HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #45

February / March 1995

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Features

GoPower

Fundamentals

Cover: Two photovoltaic modules provide lights at night for the Tumbuk Monestary in Nepal. Story on page 6.
Photo by Dennis Ramsey

Things that Work!

Homebrew

Columns

Regulars

Access and Info

Access Data

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Recycled Paper

Recyclable Paper

Above: Agate Flat and HP Central from the air.

January 8, 1995, Agate Flat, Oregon
On January 7, 1995 an intense storm pounded the US West Coast. High winds caused major power outages that affected over 200,000 homes in California and Oregon. Rain caused flooding. Phones were down. Some coastal areas have now been without power for over 24 hours. Another high wind storm is coming tonight. Who knows when power will be restored.

On Agate Flat the winds were between 35–70 mph — no power shortage here. In fact, we almost had too much. Our Whisper 1000 wind generator belied its name and screamed like a banshee. Our 12 Volt battery bank was over 16.30 Volts , with 100 overcharge Ampere-hours when we went to bed last night. The batteries were boiling. The LCB was hot. The wind mutilated our ten year old 2 meter ham radio antenna — our only casualty.

Our neighborhood is typical of many renewable energy-powered neighborhoods along the West Coast. Here the lights burned brightly and we watched it all go down on TV.

There is no doubt that Nature is powerful. The only question is, do you work with her or against her?

Richard and Karen Perez for HP Crew

People

Clare Bell
Sam Coleman
Chris Greacen
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Dan Hendrickson
Kathleen Jarschke-Schultze
Stan Krute
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James R. Udall
Mary Van de Ven
Larry Weingarten
Suzanne Weingarten
Michael Welch
John Wiles

" Think about it…"

"What is a weed? A plant whose virtues have not yet been discovered."

Ralph Waldo Emerson
Fortune of the Republic 1878

SOLAR DEPOT

camera ready
on film
four color

7.6 wide
9.8 high

this is page 5

Sun Breathing

Dennis Ramsey

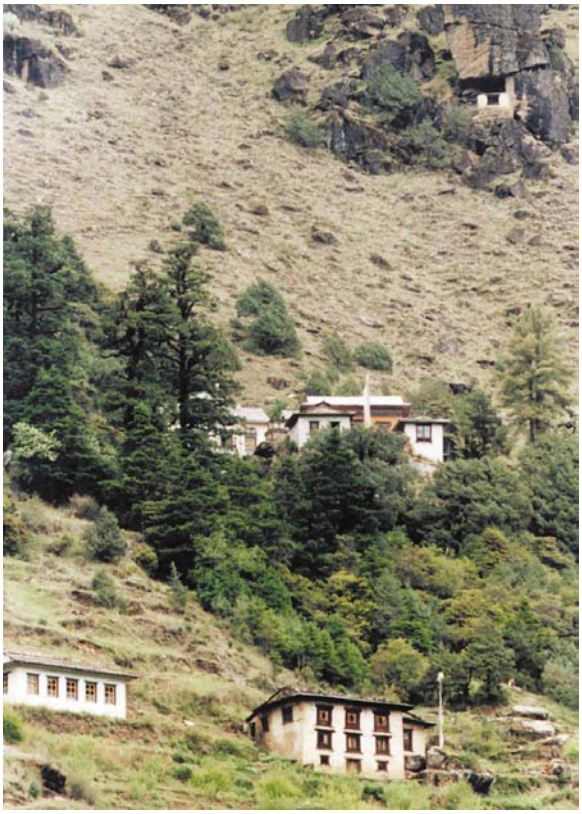
A brilliant hydro-electric project in Solu-Kumbhu, Nepal went horribly wrong a few years ago. It burned the Tengboche Monastery, near Mount Everest, to the ground. A group of well-meaning foreigners gave the monastery an 8000 watt hydroelectric system, which provided not only lighting, but heat as well. 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

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

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

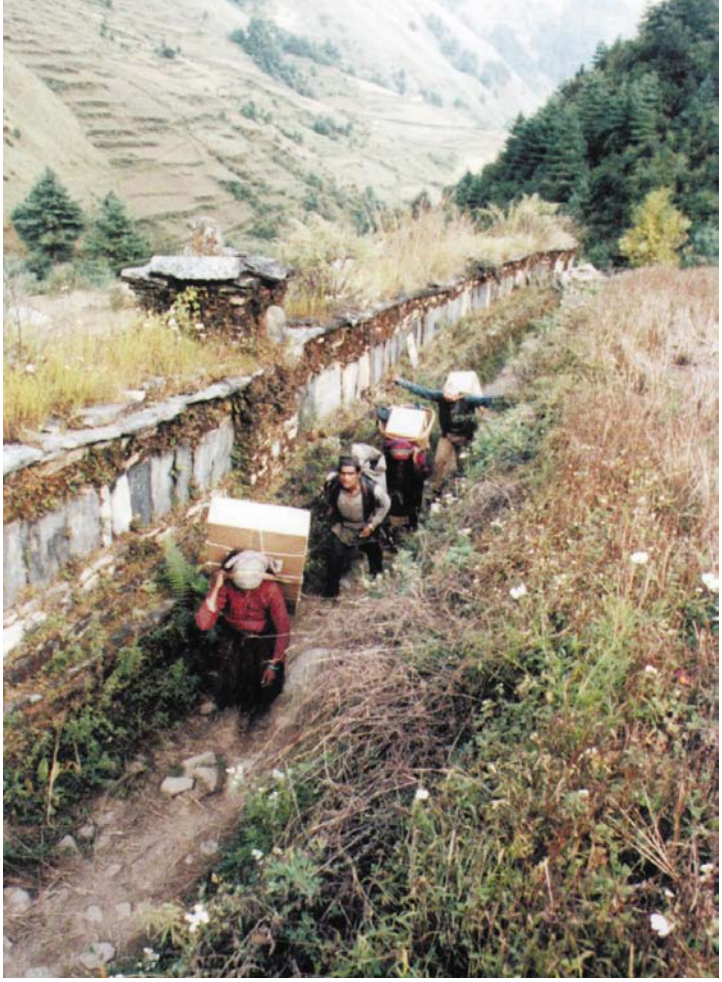
Greater Goods of Eugene for $10 each. I was touched when Greg offered the hardware at just above cost as his part of the donation. The hardware consisted of two Solarex MSX-50s, an SCI ASC 12-8 charge controller, and a Statpower 250 watt, 12 VDC to 110 vac, 60 Hz. inverter.

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.

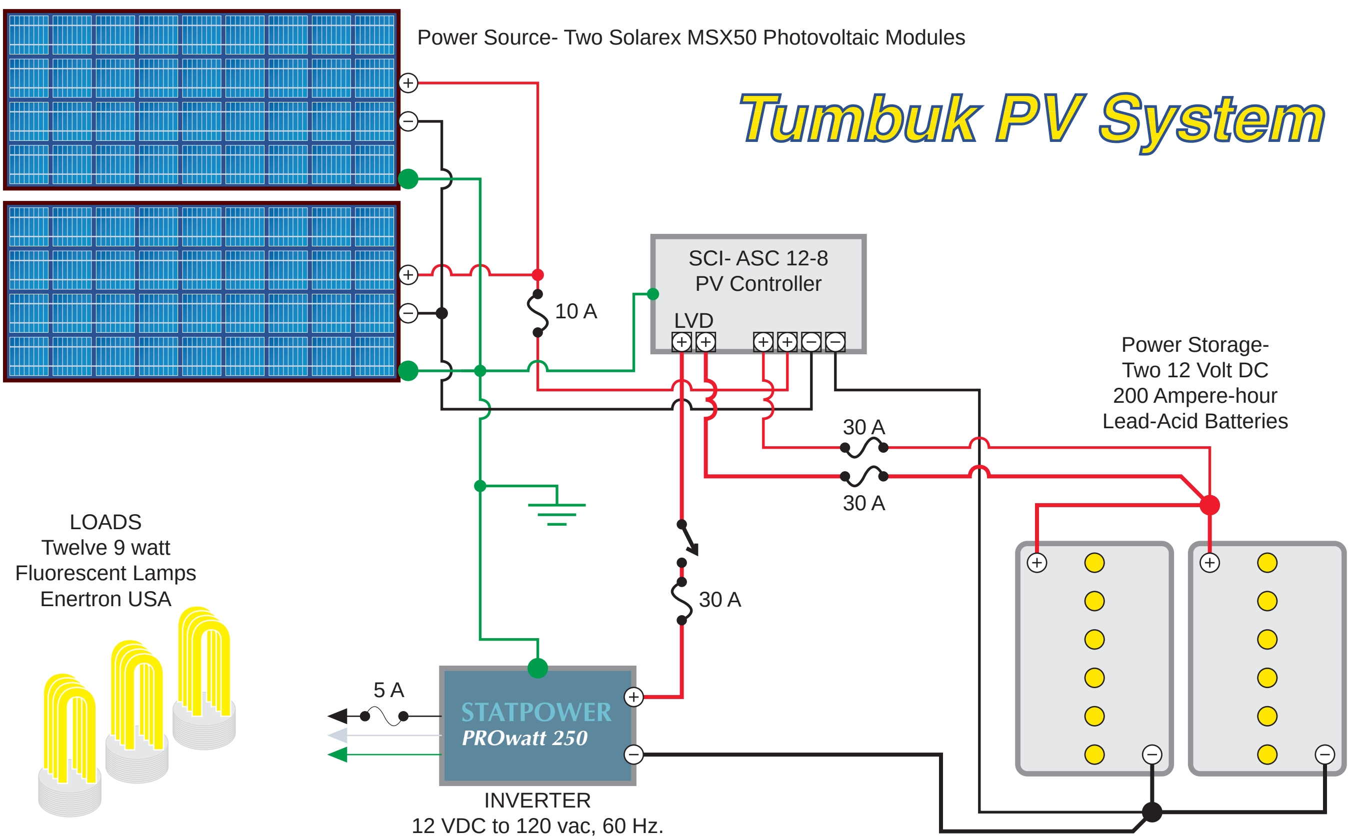
I chose the ridgepole of the kitchen house to mount the array on a bidirectional swivel frame I made in Kathmandu. Then I hefted the batteries up a tree branch ladder into the crawl space just below the ridgepole. The array and batteries are about six feet apart. The control box is located three feet 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

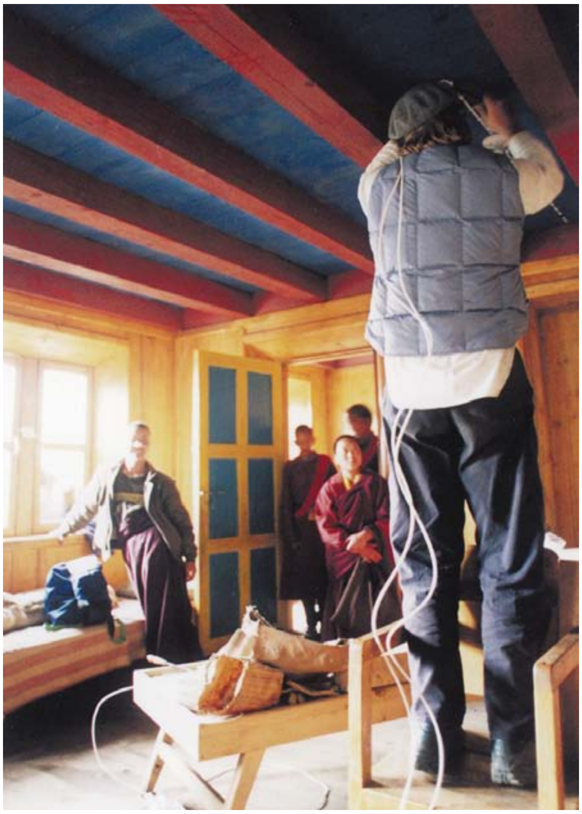
A few days later, wonderful things began to happen. People appeared from all across the valley. They had seen the light blazing across the valley at night. Long before I arrived, a special festival had been scheduled. The festival was to convocate Tumbuk and formally recognized all the hard work Topkay 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.

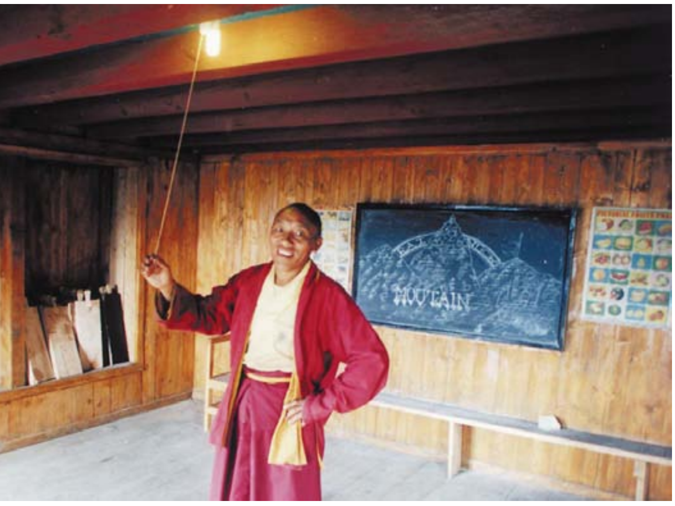
When the festival ended and everyone meandered home, I did too — back to Kathmandu and then to Eugene, Oregon for the winter. I got back to Greg Holder with the story of my adventure and with the news that I had another, bigger installation slated. Greg again provided the hardware at near cost. I assembled 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.

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.

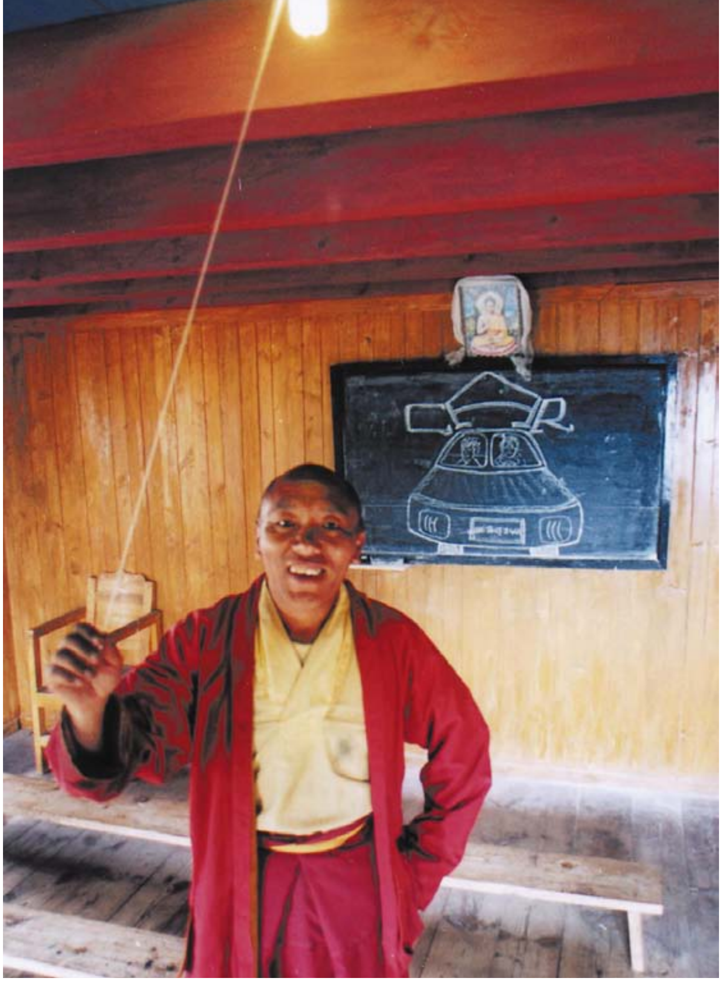
Below: Lama Ngawang Zima in the English classroom at Pungmoché.



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

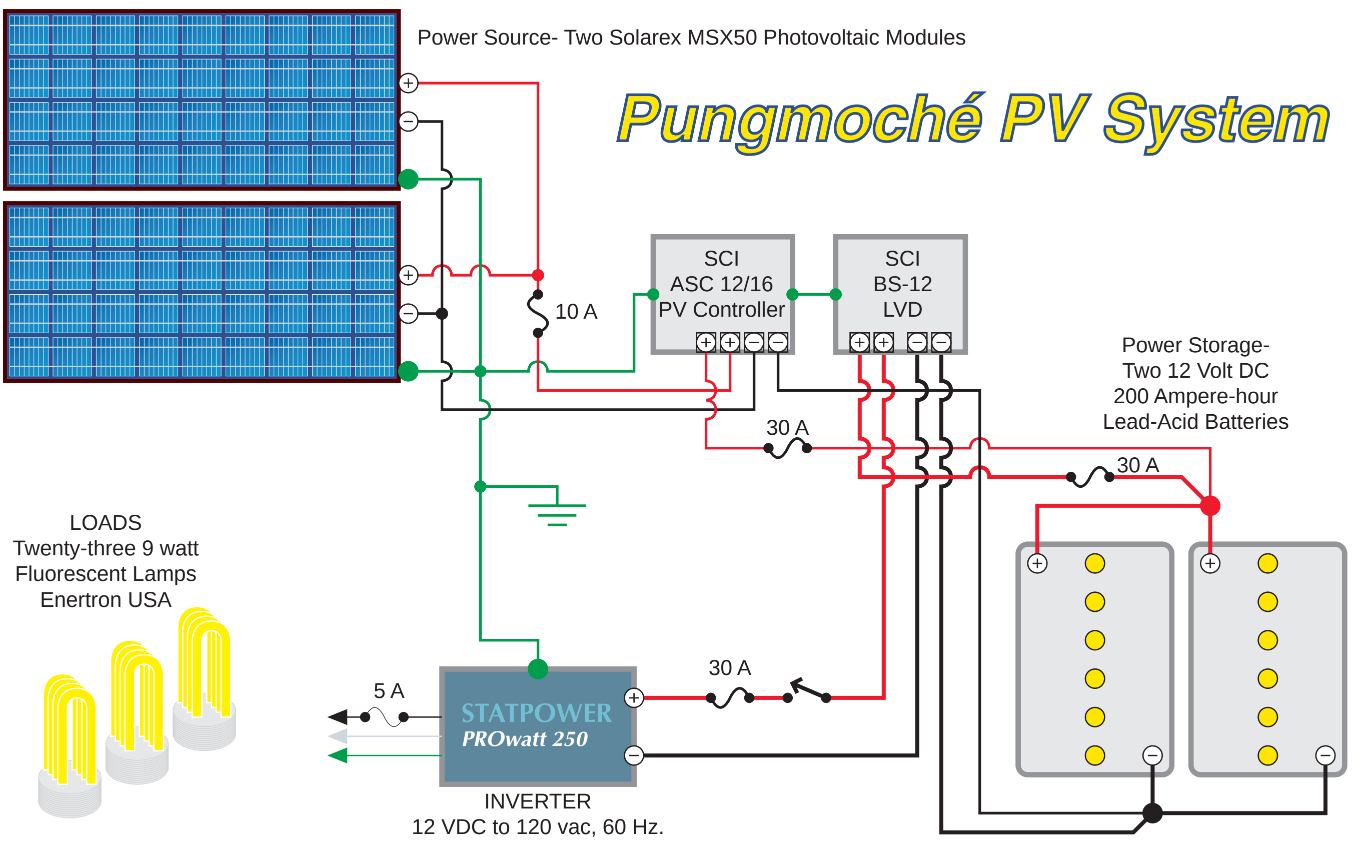
I was very nervous about doing this, but realized it was the only choice for the array. I was running out of time. I gritted my teeth and climbed the apex of the roof with a bag of tools. I straddled the ridgeline and shimmied out to the edge. With a pillow under my groin, I could hold my weight as I 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.



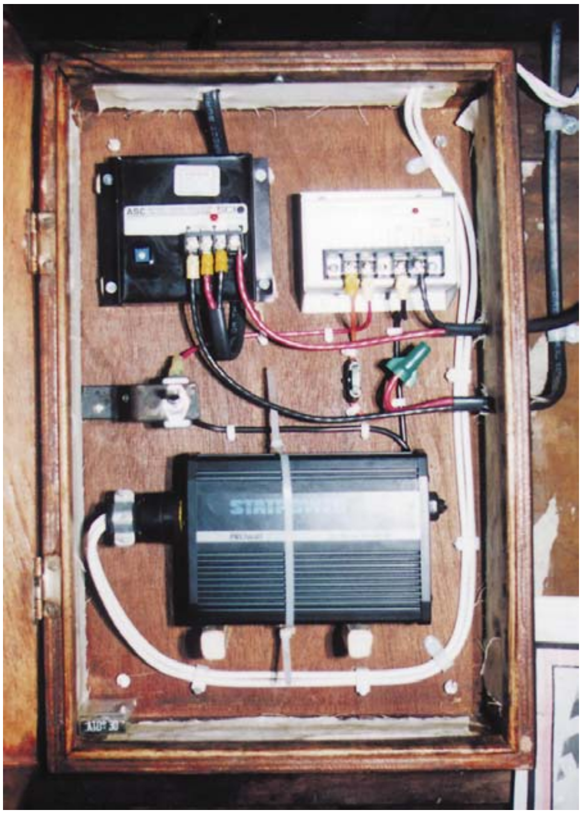
walk to the tree line. Clouds play a big role in daily solar insolation. The bi-directional tilt frame for the array allows the Lama to climb onto the roof of his quarters (he doesn't seem to mind the abyss) and change the angle and/or direction of the array weekly or daily as he likes. I taught him 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 Controls: SCI, 8954 Mason Ave., Chatsworth, CA 91311 • 818-998-5238

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

Above: Fifteen photovoltaic modules provide power to Robert Siebert's grid-connected California home.

Solar in the City

Robert S. Siebert

Our PV/grid intertie system is in a typical suburban California backyard. As an urban dweller, I couldn't claim a compelling need to add solar electric power to our domestic energy mix. I did demonstrate that it is possible, if not yet financially practical, for someone approaching 60. I did it anyway. Here's a summary of my design and installation experiences. A 1125 Watt "patio cover" is on-line and operating trouble-free.

Why did I do it?

We had already improved the house's insulation, added solar hot water, and switched most of the lighting to compact fluorescents. Providing power was a more interesting challenge. I wanted to do my bit to help the environment. The project also provided a useful experience that I will include in the next edition of "EE's Guide to Solar-Electric Applications", a how-to book for PV users. It's also fun to tell your friends that you're in the nuclear power generating business with your reactor 93,000,000 miles away.

The Solar Electric Array

Fifteen Siemens PC4-JF modules are connected in parallel in groups of five. The parallel groups are then connected into a single series string to form a nominal 50 Volt DC, 22 Ampere array. Physically, the array width is four modules on their long sides (about 16 feet) and four rows deep. I chose the low orientation so that when the array is tilted to the winter position it wouldn't be too obvious to my neighbors. It turned out that the neighbors aren't bothered. They're quite interested. I wired three rows of four modules each in parallel. The fourth row has only three modules so each panel was wired separately to a waterproof junction box (4" X 8" X 12") on top of one of the cross beams. Each of these three modules was paralleled with one of the other three rows, and all three parallel strings were wired in series, using split bolts.

