Sun Breathing

Dennis Ramsey

A brilliant hydro-electric project in Solu-Kumbhu, Nepal went horribly wrong a few years ago. It burned the Tengboche Monastery, near Mount Everest, to the ground. A group of well-meaning foreigners gave the monastery an 8000 watt hydroelectric system, which provided not only lighting, but heat as well. The intention was to give the monks and lamas enough energy to replace some of their fuelwood consumption — a great idea until someone kicked over a space heater….

From Misfortune

My project was born from this tragic misfortune. I have lived and worked in Nepal for twelve years. I've spent a lot of time in Solu-Kumbhu. I reasoned that this hydro-powered accident happened because a group of non-technically oriented people, the monastery, was given far too much power — beyond their ability to manage. With 8000 watts on-line, an accident was bound to happen.

About 40 miles from the now-restored Tengboche is the valley of Junbesi, around which are five other Buddhist monasteries. One of them is Tumbuk. I had known Topkay Lama of Tumbuk for six years when I decided to install a photovoltaic lighting system for him. I've seen Topkay build his monastery from nothing but a bare hillside. I knew that neither he nor his monks knew the first thing about electricity. To avoid another tragic accident, the system had to be low power and automatic. Since they have no appliances, the system would power only lights. I didn't intend to install any plug-in receptacles either, so that no unsuspecting soul could damage or overload the system.

Below: The Tumbuk Monastery nestled in the Valley of Junbesi.

I was back in my hometown of Eugene, Oregon on vacation in August 1993 and had a vague idea about what I wanted to do. I'd read Fowler's *Solar Electric Independent Home* book and had done some calculations. I knew how to wire and install, but I knew nothing about the hardware or how the systems operate. By good fortune I opened the phonebook and out of the blue called Greg Holder of Alternate Means in Fall Creek. We had lunch the next day. I told Greg I needed about ten lights on a wire run of approximately 300 feet between three buildings, one of which is the monastery. I explained the accident at Tengboche and emphasized that the system must be fool-proof. It couldn't be mounted on the monastery itself because I was afraid of fire. We figured insolation, altitude, and approximate load. Greg designed a system on the spot, based on my budget and needs. He suggested that I invert the current so that the power could be sent a long distance on reasonably sized wire. By using ac the system could be installed anywhere in the complex. Greg recommended Enertron low-watt fluorescent quad lights, available in quantity from Greater Goods of Eugene for $10 each. I was touched when Greg offered the hardware at just above cost as his part of the donation. The hardware consisted of two Solarex MSX-50s, an SCI ASC 12-8 charge controller, and a Statpower 250 watt, 12 VDC to 110 vac, 60 Hz. inverter.

Above: Ngawang Zimba, Pungmoché's Lama inspects the new addition to the roof of his bedroom.

Below: Two photovoltaic modules are almost enough to power all of Pungmoché's lights.

I was ten days away from leaving again for Nepal when I first talked to Greg. He got the equipment post-haste. I bought the screw-base lamp fixtures, lights, extra bulbs, crimps, switches, fuses, and various tools. I packed the entire assortment, panels included, into a cardboard box that weighed 70 pounds and measured 39 x 5 x 20 inches. Each passenger going to Asia is allowed two pieces of this maximum weight and dimensions. I took the entire PV system to Nepal as luggage, basically free. It was easy talking Nepali customs into letting me pass once they knew it was a donation.

In Kathmandu I scoured the bazar for 12 gauge wire, some Indian and Chinese tools like a shoulder drill, hammers, dykes, saws, nails, wire clips, battery cables, etc. Since deep-cycle batteries aren't yet available in Nepal, I settled for two dry-charged 12 Volt, 200 Ampere-hour National truck batteries, made in Malaysia. After all this assembled gear, plus my food and grip, was packed-up and ready to fly into the mountains, it weighed in at 100 kilos (220 pounds). It took two taxies to take me and the gear to the airport one cool October morning to catch the Dornier 12 seater that flew us to Phaplu — about 40 miles from Mount Everest. Old friends greeted me, and the huge pile of gear, at the airport. We quickly assembled six porters (three of them women) and started the five hour trek up the valley wall to Tumbuk at 3100 meters (9448 feet).

