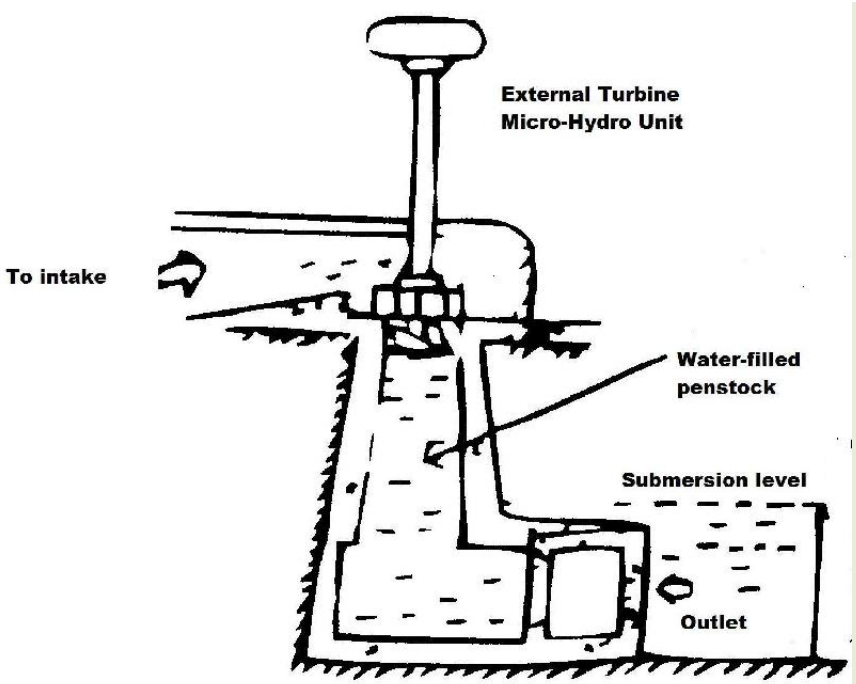
The External Turbine Unit Option

However, should the local water supply lack the minimum 5-7 m drop, an external turbine unit that can operate with significantly less drop (1.8-3.2 m) may be an option. For example, where less-steep terrain in the Shan State offers an adequate source of flowing water, part of the stream can be diverted into channels specially made for powering external turbines.

Rev. Lazarus explains that channels providing a necessary flow of water for external turbine units should measure approximately 1 ft. deep by 1 ft. wide (0.3 m x 0.3 m) for 1 kw micro-hydro units. Larger 2 kw units require 2 ft. x 2 ft. (0.6 m x 0.6 m) channels, whereas slightly larger channels are needed for 3 kw generators.

The most important component of such channels is a feature that forces water to ultimately spin in a clockwise vortex which in turn causes the external turbine of a micro-hydro unit to rotate. To enable the vortex effect, the end of the channel should be rounded and include a minimal 5-6 inch (12.7 cm - 15.2 cm) intake opening through which water can spin into the top of a cement or PVC penstock (a vertical drainage shaft). External turbines are installed in these intakes to take advantage of the vortices.

The height of the penstock is a critical component for the function of external turbine units. Depending on the electrical output of generators, drop should range between 6-10 ft. (1.8 m - 3.1 m). Additionally, to intensify the vortex effect, the diameter of the water outlet at the bottom should be twice the diameter of the top intake with water exiting from the side of the penstock rather than being dumped vertically. User manuals for the micro-hydro generators also recommend that the outlet at the bottom of each penstock be fully submerged in the water course into which it empties.



Community-Based Generator Installation and Maintenance

Through RIDP's ongoing work, one to three generators (1.5, 2 or 3.5 kw units) are installed in each focus community. Rev. Lazarus states that although 5 kw generators are available, they are more expensive, require more water and are more difficult to install.

According to the capacity of each community, the residents contribute a percentage of the overall cost of the generators. And after initial training, community members are fully responsible for the installation of the equipment and the construction of necessary infrastructure such as water channels. However, the RIDP team provides follow up and offers trouble shooting assistance as needed.

Because two ball bearings within the generators are often of inferior quality, Rev. Lazarus recommends that the components be changed out for higher quality bearings within six months of initial use. However, little additional maintenance is required except to protect the inner works of the generators from rainwater, sand and corrosives such as salt.

Additionally, leaves and other debris can collect in the channels which feed water to the external turbine units, causing water intakes to clog and turbines to stall. Therefore, channels and drainage shafts should be checked regularly and foreign materials removed as needed.