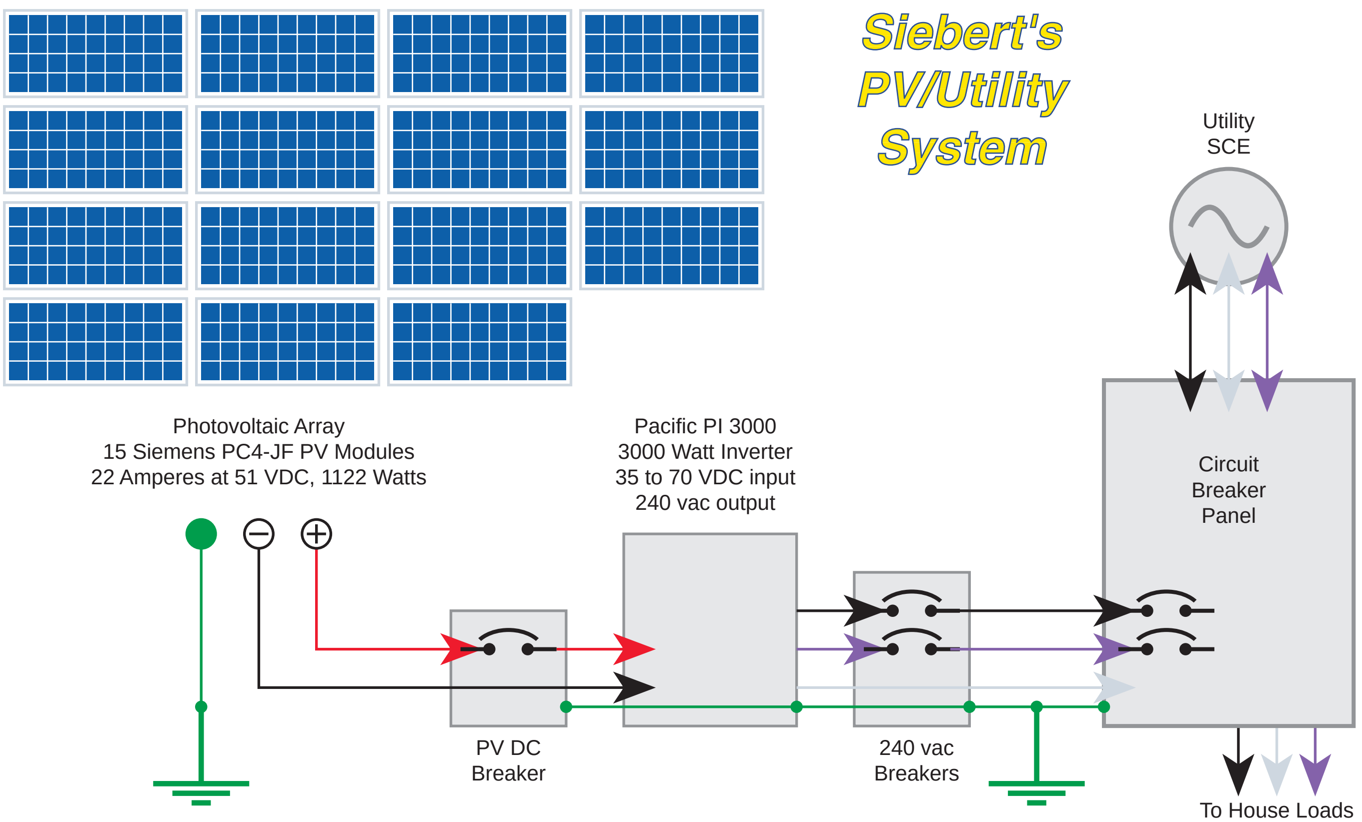
I bolted the modules to a tiltable frame made of 1" X 2" X 1/8", U-shaped aluminum channel (3/16 inch thickness would be better where center support isn't practical). The frame for row was then wired to the supporting metal rails. Galvanized steel with pre-punched holes was very handy on top of the wooden cross members. The rail is grounded by #6 solid wire to an eight foot ground rod driven into the earth at one corner of the array. Tilt positions are set by angled 2 X 4s.

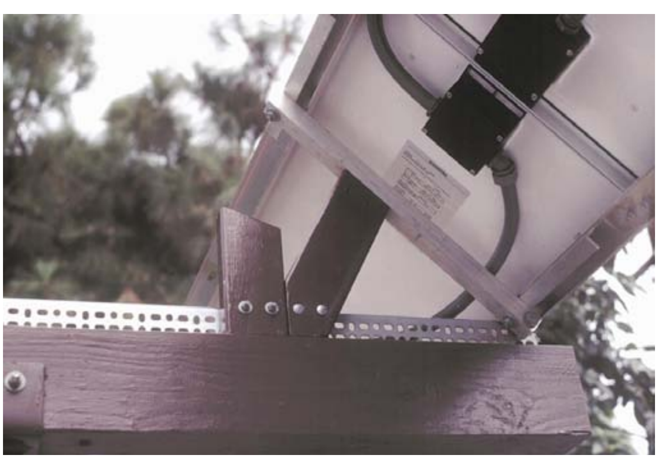
Wiring

The wire run from the top of the array support to the DC circuit breaker at the inverter is 65 feet. I used #4 AWG to keep the voltage drop to about 3%, maximum. I eventually ran a 3/4 inch PVC coaxed conduit under about 18 feet of concrete.

Right: The 1125 Watt photovoltic array doubles as patio cover.

Below: With the PV array hidden from view, it's impossible to tell that solar energy is powering the house, or putting energy back into Southern California Edison's electric utility grid.





Above: A schematic of Robert's PV system.
Left: A view of the back of one module showing the wiring and J-box detail.
Below: The Pacific PI 3000, utility intertie inverter and its two associated circuit breaker boxes.

The distance from the DC breaker to the inverter is approximately 15 inches. I used #6 wire to make two tight turns a little easier. It's another 15 inches from the inverter to the ac breaker. On the ac side, at a nominal 240 volts, much smaller wire #12 was used and very welcome.

For the connection to the house's wiring, I added another two breakers in the distribution panel. I "back-fed" them with the solar-generated power. Vertically every other breaker is on the opposite side of the input service so a ganged-together, (dual) breaker could be used. This guarantees that if one side goes, they both open up.

I chose Square D's breakers because their QO series breakers are DC-rated. Square D's small sub-panel boxes are harder to find and are more expensive. If anyone knows of other DC-rated breakers they can probably save a few bucks.

The Inverter

I used a Pacific Inverter PI-3000 over others — Trace, Omnion, etc. for three reasons, all of which will likely be rated differently for other applications.

1 Battery backup. Only once in the past 15 years has my grid power failed for more than 15 seconds. I considered the value of this feature small compared to such considerations as battery cost and maintenance. (The Trace requires small batteries for operation even if battery backup is not required.)

2. Experience. Pacific Inverter has been making line-tie inverters for about 10 years. I valued that experience. Other experienced vendors, e.g. Omnion, sell larger, more expensive units.

3. Output voltage. The PI unit outputs a nominal 235 volts, a natural match to the input power. No doubt, the Trace unit would work fine at 117 vac. My sense of symmetry was more comfortable at 235 volts. In other words, across both ends of the utility transformer's secondary, rather than one end and the center tap.

The Process

To do a line-tie installation several official approvals — besides your spouse's! — are necessary. In my case, the utility (Southern California Edition, SCE) insisted on a waiver (called a rider) from my homeowner's insurance company. SCE also required the city's electrical permit sign-off and their own "method of service study". Method of service means "What kind of meter do we want to install?" The method of service study came after we signed a contract full of escape clauses. It wasn't as bad as it sounded, though reading through it gave the clear impression that they virtually always work with much bigger fish. The implications are that they work on a big project planning time-scale and are not shy about specifying capital costs for the co-generator.

SCE thought I was some kind of curiosity .They called four of their staff into an office to meet me. SCE had a hard time trying to choose how to meter the site (see sidebar). But, they were supportive and explained several billing options. I choose the one where my production subtracts directly from my consumption — at a retail basis. SCE buys any excess production at wholesale prices. The difference in prices is large — retail is approximately 10¢/kwh, wholesale is about 2.5–3¢.

My experience with the city building department and inspector was instructive. The permit-granting fellow behind the counter admitted they he had never seen this type of system. He declared that for purposes of computing, the cost of the permit the entire array was "one unit". The inverter and its input & output breakers were each another "unit". The permit cost the standard $50 minimum. As for the inspections, one was required to verify the depth of the underground conduit and another for the final system. The inspector liked the extensive use of standard conduit, sub panels, fittings and clamps — it looked familiar. He didn't ask many questions about how it worked. He was more interested in what the utility thought. All in all, he took less than ten minutes to sign me off.

Above: One of the major PV array junction boxes and the array-cleaning owl, who keeps birds and their droppings off of the modules.

Robert Siebert's PV/Utility System Cost

Item	*Cost*	*%*
15 Siemens PC4JF PV Modules	$5,000	54.9%
Pacific PI 3000 Inverter	$3,000	33.0%
Structure, steel	$400	4.4%
Structure, other	$250	2.7%
Misc. permits, hardware, wire	$450	4.9%
Total	$9,100	

No technical problems, but…
Metering Is Not Simple And May Not Be Cheap

In principle, all a utility needs to do is determine that your installation is safe and that your name is on a contract letting them off the hook if anything goes wrong. In practice, they may not be content to simply let your present meter run backwards when your power generation exceeds your consumption — typically from 9:00 a.m.until 3:00 p.m. The reason they give is that if you produce more than you consume in any billing period, their billing computer will flag this as an exception and they will have to send someone to verify that the customer is not stealing power. (A simple entry in the billing program is not deemed feasible by my utility.)

The proposed solution is to install two meters — one reading only incoming power and one reading only outgoing power. Then the meter reader will record both readings. Someone, somewhere, will bill the customer for the difference. Some red-letter day, they will have to send their co-gen customer a check for the surplus — at wholesale rates of course. The only problem with this approach is that they want to charge the user for two new meters. They also are likely to require installation changes to accommodate the meters that could result in major retrofits to the existing, usually built-in, circuit breaker panel. Two months after I began producing power on a test basis, the utility has proposed a $1300 two-meter solution. After I balked, SCE said that they realized this solution was more appropriate to a 100 kW (and up) installation. They said they would try to find a common-sense solution. SCE is very friendly but very slow.

Conclusions:
Everything worked as advertised. Except for some welding, I installed everything myself. The total cost was $9100. It was quite a thrill seeing the watt-hour meter go backwards for the first time. It's still fun to watch. The real lesson from the project is that plenty of opportunity exists for cost lowering if production volumes can be brought up. Solar module costs, especially inverter costs, would react favorably to increased volume. The utility should get used to the process and come up with a simple metering policy, etc. Conservatively, if houses across the country provide just one-third of their energy requirements on-site the nation's CO_2 production would be reduced by 400 million tons per year.

The Real Bottom Line
Data on costs/energy saved between 1993 and 1994 can only be evaluated for two months (September and October). These figures are subject to error due to the small sample size. What is certain is that from September 6 to November 30, 280 kwh were produced and sold to Southern California Edison. The cost savings was better than expected because of the billing level at which we were operating. Specifically, SCE was charging us 13.9¢ per kwh above a baseline of 258 kwh per month and 11.6¢ per kwh for those below. Our net level of consumption for October and November is about 200–210 kwh per month, so all billing avoids the 13.9¢ rate.

Access
Author: Robert S. Siebert, Energy Efficiency, 1308 Fairway Drive, Orange, CA 92666 • 714-997-0190

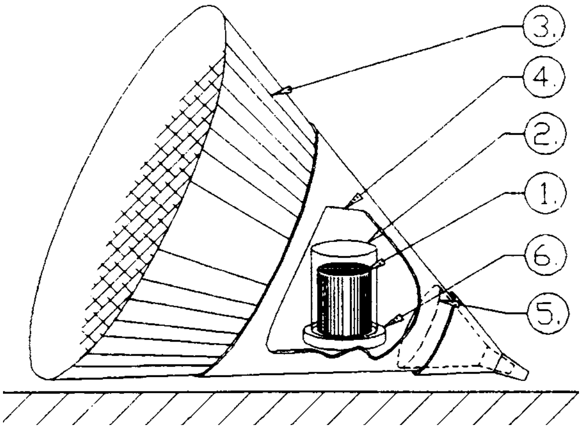
Inverter Manufacturer: Pacific Inverter, Inc., 509 Granite View Lane, Spring Valley, CA 91977 • 619-479-5938 • FAX 619-479-1549.

Above: A backpack solar cooker in action at 13,000 feet on the Gangapurna glacier above Mamang, Nepal.

Solar Cooking In Nepal

Allart Ligtenberg

Namasteh! (Nepalese greeting, hello or literally, "I greet the Gods within you.") Nepal is a beautiful country between India and Tibet that showcases the highest mountains in the world. Its altitude ranges from a few hundred feet above sea level to Mount Everest's 29,028 foot highest peak. The climate ranges from tropical to polar, depending on the altitude. The incredibly complex geography of steep hills, valleys, mountains and gorges provides an enormous challenge to survive and grow crops. Nepal's rapid growth in population and tourism have placed tremendous demands on its natural resources. Cooking accounts for over 90% of Nepal's energy needs. Most of this energy comes from wood and dung. Nepal's primitive dwellings typically have no chimneys. Deforestation, soil erosion, landslides, and air pollution cause severe environmental deterioration. Contaminated water causes major health problems. Open-fire cooking causes major burn, respiratory, and eye problems.



Top: A diagram of the backpack solar cooker.
Bottom: A view of the interior of the cooker.

Promoting Surya Sakti (Solar Power)

During 15 years of frequent visits and solo-treks in remote regions, I observed and documented environmental and health problems. An early retirement incentive from my engineering manager position at Hewlett-Packard allowed me to pursue my dream — promoting solar cooking and water pasteurization in the developing world, particularly in Nepal. In the fall of 1992, I left for Nepal. Spreading this technology is extremely difficult because of poverty, cultural and geographical barriers, different languages, and ethnic groups. My approach is very simple. I talk to as many people and organizations as possible, anywhere, any time. I give taste tests of solar cooked food. I look for organizations where solar cooking would be a natural addition to their existing programs. These groups include NGOs (Non-Government Organizations) at the multi-national, national, regional, urban, rural, and mountain area levels. I also pursue consulates, universities, colleges, schools, small business, and government. I am as interested in talking with people of stature (community and religious leaders, teachers, and lodge-keepers) as with people and children on the street or trail. After meeting with many agencies in 1992, I was very happy to find CRT (Centre for Rural Technology) in Kathmandu. I helped them initiate a solar cooking program. Now, CRT has a five year program. CRT is a very capable, professional, well-connected NGO with experience in bringing new technologies into rural areas. They conduct programs in water mills, micro-hydro, Chulo ovens, bio-gas, forestry, and agriculture.

At CRTs request I returned to Nepal in the fall of 1993 to help with solar cooker workshops, promotions, demonstrations, networking, and give advice. I also wanted to repeat a previous trek to the remote Annapurna mountain region to demonstrate solar cooking along the way with my lightweight portable version.

Lightweight Backpack Cooker: An effective teaching tool

Rather then lugging a solar box around, I designed a portable cooker that weighs less than a pound. I always had it with me.

The diagram shows the parts of my one-person "trekking cooker": 1. The cooking pot is an aluminum beer can and lid, both are painted black. 2. Glass light fixture or jam jar placed over the can to contain the heat. 3. Cone-shape (roll-up)

Below: Near Annapurna, Tashi, a Braga village leader cooking dahl-bhat (lentils & rice) in the backpack cooker.

reflector made of very thin aluminum coated plastic (80–90 % reflective). 4. Thicker plastic (roll-up) cone to provide structure for reflective material. 5. Two funnels to hold the reflector. 6. Disk to horizontally support the glass enclosed container.

Assembling and focusing the cooker is easily done in less than a minute. The cooker is focused by pointing the reflector toward the sun, sticking the funnel into the ground, and supporting the cooker at the proper angle with rocks. Cooking usually takes an hour or less so re-focusing is not critical. I solar cooked rice, lentils, potatoes, dal-bhat, tea, and hot lemon. The reflectors roll-up into a small compact cylinder. Backpackers who want minimum weight (half a pound) can replace the glass fixture with a Reynolds oven bag. Place the can inside the oven bag, blow air into the bag, and close the bag with a clothespin or strap.

Experiences On The Annapurna Trek

I repeated a portion of a solo-trek I did six years ago to the remote Annapurna mountain region. I wanted to assess changes in the environment, and demonstrate solar cooking and water pasteurization. The backpack cooker was invaluable. I demonstrated solar cooking to highly interested and curious local people along the way. I cooked rice and let the bystanders touch and taste the food. Many wanted to make solar box cookers. I referred them to CRT. Local people are more concerned about the environment now than they were few years ago. However, much more needs to be done to have a real impact.

I reached the remote, high altitude villages of Braga and Manang after 10 days of strenuous walking. The incredibly beautiful Annapurna Mountains have abundant sunshine, but not much firewood. In Braga, I stayed in the lodge of Tashi, a man I'd met six years ago. He is a well-respected, unselfish community leader. Tashi is very concerned about the disappearing culture, deteriorating environment, poverty, and health problems. I was delighted by the simple solar water heater/shower on his flat roof! He also had built a water heater around the exhaust pipe of his kitchen's wood stove. It did not take too long to get Tashi excited about solar cooking. Tashi plans to build 10 wooden cookers this year and double the quantity each year for the next few years.

Tashi and I spent two days visiting head Lamas in five monasteries. We succeeded in getting their important support and blessing. We lobbied the Annapurna Conservation Area Project (ACAP). Solar cooking fits ACAP's programs to protect the delicate environment of the entire Annapurna region. ACAP had just opened an office in Manang and started to investigate projects to pursue. We were successful. Half a year later ACAP had sent solar cookers to Manang and was ready to start training.

The rest of my time was spent on discussions and demonstrations to the "King of Manang", the Himalayan

Above and below: Traditional methods of Nepalese cooking, using wood for fuel.

Rescue Center medical post, lodge keepers, women's groups, cooks, and trekking tourists. "The King of Manang", an important political figure, promised to cooperate with a solar program.

Activities In Urban Areas

After the trek, I helped CRT with their four-day workshop on "How to Build and Use Solar Box Cookers and How to Pasteurize Water." NGOs and community groups attended. Everyone built two cookers for home use. One was made out of scrap materials and the other of high-quality cardboard. The participants developed plans to teach solar cooking in their villages and projects. Water samples were taken from different sources (rivers, taps, hotels, and pumps). I tested for Coliform and fecal E. Coli contamination. The results showed contamination in 45 percent of the water samples. We successfully pasteurized the contaminated samples by heating the water to over 150°F in the solar cookers.

Public Solar Demonstrations
In Kathmandu's busy Basantapur Durbar Square we cooked in eleven box cookers (wood, cardboard, bamboo, metal, fiberglass, and scrap), a large parabolic cooker, and my tiny backpack cooker. An estimated 2000 people showed such interest that crowd control was sometimes difficult. We had TV coverage on the evening news and newspaper coverage for the next few days.

At the five-day International Centre for Integrated Mountain Development Exposition, CRT volunteers prepared food and hot tea in solar boxes and with a parabolic cooker. This provided great exposure to environmentalists, scientists, and community leaders of all eight participating countries of the Hindu-Kush Himalayan region.

A joint solar cooking program was started with CRT and RUCODES (Rural Community Development Society). RUCODES helps generate employment and skills for the disadvantaged and poor. At the request of the mayor of Banepa, I spoke at an environmental conference and later at a literacy campaign graduation. The mayor promised to actively support solar cooking. He is also considering changing the building code to favor passive solar energy.

I met with SUNWORKS, a solar water heater business. They now market solar cookers. Other encouraging (repeat) meetings were with Save The Children US & UK, Women Development Office, UNDP, UNICEF, CARE, ICIMOD, the Dutch Consul, St. Xavier College, Plan International, Jaycees, and Rotary Club. The Jaycees and Rotary Club are interested in a joint project with their USA counterparts.

Back in the United States
During several visits to HSU (Humboldt State University), I lobbied to establish a link between CRT and this highly regarded, appropriate technology university. This could be very

Above: Anita Manandhar of the Centre for Rural Technology in Kathmandu, supervises a solar box cooker class.

valuable to the continued success, follow-up, and new ideas of CRT's programs. As a result, HSU's International Development Technology program is now actively searching for qualified graduate students and engineers to work on mutually defined projects at CRT. The first graduate student has been selected and will leave this year for Nepal!

The Himalayan Foundation has requested a proposal, which I've submitted.

Challenges And Progress
I'm grateful to have met so many dedicated people. Even though the challenges are enormous — we can make a difference.

In 1992, essentially no solar cooking was done in Nepal. Now, there is CRT, a local, well-respected hands-on organization. They provide the education and outreach needed to spread this technology. Public demonstrations have exposed close to 10,000 people to solar cooking. TV, radio and newspaper coverage have effectively increased awareness. An infrastructure is in place. Many organizations are working together. On my Annapurna trek alone, I exposed roughly 500–600 people to SURYA SAKTI. In Braga and Manang, a solar project is now underway.

In 1992, there were two solar cookers being used in Nepal. In 1993, there were 150. In 1994, an estimated 600 plus are being used. These numbers don't seem large. I wish they were higher, much higher.

People caution me to be more patient. At least, a start has been made. I will continue to promote solar cooking in Nepal and support CRT's successful program. More solo-solar-treks, with a backpack cooker, will happen in 1995. I will assist NGOs who recently asked for help. I will also follow-up and initiate projects with organizations in Nepal and the USA.

It would be great if a multi-national development organization or charity organization would recognize the enormous potential of this, low-cost, simple, effective technology. We need to act now to help solve the critical health and environmental problems in Nepal and other developing nations. Time is running out.

Access

Allart Ligtenberg, 800 Loyola Drive, Los Altos, California, 94024 USA, Tel/Fax (415)948-8294

Solar cooker kits are available, all proceeds will be used to fund solar cooking projects in Nepal. Send an SASE to Allart Ligtenberg for more information about these kits.

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Water Heater Maintenance — Another Way to Save Energy

Larry and Suzanne Weingarten

Energy comes to us in various forms. We are used to thinking of energy as electricity, liquid or gaseous fuel, wood, or sunlight. But there is also energy embodied in the things we own. Some of the things that we normally use up and toss away can be saved. Tank-type water heaters, fairly common residents in homes both on and off-grid, are a good example of something most people consider to have a limited lifetime. But it ain't necessarily so.

Normally, you install a heater, it lasts about ten years, it leaks and you put in a new one. There's more energy than meets the eye involved in that vicious cycle. It takes energy to manufacture a water heater, to gather and transport its raw materials, to install it, to remove it, and to dump or recycle it — energy which you pay for. When a water heater leaks, your personal energy must be spent cleaning up the mess, wondering if and when you'll have hot water for showers and having a new unit installed. You can plug this energy drain. We'll show you how to save energy by making your water heater last a very long time.

Most water heaters in the U.S. are tank-type units made of glass-lined steel. It isn't common knowledge that heaters can be maintained. We replace a tremendous number of them each year. About six and a half million heaters were replaced in 1993. There are a variety of things that can be done to correctly install a water heater, make it efficient, and prevent troubles. We'd like to focus on the most important aspect of tank longevity — the sacrificial anode rod.

Anodes Prevent Tank Corrosion

Every glass-lined tank comes equipped with a solid rod made of magnesium or aluminum, suspended from the top of the heater. In a manner akin to what happens in a battery, the anode corrodes away little by little to prevent any rusting of the steel tank at imperfections in the glass lining. This is what protects your water heater and prevents it from leaking.

Once the anode is used up the steel will begin to rust. In a few years the tank will fail.

If you replace the anode periodically, before it is too far gone, the tank will not rust. With a working anode, rusting isn't merely slowed, it is stopped. In theory, there's no reason you should ever need to buy another heater if you maintain your present one. Statistically the average life of heaters is from nine to thirteen years. We continue to maintain tanks which are now over thirty-five years old. Replacing anodes works!