The Tumbuk PV System

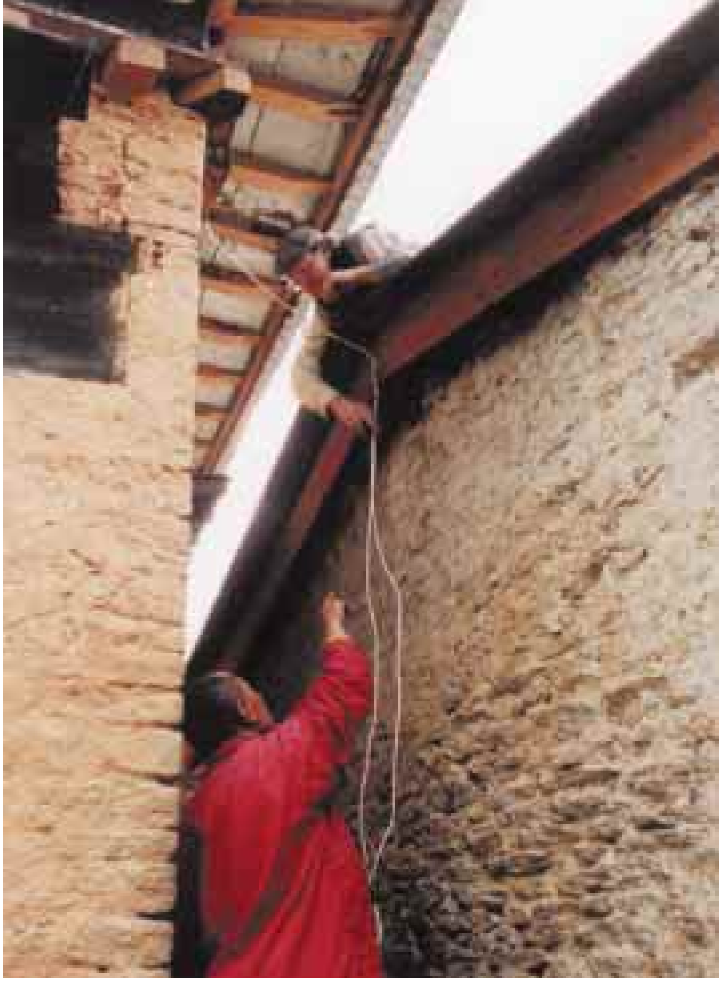
I had given myself a month to do the installation, so I spent the first few days wandering around the complex figuring out how I was actually going to accomplish this feat. No one at Tumbuk understood about electricity or photovoltaic systems so, basically I worked alone. I did have plenty of encouragement and lots of tea.

Above: Porters hauling the 100 kilos of equipment on the five hour trip to Tumbuk Monastery.

Below: Dennis fabricated the photovoltaic racks in Kathmandu. The racks swivel to allow adjustment for maximum solar gain.

The task sounded simple — put a light in every room in the three building complex, plus one outside in front of the monastery to light the courtyard. The main problem was the light inside the monastery. Every square inch of the inside is very elaborately painted with images of the lush Buddhist pantheon. It would be impossible to lay any wire on the inside. The solution was simple in the end. The room upstairs from the painted room has a mud floor overlaying the painted room's ceiling boards. I ran a wire down a post upstairs, then dug a channel in the mud floor. I inserted the wire through a hole drilled where we wanted the light on the ceiling below. I repacked the channel with mud, and the wire is totally hidden. In most cases, I found that with just a little more effort I could easily hide nearly all of the wiring in the walls or ceilings. The wiring took about two weeks. It involved disassembling walls and roofs and rummaging around in dark crawl spaces that hadn't been visited by humans in a long time. I was filthy the whole time and itched constantly. Thankfully I'd brought along plenty of Benedryl to help me sleep at that altitude.

System safety was paramount. The most difficult parts were installing the control gear properly, and placing everything for maximum safety. I knew I didn't want the place to become an example of what not to do. I did not want to put the



Above: Lama Ngawang Zimba helps Dennis Ramsey install the system's wiring at Pungmoché Monastery.

equipment in the monastery building. If there was an accident, such as a battery explosion, all of Topkay's work would go up in smoke.

I chose the ridgepole of the kitchen house to mount the array on a bidirectional swivel frame I made in Kathmandu. Then I hefted the batteries up a tree branch ladder into the crawl space just below the ridgepole. The array and batteries are about six feet apart. The control box is located three feet below the battery bank in the room downstairs. The array current travels about twelve feet to the controller on ten gauge type TC. The 110 volt ac output branches once after coming out of the inverter to run the cook house's two lights, then the main line runs through 300 feet of twelve gauge wire to nine other lights in the complex.