Electricity in Eden

Rev. Jabo, pastor of the Baptist church in the RIDP focus community of Eden on the outskirts of Keng Tung, reports that among 140 households there are currently 20 micro-hydro generators in service, including both pipe-fed and external turbine units. The first village micro-hydro unit was purchased from a Chinese trader six years ago. Today, dozens of electrical lines crisscross the village, connecting homes to an array of generators that line a tumbling stream beyond the village.

The church pastor explains that each 1 kw generator serves five households, providing enough power to operate a few light bulbs, a radio and perhaps a TV.

It should be noted, however, that basic micro-hydro generators are not equipped with voltage regulators needed to maintain a steady electrical supply for the efficient operation of household appliances. To avoid electrical load problems for appliances being powered by micro-hydro, ENGINEO's Dr. Thanad recommends the use of an automatic voltage regulator (AVR) or stabilizer.

Despite the limited amount of electricity that each household receives, Rev. Jabo says that the benefits from micro-hydro units are significant. For example, because children have more time to study after sunset, school performance improves. The availability of electricity also makes it possible for women to spend more time on handicrafts in the evening, which in turn improves household income generation. And on a community level, local micro-hydro power allows church members to conduct choir practice and other church-related activities after dark.

The Regional Spread of Micro-Hydro

Rev. Lazarus observes that access to the Chinese-made micro-hydro generators is not limited to the Shan State. He has received reports that the technology has spread to other mountainous regions of Myanmar, including the distant Kachin, Chin and Kayah States.

And RIDP is not alone in promoting alternative energy in the region. Inside neighboring Thailand, Palang Thai , a non-profit organization, and the affiliated Border Green Energy Team (BGET) promote alternative energy options including the installation and sustainable operation of micro-hydro systems.

Related to such micro-hydro installation, Palang Thai/BGET has filmed the process in various locations with related videos posted on YouTube. The following links include micro-hydro work at Mae Wei , a 200-watt system at Mae Klang Luang, another 500-watt system at Mae Klang Luang, and the Kre Ki hydropower project.

In the Myanmar border town of Tachilek, as well as Keng Tung, the Chinese-made micro-hydro units are readily available in hardware stores. However, in Thailand, where most of the population is already connected to the national power grid, such units are somewhat difficult to locate. And due to import taxes, the cost of units is approximately twice those in Myanmar.

Meanwhile, the spread of micro-hydro power in the eastern Shan State is obvious from the number of light bulbs seen glowing in houses along remote stretches of the road between the Thai border and Keng Tung. Impressively, all this is made possible by the availability of affordable appropriate technology, natural resources and innovative people.

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Thanks to Sarah Rutherford and Ayixianmu Maihesuti for helping to translate portions of the Chinese micro-hydro generator manuals.

Crotalaria juncea, a promising green manure crop for the tropics

By Jeff Rutherford
Fair Earth Farm
Chiang Mai, Thailand

Crotalaria juncea, or sunn hemp, is a member of the pea family (Fabaceae) grown in many countries as a green manure or forage crop. Originating in South Asia, but with a common cultivar developed in Hawaii, it is a fast-growing, drought-tolerant and aesthetically pleasing plant with real potential for integrated farming in the tropics.

Because sunn hemp is a strong nitrogen fixer with a reported resistance to root knot nematodes, and can be incorporated into the soil with little more than a month of growth, it can be used rotationally between primary crop plantings in both paddy and dryland fields. However, as sunn hemp needs well-drained soils, it does not seem appropriate for paddy farmers with drainage problems. The crop is also grown as forage and fiber, especially in South Asia. However, it is not a true hemp of the *Cannabis* genus.

Although Sunn hemp in northern Thailand is promoted by agencies such as the Land Development Department, it is apparently not commonly used by paddy farmers. It is known as *por teuang* in Thai, though it is known by some farmers as *tua pui*, or "fertilizer bean."

On our small experimental farm 20-km north of Chiang Mai city, we first planted a test plot, drilling a 1-cm deep hole and adding about a dozen seeds, leaving the holes uncovered. This was during the rainy season, and the sunn hemp grew rapidly and vigorously, gaining a meter of height within three weeks and flowering in less than six weeks. The bed of pretty yellow bean flowers prompted passers-by to stop and ask about them, most locals being unfamiliar with the plant. One visitor did know sunn hemp, saying that it is commonly grown in his district of Mae Sariang along the northwestern border with Burma. Farmers there grow it in their paddies between a dry-season garlic crop and wet-season rice. The man said they broadcast the crop and plow it under after a month or so, reducing their fertilizer bill.