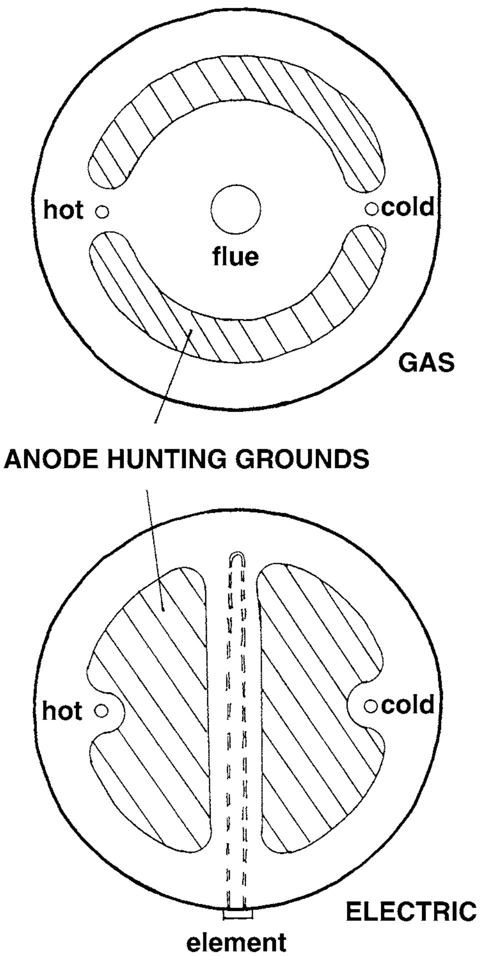
If you're going to change your anode, find out what type rod your water heater has, what type you will replace it with, and where you can get a new one. You will need to have access to the new one before removing the old.

Before you begin, make sure your tank is a candidate for maintenance. Check the outside of the tank at all fitting penetrations. Check the combustion chamber and flue in gas heaters. If you see no evidence of heavy rusting or water marking, go ahead and replace the anode. If there are signs of leaks, start shopping for a replacement heater.

Locate Your Anode

Although anode length will vary with tank size, the rods are usually about 44 inches long and 3/4 inch in diameter, with a 1 1/16 inch hex plug at the top. If you're lucky, the hex head will be out in the open. However, it may be under a plastic disk or a mound of fiberglass, or there may be a knockout in the sheet metal top over the anode.

If you're not lucky, the anode will be hidden under the sheet metal top. The best way to find it is to drill a 1/4 inch hole in the sheet metal and poke a slim screwdriver around, trying to locate the anode. You may need to do this a few times (see Anode Hunting Ground diagram). Once found, use offset tin snips to cut a permanent access hole. Bend down or tape the sharp edges to avoid sliced finger-tips.



Sometimes you'll find a pipe nipple at the top of the anode instead of a hex head. This combination anode is in the hot water outlet at the top of the tank. You'll be able to determine if it's this type by disconnecting the hot side plumbing and poking a long, stiff wire down into the pipe nipple. If it stops firmly two to six inches in, you have found the anode (or one of the anodes). If not, the anode is hiding elsewhere.

Better tanks may have two anodes. The main (if not only) physical difference between five and ten year warranted tanks is the addition of a second anode. The cost of a ten year tank is many times what it would cost you to replace the second anode yourself. If your tank is hard to work on, consider installing two anodes so that you won't need to deal with it again any time soon.

Other Anode Considerations
Aluminum and magnesium are the most common metals formed around an anode's steel core wire. You can tell the difference between them by bending. Aluminum is soft and bends easily, while magnesium is springy and more resistant. (We replace aluminum anodes whenever found because aluminum many be a contributing factor in Alzheimer's disease. Until aluminum is proven innocent, we believe it is safer to avoid using aluminum rods.)

If rotten-egg (sulphur) odor is a problem, a zinc/aluminum anode is available. In combination with other methods, zinc rods help eliminate this odor problem.

If you have limited overhead clearance, you may want to use a flexible link-type anode as your replacement. Flex-rods are segmented so they can be bent for easy installation.

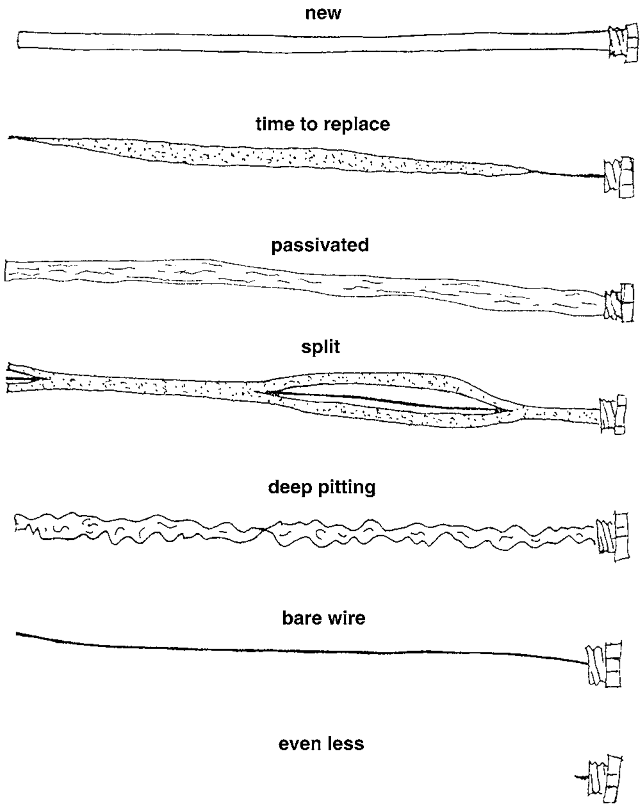
Where can you get a replacement anode? Plumbers rarely have anodes in stock, but they may be able to obtain them from plumbing supply houses. We get ours from Gull Industries in San Jose, California (1800-748-6286); you can too. A resource of last resort, because of generally higher cost, is the water heater manufacturer. Anodes should run around $18–$30, depending on the type needed.

Getting Into Your Tank
Before unscrewing anything, turn off the power. If gas, turn the heater to the pilot position, so you won't need to relight the pilot. Turn off the cold water supply to the heater. Attach a hose and open the drain to relieve pressure. Leave the drain open so pressure cannot build up.

If you have a hot outlet type anode, all you'll need is a pipe wrench to unscrew and replace it. The hex plug type will need a 1 1/16 inch socket, a strong wrench and a cheater bar. For really entrenched anodes, use a six-point instead of a twelve-point socket. It won't round off the corners of the hex plug. (Anodes can be a real trail to remove. Professionals use an expensive tool called a torque multiplier. It trades speed for force and triples the available torque. If your anode absolutely won't come out, you can leave it in place and add a hot outlet type anode.)

As you unscrew the anode, listen closely for the sound of air being sucked into the tank. You want to hear that hiss to make sure the tank is not under pressure. If the tank were still pressurized, the loosened anode could take off like a rocket. So if water seeps from around the threads as you unscrew the anode, stop and relieve that pressure. A faulty cold water shut-off may allow leakage into the tank, or the drain may be clogged.

Inspect the Anode
Normally, if six inches or more of the core wire is showing, it's time to replace your anode. If you find the



ANODE DETERIORATION

anode is aluminum instead of magnesium replace it even if no core wire is showing (see above).

Inspecting the anode will give you information about the condition of your tank. If there is still some sacrificial metal left on the core, your tank is probably in acceptable shape. In general, the less core wire exposed, the better protected your tank.

One condition which can mislead you is anode passivity. You will see much sacrificial metal left and believe your tank is being protected. In actuality, the metal is covered with a hard, dense coating which prevents further sacrificial action. Test for this by bending the rod. If flakes of scale crackle off, the rod has passivated and needs replacement.

Should you find only a bare wire or less, rusting has begun inside the tank (see Anode Deterioration diagram). Examine the tank's exterior (at fitting penetrations, in the combustion chamber and flue). If there is no external evidence of rusting, anode replacement is likely a good bet.

Tips for Anode Replacement

Overhead clearance can be a concern when you replace your anode. If the anode misses fitting into the tank by just a little, it's possible to bend the rod at its center, slip it half way in, and then straighten it against the opening and slide it the rest of the way in. When doing this, check for straightness by tilting the rod when it's about half way into the tank so its lower end touches the tank wall. Then rotate it and see if the top wobbles. If it does, a little tuning is needed. The anode must be straight enough so it can be screwed in without touching anything in the tank.

If you have a gas heater and if the vent goes straight up, you may.be able to slip the anode up the vent and then down into the heater without any bending at all.

If you have less than about 2 1/2 feet overhead, use a segmented anode to prevent frustration. These anodes are bent at the joints and straightened as they're inserted into the tank. In worst case, if you have no other choice, you can drain the tank, disconnect it, and tip it enough to insert the new anode.

Use plenty of teflon tape to seal the threads of whichever anode you use. This will ensure easy removal the next time.

Check the anodes every three to four years. If you have very hard, acidic or softened water, check it in one or two years. Also, if the old anode was long gone, check the new one when it's a year old to determine how fast it's being used up. Keep a record on the side of the tank showing what you did and when. It will help remind you when to have another look.

Our experience suggests that water heaters will last as long as you're willing to maintain them. You may already have the last water heater you'll ever buy.

Access

Larry & Suzanne Weingarten, PO Box 928, Monterey, CA 93942. Phone/Fax 408-394-7077

Replacement anodes: Gull Industries, San Jose, CA, 800-748-6286

Things that Work!

Things that Work!
tested by *Home Power*

Sun Frost's RF-19 Refrigerator/Freezer

Richard Perez and Sam Coleman

We tested our two-year-old, 12 VDC Sun Frost RF-19 refrigerator/freezer. The test was carried out in three sections over a period of ten months. We recorded both temperature and electrical data. Temperature data was taken using a Micronta indoor/outdoor digital thermometer with a min/max recording function. Electrical data was taken using an SPM2000 ampere-hour and watt-hour meter.

The RF-19

This is Sun Frost's largest refrigerator and freezer combo. Our particular RF-19 here at Agate Flat is a 12 VDC model powered directly by our main system's battery. The RF-19 is large — outside dimensions are 34.5 inches wide by 65 inches high by 27.5 inches deep. The interior space of the unit is about one-half freezer and one-half refrigerator. We have no trouble storing enough food in the freezer for several months.

The RF-19 uses two Danfoss motor/compressors, one for the freezer and one for the freezer. Each compressor consumes 4.5 Amperes at 13.5 VDC (about 60 Watts).

The Tests

Before beginning the tests, we set the refrigerator to 37° F. This setting was not changed throughout the evaluation. At the beginning of the first test, the free air temperature of the freezer was set to approximately 0° F. During this time the temperature varied from -3.5° F to 3.0° F, with an average of 0.36° F. Then we moved the freezer temperature probe so that it was situated well within the mass of food in the freezer. After the first test, the freezer motor controller (made by Danfoss and under warranty) failed and was replaced. No other changes were made at this time. After the second test we defrosted the freezer. After defrosting, the thermostat was visually set back to its original 0° F setting.

The Data

During all of the tests we took room temperature and freezer temperature for all data points. During tests two and three, high and low temperatures for both room and freezer were also taken for each data point except the first two points in test two. We used all temperatures taken to calculate averages. The temperature data is summarized in Table 1.

The date and time was recorded when data points were taken. The total Ampere-hours and Watt-hours were recorded for each data point in all of the tests. The SPM2000 was reset after each test. The electrical data is summarized in Table 2.

During test 1, 75 data points were taken. Test 2 had 44 data points. There were 22 data points taken during test 3.

Table 1

	Room Temperature in °F			*Freezer Temperature in °F*		
Test	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*	*Average*
Test 1	86.2	55.0	74.0	16.5	1.0	5.7
Test 2	91.4	49.1	74.0	15.1	-0.6	3.5
Test 3	88.9	47.5	69.5	15.4	-4.0	4.0
All Tests	91.4	47.5	72.5	16.5	-4.0	4.4

Table 2

Test Number	*Total days of Test*	*Total Amp-hrs*	*Total Watt-hrs*	*Amp-hrs per day*	*Watt-hrs per day*	*Kilowatt-hrs per year*
Test 1	110.2	8,642.6	115,110.3	78.4	1,044.6	381.6
Test 2	96.1	8,067.2	108,012.6	84.0	1,124.4	410.7
Test 3	81.0	5,449.4	71,317.3	67.3	880.2	321.5
All Tests	287.3	22,159.2	294,440.2	77.1	1,025.0	374.4

Discussion
Test 2 used an average of 7.6% more energy per day than Test 1. The factors involved were a new controller, lower average freezer temperature, and because no high and low temperatures were recorded for the data points in Test 1. Ice build-up in the freezer was also a factor.

Test 3 used about 15.7% less energy per day on the average than Test 1 and 21.7% less than Test 2. The major factor here was defrosting the freezer between Test 2 and Test 3. Defrosting the freezer really saves energy. Another factor was the lower average ambient temperature for Test 3.

Maximum freezer temperatures always occurred right after large amounts of new food were added to the freezer. The minimums always occurred when no new food had been added for at least a week.

After we added large amounts of new food, the refrigerator took as long as three or four days to drop the temperature the average for that particular test. All Sun Frost units use very low power (about 60 Watt) motor/compressors. These small compressors take awhile to pump the box down to average temperature. This was true of all three tests. During part of this time energy consumption was as much as 30% above average. Three examples are given in Table 3.

Table 3 Adding Food To Freezer

Test Number	*Number of days*	*Total Watt-hrs*	*Watt-hrs per day*	*% over Average*
Test 1	3.01	4092.5	1359.2	30.1 %
Test 2	1.98	2586.4	1308.9	16.4 %
Test 3	1.94	2054.7	1059.7	20.4 %

Refrigerator/freezer tests must be run over a long period of time — months at least — to avoid measurement anomalies.

Conclusions
When we look at the combined results for all three tests we can see that the Sun Frost RF-19 operates well within the manufacturer's stated parameters. With the refrigerator at 37° F and the food in the freezer at an average of 4.4° F, there was an average consumption of 1025 Watt-hours per day. This works out to 374.4 Kilowatt-hours per year. This is exactly what the manufacturer claims for a 38° F refrigerator and a 10° F freezer.

On the home front, we love our RF-19. I'm still amazed and delighted with cold drinks on a hot summer's day. We only have one minor complaint — the diameter of the refrigerator floor drain is too small and water will sometimes build up at the bottom of the frig.

At a $2,733 retail price, the Sun Frost RF-19 is an expensive refrigerator/freezer. It is also the most efficient refrigerator/freezer of its size in the world.

We figure the Sun Frost's additional cost is offset by the reduced number of PV modules and batteries required to power it. Over the last two years it took about five of our 50 Watt PV modules to run our Sun Frost RF-19. Here on Agate Flat, Oregon we receive an average of 240 full sun days per year. A conventional refrigerator/freezer would require twice as many PV modules, and we don't even want to think about the additional batteries.

Access
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Sun Frost: PO Box 1101, Arcata, CA 95521 • 707-822-9095

Things that Work!

Things that Work!
tested by *Home Power*

The Tri-metric Battery Monitor

Tested by Richard Perez

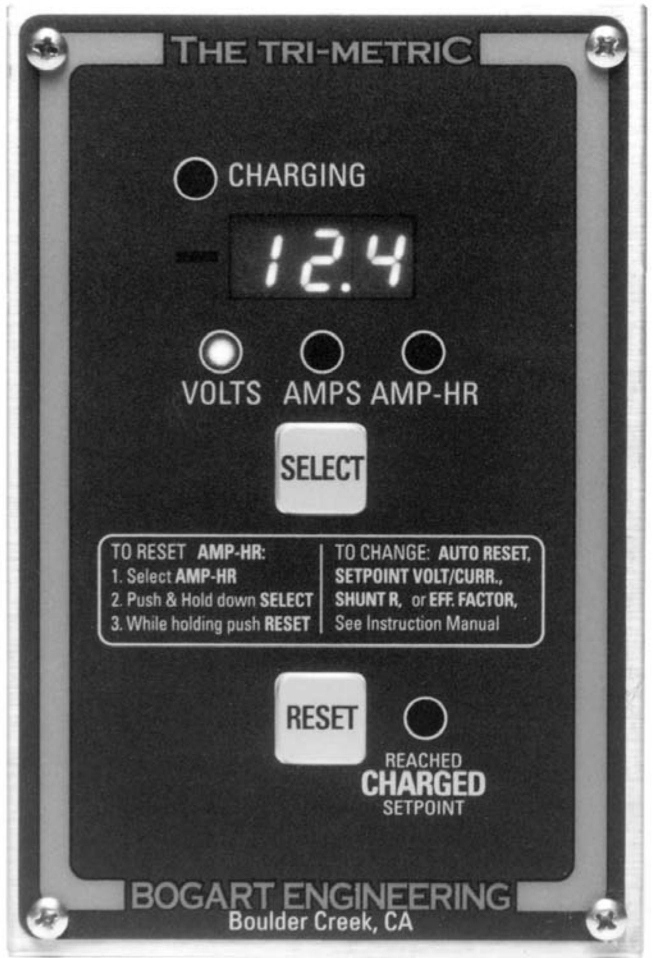
The Tri-metric measures Ampere-hours, Volts, and Amperes. It is an ideal instrument for smaller systems because it is inexpensive, accurate, and easy to use.

Bogart Engineering's Tri-metric Meter
The Tri-metric is an electronic voltmeter, ammeter, and ampere-hour meter. It measures battery voltages between 8.0 and 30 Volts DC, making it suitable for both 12 or 24 Volt systems. The ammeter uses either a 100 Ampere/100 milliVolt shunt or a 500 Ampere/50 milliVolt shunt to measure current. The shunt is available from most RE dealers and is not supplied with the meter. The current measurement range extends from -999 Amperes to +999 Amperes with the larger shunt. The Tri-metric uses a three digit, seven-segment, Light Emitting Diode (LED) display.

Physically the Tri-metric is small — 3.25 inches wide by 4.75 inches high by 1.25 inches deep. There are two push button switches on the front panel for display selection and programming the meter. In addition to the LED numerical display, five LED lamps indicate battery charging, display selection, and a unique "battery got full today" indicator.

The documentation supplied with the Tri-metric is detailed and well written. I had no trouble installing the meter in two different systems for testing.

The Test System
I installed the Tri-metric in our main system to test its accuracy against other instruments. After four weeks of testing in our main system, I moved the Tri-metric to its intended permanent home in our radiotelephone PV/battery system. I wanted a permanent instrument just to monitor the condition of our radiotelephone (RT)



system. I installed a Deltech 100 Ampere/100 millivolt shunt in the battery's main negative power cable. The RT uses a 100 Ampere-hour, 12 VDC battery made up of ten series connected Alcad nickel-cadmium cells. Two Solarex MSX-60 photovoltaic modules provide the power for our essential communication link with the outside world. The reason we placed our radiotelephone on its own separate power system is reliability.

The Tri-metric is user programmable for shunt size, full battery voltage and current set points, and battery efficiency factor. All these battery/system parameters are easily set from the front panel using the two push button switches.

Tri-metric Performance
I found this instrument to be accurate, stable, and reliable. After four months of testing against three different Fluke 87 digital multimeters, all of the Tri-metric's measurements are within its maker's accuracy specifications.

The ampere-hour counting function of the meter took two adjustments to find exactly the right battery efficiency factor for our battery. Once I found the right factor (94%), the Tri-metric has been accurately tracking the battery's state of charge. A unique feature of the Tri-metric is its ability to resolve current and ampere-hours to 0.01 in its low ranges. This resolution is ten times greater than system instruments costing twice as much.

The Tri-metric has several operational features that I find useful and convenient. One is what I call the "battery got full today" feature. If the battery reaches a full state of charge, then a special LED lamp on the Tri-metric is lit. This LED remains lit until the user resets it. Another LED indicates charging when current is flowing into the battery.

The Tri-metric's LED display is very readable and bright. It is easily visible at night. Most instruments using LCD displays are not. The only problem with LED displays is that they are power hungry in comparison to LCD displays. And Bogart Engineering took care of this by providing a display selection which blanks the display and saves power when the display is not required.

My only complaint is that the instrument is designed for panel mounting, like most system instruments. Mounting the Tri-metric on a flat surface will require either cutting a hole in the surface or building a small box to house the instrument.

Conclusions

The Tri-metric is a very accurate, stable, and informative battery system instrument. With a pricetag of $160 it is much less expensive than other system instruments. The Tri-metric is simple to install and program. Its information is presented in an easily understood, user-friendly, format.

Access

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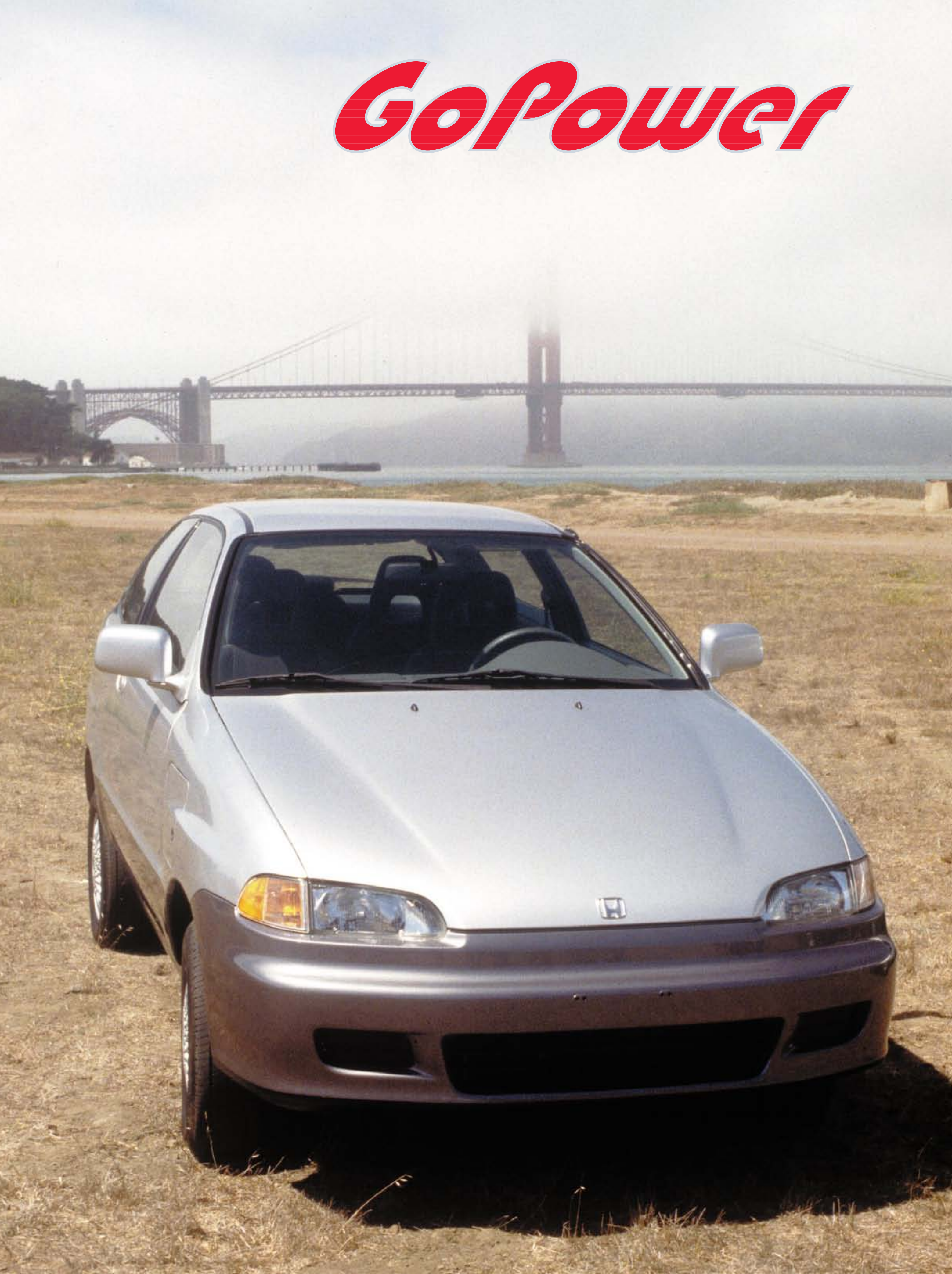
Instrument Maker: Ralph Hiesey, Bogart Engineering, 19020 Two Bar Road, Boulder Creek, CA 95006 • 408-338-0616. The Tri-metric is available from most RE dealers.