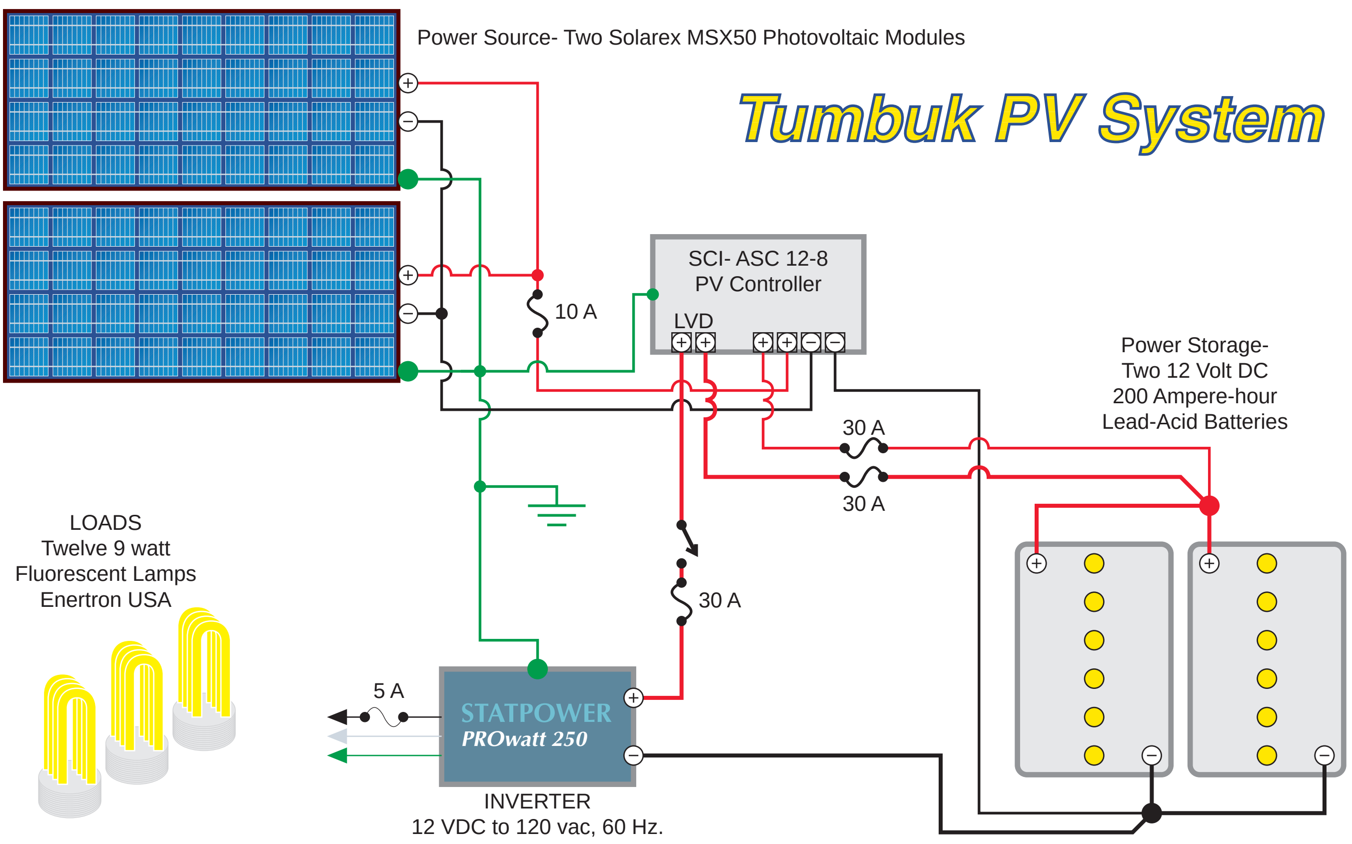
Battery Acid Blues

Distilled water wasn't a problem. I used a solar still. But, I have to admit that I did something incredibly stupid that nearly jeopardized the project. In Kathmandu I calculated the amount of concentrated H_2SO_4 I'd need for the battery acid. I was mortified to realize I misplaced a decimal point. I'd only brought one-tenth the amount needed. Somehow, I couldn't comprehend that we needed so much concentrated sulfuric acid.

Otherwise, the work was all finished except for the acid problem. One of Topkay's young monk's father worked in the trekking business. He was going to Kathmandu the next day and would bring back the battery acid. He'd walk three days to the road-head, then ride one full day by bus to Kathmandu. He intended to spend two days in Kathmandu, then repeat the journey of four days to return home. I took the label off of a one litre bottle of 1.250 battery acid and gave this to the monk's father with $39 worth of Nepali Rupees.

Eleven days later he returned with a jug containing 35 liters. He proudly presented it to me. Everyone gathered around shouting congratulations. We were most happy. I was so totally thrilled that I rushed the jug immediately up the tree-branch ladder into the dark crawl space where the batteries lay waiting for life to be breathed into them. I ripped off the foil vacuum seals on each of the six cells of battery #1 and gleefully poured the essential elixir into three thirsty cells before I realized in the dim light that this didn't pour like battery acid — in fact it wasn't. It was distilled water. I was so livid I nearly overcharged and exploded.