Early production and harvesting seed

After the success of the limited trial, we began planting sunn hemp at the southern fringe of a 4-meter wide dyke separating our fish pond and the neighbor's paddy. We grew it right along the paddy to demarcate the boundary and to multiply seed. Our farmhand, possessing the local farmer's antipathy to cultivating a plant only to cut it and "throw it away," and still not clear on the concept of green manures, planted the sunn hemp in neat rows, about 30 cm apart. This is fine for seed production, but too sparse for compost material or mulch.

Since then, we have been self-sufficient in sunn hemp seed, harvesting the pods, which are leathery, puffy and the size of a

large medicine capsule. It is easy to tell when the pods are ready to harvest: just give the plant a shake. If it makes a rattling noise, it's time to harvest (thus one common name for Crotalaria species, "rattlepod."). We strip the pods by hand, sun dry them, crush them under foot in a fertilizer sack, and winnow. It is a quite labor-intensive process, but sunn hemp seeds sell for 35 baht ($1.06 US) a kg at a nearby agricultural supply store. A program at Chiang Mai University sells seed for a more affordable 15 baht per kg, but a sack would still run more than 700 baht, making worthwhile the labor of harvesting the seed.

One neighbor approached me and told me that he saw on TV that the young flowers of sunn hemp can be eaten, most usually in an omelet. I tried it at home and it was edible, but did not make a remarkably delicious omelet. Many Crotalaria species contain toxic alkaloids, but apparently not this cultivar. Still, literature on *C. juncea* suggests limiting its proportion in animal feed to 45 percent or less.

Pests

After harvesting the seed, the plants quickly re-flower. We were able to get three harvests, though with decreasing yields, from the same plant. This, however, and perhaps over-production, led to a pest problem. Eventually, we expanded production to include a strip along the northern boundary, beside the canal at the eastern edge of the property, and in various places throughout the farm. This eventually led to an infestation of the larvae of what might be the blue bean butterfly (*Lampides* sp.). I noticed a small hole in almost every pod of older plants growing along the southern boundary, where we first began growing a lot of sunn hemp. The pods were fully formed but empty of all but dust.

Since then, we have tried to limit the sunn hemp seed production to widely scattered clumps around the farm. As the splash of yellow flowers is quite appealing - the dried brown seed pods much less so - sunn hemp makes an attractive addition to the garden. The flowers are very popular with bees,

including the big local bumblebee. In the intervening six or so months since we noticed the infected pods, we have not observed any more pest attacks.

The dried stored seeds do not seem vulnerable to attack by pests like weevils, which are abundant in our other stores and would have ample opportunity to attack the sunn hemp seeds if so inclined.

Growing as green manure

The pest problem is only relevant for seed production. The main use of sunn hemp is to be a soil amendment whereby the plants are cut as mulch or compost or incorporated into the soil after flowering but before setting seed. According to the Tropical Forages website, this is the optimum time to make use of the crop's nitrogen-fixing capacity. "Nitrogen content is greatest at the onset of floral initiation to mid bloom, and declines as N reserves are allocated to seed development." Furthermore, at this stage the plants are not fibrous and are easy to cut and use in compost. We grow sunn hemp as a break crop and soil amender in vegetable beds.

We also tried several approaches with sunn hemp as a green manure on a larger scale, in both the paddy and a portion of land newly raised from the paddy and filled along the northern boundary as a broad dyke. This dyke was designed to serve several purposes: to separate the neighbor's paddy from ours and to site vegetable beds along the canal, as well as to provide a walking trail and an agroforestry strip along the boundary.

Paddy soil, such as we used to develop the dyke, when dug up by a backhoe and having its horizons mixed and exposed to the sun, turns into an abominable concrete-like surface, completely unsuitable for growing plants in the first year. Taro, maize and a range of other plants - even with the help of compost - died or were completely stunted. Mung beans survive in the moister cracks and do moderately well. Sunn hemp, when the rock-hard clods are broken up and shallow holes drilled, grow remarkably well. We planted the area with sunn hemp and a variety of beans - rice, black and mung - in the

heart of the dry season and the strip greened up with the help of daily early watering, reduced to twice a week after the plants were established.