GoPower



Above: The Mona La, a solar electric racer, on the streets of Hawaii. Photo by Mary Van de Ven

Schemes and Dreams

Michael Hackleman

The CO_2 levels are climbing. According to scientists looking at data from a French satellite, so are the oceans. Global warming? "Inconclusive", say other scientists, heads in the sand.

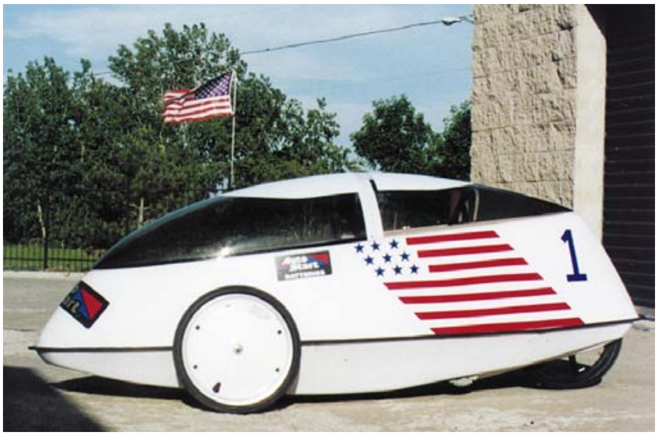
This issue the cover of the GoPower section is graced with a shot taken at the Presidio in San Francisco as American Honda delivered two of five electric cars to PG&E. These are *not* production vehicles, says Gunnar Lindstrom.

I picked up Otmar Ebenhoech on the way to San Francisco. We were the first two to drive the two prototypes. I fantasized drag-racing them, side by side, or playing chicken, but didn't. I wasn't afraid of what it would do to my reputation (that's already well established and actually in line with that kind of stunt). Nope, I was afraid of cardiac arrests amongst the crowd. So, Otmar and I just ran them through their paces. Good stuff. Good job, Honda. High-voltage pack, brushless DC motor, regenerative braking, good acceleration, handles nicely. Look closely. It's just a Honda Civic VX "tin", boosted up to give space for a battery pack underneath. Still, it was the completion of a cycle, for Otmar and I, since we built an electric car for Honda R&D in 1991. Positive Car-ma.

One cycle closes, another commences — Internet, via the HPBB (Home Power Bulletin Board). Now, I'm getting E-mail from all over the world! HP readers, be warned. I am not likely to respond directly. Instead I'll probably do something like this section's Internet Q&A, so a larger audience sees the question and response.

At long last, as promised, in this issue there's a story behind the photo of the Sunray (EV Happenings, HP 40). Jonathan Tennyson has been crankin' on purpose-built EVs for more than a decade, as the photos attest.

I'll wrap up this section with a favorite photo. (And my apologies to C. Michael Lewis for the lack of photo



Above: This Colorado Electrathon racer has already been race tested. Photo by Dan Hendrickson

credit in HP #44 for the shot of the electric Doran and HPV Vector in *Going Electric in 1995*). Surprisingly, the first chapter I wrote in my recent book — *The New Electric Cars* — was on human-electric hybrids. Replacing all IC-engined cars with EVs will *not* relieve congestion, so something that scoots through and around gridlock is going to be *very* practical and popular in the years to come, if you're city-fied. This human-electric-solar bicycle is just the ticket.

Just got back from the ESCR (electric shopping cart races) in Alameda, hosted by Jim and Nancy of McGreen-ZAP fame (HP#43). If the photos turn out, look for an article next issue.

In this new year, may all of your dreams move forward.

Access

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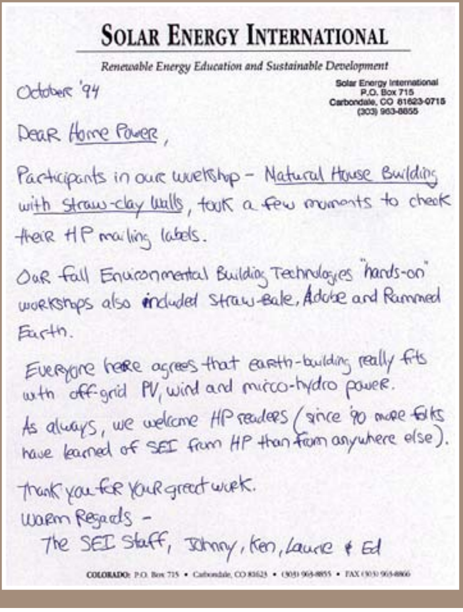
Check your mailing label!
Don't miss an issue!



SOLAR ENERGY INTERNATIONAL

Renewable Energy Education and Sustainable Development

Solar Energy International
P.O. Box 715
Carbondale, CO 81623-0715
(303) 963-8855

October '94

Dear Home Power,

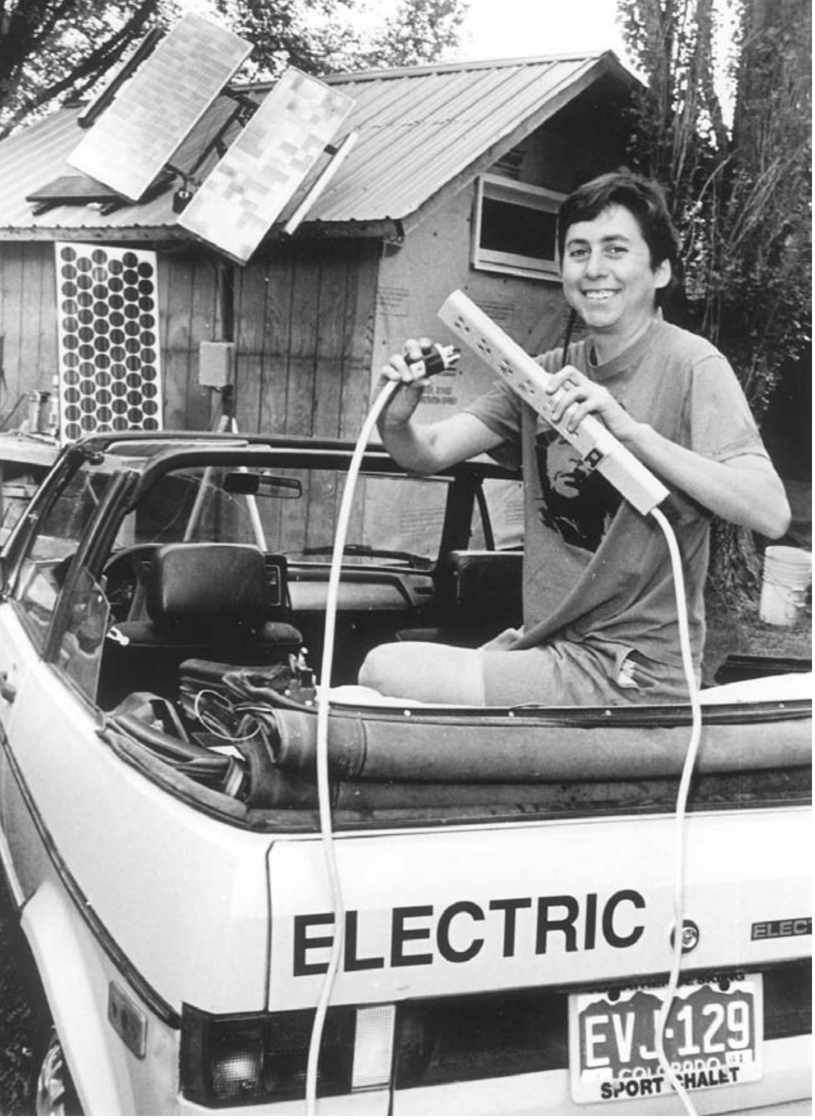
Participants in our workshop - Natural House Building with Straw-clay Walls, took a few moments to check their HP mailing labels.

Our Fall Environmental Building Technologies "hands-on" workshops also included Straw-Bale, Adobe and Rammed Earth.

Everyone here agrees that earth-building really fits with off-grid PV, wind and micro-hydro power.

As always, we welcome HP readers (since '90 more folks have learned of SEI from HP than from anywhere else).

Thank you for your great work.
Warm Regards -
The SEI Staff, Johnny, Ken, Laurie & Ed



Top: Laurie Stone plugs her electric Voltsrabbit into the sun instead of the gas pump. Photo by Carol Craven

Above: Mike Brown of Electro Automotive supervises inserting the electric motor into the the space where this VW's gasoline engine used to be.

Me and My EV

Laurie Stone

I have always been adamant about not owning a car. I hated the thought of having to buy gasoline for a personal vehicle. I felt I could get anywhere on my bicycle or by public transportation. I remember as a child, being fascinated with solar energy. I said "I'm never going to own a car unless I can have a solar car." My family thought I was nuts.

The EV Decision

Well, as I got older, reality struck. Sure, I could still get places on my bicycle, but the small mountain town in which I live made the winters tough. Public transportation never seemed to go or come when I needed it. Living in a small town forced me to travel to other towns in our valley for essential items. My laundry also seemed to be growing (more clothes as I got older, or just larger clothes, I'm not sure) making trips to the laundromat on my bicycle a difficult task. I felt like maybe it was time to mellow out on my idealistic purism and get a car. However, I was still adamant about not owning a conventional gasoline car. I wanted an electric car.

At Solar Energy International (SEI), where I work, we all liked the idea of doing an Electric Vehicle Conversion Workshop. Here was my chance to not only own an electric car, but actually participate in building it. We invited Mike Brown and Shari Prange from Electro Automotive to be the guest instructors for the workshop. They have been converting cars to electric power for 15 years.

I was excited about the prospect of having an electric car, but I definitely had my reservations.

Could I really do it? I knew nothing about car mechanics. I knew the underneath of a car hood like I knew the inside of my calculator. I had no idea how it worked, just that it does what I need it to do. I figured it would be a great learning experience. It definitely was.

Finding a Donor First
I needed a donor car. I read Shari's *Home Power* articles about what to look for in a car. I called Shari and Mike quite often with numerous questions. I wanted a light weight car with manual transmission, room for batteries and a body in good condition. I knew that Mike and Shari convert a lot of VW Rabbits. They actually have a "Voltsrabbit" kit. I thought a rabbit would be a perfect choice. I finally found the perfect car. A 1983 VW Rabbit convertible which is (best of all) solar yellow.

Prepping the Car
Then came the task of getting it ready for the conversion. What a task that was. Pulling out the engine and the entire fuel system was much harder than I had originally thought. Fortunately, I have good friends who know about cars. They offered to help me out. Master Mechanic Brett Lundy and SEI Instructor Ed Eaton spent days with my little yellow car removing its internal organs. Brett labeled all the wires from the engine and transmission as he removed them so we would know what went where. We saved all of the original nuts and bolts as per Mike and Shari's instructions.

EV Conversion Workshop
Then came the workshop. Ten people came from all over the country to learn from EV experts Mike and Shari, and to help me convert my little yellow car. We spent the first part of every day in the classroom going over the whole process of a conversion. We started with Basic EV Facts, Safety, Choosing a Car, and Removing the IC System. Then we went into the shop and worked on the car. Each day in class we covered the different parts of the conversion kit that we were going to install that afternoon.

The first day in the shop was the most difficult one for me. The day was spent cutting and drilling into my car to make room for the battery racks. It would be an understatement to say it was slightly disconcerting to see people going at my little yellow rabbit with a drill and a Sawz-All. Mike and Shari definitely knew what they were doing. Not a cut was made in vain.

Top: Batteries are added to the front of the VW.
Center and Bottom: The rear compartment is modified to also accept batteries.

Top: Shari Prange applies the electric decal.
Center: Mike Brown and Shari Prange
Bottom: The SEI EV Conversion Class and the completed Voltsrabbit

The next few days were spent installing a medium Advanced DC motor, controller, potbox, batteries and vacuum brakes. The Curtis PMC Controller meters out the electricity to the motor according to demand, as signalled by the throttle pedal. The potbox is the interface between the throttle pedal and the speed controller. Electricity is stored in 16 Trojan six Volt 125 Amp-hour batteries. We installed a power brake vacuum system because disc brakes need a power assist, which relies on vacuum from the engine manifold. This vacuum source is lost in the conversion, but can be replaced by a vacuum pump and reservoir.

We added batteries and motor and removed the the IC engine.The final car ended up weighing about 880 pounds heavier. We replaced the struts, shocks, and springs with heavier-duty versions because of the extra weight.

We also installed a DC/DC converter because the electric car still uses a 12 Volt battery to power the lights, windshield wipers, horn, etc. Since there is no alternator to keep this battery charged we use the converter to tap off of the full battery pack. This eliminates the uneven discharge from the tapping-off of two six Volt batteries.

Three gauges were installed in the car. The ammeter gives a continuous reading of current usage. A state-of-charge gauge measures the voltage in the main battery pack. The voltage meter monitors the charge level of the 12 Volt battery.

We spent the last day installing the K & W 110 volt battery charger, connecting the batteries, and putting on the ‘electric’ graphics. According to Mike and Shari, a good charger is crucial to electric vehicle performance. While a 220 volt charger will charge the pack faster, it is bulkier and heavier. Plus, 220 volt outlets are less available. A 110 volt charger will charge more slowly. We used the 110 volt charger because it’s small, light enough to be mounted on-board, and I can charge anywhere there is 110 volt power.

All of the above items that we installed in the car are part of the Voltsrabbit kit. Mike and Shari also provided me with a hydrometer so I can check my battery electrolyte level, a battery filler to help me add distilled water to my batteries, extra cable, shrink tube, and the miscellaneous parts I need to keep my car in top condition.

Goodbye to Gas Stations

Now, the only thing I need gas stations for is to fill up my tires with air. I stuck to my ideal of never owning a gasoline car. Although I still use fossil fuels, EVs actually produce only one-tenth of the pollution emitted by a gas burning car, even figuring in the emissions from the power plant. They don't rely on foreign oil, produce exhaust, or noise. EVs don't waste energy while at stoplights or stalled in traffic.

Most conversions that use the Voltsrabbit kit have a range of 60 to 80 miles. Since I live in a hilly area, my range is usually around 60 miles. Going 55 mph isn't a problem. That's plenty for my needs.

Renewable Energy EVs

I haven't realized my childhood dream of owning a solar car, but it isn't too far in the future. We hope to eventually install enough PV panels at SEI's office for a charging station for my car and the electric motor bike that we also converted in the EV Workshop. Solar charging would take care of one of the main controversies of electric vehicles. Many people believe that recharging EVs off the electrical grid just shifts pollution from city streets to electric power stations in outlying areas. However, when I charge my EV I am using existing generating capacity. A study by Southern California Edison indicated that the utility could absorb 600,000 EVs without increasing capacity. Nevertheless, it is possible to charge up your EV with your wind turbine, hydro system or PV panels. Then you have a truly clean, renewable energy car.

Right now, the US has the highest number of passenger cars per capita. There are approximately 145 million personal vehicles used regularly in this country. Over 90% of these cars are driven less than 25 miles per day. Think of the incredible change if we were all driving renewable energy-powered EVs.

I'm very happy with my electric car. I learned that converting a car to electric is not that difficult. Sure, I had a lot of help. Mike and Shari's kit has easy to follow manual, with step-by-step instructions.It was easy, even for a novice like me. When I'm driving my silent, exhaust free car people ask, "Where did you get your car?" I say, "I made it!"

Access

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Publication: Convert It, Michael Brown and Shari Prange, Electro Automotive, PO Box 1113, Felton, CA 95018-1113, 1993.

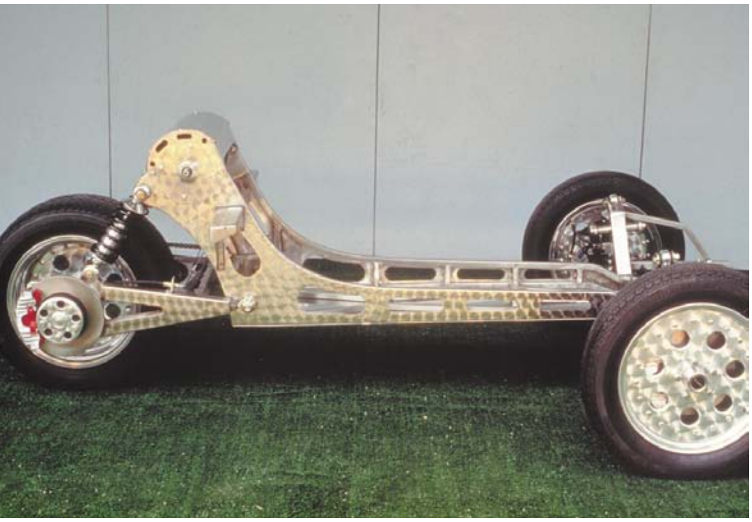
Build Your Own Electric Vehicle, Bob Brant, TAB Books, Blue Ridge Summit, PA 17294-0850.

Conversion Services EcoElectric Corporation, P.O. Box 77100, Tucson, AZ 85703. (602) 887-9449.

Electro Automotive, P.O. Box 1113, Felton, CA 95018-1113. (408) 429-1989.

Solar Car Corporation, 1300 Lake Washington Rd., Melbourne, FL 32935 (407) 254-2997

Solectria Corporation, 27 Jason St., Arlington, MA 02174. (617) 894-6670



Top: The Suntera Sunray. Photo by G. Brad Lewis
Center: Sunray chassis. Photo by Stevi Johnson Paul
Bottom: Sunray front end. Photo by Stevi Johnson Paul

Island Electrics

Michael Hackleman

Detroit and the big island of Hawaii have little in common — or do they? If Jonathan Tennyson and his crew have their way, Hawaii may become the newest state to churn-out automobiles — using electric drive.

Jonathan has been designing and building EVs for several decades. His newest prototype is the Sunray, a compact two-seater that may help the Hawaiian islands regain their former clean and sunny look.

"Hawaii is ideal for electrics," says Jonathan. "There's no destination further than 80 miles away! Remember, people come here for the sunshine and breezes!"

The modular, 3-wheeled design of the Sunray, as the pictures will attest, is clever and cute. With a length of only eight feet, a width of just over five, it takes up less than half the parking space needed by a standard car. It is unusually tall, its 6-foot height creates a profile that ensures visibility to other drivers.

The most noticeable aspect of Sunray's body style is the "happy face" that shows when you view the car head-on. The composite/epoxy body won't rust in the tropical climate. It also tilts back as a single unit to expose the mechanical and electronic components for easy servicing. The 12HP series motor, 120V lead-acid battery pack, and solid-state MOSFET controller moves the 1500 pound (curb weight) runabout along briskly on the street or highway. The quiet belt-drive preserves the revered island ambiance.

An EV Pioneer

Jonathan Tennyson is no stranger to electric propulsion technology. In fact, he is an EV pioneer.

I met Jonathan for the first time when I was hiking around the Big Island in early 1987. For a long time, I walked along a stretch of highway, hoping for a ride. I finally got one from a young woman, who told me about a local source for solar panels and electric vehicles. When I reached the area and called the number she gave me, I gave my name, and the usual "you don't know me but I'd love to visit." Jonathan drove down to pick me up. I rode back up through the volcanic shield in an electric pickup truck! I was grateful for his courtesy since I know what it's like to have people arriving at my doorstep unannounced. Jonathan immediately showed me his library shelf, pointing at the section that contained all of my previous books!

Jonathan and crew were just beginning construction of the Mana La, a solar-powered car that would be the John Paul Mitchell Hair Products entry in the transcontinental Australian Solar Challenge later that year. Jonathan was in partnership with the company at that time, producing awapuni, the Hawaiian ginger used in their hair care products.

Since the Solar Challenge doesn't specifically prohibit wind power, Jonathan developed a scheme to build his solar and wind powered Mana La, styled after Jim Amick's Windmobile. Solar cells covered the exterior surface of the Mana La's huge wing. Twin motors, each mounted near the rear wheel along with batteries, powered the vehicle. I talked the team into buying a video camera to document their entry. (Several years later, I edited it down into a 20 minute piece that may appear in *Solar Cars*, one of the videos in the *HandMadeVehicle* series.)

As the accompanying photos attest, the Mana La was beautifully crafted, but it proved no match for the GM's Sunraycer in the 1987 Solar Challenge. The race was definitely a little guy-big guy matchup that year, with a fifty-fold difference in budget between Sunraycer and other solar car entries.

Sunraycer's expensive sophistication was far beyond what Jonathan and his crew could build in the time they had. Although the experts doing post-race analysis of all the participating solar cars were quick to point out flaws in the Mana La's design, I wonder how many of the college-built vehicles for another event, the GM Sunrayce, would have faired as well *without* the detailed Sunraycer plans provided to them? And twice as much time to build something competitive!

Tennyson dreams of bringing EVs to the world, particularly developing countries. I can still recall an amazing word-picture that he painted while we sat in the airport awaiting my flight. He envisioned facilities building EVs , manufacturing their own batteries and solar modules on-site. I recalled then that Henry Ford had wanted his cars to be alcohol-fueled, so that farmers could "grow their own". Most of all, Jonathan wanted Third World countries to avoid dependence on the internal combustion engine and imported gasoline.

What better place to start than the Hawaiian islands! Here lightweight EVs have a natural niche. Here are some of the advantages. Range is less of an issue, since you can't go very far without running into the ocean Tourists year-round wanting to enjoy paradise. No imported noise and pollution from cars and gasoline. A need for personal transportation. Year-round sunshine to power the dream.

Top: Sunray's rear drive assembly.

Photo by Stevi Johnson Paul

Bottom: Jonathan Tennyson sits in the Mana La.

Photo by Mary Van de Ven

Imagine it! Zippy, lightweight, quiet, open-air, little machines taking you to magic places!

The Sunray is designed for the task. Its short wheelbase eases curbside parking. A sturdy 3-wheeler that avoids licensing complications, Sunray has two-person-plus-baggage capacity. The 120V battery pack gives zip while its centered weight gives low-down stability for that warm-tummy feeling. The two-stage, fixed-ratio drivetrain uses gear belts for silent, low-maintenance operation.

Top: Jonathan's EV tractor. Photo by Mary Van de Ven
Center: The EV tractor. Photo by Mary Van de Ven
Bottom: Jonathan's electric pickup. Photo by Mary Van de Ven

Suntera, the company formed to promote the Sunray, is already thinking about hybrid packages. However, an oil-based energy partner will *not* find its way into one of Jonathan's designs. Instead, he's working with flywheel technology. This should supply the modest energy gain needed to make Sunray useful anywhere on the island.

Suntera has received some ARPA money to fund their efforts and is eligible for more. I hope it happens. In order to be politically positioned to receive ARPA dollars, many companies have been built around "paper products" and "vaporware". Jonathan is a doer and a visionary who will help ensure that electric propulsion does more than replace internal combustion. He knows that EV technology must align itself with sustainable energy sources, confronting pollution and resource depletion issues. Current auto makers don't include these factors in their designs. Only their marketing and advertising departments use them — as sales rhetoric.

Jonathan has pointed out the advantage of the Big Island of Hawaii in testing electric vehicle technologies. After all, seventeen of the world's twenty-one microclimates are represented there. Where else can you test a car in the tropics, in the desert, and in the snow — all in the same day!

Access

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(This article is largely an excerpt from my upcoming book, The New Electric Cars: Simple, Efficient and Reliable, by permission of Chelsea Green Publishing, available July 1995.)