Below: Dennis drilled holes to run the wiring from the roof to the rooms below.



Whatever really happened to our kind courier friend in Kathmandu, one thing was certain — he had a good time with the money. He said he gave the battery acid label to the shopkeeper, and just took what he was given. At first I thought it was plausible that the shopkeeper gypped him. Our friend can't read — but did produce the shopkeeper's bill of $4. It seems that he didn't give the label to the shopkeeper after all, not thinking it important he merely asked the shopkeeper for "that kind of water they put in batteries." The rest of the money went to expenses.

I did the only thing I could — I flew home to Kathmandu. I was not defeated. Living next to me is the largest importer of Indian chemicals into Nepal. He supplies the city and nation with sulphuric acid. I explained my problem and told him I needed 40 liters of 1.285 battery acid ASAP. He had it for me in two days. I contacted a friend who works in the trekking business and he put me in touch with a Sherpa guide who agreed to hire two porters. At the road head, after the day long bus ride from Kathmandu, the porters would carry the acid for three days and deliver it to me in Junbesi, two hours walk from the installation. The Sherpa guide left on the bus the next morning with two 20 litre jerry cans, my blessings, and a box of baking soda. The Tumbuk PV Project was up and running again!

A week after I'd left Tumbuk to find battery acid, I was back at Tumbuk with the right acid. The system worked well. The light was so bright, clean and brilliant, that the 15 people watching stood gaping. We all moved toward the light in amazement. I was so relieved I cried.

A Solar Lit Festival

A few days later, wonderful things began to happen. People appeared from all across the valley. They had seen the light blazing across the valley at night. Long before I arrived, a special festival had been scheduled. The festival was to convocate Tumbuk and formally recognized all the hard work Topkay had done making Tumbuk a legitimate, fully recognized religious institution. The Venerable Tushay Rinpoche came on his horse, with a huge retinue of lamas, masked dancers, and servants. They stayed for three days performing the main ceremony, plus various pujas and blessings. The event attracted anthropologists, tourists, villagers, and a hundred or so monks who participated in the convocation. It was merely coincidence and auspicious timing that the festival took place on the third day the lights were on. Needless to say, the new lighting system was the big topic of conversation. Swiss anthropologists, Eberhand Berg and Verena Felder, were captivated by the possibilities of the technology, and asked lots of questions. They had been living in Solu-Kumbhu for two years, and wanted to give a similar system to the monastery/school of Pungmoché, on the opposite side of the valley from Tumbuk. We'd known each other two days when we struck a deal. If they would provide the funds for equipment, I would donate the installation and travel expenses. We visited Pungmoché the next day to assess their needs.

The Pungmoché PV System

Pungmoché is a two hour hike down to the valley floor from Tumbuk. Then a three hour walk up the opposite side. We spent two hours there discussing the plans with Ngawang Zimba, Pungmoché's Lama. After surveying the complex we realized we would need twice as many lights as Tumbuk. I calculated that by using the same hardware as Tumbuk (2 MSX50s, a Statpower 250 watt inverter, an SCI controller, and a 400 A-h battery bank), ten more

Above: The 150 foot drop made installing the PVs exciting for Dennis.

Below: Dennis wires the lights while the Pungmoché monks look on.

lights could be added and not overload the system. The only added expenses in the second system would be ten lights, replacement bulbs, ten fixtures, double the wire, wire clips, etc., and twice the time to install. The total cost of the Pungmoché installation was $2,500 minus travel expenses. After our two hour assessment at Pungmoché, we beat-it back across the valley to Tumbuk before dark.

When the festival ended and everyone meandered home, I did too — back to Kathmandu and then to Eugene, Oregon for the winter. I got back to Greg Holder with the story of my adventure and with the news that I had another, bigger installation slated. Greg again provided the hardware at near cost. I assembled all the gear, lights, fixtures, etc. in a cardboard box and took it to Nepal, free, on the airplane. I talked my way through customs, again. I scoured the Kathmandu bazar for tools and parts, and again approached my neighbor for 40 litres of battery acid. I again sent the Sherpa guide off on the morning bus with two twenty litre jerrycans and a box of baking soda.

In early May 1994, seven porters and I hiked from the airport to meet Eberhard and Verena, the Swiss donors, at a lodge in Junbesi. We spent two days organizing ourselves and talking about the installation. We sent a message to Pungmoché monastery to send students down to help pack up the gear — a hard climb of four hours (fully loaded) to Pungmoché at 3400 meters (a little over 11,000 feet).

Pungmoché is a Sherpa culture school, besides being a monastery for religious teaching. It sits on an enormous rock that juts from the mountainside. The monastery was built in the 1930s. They recently received a donation to build two large buildings for dormitories and classrooms. Pungmoché has 60 students, a lama for religious functions, two teachers, five dogs and little else. The students subsist on rice gruel and Tibetan tea. Occasionally they even salt the gruel. In the winter, as you might imagine, it's no fun here.