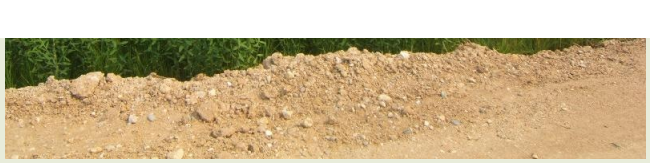
The paddy experience was a different matter. In January, after completing the earthwork discussed above, we hired a tractor to dry plow the paddy and erase the backhoe tracks. We briefly flooded and drained the paddy and then broadcast a variety of legumes in test strips, specifically sunn hemp as well as five types of bean (rice, mung, black, lablab, winged). Germination was not very good, and I was concerned that the surface of the soil was drying out and inhibiting proper germination. In retrospect, though, I was too hasty. In fact, the subsurface soil was probably still saturated.

Consequently, we flooded the paddy again and most of the beans failed to germinate. The black and mung beans sprouted but failed to grow beyond small plants. The soil was still likely too wet and the roots were affected.

On the other hand, on some ridges in the roughly leveled paddy the sunn hemp did well. This led me to believe that the problem was too much water, not too little, and a second broadcast of just sunn hemp resulted in about 40 percent cover.

At the same time, I set aside two test plots in a higher corner of the paddy, each about 5 m x 5 m (16.4 ft. x 16.4 ft). In one plot I thickly broadcast sorghum (for organic matter) and sunn hemp. In the other, we drilled mixed holes of the two crops. Both plots received no fertilization. Each was watered by hand daily for about seven days and then twice a week for about two more weeks.

In each plot the sunn hemp grew thickly - more thickly in the broadcast plot - with better sorghum establishment in the drilled plot. After solid establishment in about three weeks we stopped watering. This was in the driest period of the year. With the exception of a few unseasonably wet days in late



February and March, there was no rain.

Using a hand sickle, I cut back both the sunn hemp and sorghum to about .5 meters (19.7 in.) when the former began to flower in just under six weeks, setting aside about five plants in each plot for seed. I allowed the biomass to fall as mulch, and repeated this twice over the next six weeks. We used a mechanical weed "whacker" to cut back the sunn hemp in the rest of the paddy. I also did a one-time harvest of seed from the remnant plants.

While weed growth in the test plots was greater than in a dry adjacent field, the sunn hemp did help suppress weed growth, especially when compared with another paddy section that was fertilized with compost and planted with pumpkins.

In May we dry plowed both the paddy and the broad dyke after the latter was spread with some sandy soil and horse manure. In both cases, many of the mature sunn hemp pods that had previously been unharvested were incorporated into the soil. Eventually, in both sites, a lawn of young sunn hemp emerged thick and vigorous before we could plant any new seed, although in the paddy this was true only in the higher, drier corner where the test plots were situated.

As the plants began to flower, they were cut back along the dyke. Some were collected for compost, while some were allowed to fall as mulch. In the paddy, we flooded and plowed to prepare for the rainy season rice crop.

By mid-October 2009, around one month shy of harvest time, the rice fields were yielding approving comments by local rice farmers -- and this with no use of synthetic fertilizers for three years. And along the dyke, in what will become a 50 sq m strip of vegetable beds, we are sowing a long "mulch bed" of mung beans, sunn hemp and sorghum (for organic matter) amidst the re-

sprouting sunn hemp (although in some areas the mulch is too thick for broadcasting).

The plan in the paddy is to broadcast sunn hemp after (or just before) the rice harvest in December. It will be cut back in late January or early February before growing a dry season crop of rice, soybeans and other things. For that to happen, we have set aside clumps of sunn hemp in the "mulch" beds for seed. The bright yellow flowers and pollinating insects that visit them are a welcome sight around the farm.

[Editor: Jeff can be contacted at tjeffrutherford@gmail.com.

For more information about sunn hemp, readers may refer to ECHO's Green Manures and Cover Crops page at: http://www.echotech.org/technical/az/aztext/azch6gre.htm.

Additionally, sample seed packets of sunn hemp can be ordered (when available) from the Leguminous Ground Covers and Green Manures section of ECHO's seed bank page at: http://www.echonet.org/content/SeedBank/550]

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ECHO
17391 Durrance Rd.
North Fort Myers, FL 33917 USA
Phone: (239)543-3246
Fax: (239)543-5317