Electric Vehicle Testing & Troubleshooting

Shari Prange

When you have finished assembling your electric car conversion, you need to test your circuits to be sure everything is right. During the life of the car, you may also need to troubleshoot problems from time to time. The techniques for both situations are similar.

Tools

Your most important diagnostic tools are a volt/ohm meter and your brain. A good hand-held volt/ohm meter (also called a multi-meter) can be bought from Radio Shack for about $25.00. Be sure it is scaled high enough for a fully charged battery pack and is intended for DC current. Carry it in your glove compartment.

Your original equipment brain should work just fine, as long as you keep it operational while working on the car.

Principles of Testing

The technique for testing an electric circuit is to imagine yourself as an electron in that circuit. Follow the path of the circuit, at each “gate” in the path check for two conditions: is the “gate” open, and does it open in the right direction? In other words, is the electricity passing through this point and is it going to the right place from here?

To do this effectively you have to isolate and test one item at a time. Sometimes you may test a short section with several “gates” in it. If you find a problem within that section you will need to isolate and test each “gate” in sequence until you find the culprit.

It is important to test items in the circuit in sequence. If you skip around, you won’t get a full and reliable picture of the circuit. If the first part of the circuit is good, you can build on that foundation only if you test every step along the way.

Above: Testing each battery pack for full voltage separately, before connecting them.
Photo by Shari Prange

Safety

It is difficult to give hard and fast safety rules for diagnostic procedures. For example, it’s a good idea to to have the circuit breaker off — except when the test you’re doing requires it to be on.

In general, it’s good practice to disable everything that isn’t required for the test you are doing. This could include turning off the key, opening the circuit breaker, or even disconnecting a crucial connection. It also includes disabling mechanical components such as having the car in neutral, the emergency brake on, and the drive wheels off the ground.

If the test you are doing requires you to engage part of the system, be sure the are other parts are disabled. This practice also helps you isolate the components you are testing.

Making Connections

Test high voltage connections before bolting them together. For instance, each battery pack should have a fusible link installed in the middle of one of the interconnects. Install the fused interconnect last in each pack. When you install it, touch it lightly across the two battery terminals it will be connected to.

If there is no spark, install the interconnect. If there is a spark, check all the batteries in the pack for proper positive/negative orientation Also check the positive and negative cables into the pack for improper contacts.

Building Pack Voltage

Most conversions have two (or more) battery packs. When testing, start with the pack on the most positive end of the circuit. Check the most positive and most negative points on that pack for the voltage of the pack. If eight 6-volt batteries don’t give you about 48 volts,

Above: Testing specific gravity with a hydrometer will pinpoint weak batteries.
Photo by Shari Prange

there is a problem within the pack. If the volt reading is good, you can move on down the circuit.

Check each pack individually. If they all check-out, begin connecting the packs. After each connection, check both ends of the circuit you have just made. Be sure the voltages add up correctly.

It may be awkward to test full battery pack voltage if the most positive and most negative ends of the circuit are far apart. In this case, it's handy to have a test point. You can build one into the car with two 16 gauge wires from the positive main contactor terminal and the battery negative controller terminal. Tape them together into a loom, run them to a convenient location, and terminate them in insulated connectors that will accept your meter probes.

Drive Components

Add each component to the circuit individually, in sequence. Test the input and output. Don't forget to test both "on" and "off" conditions. If a component is live with the proper voltage when it is supposed to be, that's good. However, if it is live when it's supposed to be dead, that's not so good. You will need to know about that component.

For example, when you turn on the ignition key, nothing should happen. If the contactor closes without the throttle being depressed, you need to check your throttle linkage to the potbox, and the potbox and microswitch themselves.

Test for the proper voltage from the battery pack all the way through to the controller. The last connection and test will be on the motor. Do this test with the car up on stands, in gear, with the parking brake on. There are two parts to this test. First, be sure the motor spins when the throttle is opened a little. Second, be sure the drive wheels turn in the right direction. If you have one speed forward and four in reverse, check your motor connections.

Above: A pair of insulated connectors make a convenient test point for measuring full battery voltage.
Photo by Shari Prange

When It Won't Go

If one day your car won't go, check the obvious things first. Do you have a full charge? Is the charger still plugged in? Do your lights and gauges come up normally when the key is turned on? Is the circuit breaker closed? Are all the fuses okay?

If you find a blown fuse or thrown breaker you need to figure out why. Fuses and breakers are Mother Nature's way of telling you something is wrong.

One of the controller's safety features may be shutting you down. That's its job. If the controller gets hot from too much current, it will cut back your power. If you try to start the car with the throttle depressed, it will not engage.

Check for loose connections. It may be something as simple as a loose cable on the accessory battery.

Mechanical Problems
If everything seems normal, don't immediately assume you've blown a component. In gas cars, drivers have traditionally blamed the poor carburetor for everything, even though it was rarely the carburetor's fault. In an electric car, the novice will often blame the controller when, in fact, the problem is elsewhere.

Don't ignore the possibility of a mechanical problem, like locked brakes or a flat tire. Probably the most common mechanical reason an electric car won't go is that the car is in the wrong gear — third, instead of first. Sometimes this is merely driver error. Other times the shift bushings are worn out, allowing the shifter to slip into the wrong position. This is easily cured.

Component Testing
If you are still without a clue, start testing your drive circuit.Test it the same way you did when you first built the car. Imagine yourself as an electron. Check the paths and gates. Check each component in isolation for proper input and output.

Poor Performance
Maybe the car will go, but not very well. The first thing to check is tire pressure. Tires can get a little soft without you noticing. This will make a dramatic difference in performance.

Other mechanical problems that could affect performance are dragging brakes or poor alignment.

If you suspect one or more bad batteries, there are several ways to spot the slackers. If you turn off your charger and notice that all the battery tops are damp except one, the dry one is weak. It will not come up to full charge. The charger is gassing the other batteries trying to bring up the weak one.

You can check the voltage on individual batteries with your meter. A bad battery may look fine right after charging, but may fall off quickly under load. Check the batteries after driving the car a little. Look for one or more that are significantly lower than the rest.

The most definitive test is a specific gravity test, done with a hydrometer. This is best done when the batteries are fully charged. Kneel so that the calibrations are at eye level (and wearing safety glasses). Suck up enough fluid with the hydrometer to lift the float inside it. Then read the number at the fluid line. You will need to test each cell of each battery separately. A fully charged lead acid battery should read about 1.265 Volts per cell.

If a battery fails early in the life of the pack, there should be some warranty on it. Replace the bad battery and equalize the pack. If you start to get failures after three years, though, you should think about replacing the whole pack. New batteries will not equalize well with old ones and you will shorten the life of the new batteries.

One Step At A Time
Testing and troubleshooting an electric car may seem like a daunting task. It's really much simpler than troubleshooting a gas car. Just test each component in isolation, work in a logical progression, and don't get so fixated on one component that you ignore other possibilities — including plain old mechanical problems.

Access
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Grazing and Browsing: EV Q&A from the Internet

Michael Hackleman

Somebody at HP headquarters and Redwood Alliance had to go and hook up the HPBBS with Internet. Then, they started screaming at me to clear the logjam (FET jam?) of messages sent to me. Well, I know how to deal with burea-o-crazy. I'm going to feed it all right back at *you*.

I warned HP readers of a relay problem (HP #43, Letters to Editor) with the circuit for the series-parallel motor controller (HP #39, P53, Motor Controllers for Simple Electric Vehicles) and asked for some help in finding a replacement. I got it.

Relay Request

Your request for a power relay mentioned a 12V coil with contact ratings of 40-60A for less than $50. Surplus auto winch relays (40A, 12V coil and 12VDC contactor rating) are less than $5. Bob Gobeille

Hi Michael! I've read some of your articles in *Home Power*, as well as seeing your messages on Home Power's BBS. I've been interested in EV design for several years now but have not attempted to actually build one yet. I'm an electronics/software engineer type and I live and work in Scotts Valley. Currently I'm installing a 900-watt peak PV system on my workshop roof. I have a replica 1966 Shelby Cobra in the garage that I built and will try to sell after a little more detail work is finished. When that is gone, I'll have room (and money) to start on a kick-ass EV project.

In *Home Power* #43 you asked if anyone knew of a 40-60 amp relay for less than $50. Have you considered using power MOSFETs in the design? Digi-Key sells a series of high power ones from International Rectifier. I bought some that were rated at 70 amps/60 volts for $7 each. (I built the shunt charge regulator from *Home Power's* plans but upgraded it to the 70-amp part.) You could parallel several of them if you need more amps or higher voltage devices with high amps.

For just a simple on-off application the circuit would be extremely simple. It would even be easy to add a soft-start or speed control option. These FETs are designed for use with inductive loads and have a built-in reverse bias diode of the same amp rating that can possibly be used for re-gen currents. A 4-5hp H-bridge could be made with 4 of the 70 amp devices at a cost of $30. This would allow forward and reverse operation.

I also upgraded my cheapo 600-watt mod-sine inverter with these FETs. It is a 1kw peak (600-watt continuous) unit from Fry's for $230. It kept blowing itself when running my laser printer until I replaced the 35-amp FETs with the 70-amp ones. Now it can sustain peak power almost indefinitely and runs very cool. Gerald O'Docharty

Thank you, Bob and Gerald, for the info. Shopping around is definitely the way to keep dollars from evaporating in a project. Unfortunately, I haven't found any $5 relays with the right ratings, but a fax response to the request has me linked up with a $55 relay that will handle 100 A DPDT. I'll let you know how it turns out. Gerald, how about a circuit diagram of the gizmo you talked about, using FETs. I'd like it to be able to handle regen and dynamic braking. Sounds useful. I'll bet it will be popular with HP readers. MH

Electric Wheelbarrows

I'm a subscriber to *Home Power Magazine* and just got the latest issue. I enjoyed your story, "Time Out!", and was intrigued by the photo of Bob Schneeveis' electric wheelbarrow. I'm interested in building something similar to haul firewood from my wood shed to my house. Can you point me to printed resources that might have plans or talk about such a beast? The idea of electric mules is also interesting. Any help would be much appreciated. Ron Granich, Lummi Island, WA 98262

Ron, Bob Schneeveis can be reached in Palo Alto, CA. I'll ask him about doing an article on the Electric Wheelbarrow. It is a popular piece of hardware, and proved a real workhorse at Phoenix in 1992. (Bob was on the Hackleman-Schless team and used the wheelbarrow to haul stuff between the garage and pit row.) I'm joining Bob tomorrow to travel to Alameda Friday night for some "electric shopping cart" races. I'm not kidding. I will try to capture some on celluloid (for HP readers) and videotape. MH

Electric Car Racing

I live in the Isle of Man, part of the British Isles which sits in the Northern part of the Irish sea between Northern Ireland & SW Scotland. (Get your map out!) I tell you this because our location creates a strong wind off the Atlantic. In the Winter months I average 20 amps from my LMW 1003 (Dutch) 1kw 24 V system, sometimes more. We have the best wind in Europe. The whole idea of putting up a Windgen was to drive an electric car around my island for free. It's 34 miles by 18 miles in size, but hilly, some roads have a 25% grade. I have been waiting for my eldest son, a designer at LandRover (across in UK) to create the car but he is too busy it seems. So the car has been a long time coming.

I am an avid reader of your mag for 2 years. The Isle of Man (IOM) is famous world wide for its annual motorcycle TT races every June. We close the public roads, 34 miles worth,with several classes of motorbike, inviting the world to see. They come from all over. I strongly believe we will not persuade the public in large enough quantities to use electric cars unless it is developed through the "Racing Fraternity". The IOM has a European pull. I could perhaps organise our IOM Government's Tourist Board to be a strong sponsor. They provide $450,000 for the TT, because it brings in tourism.

There is no mag equivalent of HP in Europe, I know, I have been all around European airports' bookstalls looking! I like the Leeds Speedster with outrig front wheels. It could be the kind of specification which could go forward as a standard for road "Endurance", all electric. Perhaps another spec for HEVs. We would love the IOM to be the first in Europe to create this potential. Perhaps you have already been approached? The winner is the one that goes the furthest on a set amount of energy in W/hrs? Would you tell me your Tour rules again? You did in an earlier mag, but I find people borrowing them and not returning them. That's another thing about your HP mag. It's like hot cakes. Could we order the mags direct here? At what cost?

I am part of a Society which is called the Manx Energy & Natural Resources Society. We will do anything to improve the Ozone. It's pretty poor over the IOM. I am retired but lecture on alternative energy to all ages of school children. We are now having to pay 8.5% energy tax, 17.5% beginning next year. So our efforts to explain energy conservation has created Energy Awareness Week, at the end of October. It is organised by me on behalf of the Society. I am bringing over three Continental electric cars which are terribly expensive. We will do a "test" over our terrain and measure the charging costs overnight. A little 2 seater Microcar costs $17,000. This is enough words for now. Please let me know what you think. Tom Durrant

Tom, thank you for letting us know what's happening on the Isle of Man. I agree that a big part of turning some heads about electrics is sponsorship. Racing itself won't do it, although I'll admit the Speedster does have that classic look. There's a lot of racing here in the USA but it's gone largely unnoticed. So, publicity is the key. Inviting the press may or may not produce the results. I "teased" the press into coming to the Solar Eagle's rollout by sending them edited videotape of the project on a video format they standardly use. With a brief write-up (something they could literally read while the tape was being shown), we made every station in town. Maybe it was a dull news night, maybe it was a good idea. Thanks for holding up your end of things. MH

Hi Tom, Contact Steve Wade, Wind & Sun, The Howe, Watlington, Oxford 0X9 5EX, England, 0491-613859, Fax 0491-613111. I'm not sure of the cost. Steve resells Home Power in The United Kingdom. Steve also sells an extensive array of RE equipment. Karen Perez

Zap Power System

Can Jim McGreen be contacted over the internet? I am very interested in the ZAP kit, but am wondering how it would stand up to Scotland's outrageously wet climate. UK to US paper mail is slow, and our 8-hour time difference makes telephoning difficult. HP#43 was my first issue, picked up while on holiday in the midwest. I like it, and will be subscribing soon. The company I work for does utility scale windfarm consultancy. We run two wind farms in England. Personally, I'm looking for a job in renewables in Missouri or Kansas so I can be with my girlfriend. Oh, do you have information on that electric Land Rover? I run an identical diesel model. Stewart C. Russell

Hello Stewart, I will see Jim McGreen at the electric shopping cart races in Alameda. I'll will ask him if he does Internet or HPBB. The electric Land Rover was a big hit at SEER '94. I'll try to solicit an article. Good luck with wind and love in the midwest. MH

Small Utility EV

I've read with interest over the past months the various articles in HP on electric vehicles, with references to electric tractors and even an electrified Kawasaki 4-wheeler. We live on a small property south-east of Fargo, N.D. The landscape here is extremely flat. I've been dabbling in building a small gas-powered vehicle for pulling small farm wagons around. The three wheeler that came out of the endeavor is a bicycle frame bolted onto a wooden platform. The front single wheel is steered just like a regular bicycle. The two rear wheels are mounted on a live axle, which is powered by a 3.5 hp Briggs engine. There is a belt which goes from a 2.5" diameter pulley on the Briggs to an 8" pulley on an intermediate jack-shaft. Then the chain goes from a 13 tooth sprocket on the jack-shaft to a 36 tooth sprocket on the rear axle. The V-belt is loose around the pulleys, until a foot-operated idler pulley is tightened against the belt, at which time the belt engages and the vehicle begins to move. Also, only one of the rear wheels is keyed (fixed) to the axle — the other spins freely to act as a differential. The problems: (1) I'm convinced that 3.5 h.p. is all that I need for power, but it seems that my gear ratios must be way off. The vehicle goes ~15-20 mph on the road, but is useless in the farmyard. Very poor torque is available from this set-up for pulling. Is there any other gearing system other than a series of step-down pulleys/sprockets? What is used in slow moving tractors — worm gears? (2) The V-belt slip-clutch set-up seems to be inadequate. Even when the vehicle is trying to start at a slight incline, the belt prefers to smoke than engage. Any other homebrew clutch designs out there? Perhaps the best solution is to work with components that have already been designed for small garden tractors, i.e. differentials, hydrostatic drives, etc., but I was really hoping to stick to something I could service myself. Any suggestions or lists of component suppliers would be appreciated. I know that you prefer to work with EV solutions, and we hope to get EVs in the yard at sometime in the future, but my calculations indicate that, for the same horsepower, a small gas engine is still cheaper. When my budget can handle it, I will convert. Thanks! John Weiland

John, I'm curious about the size of wheels you are using. Still, several thoughts occur. First, your overall drive ratio is about 9 to 1. That means 200 rpm on the rear shaft when the engine is only at 1,800 rpm. If that's the 3.5HP Briggs I'm thinking about, it likes to do its work at 3,600 rpm or higher. With only a 12-inch wheel, the vehicle will be at 7.5 mph at 1,800 rpm and 15 mph at 3,600 rpm with that ratio. Sound familiar? Neither speed is close to plowing speed. So, unless you have very tiny wheels, things are definitely rigged for road speed and not land work. If you DOUBLE your overall ratio, you will still be shy of the needed torque. An overall (minimum) ratio of 30-40:1 would be more like it. Phil Jergenson's SolarBear had a tranny with an overall ratio of 156:1 or something similarly absurd. It could climb walls.

Second, V-belts are notoriously bad at low rpm for transferring torque, so you've got to get it TIGHT. Better yet, go to two belts, or three, side-by-side. One wide (3") gearbelt would be the right ticket.

Third, bring the other wheel into the act. You've got to transfer the torque into the ground if you're going to lift that bale, and tote that barge. A differential is not absolutely necessary off road. The wheel on the inside of a turn will simply slip when off pavement. Watch out! If a turn is part of the work, use a differential.

And, fourth, if you make the thing electric-powered, you don't need a clutch. A 1.5HP series motor should do it. Old golf carts are an inexpensive source for these. Oil bath, differential, brakes, right size wheels, decent gear ratios, etc. Grab the whole rear assembly, any electric controls, and however much of the chassis you can effectively use. Remember, it's hard to stall a series motor. MH

Access

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DC Motor Controllers: 12 Volt, 24 Volt, Variable Speed, Hi / Low Speed

Homebrew

Chris Greacen

Small motors which are on much of the day can use a butt-load of power. For example, a number of companies (Backwoods Solar, AEE, Electron Connection, etc) sell 12 and 16 inch diameter ventilation fans with DC motors. At 12 Volts the bigger fan draws 1 Amp and pushes 500 cfm. If it needs to be on 24 hours a day, that's 24 Amp-hours — the day's output of a couple 50 Watt solar panels. At 24 volts, the same fan pushes more air, but draws 2.75 Amps. That adds up to 66 Amp-hours a day — the daily output of about six 50 Watt panels. Clearly, if you need a fan that's on for much of the day, you'll want to be careful to get one that uses no more power than necessary. Surplus catalogs like C&H Sales have a plethora of DC motors, so there's good chance you'll find what you need.

The easiest solution is to get the motor that's exactly the right size, and avoid motor controllers altogether. If you want a motor with variable speed, or if you're set on a certain motor, but want to throttle back its speed and power consumption, you need a motor controller. You can buy these — AEE sells 12 and 24 Volt controllers for $45. A client blew up one of the commercial 24 Volt controllers. He hired me to build him a replacement. The circuit I built has been in 24 hour-a-day service for 6 months, powering a 3 Amp fan. With power handling parts adequately heatsunk, the circuit will handle 10 Amps.

You can build this circuit, or its variations, for around $15 in parts in an evening or two at the workbench. Here's the design.

Basic Theme: 12 Volt Variable Speed Controller

The brains of the circuit is the NE555 timer chip, wired as a variable duty cycle (5% to 95%) astable multivibrator. What does that mean? It means it puts out a signal which goes from high to low (12 Volts to 0 Volts), hundreds of times a second. The chopped signal turns on and off a power field effect transistor (FET), which in turn switches the motor on and off, hundreds of times a second. "Duty cycle" is the percent of time the output is "high" versus the percent of time it is "low". You can vary the duty cycle of the 555 chip, and thus the speed of the motor, by turning the potentiometer attached to pin 7. (See figure 1)

Here's how the 555 part works: current flows through the upper 1.6K resistor, through the upper half of the potentiometer and wiper arm and right hand side diode, charging up the 0.1 µF capacitor. Pin 6 senses when this capacitor is charged to 2/3 Vcc.At this point the output (pin 3) switches to LOW, and pin 7 becomes conductive to ground. Now the capacitor discharges through the left diode, lower 1.6K resistor, and lower half of the potentiometer, to ground via pin 7. When pin 2 senses that the capacitor is discharged to 1/3 Vcc, pin 7 stops conducting to ground, pin 3 (output) goes HIGH, and the cycle starts again. Turning the knob of the potentiometer makes the capacitor charge faster and discharge slower, or vice versa. This changes the proportion of "on" time of the output.

The output (pin 3) can continuously source or sink 150 mA of current, and instantaneously source and sink

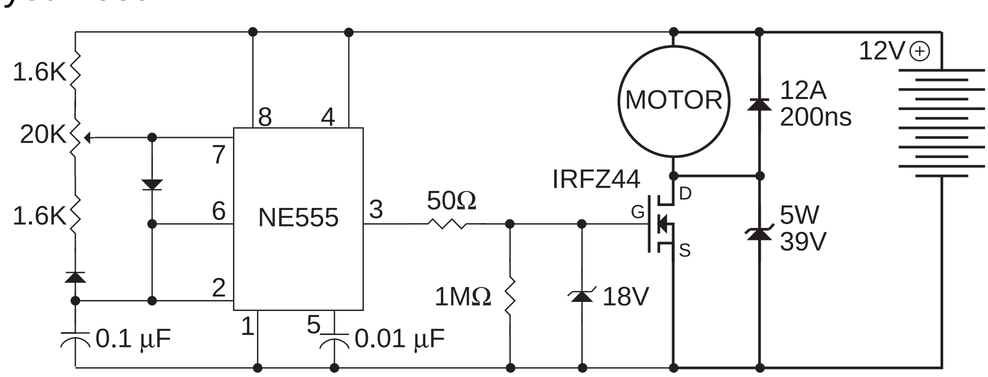

Figure 1: 12 Volt, 10 Amp, variable speed motor controller

several hundred milliamps. When pin 3 goes HIGH, it charges the gate of the FET (field effect transistor), turning it on, and allowing electricity to flow through the motor. When pin 3 goes LOW, the gate is discharged, turning off the FET. The 50Ω resistor assures that the FET is turned on and off quickly, without exceeding the output capability of pin 3 of the 555.

How Not to Blow Up the FET

FETs are robust critters. The IRFZ44 specified here can conduct 35 Amps continuously (25°C), and 200 Amps peak (5°C) (Ok, I know that's a ridiculously low temperature for electronics outside the arctic, but you get the point: these things can conduct a lot of current). There are, though, several good ways to fry them. The first is with static electricity when you're installing them. Ground yourself with an antistatic wrist strap when you handle the FET. Second, any gate-source voltage over 20 Volts will destroy the gate. The 18 Volt zener protects against transient voltages here. FETs turn on at a threshold of 2 to 4 Volts. The 1MΩ resistor ensures that stray charge doesn't accidentally turn on the FET part way, putting it in a heat producing "linear" region, halfway between off and on.