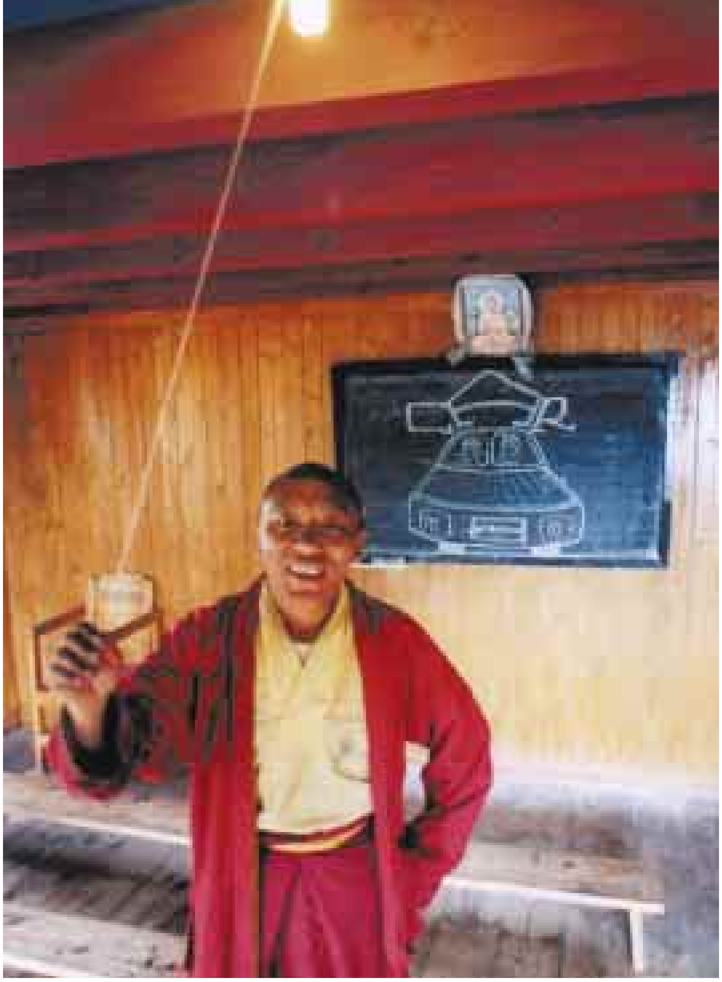
Above: Lama Ngawang Zimba has the power center on his bedroom wall at Pungmoché.

Eberhard and Verena made a good choice in deciding on Pungmoché for their donation. Lights made a huge difference in these peoples' lives. The cooks can now see what they're doing in the kitchen The food might even improve. There's a light in every classroom for those dark days and for those who don't see so well. Each dormatory has two lights, since that's where the students spend most of their time. The stairways and hall ways are lit. Four lights adorn the outsides of buildings. Darkness no longer drives people indoors. The long dark journey to the outhouse at night is a thing of the past. The monastery has two lights on the inside (again wired through the mud floor upstairs). The monks can now read their texts during ceremonies without the harsh fumes or noise of kerosene lanterns. Eberhard, Verena and I spent six very hard days laying wire and setting fixtures — a total of 23 lights on a 12 gauge wire run of over 600 feet.

Below: Lama Ngawang Zima in the English classroom at Pungmoché.

This was some of the hardest work I've ever done. We disassembled roofs and shimmied through crawl spaces on our backs through decades of rat droppings, cobwebs, soot and dirt. We hung up-side-down out of windows and teetered on the edge of roofs that dropped shear off the mountainside. By the evening of the fourth day, we felt like whipped dogs. We were grimey and filthy and were having trouble breathing in the thin air. The food was woefully bad. We'd brought bread, cheese, Bournvita, Marmite, powered milk, and Nescafe, so we weren't uncomfortable. After a week at Pungmoché, we couldn't wait to get back to the lodge in Junbesi for a warm shower and some hot home cooking — anything but rice gruel. Back in the relative luxury of the lodge, we resolved to send a couple of porters back to Pungmoché with 50 kilos of soybeans.

Eberhard and Verena were off again in two days to a religious festival far to the north. They wouldn't return for two weeks and the installation was not complete — the array,



Above: Another Pungmoché classroom has its light tested by Lama Ngawang Zimba.

batteries, and control box still needed to be placed. I was scheduled to leave for Kathmandu in ten days, so I returned to Pungmoché for three days to finish the job.

Like Tumbuk, Pungmoché had the same PV array and battery placement problems. The roof of the monastery building was the best spot because of its due-south facing side and 35 degree angle to the horizon. There was also a storage room beneath the roof for the batteries and controller. This would have been the perfect place, but as with Tumbuk, an accident could burn the monastery down. There was only one other place in the complex that didn't have shading problems. The one other place was at the end of the ridgepole on the lama's quarters. His room is built on a huge boulder outcropping. The end of the ridgepole of the roofline hangs over a 150 foot abyss. To fall from the roof would mean certain death.

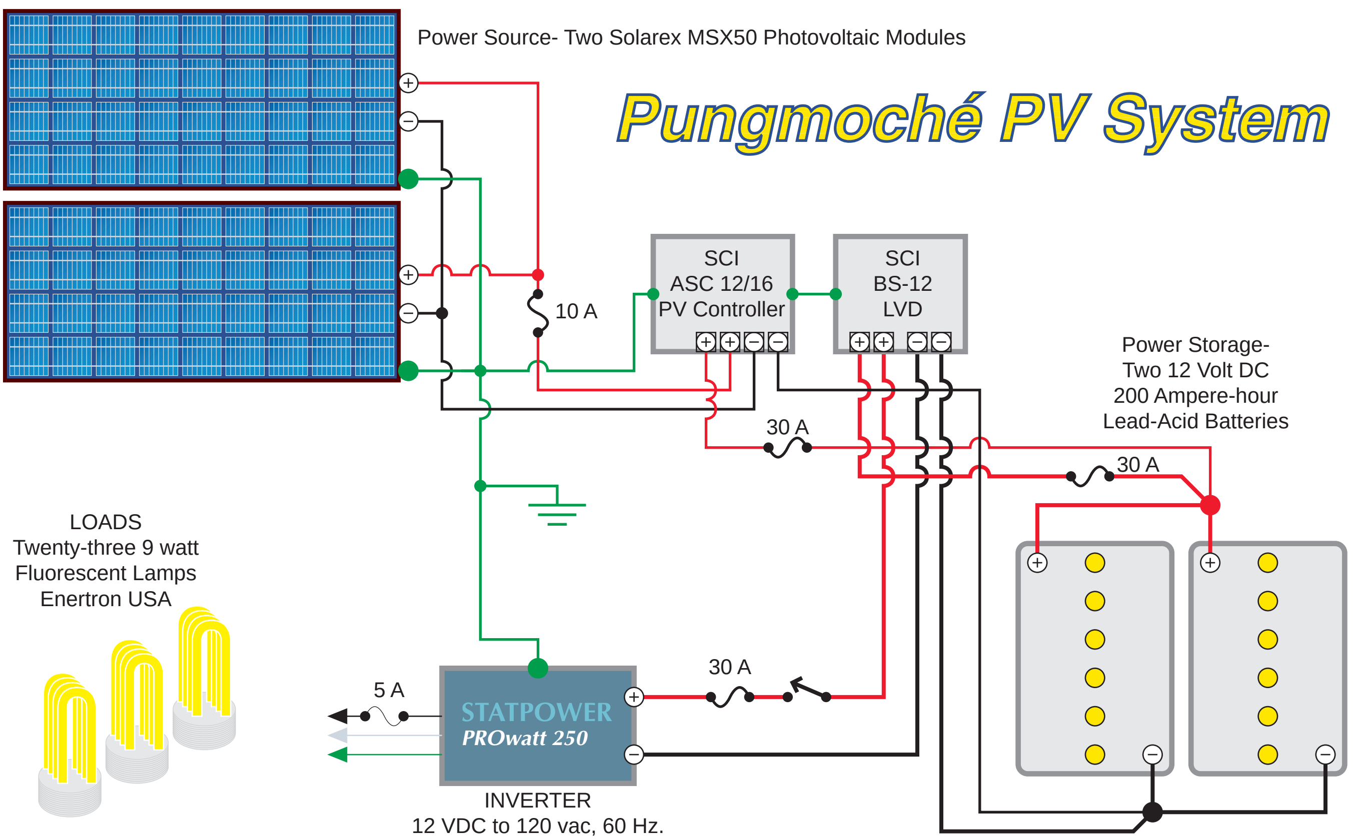
I was very nervous about doing this, but realized it was the only choice for the array. I was running out of time. I gritted my teeth and climbed the apex of the roof with a bag of tools. I straddled the ridgeline and shimmied out to the edge. With a pillow under my groin, I could hold my weight as I lay on my belly and extended my torso far enough out over the abyss to see the end of the ridgepole under the tin roof. I held the array frame base against the 8 inch diameter pole end and hammered the 8 inch long lag screws until I could screw them in with a 12 inch crescent wrench.