The third easy way to fry a FET is with a high drain-source voltage. Any time you instantly shut off power to a motor, you're guaranteed an inductive voltage spike — possibly to 1000 Volts or so, depending on how fast the motor is shut off. Current flowing in the motor's windings wants to keep flowing, induced by a dying magnetic field. The reverse biased 1N3891, 12 Amp 200 nanosecond fast recovery diode, provides a path for this inductive spike, back to battery +, where it won't do any harm. If this "freewheeling" diode weren't here, inductive voltage would destroy the FET. Use a fast recovery (500 nanoseconds or faster) diode, so that it won't be slow turning off when the FET turns on again. Digikey has a wide selection of fast recovery rectifiers. It wouldn't hurt to use an even faster one, like the HexFred HFA15TB60-ND (15 Amp, 19 nanosecond)

The NTE5144A 5 Watt, 39 Volt zener diode (from Hosfelt) provides yet more protection from an inductive spike. This zener diode "clamps" any voltage above 39 Volts.

The fourth way to kill a FET is with heat. Bolt the FET to a heatsink. Remember that the tab of the FET's TO-220 package is electrically connected to the FET's source pin. You may want to use a mica washer and heatsink compound to electrically isolate the heatsink.

Variation #1: 24 Volts

Want a 24 Volt motor controller? No problem. The only change necessary for the circuit is an LM7812 voltage regulator chip to supply the NE555. (The NE555 is guaranteed to blow up at voltages greater than 16 Volts.) Three added capacitors filter power into and out of the regulator. The FET still switches juice directly from the battery — now nominally 24 Volts.

Variation #2: Remote, Optical Coupled Hi/Low Speed Switch

My client wanted a remote low speed/high speed switch. Since the switch was to be mounted separately from the controller, I used optical coupling to electrically isolate the hi/low speed lines from the rest of the circuit. This shields the sensitive, high-impedance timing part of the motor controller from stray voltage, induced perhaps by proximity to equipment with large magnetic fields, or from accidental contact with the rest of the house's electrical system. Figure 3 shows an optically coupled switch added to the 12 Volt motor controller. You can use any switch you want, as long as its voltage rating exceeds 12 volts. The current which flows through it is scarcely a milliamp.When the switch is closed, it allows current to light up a tiny LED encapsulated in the 4N37 (pins 1 & 2). When the little

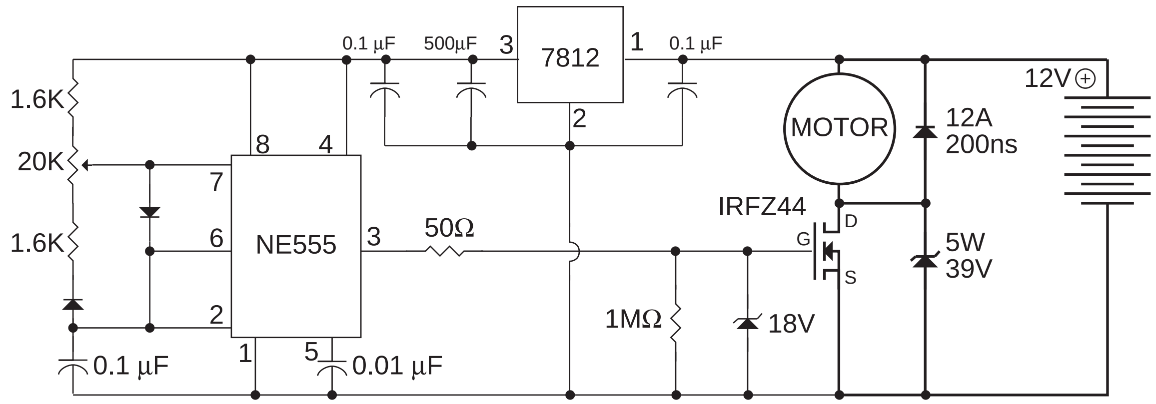

Figure 2: 24 Volt version uses a LM7812 to regulate voltage for the NE555.

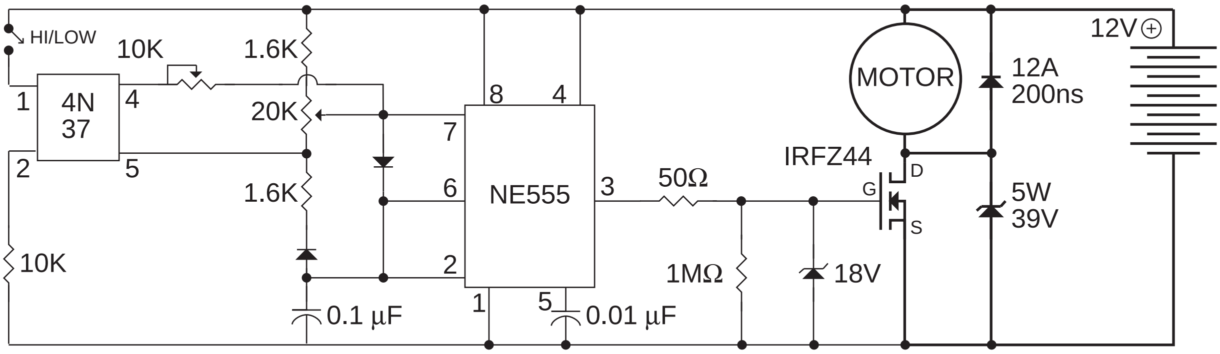

Figure 3: Optical coupling allows a remote high/low switch.

light is on, the other side of the chip (a phototransistor) becomes conductive, electrically connecting the 10K pot in parallel with one leg of the 20K potentiometer. This reduces the timing capacitor's discharge time, increasing the 555's duty cycle. The low speed and high speed can be independently set. First set the low speed by opening the switch and adjusting the 20K pot. Now close the low speed / high speed switch and set the high speed with the 10K pot.

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Parts: Motors: C & H Sales Co. P.O. Box 5356, Pasadena, CA 91117-9988 • 800-325-9465

FETs, HexFreds, electronics: Digikey: 701 Brooks Ave. South, P.O. Box 677, Thief River Falls, MN 56701-0677 • 1-800-DIGIKEY, FAX 218-681-3380

Power zeners, inexpensive electronics: Hosfelt Electronics Inc., 2700 Sunset Blvd, Steubenville, OH 43952 • 1-800-524-5414

ask NREL

The National Renewable Energy Laboratory (NREL) is one of ten federally funded national laboratories. NREL has offered to provide answers to technical questions from *Home Power* readers about renewable energy.

Question: *What is the efficiency of conventional power plants?*

Answer: The question is rarely asked about conventional power plants. The answers may be surprising. Usually, people ask about the conversion efficiencies of renewable energy sources. For comparison, flat-plate PV system energy efficiencies (sunlight to ac electricity) are 10%-12%, and have potential for improvements. Concentrator PV systems can potentially reach up to 30% efficiency. Solar thermal central receiver systems are projected at around 25% efficiency. And, wind energy systems can average around 25% efficiency.

Energy efficiency is defined as either *work out* or *energy out*, divided by *energy in*. There are many ways to define those terms, depending on the application or purpose. Typically, the energy efficiency is calculated for a very specific system. Calculating the efficiency for a class of power plants, as in this article, becomes dangerous. Average efficiencies have an inherent error, because every power plant and utility is unique.

I define the *energy out* as the ac power supplied to a home or other end user. The *energy in* is more difficult to define, as it varies with the fuel and generating technology mix. Usually the energy content of the fuel can be directly measured or calculated. However, for a conventional power plant, it takes energy to get the fuel to the plant and to transmit the power over power lines. The energy of mining or extracting the fuel and delivering the electricity to a home should also be included in the *energy in* term for the efficiency calculation, as should mining reclamation and the mitigation of negative environmental effects.

As an example, the following is an estimate of the energy efficiency of a coal-fired power system. First, the coal is mined, either surface or underground, transported within the mine, crushed, washed, and then transported to the power plant. Additionally, there is reclamation, or an attempt to return the mine to a natural state. All of these steps involve energy, and there are material losses. The energy efficiency of all those steps is estimated at 91%-93%. This efficiency is calculated from the energy content of the delivered coal divided by the sum of the energy content of the mined coal and the energy required for mining, crushing, washing, transportion, and reclamation.

For most power plants that use combustion of a fuel, the energy efficiency varies from 30%-40%. This efficiency is calculated from the electrical output of the power plant divided by the energy content of the fuel. The efficiency varies considerably depending on the energy content of the fuel; the type and age of the combustion furnace; the combustion, boiler, and cooling temperatures; and any extra energy required for emission controls, such as scrubbers.

The transmission and distribution system includes everything between the power plant and the home or end user, such as high-voltage transmission lines, substations, and transformers. The exact losses depend on variables such as distance, voltage used, type and age of the wire, and temperature. The average transmission and distribution system efficiencies vary from 87%-92%.

A complete coal power system can have an energy efficiency ranging from 24% to 34%, by multiplying the energy efficiencies of the fuel extraction (91%-93%), power plant (30%-40%), and the transmission and distribution (87%-92%). The dominant factor in the complete system energy efficiency is the power plant efficiency, which is representative of any combustion type power plant.

Now for the disclaimers: The efficiencies used are averages of estimates. Also, the energies required for waste disposal, such as fly ash from coal, are not included in these analyses. The energy losses from choosing one alternative over another, such as when surface mining of coal replaces the energy content in the grazing land, are not included. Land reclamation is not 100% efficient, and the loss of energy productivity from unrecoverable land is not included in these analyses. Because energy costs have increased since 1975, energy efficiency and productivity have become more important and some of the efficiencies may have improved. However, the energy efficiencies quoted in this article are representative of current power plants and electric utility transmission and distribution systems.

General conclusions that we can draw are 1) that the conventional combustion-type power systems have better efficiencies than current flat-plate PV systems; and 2) that concentrator PV systems, high temperature solar thermal electric systems, and wind energy systems may have comparable efficiencies. Given the uncertainties and known omissions from the above energy efficiency calculations, the conventional power plant system efficiencies are most likely the best case. When the omissions are included, the energy efficiencies will be lower.

Energy efficiency is important, but should never be used as the only criterion. The basic human energy cycle of sunlight, plant growth, eating, and physical work is estimated at 0.25% efficiency. Yet, very few people advocate eliminating the human population. Home owners, companies, and governments also use economics (pollution, societal, and investors costs), energy security (fuel interruptions, transmission, reliability, and long-term sustainability), environmental concerns, and sometimes, personal preferences when making a decision. Its never an easy decision.

Access

Energy Alternatives: A Comparative Analysis, published by The Science and Public Policy Program, University of Oklahoma, Norman, Oklahoma, May 1975.

Author: Byron Stafford, National Renewable Energy Laboratory

Send your technical renewable energy questions to: NREL, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 voice/FAX . Email via HPBBS 707-822-8640 or Internet Email to richard.perez@homepower.org

Of the People

Don Loweburg and Bob-O Schultze

With the Republican take-over of the House of Representatives and the Senate, there will be a wholesale change in committee leadership. Out go the Dems and in come the Reps. There are some legitimate concerns about how the changes will effect the nation's energy policy.

According to a report issued by SEIA, the most important changes, in terms of energy, will come from the House Energy and Commerce, House Science, Space, and Technology, and Senate Energy And Natural Resources Committees. Whether the House committees remain intact, get shuffled into a different incarnation, or get axed entirely is anybody's guess. The Senate E&NR Committee will be chaired by Senator Frank Murkowski (R-Alaska). Sen. Murkowski has supported some RE projects in the past, but is sure to try opening Alaska's National Wildlife Refuge for oil drilling. Also in limbo is the E&NR Subcommittee on Renewable Energy And Energy Efficiency. If it survives at all, the likely Chair will be Sen. Don Nickles (R-Oklahoma) That's Oklahoma with an "O" — as in OIL. Get the picture?

By the People

A survey of 1,000 randomly selected voters was conducted during December, 1994 for the Sustainable Energy Budget Coalition. When asked, "If the government is to continue funding research and development for specific energy sources, which source do you think should be highest priority?" — 42% choose RE sources like solar, wind, geothermal, biofuels, and hydroelectric, 22% chose energy efficiency and conservation, 15% chose natural gas, 9% nuclear, 7% fossil fuels (oil and coal) and 6% had no choice.

Judging by this poll, the American voters would choose RE over over oil and coal by a 6 to 1 margin. Will our legislators heed the message and govern "For the People" or.....? Time will tell, but it couldn't hurt to remind your representative that she/he was looking for a job when they found this one.

Good News for Californians

Legislation may be introduced in the California State Legislature to mandate net metering. Although Southern California Edison has for some time selectively used this policy, a state-wide mandate for all utilities is welcome news. The legislation will focus specifically on small producers, under 50 kw, allowing net periodic metering to parity. Excess production will be purchased by the utility at avoided cost. The new law is targeted at residential customers producing their own electricity with wind, solar or hydropower resources. We will keep you posted on the details, as they happen.

IPP, DRA (Division of Ratepayer Advocates of the California Public Utilities Commission), UCAN and TURN (ratepayer advocate groups representing both Southern and Northern California) have adopted a joint position opposing utility ownership of customer sited PV and other forms of distributed generation. We believe that the competitive potential of photovoltaics is best realized by commercializing customer-sited photovoltaics as a competitive alternative to utility generation." A copy of the full statement is available on request.

The Home Power Movement?

I get uncomfortable with sociological studies in general but thought this one interesting. IPP member Peter Smith dug this up while doing an online text search. Two studies (1989-1990) by J.S. Tatum, titled "The Home Power Movement and the Assumptions of Energy" and "Policy Analysis and The Home Power Movement: Technology, Behavior, and the Environment" detail some of the following findings:

"Participants in the home power movement have come to be among the most efficient and technically sophisticated of residential energy users, not only adopting but contributing to the development and marketing of super-efficient refrigerators, well pumps, and other residential appliances." "The apparent success of the movement and the effectiveness of the motives involved suggest that more attention should be given to PV-based home power systems as a means for dealing with energy and environmental problems than would otherwise be justified by a simple comparison of costs per kilowatt hour." "As a part of this movement, both the adoption of radical energy efficiency measures and the choice of electricity supply systems more than twice as expensive as traditional sources go well beyond traditional models of consumer behavior. These characteristics of the movement suggest (asking) important questions about energy policies that rely on the assumption that traditional patterns of energy related behavior are close to optimal and need only be examined at the margins. The decision making processes of movement participants also suggest a more formidable capacity for integrating the complex implications of energy choices into coherent action than is generally ascribed to ordinary consumers. In all of these respects, the movement appears to have implications for energy policy making out of proportion to the number of home-power homes."

Thank you Bill Gates.
Among the stacks of colorful catalogs arriving in early December was a software catalog from Microsoft featuring its "At Home" line of software for home businesses. I glanced through it and handed it to Cynthia. A few minutes later she handed it back and asked if I noticed anything about the cover. I looked and then suddenly, bingo, it hit me. The lovely rustic house, lit up at dusk surrounded by a snowy winter scene, had PV modules on the roof! No reference or mention of the PVs were made. It was just there. Did anyone else catch this?

Wake up!!!! Quotes
"Distributed Generation appears inevitable. The question is whether it will be planned and controlled by utilities." UPVG (Utility Photovoltaic Group, DOE corporate welfare recipients), ["Photovoltaics: On the Verge of Commercialization" June 1994, p. 32]

"There are two possible future scenarios for ownership of PV power systems: they will either be owned, installed and maintained by the utility as part of its generating plant or, the systems will be owned and operated by private entities that are both customers and suppliers of electricity to the utility." Dr. Robert Wills, The Interconnection of Photovoltaic Power Systems with the Utility Grid: An Overview for Utility Engineers, Sandia National Laboratories 1994.

These quotes — part of a long list from as early as 1989 that I've collected — clearly reveal where the utilities are at. It's like there are two realities, the sweet talk of collaboration versus these documented goals and statements of utility policy.

We're Growing
Membership is now in excess of 90. IPP encourages all people who share our views to join. There's lots to be done and a role for all whether you are an installer, dealer, manufacturer, distributor, user or advocate.

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To Join IPP: By E-mail: i2p@aol.com By phone: (209) 841-7001 or (916)-475-3402 Write and send tax-deductible donations to: IPP, PO Box 231, North Fork, CA 93643

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Code Corner

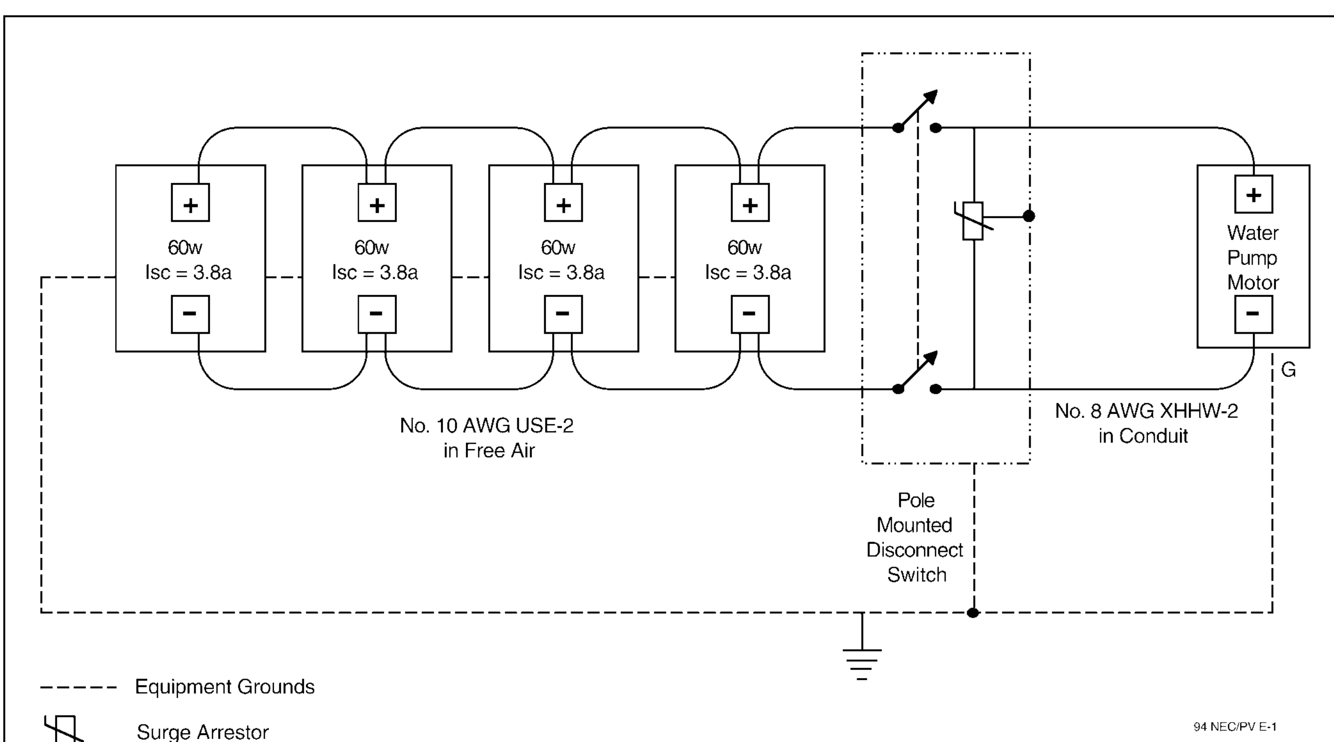
Example Systems: Water Pumping

John Wiles

This is the first of a series of examples on the selection of the wiring, overcurrent devices, and disconnects for various types of PV systems. These designs meet National Electrical Code (NEC) requirements. These are examples only and should not be used to define the requirements for any particular system. No information is given on sizing the PV array. The array sizes used and the loads driven are used only for illustration. Calculations for a specific system should use the methods presented in earlier issues of Home Power. The first example is the simplest — a water pumping system. The last example in the series will cover a complex residential hybrid PV system with a backup generator.

Direct Connected Water Pumping System Example
Array Size: 4, 12-volt, 60-watt modules Isc = 3.8 amps, Voc = 21.1 volts Load: 12-volt, 10-amp pump motor

Description
The modules are mounted on a tracker and connected in parallel. The modules are wired as shown in Figure 1 with number 10 AWG USE-2 single-conductor cable. A large loop is placed in the cable to allow for tracker motion without straining the rather stiff building cable. A jacketed cable, such as SEO W-A, could be used for this connection. The USE-2 cable is run to a disconnect switch in an enclosure mounted on the pole. From this disconnect enclosure, number 8 AWG XHHW-2 (cross-linked polyethylene) cable in electrical non-metallic conduit (gray electrical PVC) is routed to the well head. The conduit is buried 18 inches deep. Number 8 AWG cable is used to minimize voltage drop.



The NEC requires the disconnect switch. PV modules are current limited and all conductors have an ampacity greater than the maximum output of the PV modules. No overcurrent device is required, but some inspectors might require one. The disconnect could also provide some lightning protection. A DC-rated disconnect switch or a DC-rated circuit breaker must be used. Since the system is ungrounded, a two-pole switch must be used. All module frames, the disconnect enclosure, and the pump housing must be grounded whether the system is grounded or not.

If the pump motor is submersible, plastic insulated cables should not be used. Where moisture is present plastic (PVC, e.g. Type TW) cables, in DC applications, have had the insulation melt off the wire. The case of any pump motor, submersible or not, must be grounded. This means three conductor cables will be required down the well.

Calculations
The array short-circuit current is 15.2 amps (4 x 3.8).
UL 125%: 1.25 x 15.2 = 19 amps Required by the module instructions.
NEC 125%: 1.25 x 19 = 23.75 amps
The ampacity of 10 AWG USE-2 at 30°C is 55 amps in free air.
The ampacity at 61-70°C is 31.9 amps (0.58 x 55) which is more than the 23.75 amp requirement.
The equipment grounding conductors should be number 10 AWG.
The voltage rating of all components should be at least 26 volts (1.25 x 21.1).

Water Pumping System with Current Booster
Array Size: 10, 12-volt, 53-watt UL-Listed modules Isc = 3.4 amps, Voc = 21.7 volts
Current Booster Output: 90 amps maximum, 40 amps steady state
Load: 12-volt, 40-amp motor

Description
This system has a current booster connected between the PV array and the water pump. It has more modules than the previous example. Initially number 8 AWG USE-2 cable was chosen for the array connections, but this cable had inadequate ampacity. As the figure and calculations below show, the array was split into two subarrays. There is the possibility of a malfunction in the current booster, but it does not seem possible that excess current can be fed back into the array wiring since there is no other source of energy in the system. These conductors would not need overcurrent devices if they were sized for the entire array current. Since the number 8 AWG conductors had insufficient ampacity for the entire array short-circuit currents, smaller conductors are used in each subarray and overcurrent devices are needed.

Even though the array is broken into two subarrays, the maximum short-circuit current available in the wiring of either subarray is equal to the total array short-circuit current under fault conditions. Overcurrent devices are needed to protect the subarray conductors under these conditions.

A grounded system is selected and only one-pole disconnects and overcurrent devices are required. Equipment grounding and system grounding conductors are shown in Figure 2.