The batteries (two 200 Ampere-hour National truck batteries) went under the roof in their own sealed box. The ventilated control box was mounted on the lama's bedroom wall, so he can guard the on switch. The controller is an SCI manual model with a trim pot to set the high cut-off voltage. I set it to 14.8 Volts to equalize the batteries occasionally. LVD (low voltage disconnect) is accomplished with an SCI BS-12 battery saver. This allowed me to set the low disconnect voltage to 11.5 VDC and the reconnect to 13.0 VDC, or whatever points I choose. I wanted the control points to be manually adjustable so that I could manage the heavy winter load on the batteries. When all 23 lights are on (fifteen, 9 watt & eight, 13 watt), they draw about 240 watts ac, through the Statpower 250 watt inverter, the system is maxed-out. Fortunately, they almost never have more than 50% of the lights on at any one time. That load is only about 120 watts. The Statpower handles that load easily.

The monastery's daily consumption is approximately 120 watts per hour for three hours or 360 watt-hours per day. With inefficiencies, this translates to an approximate average daily consumption of 40 Ampere-hours. The two Solarex MSX50 PVs produce six Amperes per hour for an average of five hours daily or about 30 Ampere-hours per day.

Pungmoché is at a rather high and obscure location in the Himal — it's about a four hour

Below: The children's dormatory at Pungmoché.



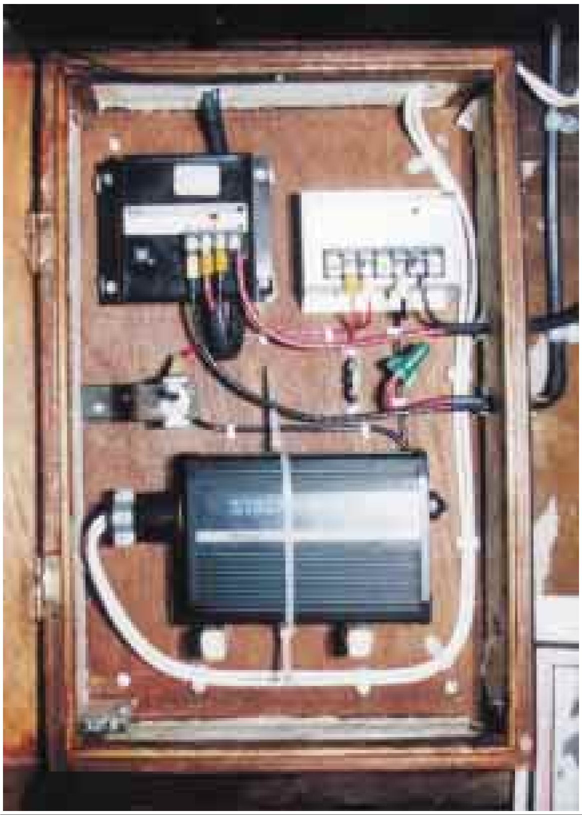
walk to the tree line. Clouds play a big role in daily solar insolation. The bi-directional tilt frame for the array allows the Lama to climb onto the roof of his quarters (he doesn't seem to mind the abyss) and change the angle and/or direction of the array weekly or daily as he likes. I taught him to use the "stick and shadow" method to aim the array. Now, one of his jobs is to adjust the tilt to maximize input for changing conditions. I thought this a rather proper job for a Buddhist Lama.

Energy Management and Automatic Controls

During the winter months of less sun, the 400 Ampere-hour battery bank has problems. If they begin the winter with an 80% full battery (320 A-h), and their consumption goes up to 180 Watts for three and a half hours (639 W-h), their use would be 60 Amp hours per day. In the winter, solar insolation is down to four hours a day and the PV array produces 24 Ampere-hours. This leaves a shortfall of 46 Ampere-hours per day which is coming out of the batteries. The 320 Ampere-hour battery will only last six or seven days in this heavily loaded scenario, before the BS-12 LVD shuts the system down at 11.5 Volts. Theoretically, the battery will be 80% discharged. The time required to reach reconnect voltage is around ten days. Ten days is a long time for the lights to be out. We couldn't give them a third module because of our budget. I could lower the reconnect voltage to 12.5 Volts and the lights might come on again in a week or less. This would encourage overconsumption and habitually draw more energy from the batteries. The battery bank would not often, if ever, reach a full state of charge. The batteries wouldn't last very long. The reason for an adjustable, rather than factory set automatic LVD, is if the batteries aren't able to equalize, I can shut the inverter off until the batteries reach full charge and boil. Then the BS-12 can be reset to 11.8 Volts for disconnect and reconnect at, say, 14.0 Volts. The effect would be to cycle the batteries near the top of their range. This would provide about the same amount of energy usage as at the lower setting. Thus, the beauty of automatic controls. Alternately, I could set the reconnect top to 14.5 Volts so that after LVD, the system doesn't turn-on again until the batteries reach full charge. The batteries would last a lot longer. But, I felt it was unreasonable for the lights to be off for a month or so while they wait for a full charge. I chose to leave the reconnect voltage at 13.0 Volts. I hoped that after the monks experienced a system shut-down, and waited ten days for the lights to come on, they would be more conservative in their energy usage. If the monastery is able to trim its winter power consumption to somewhere slightly above their winter photovoltaic production, they could have lights nearly all the time. Eventually, when I can afford another MSX50 for Pungmoché, winter should not be a problem for the system. My hope is that learning to live with a finite resource will not be a lesson in impermanence for the young monks, but a lesson in energy conservation.