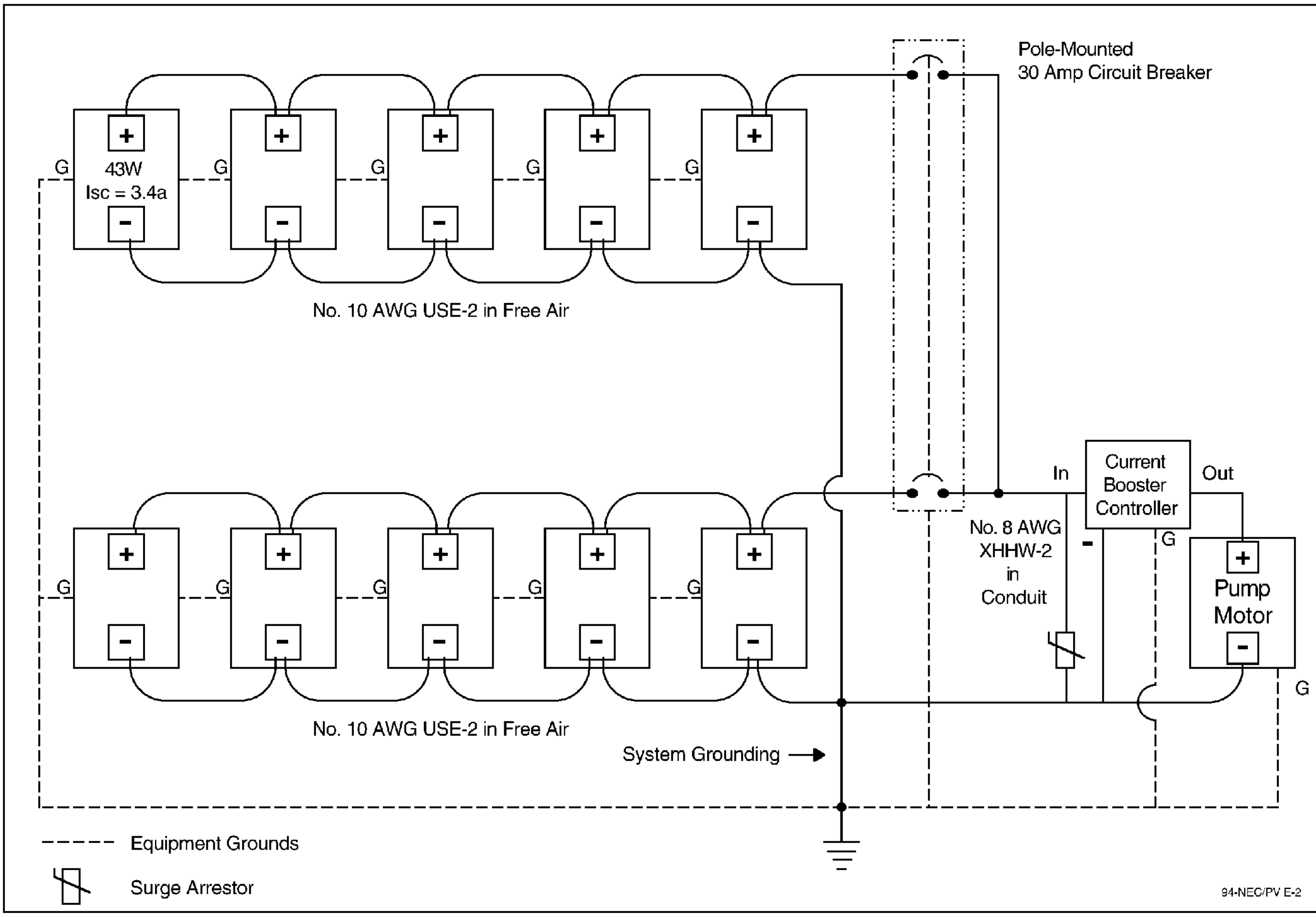
If the current booster output conductors are sized to carry the maximum current of the booster, then overcurrent devices are not necessary, but again, some inspectors may require them.

Calculations
The array short-circuit current is 34 amps (10 x 3.4).
UL 125%: 1.25 x 34 = 42.5 amps Required by the module instructions
NEC 125%: 1.25 x 42.5 = 53.1 amps
The ampacity of 8 AWG USE-2 cable at 30°C, in free air, is 80 amps.
The ampacity at 61-70°C is 46.4 amps (0.58 x 80) is less than the 53.1 amp requirement. Number 8 AWG is the largest conductor that can be connected to the modules. Therefore, the array is split into two subarrays. Each is wired with number 10 AWG USE-2 conductors.
The subarray short-circuit current is 17 amps (5 x 3.4).
UL 125%: 1.25 x 17 = 21.3 amps
NEC 125%: 1.25 x 21.25 = 26.6 amps
The ampacity of number 10 AWG USE-2 at 30°C, in free air, is 55 amps.

The ampacity at 61-70°C is 31.9 amps (0.58 x 55) is more than the 26.6 amp requirement. Since this cable will be connected to an overcurrent device with terminals rated at 75°C, the ampacity of the cable must be evaluated with 75°C insulation. Number 10 AWG 75°C cable operating at 40°C (the disconnect operating temperature) has an ampacity of 30.8 amps (0.88 x 35) which is more than the 21.3 amps requirement. Thirty amp circuit breakers are used to protect the number 10 AWG subarray conductors.

The current booster maximum current is 90 amps.
The current booster average long-term (3-hours or longer) current is 40 amps.
NEC 125%: 1.25 x 40 = 50 amps

The ampacity of number 8 AWG XHHW-2 at 30°C in conduit is 55 amps. The ampacity at 36-40°C is 50 amps (0.91 x 55) which meets the requirements, but



may not meet the overcurrent device connection requirements when such a device is used in the current booster output circuit.

The number 8 AWG conductors would be connected to the terminals of the overcurrent device. There is the possibility that heating of the breaker or fuse may occur. It is good practice to calculate device overheating. The ampacity of a number 8 AWG conductor with 75°C insulation (the maximum temperature of the terminals on the overcurrent device) at 40°C is 44 amps (50 x 0.88). This is greater than the maximum 40 amp current in the circuit. It means that the overcurrent device, if installed, would not be subjected to overheating when the number 8 AWG conductor carries 40 amps.

All equipment grounding conductors should be number 10 AWG. The grounding electrode conductor should be number 8 AWG or larger.

The voltage rating of all components should be at least: 1.25 x 21.1 = 26 volts

Summary
The calculations used in these examples are based on UL and NEC requirements. While there is some leeway in the selection of cable types, overcurrent devices, and disconnects, only DC-rated devices should be used. Over sizing the cables will lower voltage drop and increase performance, particularly where long cable runs are involved.

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Stud Muffins & Kilowatt-Hours

They Ought to Call Them Sherpa Weeks

James R. Udall

One barrier to thinking and caring about energy is jargon — the cryptic units by which energy is bought and sold.

A gallon of gasoline is easy to visualize, but what, pray tell, is a therm of natural gas or kilowatt-hour of electricity? Beats me, right? Unfortunately, until we understand how much work such terms represent, we can't hope to understand whether energy is a rip-off or bargain, or appreciate how much energy it takes to power our lives.

Consider the Kilowatt-Hour or Kwh

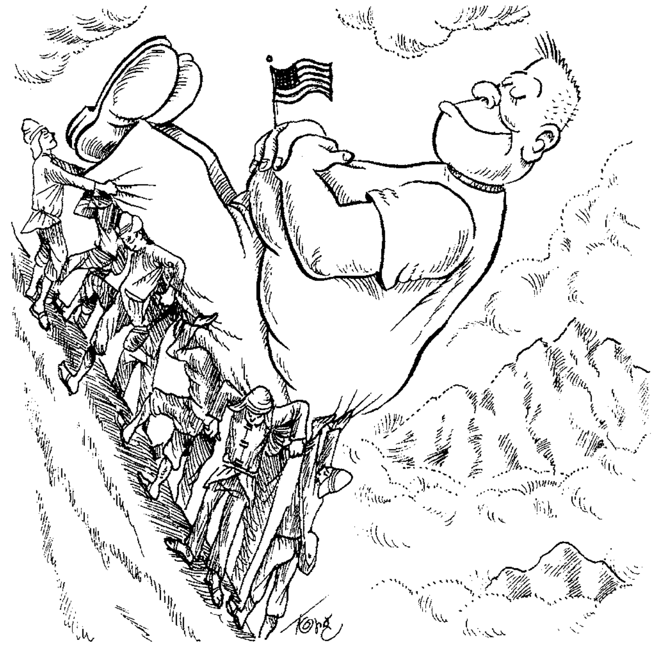
The standard definition of a Kwh, whose cost hereabouts is 7.5¢, is enough juice to run ten 100 watt light bulbs for an hour. But this tells us next to nothing about how much effort, in human terms, the unit represents.

With some math and head scratching it is possible, however, to convert kwh into more useful measures. It turns out that one Kwh is equal to about 2,600,000 foot-pounds; that's enough work to lift 2,000 pounds a distance of 1,300 feet. If that sounds like a lot, it is. Hire a strapping young man, a real stud muffin, to carry nine 94 pound bags of cement up a 3,000 foot-high mountain. You've bought a kilowatt-hour of work. Of course, the stud muffin would charge much, much more for it than your electric utility does.

Here's another analogy, carry (or hire a Nepalese Sherpa to carry) a 90 pound pack from sea level to the 29,000 foot summit of Mount Everest. In carrying the pack upwards, you or he would do about a kilo-watt hour of work.

Kilowatt-Hours? Or Sherpa Weeks?

Once we grasp that a kilowatt-hour represents a great deal of work, we can begin to appreciate how much energy it takes to keep American farms and factories, shops and schools, homes and hospitals, government and industry running.



If you divide total US energy use by the number of Americans, you discover that each American uses, in diesel, gasoline, jet fuel, natural gas, and electricity the equivalent of 240 kilowatt-hours — or 240 Sherpa weeks — per day.

Again, that's 240 pack loads up Everest — per person, per day. Hard to believe, but true.

Access

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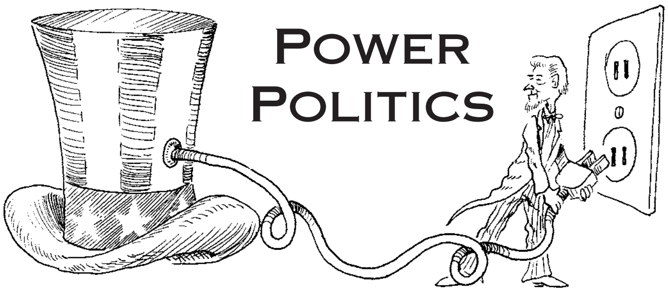


Be a Participant in the Energy Revolution

Michael Welch

This may be it folks... the one we've been waiting for to finally increase the use of PV by decreasing its cost. But, we'll need your help.

German P-V Program Re-Visited

The entire *Home Power* staff is very excited about the German rate-based incentive model described in the last issue (HP #44 pages 20 and 71). Applied in the U.S., it could be a major boon for the solar electric industry, bringing down the price of modules and other home-scale power equipment. PVs could become affordable for anyone, not just rural home owners facing long utility line extensions. The strategy would also work for small-scale wind and microhydro systems.

These incentives are designed to increase long-term demand for renewable energy sources by paying home-owners more for the electricity they put back into the power grid. This demand would increase investment in module manufacturing facilities, and hopefully bring the price of RE sources down. The money to pay small-scale producers would come from a one or two percent increase on utility bills.

The funds wouldn't help owners purchase equipment, instead, it would subsidize a higher than normal buyback rate. System owners would recover their investment in a very short period of time. The buyback price is typically about 50 cents per kWh. That's ten to fifteen times the normal utility buyback rate. Most individual's power systems could be paid-back in just two or three years, at those rates. Programs might be implemented on a variety of levels: state-wide, utility service areas, county-wide or even on a municipal basis.

We are interested in getting feedback and/or support from our readers and advertisers about this type of program. We hope that rate-based incentives will provide the missing recipe for giving renewable energy a boost. We'd like to find out if you all agree and would like to help.

Redwood Alliance and Independent Power Providers are interested in helping make rate-based incentives a reality. As a grass roots renewable energy advocacy group, Redwood Alliance may be a good choice to do some of the early research and program development to help make this approach a widespread success.

Lots has to be done, andots of help is needed. For example, we will need to find out if, as suspected, the public will accept a small amount added onto their utility bill in order to fund the program. We'll need to learn if this is generally true, or if such an inquiry has to be made on a community by community basis.

We will need to test the waters to figure out which governing and/or regulatory bodies will be the most receptive to implementing rate-based incentives.

We will need to begin the footwork to get these programs in the works in a few communities. Once some practical experience is acquired, the lessons of that experience can be shared with others wanting to implement similar plans in their locale.

We will need to figure out how to get that information to the right people and how they can implement incentives in their communities. Maybe, it would even be helpful to compile a "how-to" guide based on early experiences and other more general concepts for community activists.

Can We Pull This Off?

As with most "profitable" ventures, the job won't be easy. It will require significant support, funding and organizing of effort in order to get the job done. But, also like other "profitable" ventures, the payoff can be rewarding. Remember folks, this could be "the big one" we've been waiting for. There are no guarantees. The only way to find out is to start the process.

Another more tangible potential payoff is job creation for activists working on these projects. For example, if one of these incentive programs is started in your municipality it will need staff to oversee the program.

Who better than those that actively formed and passed the program? Such a job will require a knowledge of local government politics, energy rate economics, renewable energy systems design and implementation, and a knowledge of local renewables businesses — all the same knowledge necessary to organize one of these programs.

So give it some thought, and contact us with those thoughts. We need lots of feedback — the sooner the better.

News Flash, DOE DOA?

The Clinton administration is considering eliminating the Department of Energy (DOE). At first glance, it seems like an acceptable part of a plan to head-off Republican efforts to cut back on government. The Clinton administration wants the public to see that it can cut back just as well as its opponents. But, they appear to be putting this decision on the fast track. If they go for it, it will have been done without appropriate feedback from the public.

Further review indicates eliminating the DOE may be a bad idea. Imagine the Defense Department, famous for trying to cover up rather than doing the right thing, taking charge of the clean-up of massively contaminated nuclear weapons plants. Civilian radioactive waste and nuclear research programs could end up with the infamous, Nuclear Regulatory Commission (NRC). They have a propensity to support and err on the side of the nuclear industry, instead of standing up for safety — as is their dictate. Other energy programs could end up with the Departments of Interior or Commerce. Who knows who would end up overseeing renewable energy programs or if they would even survive!

Energy supply is important enough to make a cabinet level department an absolute must! While certainly, some of the programs run by the DOE could move to other departments, the only good reason for this would be to allow the DOE to concentrate fully on encouraging a renewable and energy-efficient future for the nation.

News Flash #2,

The last of the nuclear power plants under construction in the U.S. have been scrapped. The Tennessee Valley Authority (TVA) announced that it would not finish three partly built nuclear reactors. It does have one plant that is "finished", pending an NRC OK to load fuel and begin testing.

Over the years, TVA has spent about $6.3 billion on the mothballed plants. TVA stated that it would take approximately $8.8 billion in additional funds to complete the plants. That's about what the most recent plants have cost to put on-line in recent years. But, keep in mind that utilities have always severely underestimated nuclear power plant construction costs, so it would likely cost even more.

A good example is the Diablo Canyon Nuclear Power Plant. It had a construction cost estimation of around $200 million, Diablo ended up costing over $5 billion. None of these figures included capital outlays over the lifetime of the plants (estimated at $5 billion each) or decommissioning costs — estimated to be the same as plant construction costs, or around $5 billion each.

Yup, that totals $15 billion for each plant. When TVA chairman Craven Crowell announced the stoppage he said, "We are still building nuclear plants and piling up debt guided by policies that are decades out of date." It's not coincidental that the public has been decrying these policies for all of the decades Crowell mentions. To the utilities: "It's about time you get our message."

This isn't to say that the nuclear industry is giving up. They hope to convince the public that a new generation of nuclear power plants should be built. According to the industry, the new plants will not have the same safety problems that the current generation of reactors has been plagued with.

Long ago, the industry made claims that power from those reactors would be "too cheap to meter." Now the industry is claiming that the next generation of nuke plants will be inherently safe. Their new promise is "too safe to worry". They mean they're planning the next nuke plants to not need the many redundant safety systems that current designs need to keep the risk of catastrophic accidents to a minimum. Dream on.

Are you ready to believe an industry that has been trying to pull the wool over public eyes for nearly 40 years? I'm not. Suppose, by some slim chance, they do happen to come up with a reactor design which is a lot safer. That still doesn't address the rest of the fuel cycle, which includes the mining (commonly done by aboriginal peoples on their native lands), the processing (with its dangerous by-products and worker exposure), and what should be done with the highly contaminated spent fuel.

Give it up, suits, we don't want your poison power.

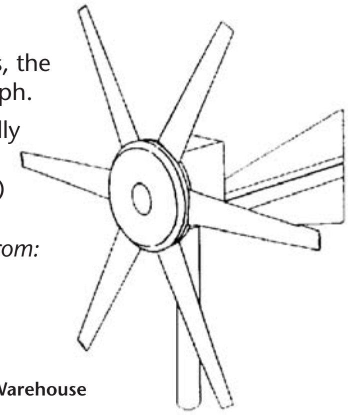
Buying Time

To hook it all together, we've been able to avoid new power plant construction in the U.S. based on a push for energy efficiency and conservation. But, that can only last so long, since "growth" seems to be the goal of every politician, businessperson, and economist.

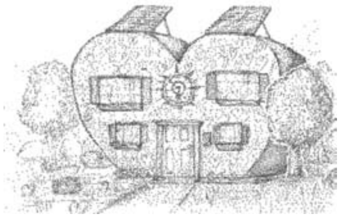
Eventually, we will outgrow our electrical supply and have to start producing more. For the well-being of the planet, that supply needs to come from renewables. Our DOE needs to help develop new, cheaper technologies. We need incentives, like rate-basing, so that the general public can afford to put PVs on their roof tops.

Access

Author: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521. (707)822-7884 voice, (707)822-8640 computer BBS, Internet: michael.welch@homepower.org



Home & Heart



Kathleen Jarschke-Schultze

Finding an efficient washing machine that will work on or off-grid is of great interest to *Home Power* readers. I've been given lot of good information by conventional letter, E-mail, and telephone. I'm sharing this with you. I will continue further research.

Ian Woofenden
After our used and venerable old AC washing machine died, my wife wanted a new one. We got a White Westinghouse. After ascertaining that it was conceivable to convert it to DC, if it was too much of an energy hog on AC.

We burned out two AC motors (it didn't like our inverter or gen power, I guess). Then we got Windy Dankoff's conversion kit. This was because I have time on my hands and 'like' lying under washing machines — NOT! The conversion was a pain. It took cobbling up brackets and such. It would have been a lot easier if I'd had the tools and welder I have now.

It did work after a fashion, but the motor speed was a problem. At 24 Volts it ran too fast and the clothes didn't drop. At 12 volts it was too slow. So Windy (patient, gracious Windy) sent us resistors and then more resistors until we got the speed down to a reasonable level. The only drawback now is that when we're charging with the gen and the voltage is way up there, it still runs too fast. We're thinking the long term solution is perhaps to put a rheostat in so we can adjust the speed for the voltage. Sounds complicated, but we find that if the speed isn't right with a front loader, the clothes don't really get clean.

I've been back under there several times trying to keep the thing going (it's a hobby). Mostly because I didn't make the wiring and connections stout enough at first. The motor is attached to the drum and shakes, rattles and rolls along with it. Everything has to be skookum. Anyway, that's my experience. Any questions are welcome. Ian.Woofenden@f525.n101.z1.fidonet.org

Deac Manross
We've owned an ASKO washer/dryer for the last year (on-grid unfortunately). Here are some of our experiences. Overall, we really like it but it does take some getting used to.

1. Wash day takes much longer: Washing darks takes just under an hour and whites can go close to one hour and 45 mins. On top of that the load capacity seems smaller The sales people will argue vehemently as they tie seven bath towels together and stuff them in the door — doesn't seem to work in practice.

2. On the digital model that we have, YOU set the water temperature yourself in increments of 5 degrees. I don't know if the machine could sense the temperature of your incoming solar heated water or whether the sensor is located somehow different. It might work just to set it's temperature selector to the incoming temperature of your heater.

3. Cold water washings do seem to be common out there, but let me caution you on washing whites. ASKO tells you NOT to use bleach. If you wash whites at anything much less than 95° C AND don't use the pre-wash cycle the whites come out pretty dingy and perspiration stains won't go away like they did for our old agitator-based dinosaur. DeacM@aol.com

Frank W Hauser
We've had two White-Westinghouse machines in use during the seasons of 1993 and 1994 (May through October).

We use them to wash sleeping bags. In season these machines start up at about 7AM and sometimes go until 9PM. So far we have not had one minutes trouble with these machines.

We got them to avoid using our 30 lb. capacity Speed Queen front load commercial washer. We discovered that the Speed Queen reverses every 30 seconds during the wash cycle. This is just like starting a load every 30 seconds. This dragged down whatever power source we were using at the moment, be it diesel power or AES inverter. We measured about 25 amp at 240 momentary on the Speed Queen.

The White-Westinghouse units, two of them at the same time, run just fine on the AES along with all our other loads.

We have a pretty large solar system installed by Chad Lampkin. Our power needs are very large during the season, but we do run on inverters from 6PM until about 9AM the next morning every day. This includes a walk-in freezer and cooler.

I would not hesitate to buy the White-Westinghouse units again. In fact we will probably get two or three more units this coming summer. Sawbill Canoe Outfitters Inc, Toete, MN 55615

Jennifer Stein-Barker
White-Westinghouse: This front loader is now the most popular model they sell. The front-loader that is referred to in the August 1992 Consumer Reports was a stackable apartment model with a mechanical (belts and pulleys) speed control. That one has been discontinued. The new model is controlled by a triac. According to a source in Utah, he can get it to run on his Heart 2800W MSW (modified sine wave) inverter, as long as he doesn't put in a heavy load. A source in Sandpoint, Idaho says it won't run on her MSW inverter (brand unknown). Clyde, at Trace engineering, predicted it wouldn't run on their MSW inverters. If you have a true sine wave inverter, it will not only run, it will do a load for about 170 watt-hours (per White-Westinghouse, a very difficult number to obtain from them, but I finally managed).

Asko: the only model we've looked at so far is the middle-of-the-line #12004. They supposedly run a load.for about the same watt-hours as the W-W. But, they spin much faster — a big benefit if you are hanging your clothes in the house to dry in winter because it extracts a lot more water. The big drawback to this one is that you can't turn the internal heater off or disarm it. The lowest setting is 68 degrees F. If you turn it below that, the machine just won't run. If you can guarantee that the water going in will be above 68 degrees, of course the heater won't turn on, but we can't guarantee that at our house. Jade Mountain sells a lower-tech model Asko #10504 (their stock #AA611), which they say will run on a MSW inverter. I'm sending them a copy of this letter to ask if the heater can be turned off in that model. Jennifer Stein-Barker, Izee Route, Canyon City, OR 97820

Tim Hastrup
I'm a fairly new subscriber to Home Power, but thoroughly enjoy each issue. Lately I've been interested in your comments on European appliances. Being Danish I'm familiar with some of the brands that you've mentioned.

On the washing machine front my wife's parents have a German AEG OKO-Lavamat. My mother has a Danish Volund brand washer. (Our parents all live in Denmark.) Both are very nice front loading units that appear ready to last forever (or just about forever). Like you, we'd like to find a front loading efficient, reliable washer for our home here in California. In the December 5, 1994 issue of Design News (a magazine for Design Engineers) I saw an article for the US made Staber System 2000 machine. I thought that you and the rest of your readers might be interested in this.

Tim Hastrup, WB6PZW, Granite Bay, CA 95746

Staber System 2000
Five people steered me to the Staber washing machines. Staber Industries Inc. called me because they'd been told I might be interested in their line of washers. I am.

Brothers William and Jim Staber, are now marketing a European-style washer. It tumbles clothes on a horizontal axis, rather than churning clothes with an agitator. A horizontal- axis (H-axis) machine is considered far more efficient than models with vertical axis. It uses less water. The Stabers' decided to take a clue from the European appliance makers and simplify the washer while making it more efficient. The machine loads from the top. The lid is locked until nearly two minutes after the washer stops. Clothes can't be added during the cycle, a safety feature used by European models. By utilizing the oddly shaped six sided tub, the Stabers say clothes get cleaner.