The lesson I learned from these PV systems is that rural solar electricity in developing nations is a very viable idea. With even small energy inputs, living standards are improved and economic opportunities created. If poor rural villages had a PV powered public utility, it would assist the villagers in many important ways. Irrigation is a serious problem. PV water pumping could improve crop yields, an urgent need. PVs could provide water to grow saplings for reforestation and lessen the burden, usually bourne by women and children, of carrying water. PVs would provide the community with more time for other activities. Photovoltaics could also be used to improve agricultural processes and create new enterprises. PV

Below: A close-up of the power center on Lama Ngawang Zima's bedroom wall.



Above: Thupten Choling nuns during a visit to Pungmoché Monastery and School.

powered egg incubators would increase the number of chicken hatchlings, providing more dietary protein and cash income. PV-assisted solar food driers would extend a communities food supply and increase income from marketing dried produce. PVs could provide electricity for water purification through ultra-violet radiation systems, reducing infant mortality, adult illness, and burning firewood to boil drinking water. PVs could light schools, monasteries, remote medical facilities, and homes. PVs could be used for vaccine refrigeration in rural health clinics. Solar electricity could recharge flash light and radio batteries. Utility's could employ village people to operate and maintain these facilities and manage community resources.

Such a development scheme might help to solve some of Nepal's over-crowding in the cities. If rural living standards were improved, people would want to remain in rural areas instead of migrating to the choking cities. In cities, they can only become the urban poor instead of the rural poor.

I've written a proposal for a project that will work to accomplish these goals. I've sent it to 25 various charitable

foundations and trusts across America seeking funding. I'm hoping to receive enough support to get this project off the ground and into the air again.

Cheers from Nepal!

Access

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System Update — December 1994

I was sitting in my kitchen in Kathmandu when Karen Perez of Home Power Mag called me from Oregon. Home Power has donated a third module for the PV system at Pungmoché. What excellent news!

I had just spent two weeks in Junbesi, Solu installing more lights and inspecting the systems when Karen called. The systems are operating automatically, as per design. The only problem has been one failed 9 watt ballast and generally low battery cycling. The blown ballast created a small problem. When the ballast blew out it blew the bulb too. The Lama, rightly, tried changing the bulb. The faulty ballast blew the next blub too. Unfortunately, the Lama tried all five of his spare 9 watt bulbs in this ballast. They all blew out. We all know what our own learning curves were like when we first tried to sew or fix the plumbing. It isn't surprising that the Lama made such a mistake in his first attempt at trouble shooting the system. He now knows not to waste bulbs on a dead ballast. Next time he'll change the ballast if it doesn't work on the first blub and throw the bad ballast in the garbage. I knew the ballasts would begin to burn-out over the years. It will probably happen just as it did with this one — burning out bulbs and then burning out every spare bulb that's tried. That's at least two bulbs for every failed ballast. Although only one ballast failed out of 33, that's only 3% of the total. Potentially this could eat alot of bulbs in the coming years. I'm quite confident that the Lama will learn from these first mistakes. I learned from my mistake of putting distilled water in Topkay's battery. Attention and concentrated H2SO4 salvaged the battery and it's now working fine.

In systems as tightly sized as these, low battery cycling is a problem. The two monasteries' tendency over the past year is to try to consume more energy than they receive every day. The batteries are cycling between LVD and reconnect voltage. Both systems occasionally need to be manually set on equalization charge and the load shut off. (I visualize an automatic device that senses poor battery cycling and shuts down the system for equalization "healing time.") The SCI BS-12 battery saver on the Pungmoché system is not manually adjustable over a wide range to truly compensate for consumption habits by turning up the reconnect voltage to full charge. It wasn't exactly designed for that anyway. This technical trick to save the batteries would push the off-time into the 14 day range, while they awaited reconnect voltage in the winter. The real solution is to install a third module, which Home Power has graciously donated, I'll install it in Summer '95. Thanks! Dennis Ramsey