The machine's only mechanical components are an electric water pump and a DC electric motor. The motors are from AEG and Siemens in Germany. The pumps are from Askoll Tre in Italy. The motor is electronically controlled and has a soft start feature. According to Jim Staber, the motor draws a peak of 6 amps @120 vac and a running current draw of 4 amps.He claims his machine consumes approximately 150w/hrs during an average cycle. The machine is easier to repair because key parts are accessible from the front. The Stabers also claim the System 2000 gives a consistently better wash using less resources to launder comparable loads. A typical cycle includes a 15 minute wash, two five minute rinses, a five minute spin (at 700 RPM) and some time to fill the tub.

Three models are available, ranging in price from $799 for the most basic house unit to $1099 for a coin operated commercial model. That's a lot of money, but it's comparable to the cost of a White-Westinghouse or an Asko.

Maytag officials washed their clothes at a coin-operated laundry that's testing the Stabers' System 2000 machines in Columbus, Ohio. Word is they're thinking about adding an H-axis washer model to their line. I'll continue looking into washers and reporting back.

Access
Kathleen Jarschke-Schultze, wishing for a washer at her home in northern-most California, c/o Home Power Magazine, POB 520, Ashland, OR 97520 916•475-0830 Internet Email: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

Staber Industries, Inc., 4411 Marketing Place, Groveport, OH 43125 • 614-836-5995 or 800-848-6200 FAX 614-836-9524

Asko, Inc., 903 N. Bowser #200, Richardson, TX 75081

AEG OKO-Lavamat, The Andi Co., 65 Campus Plaza, Edison, NJ 08837 • 908-225-8837

White-Westinghouse, 6000 Perimeter Dr. Dublin, OH 43017 • 800-245-0600

HAPPENINGS

AFRICA
The 1995 ISES "In Search of the Sun" Conference, "The World Solar Energy Exhibition and the finish of a solar car race is scheduled for September, 11–15, 1995 in Harare, Zimbabwe. For exhibitor and attendance information contact Peter Armstrong, exhibitor director, In Search of the Sun, PO Box 2851, Harare, Zimbabwe, Phone: (263-4) 730707, Telex: 0907 (26623 ZW), Fax: (263-4) 730700, e-mail: xcarelse@zimbix.uz.zw

CANADA
Are you operating a diesel or gas generator with their high fuel and maintenance costs, or just doing without electricity? Have you ever wondered about the energy available in falling water? This course will tell you how to determine the feasibility if a low maintenance water power option — not necessarily nearby. These two day, fourteen hour micro-hydro courses are suitable for everyone, regardless of technical background. The course includes an overview of electricity & energy and terms & concepts. Upon completion, you will be able to assess the potential of your stream or creek to meet your electrical needs. Learn how to size system components, estimate costs, and have some basic installation guidelines. The cost of each two day course is approx. $90 Cnd (approx. $65 US). March 25 & 26 — 1995, Selkirk College, Nelson BC V1L 1C8, (604) 352-6601. May 13 & 14, 1995 — Univ College of the Cariboo, Williams Lk, BC V2G 3P7, (604) 392-8043. For more information contact, Bob Mathews, course instructor, at 604-679-8589. Field trips and other course dates will be scheduled as demand requires.

NATIONAL
American Hydrogen Association Bulletin Board System: Solar Hydrogen BBS, 415-494-3116, 1200–14,400 baud V.32bis. V.42bis 8N1, Prosperity without Pollution: also AHA Tempe BBS (602) 894-8403.

Free Energy-Saving Information for homeowners who are preparing for the arrival of winter and would like information on cutting their residential energy bills. The Energy Efficiency and Renewable Energy Clearinghouse (EREC), is offering a free booklet entitled "Heating The Home".To obtain a copy contact EREC by calling 1-800-DOE-EREC (363-3732) or by writing EREC, PO Box 3048, Merrifield, VA 22116

EAST COAST
American Tour de Sol — National Road Rally Championship for Electric and Solar Electric Vehicles, May 20–27, 1995, Waterbury, CT—Portland, ME, traveling through five states: CT, MA, VT, NH & ME, with pit stops in Northampton and Greenfield, MA, Brattleboro, VT, Mount Monadnock State Park, Lexington, MA, and Dover, NH. The public is invited to view over 50 electric and solar powered cars on secondary highways and free public displays in Connecticut, Massachusetts, Vermont, New Hampshire and Maine the week of May 20–27. These non-polluting vehicles will be competing in the American Tour de Sol for the national electric and solar vehicle championship title, and clean air for the region. Production electric vehicles built by the big three and other electric vehicle manufacturers, students and individuals from around the country and abroad.

For more information about the event, volunteering, participating, sponsoring, or exhibiting please contact Northeast Sustainable Energy Association (NESEA), 50 Miles St, Greenfield, MA 01301, (413) 774-6051, Fax (413) 774-6053.

ARIZONA
Solar Energy International (SEI) will be presenting a workshop in Photovoltaic Design & Installation in Tucson from March 27 through April 1. The workshop will cover design and sizing of photovoltaic systems, Participants will learn the basics of PV through labs and a hands-on installation. Participants will tour residential PV systems, a utility-tied PV system, and the Tucson Electric Power Company's generating facility. Contact Solar Energy International, PO Box 715, Carbondale, CO 81623-0715, or call 303-963-8855.

ARKANSAS
Sun Life is now conducting "Third Saturday Seminars" on inexpensive building techniques. The focus of these seminars is to teach others how to build their own homes from materials that can last a thousand years and cost less than conventional wood-framed homes. These are hands-on, all day workshops. Contact Loren at PO Box 453, Hot Springs,AR 71902

CALIFORNIA
Offline Independent Energy Systems Workshops: Designing Your Home PV Power System for Beginners — Sunday March 5, 1995. The class will begin with a tour and discussion of a working PV system. This PV system is one of the first in Central California and has been in operation for eleven years. We will then develop the following topics: basic systems types, determining power needs, the PV array, the battery, and inverters. We will discuss how it's all put together — special wiring, code requirements, safety, instrumentation and controls. We will look at how to Live with PV in relation to appliances, computers and entertainment equipment, attitude and awareness. The workshop will be held at Sun Mt near Auberry, CA. Cost is $35 per person or $45 for two together. For further information, reservations, and directions, please call, write, or e-mail Don And Cynthia Loweberg, Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643, 209-877-7080. internet ofln@aol.com

Solar Energy International (SEI) will be facilitating a workshop in Advanced Photovoltaics and Utility Interface at the Sacramento Municipal Utility District (SMUD) headquarters March 13–18, 1995. The workshop will cover advanced topics in photovoltaics, utility-tied systems, large-scale solar electric generating plants and residential and commercial installations. The workshop will include labs, tours of SMUD PV generating plants and a special presentation by Don Osborn, Senior Solar Manager of SMUD. Contact Solar Energy International, PO Box 715, Carbondale, CO 81623-0715, or call 303-963-8855.

Convert It: The Workshop: Electro Automotive in Felton, CA is offering a hands-on electric car conversion workshop, February 22–25, 1995. The class is for the amateur mechanic interested in learning about converting a car to electric. The four day class will include lecture segments, but the primary focus will be the actual assembly of an electric conversion. This is a hobbyist version of a workshop previously offered only to professional mechanics. Students will learn which shortcuts can make their conversion easier and which ones lead to disaster. Emphasis is on producing a safe, practical, professional-quality conversion. The instructor is Mike Brown, author of Convert It. The cost is $400.00 per person. Pre-registration required, space is limited. Call Electro Automotive at 408-429-1989 for information.

COLORADO
The 6th Crestone Energy Fair, Labor Day Weekend, September 2nd and 3rd, 1995, Crestone Town Park, Free to the public. A gathering of solar advocates, experts, and novices for a weekend of solar technology, fun, music, food, council and a tour of solar homes. This is a self organizing solar potluck and camp. Come and enjoy. Booth fee — 1 item donation to the Green Goods Raffle. Turtle Island, PO Box 222, Crestone, CO 81131

'95 Jade Mountain/Denver Electric Vehicle Council Electrathon Challenge Schedule: Electrathon Challenge '95 events will be held the third Sunday of the month. Vehicle inspection will begin at noon with competition starting at 1:00 pm. The future is electric! Join the fun at the next Electrathon. April 23rd, 12:00–3:00, 33rd and Arapahoe, Boulder, CO. May 21st, 12:00–3:00 6th Ave and RD93, Golden, CO. June 25th, 12:00–3:00, 33rd and Arapahoe, Boulder, CO. July 23rd, 12:00–3:00 6th Ave and RD93, Golden, CO. All event locations are tentative. August 27th and September 24th locations to be announced. For more information call Bill Williams (303) 449-6601 or write DEVC, 2940 13th St, Boulder, CO 80304

Solar Energy International (SEI) is offering workshops on the practical use of solar, wind, and water power. The 1995 Renewable Energy Education Program (REEP) features one and two week workshops: Solar Home Design , Environmental Building Technology, PV Design & Installation, Advanced PV, Solar Cooking & Biofuels, Micro-Hydroelectric Systems, and Wind Power. Guest speakers and professional instructors will teach the design of state-of-the-art solar homes that are self-reliant, energy efficient, healthy to live in, and earth-friendly. Participants will learn the knowledge and skills to build energy-independent homes with solar, wind, and water power. The series is for owner-builders, industry technicians, business owners, career seekers, and those working in developing countries. The workshops may be taken individually or as part of a program. The cost is $400 per week. Scholarships and work/study programs are available on a limited basis. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623-0715 or call 303-963-8855.

MASSACHUSETTS
The Seventh Annual Sustainable Transportation and S/EV95 (Solar & Electric Vehicle) Symposium, Boston, MA, October 1995 (exact location and dates to be announced) will bring together a broad coalition of transportation planners, electric and hybrid electric industry representatives, business people, policy makers, ands engineers to foster the growth of a viable electric vehicle industry, and the development of a sustainable transportation vision for the nation. In-depth workshops, concurrently held sessions and an extensive trade show have made the event the major electric vehicle conference in the United States. For more information contact: NESEA, 50 Miles St, Greenfield, MA 01301, 413-774-6051, fax 413-774-6053.

MINNESOTA
SOLAR '95 Conference, 10,000 Solutions: Paths to a Renewable Future will feature the 24th American Solar Energy Society Annual Conference and the 20th National Passive Solar Conference. Billed as the largest and most comprehensive solar energy conference. Solar '95 will emphasize practical cost-effective applications of solar energy that can improve the nations economy. Speakers are leaders in solar research and commercialization efforts. Tours and workshops are planned. July 15–20, 1995 in Minneapolis, MN. For more information contact: American Solar Energy Society, 2400 Central Ave G–1, Boulder, CO 80301, 303-443-3130, fax 303-443-3212

MISSOURI
The US Department of Energy, NREL, and Crowder College Missouri Alternative and Renewable Energy Technology (MARET) Center are sponsoring the nation's first solar powered bicycle race, June 19, 1995 on the Grand Prix race course at the Indianapolis Raceway. Solar BikeRayce USA is open to high schools, vocational schools and other secondary educational institutions. A solar powered bicycle is a pedal-powered bicycle that uses an electric motor, batteries and solar panels for added power. Riders use a combination of muscle power, solar energy and stored energy. To win, the team's best athlete must ride the solar bike to achieve the highest speed by optimizing their use of human and the bike's electrical energy. The first 60 schools submitting proposals will participate in the race. Entries will be split into two divisions: teams with a male rider and teams with a female rider. The winning team from each division will receive a trophy and a $1,000 cash award. Second & third place finishers from each division will receive trophies and $600 and $400 respectively. Applications an regulations are available from: Solar BikeRayce USA, Crowder College MARET Center, 601 Laclede Ave, Neosho, MO 64850, 816-899-5512.

NEW YORK
The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516

Earth Day Festival and Energy Fair will be held April 22–23, 1995 at the Institute of Technology in Rochester, New York: Featuring alternative transportation, workshops on solar architecture, solar electric systems, energy efficient and environmentally conscious building, batteries, rail transit, sustainable agriculture, natural gardening and landscaping, vendors of RE products, and government agency energy programs and grants For more information om exhibiting, attending or participating, contact CEI, 50 Main Street West, Rochester, NY 14614-1218, 716-262-2870, Fax 716-262-4156, EMail, ctrenvinfo@igc.apc.org

NORTH CAROLINA
Solar Energy International (SEI) will be presenting a workshop in Photovoltaic Design & Installation in Raleigh from April 17–22. The workshop will cover design and sizing of photovoltaic systems Participants will learn the basics of PV through labs and a hands-on installation, and will tour residential and utility-tied PV systems. Contact Solar Energy International, PO Box 715, Carbondale, CO 81623-0715, or call 303-963-8855.

OHIO
Solar electric classes taught at rural alternative powered home with utility backup. Maximum of 12 students. Must advance register. $30 fee per person, $35 per couple, lunch provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will see equipment in use. Dates: Feb 11, Mar. 11, Apr 8, May 3, June 10, July 8, Aug. 12, Sept. 9, Oct. 14, Nov. 11, & Dec. 9. All classes held from 10 AM to 2 PM on Saturday.. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537.

The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more information contact, Larry Dussault, GLEAA, 568 Braxton Pl E, Westerville, OH 43081-3019, 800-GLEAA-44 or (614) 899-6263, Fax (614) 899-1717. Internet address DUSSAULT@delphi.com.

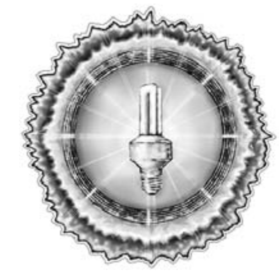
OREGON
The Lost Valley Educational Center is an intentional community and learning center devoted to developing the skills and awareness that will create a sustainable lifestyle. They are offering various low-cost workshops covering everything from low-cost underground housing to building solar ovens. For more information call or write Lost Valley Educational Center, 81868 Lost Valley Ln, Dexter, OR 97341, 503-937-3351

WASHINGTON, DC
March 26–30, 1995—American Wind Energy Conference: Windpower '95. Contact Linda Redmond, Meetings Coordinator, AWEA, 122 C St NW, fourth floor Washington, DC 20001, (202) 383-2500, Fax (202) 2505.

WISCONSIN
May 6 and 7, The Midwest Renewable Energy Association presents a two day workshop, Designing and Detailing for Energy Efficiency in Home Construction. Workshop presents Mark Klein, Ray Resar and Jim McKnight of Gimme Shelter Construction, Amherst, WI. Gimme Shelter is a construction firm long dedicated to energy efficient and renewable energy design and construction methods. Their hand-built homes dot the countryside throughout Central Wisconsin. This course covers residential siting, passive solar design, active solar, in-floor hydronic heating systems, energy efficient and environmentally friendly building materials, super insulation, daylighting, and more. A portion of the class will take place at a Gimme Shelter construction site, The workshop topics discussed may be developed by individual interests of participants, to further draw on the wealth of knowledge Gimme Shelter brings to the course. The two day workshop is located in Amherst, WI, cost $200. For more information: MREA, PO Box 249, Amherst, WI 54406. Ph. 715-824-5166.

The Sixth Annual Midwest Renewable Energy Fair will be held June 23–25, 1995 at the Portage County Fairgrounds, in Amherst, Wisconsin. Contact Midwest Renewable Energy Assn., POB 249, Amherst, WI 54406 • 715-824-5166

Home Power's Business



"The man who on his trade relies
Must either bust or advertise."
Sir Thomas Lipton — 1870

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Back Issues of Home Power Magazine

Back issues through #20 are $3 each ($4 each outside USA) while they last. Sorry, no more issues #1 – #10 or #15, or #36. Back issues of #21 through this issue are $4.50 each ($6 each outside USA). Back issues shipped first class mail in an envelope or box. See ad index for specials.

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the Wizard speaks…

Free Energy Impacts

The advent of free or nearly free energy will bring about many changes. These changes will occur regardless of the source of this energy. It could be the zero-point field, ultra-cheap solar, or some other new technology. These changes will occur in the fields of economics, politics, and the environment. There will be sociological effects as well.

Economics
In economics there will be great shifts of money and power. Some companies will fail, while others will arise to take their place. There will be large losses and large gains on the stock market and in other investment and trading arenas. The overall effect will probably be positive, especially in areas of high energy usage, and in industries which use non-energy related fossil fuel products. People will enjoy extra disposable income due to low energy prices. The greatest negative effect will be felt in economies based largely on fossil fuels.

Politics
The political landscape, not only of the United States but of the world, will change, often radically. Governments, especially of fossil fuel based economies, will have the tendency to collapse. There will almost certainly be turmoil in many of the oil producing and exporting countries. Even where governments are stable changes will occur due to shifts of money and influence. New power brokers will arise.

The Environment
The environment should benefit from this new energy paradigm. Air pollution, smog, global warming, and acid rain will virtually disappear. There will be no economic excuses for dumping chemical and other waste products in rivers and land fills. Free, or nearly free energy will make the total recycling of all resources truly economically viable. This recycling will also more than offset any increased resource usage due to ultra-cheap energy. Winter food production in greenhouses should increase.

Life-style
Free energy will give people more freedom. More people will move further out into the country. The number of homes-on-wheels will increase. The decentralization brought about by tele-communications and the information revolution will be accelerated.

Conclusions
All of the above should mean a better life for more people. A reward should be offered for a working, commercially viable free energy technology. I believe this technology will be available in the future. I hope it will be soon.

Letters to Home Power

Voodoo Electronics — An Answer

I appreciate the opportunity to provide further clarification of my Code Corner article in Home Power #43 (page 88). The letter in Home Power #44 (Letters, page 84) deserves my full attention.

The National Electrical Code (NEC) in Sections 90–7 and 110 requires the use of equipment that has been examined for safety. In particular, Section 110–3 (b) requires that listed equipment be used or installed in accordance with any instructions included in the listing or label. Definitions in Section 100 fully define all terms.

Electrical inspectors (Authorities Having Jurisdiction — AHJ) that I have talked to throughout the United States say that they rely on the testing and listing by Underwriters laboratories (UL) and other approved testing agencies. They take the information from the manufacturer's installation manual and labels (required by UL) on the product and then apply the NEC requirements to the installation. While they are willing to issue waivers in some areas and each has his own interpretation of the NEC, they generally appear unwilling to accept the liability associated with ignoring a definite UL or NEC instruction.

The instruction/installation manual for any UL-Listed PV module (Solarex, Siemens, ASE Americas, Tidelands Signal) contains the very definite instruction: "Multiple the rated Open-Circuit Voltage and Short-Circuit Current by 125% before applying any additional multiplying factors required by the NEC local codes." I think my Code Corner article adequately explains the reasoning behind these required multiplications.

Concerning Circuit Breakers. The Square D QO plug-in circuit breakers are tested and listed by UL for a maximum of 48 volts DC. The QO load center that accepts these breakers is also listed for 48 volts DC. Main breakers are not listed for DC in these load centers. Square D does not accept any liability for use of these devices above 48 volts DC. In a 24 volt nominal system, the open circuit voltage at Standard Test Conditions (25°C) is about 44 volts for 36-cell modules. On colder days the voltage could be above 48 volts. Although, the circuit breaker might be able to withstand voltages higher than 48 volts open-circuit, neither Square D or UL are willing to guarantee that it can always open a faulted circuit with a short-circuit current of 75 amps, for example, and an open-circuit voltage of 55 volts. The high current starts the arc as the breaker begins to open and as the voltage increases toward the open-circuit value, the increasing voltage may sustain the arc. The circuit breaker may be unable to extinguish the arc or the arc could jump to other adjacent QO breakers or the nearby grounded surfaces.The QO Load Center may play a considerable part of the 48 volt limitation on these breakers.

The Ananda Power Center uses QOU breakers and they are slightly different from the QO breaker. The low-current QOU breakers are UL-listed at 48 volts DC while the high-current QOU breakers have a 60-volt UL DC listing. Square D will provide a factory certification of the QO and QOU breakers up to 125 volts DC when used as part of a system that has been fully tested and listed by UL at the higher voltages.

More importantly for the installer and the inspectors the fact the UL has tested and listed the Ananda Power Centers for use with 48 volt nominal PV systems (Open-circuit voltages up to 100 volts). You have probably noted the interior construction of these Power Centers including the component spacing and deratings (current and voltage) of some of the power handling parts differs significantly from the typical Square D Load Center. All these differences are the result of the UL-Testing and Listing process.

The bottom line is there are no voodoo electronics loose in the Code Corner Columns in Home Power Magazine. Most PV installers and Electrical Contractors are paying close attention to the UL Listing and labeling on the electrical equipment that they install. When inspected, the inspector is also looking for any restrictions. Few are using equipment in a manner that disregards either the UL or NEC requirements. Liability issues when systems fail (and there are always to sort when every one has followed the law. John Wiles, Research Engineer, Photovoltaic, SW Technology Development Institute, Box 3001/Las Cruces, NM 88003

John, Your rebuttal lends even more credence to the "What's safe vs. what's silly" debate. If it's true the Square D will provide certification to 125VDC for their breakers under certain conditions, it tells us that the chance of failure at the barely possible 55VDC open circuit voltage with zero or near zero current flowing is extremely low. Let's look at your example of a 24V PV system with a specification of 75A short circuit current(Isc) and 44V open-circuit voltage (Voc).

According to your formulas in HP#43, pg 89, we multiply the Isc by 1.56 (125% x 125%) and the Voc by 125%. This requires an over-current device rated for 117A and 55V. Oops! Square D doesn't offer a QO breaker over 100A. Haven't done many of these, eh? Let's try a Isc of 50A. We would need a CB capable of 78A @ 55V. The Square D QOU180, rated at 80A@60VDC would do the job. No special or expensive enclosure needed. Just stick it in a can (excuse me—UL listed enclosure—available anywhere, cheap) large enough to accommodate the breaker(s) and wire requirements. Done. Legal. Code compliant. By the way, there is no difference between the thermal-magnetic circuit breaker capabilities of a QO and a QOU breaker of equal amperage rating. The only differences are the mounting and wire terminal configurations.

Your arcing argument for the smaller 40VDC rated breakers is also suspect. If the circuit is faulted, you don't have open circuit voltage, do ya? In fact, if the circuit is shorted, the PV voltage will be nearer to zero than to Voc. As long as current flows (as in arcing), the PVs are producing considerably less than Voc. In the milliseconds it takes to open the breaker, the voltage will indeed rise, but as the voltage tries to rise to Voc, the current tries to fall to zero. Assuming the breaker was sized to handle the Isc PLUS 25%, is it going to sustain an arc running very little or no current even in the improbable circumstance of the voltage exceeding the rating by 13%? I think your odds of winning the lottery are better.

It may not seem like it at times, John, but I appreciate your efforts to make PV safe. I'm just unwilling to burden the growing PV industry with unnecessarily expensive components in the name of safety. The goal can be achieved as well with readily available equipment which doesn't price a PV system out of the reach of many folks. If you feel a Volvo is somehow safer and can afford one, fine. Drive one! Just don't try to protect us from ourselves by outlawing all the Fords and Chevys. The goal is universal acceptance and affordability of RE systems. Right? Bob-O Schultze

The Burning Ring of Fire

Good news & bad news. The bad first, I'm selling my Titan aka "Burning Ring of Fire" (see page 18, Home Power #40). The good news is the replacement! I'm going to purchase a truck similar to a step van. I've been pricing rigs and have started drawing up plans. I have found out with my no overhead gypsy life style — you must jump on anything that comes along (worth wise) out here in the desert. So the only solution is to take my shop indoors to be able to tear down a transmission or fabricate things for people on the spot. So 3/4 living space framed out for windows and a fold down wall that becomes a patio/deck, 1/4 shop area with tools and power equipment, hydraulic lift gate and I'm set for good!

Of course nothing but solar power for my new rig!

Oh, now is the hard part — selling my old rig! I want to ask you where or how the best way to sell it would be. I'm leaving everything in and on the Titan so someone can move in and live the gypsy low cost life

I've got a buddy in San Diego where I could hang out. I figure , but don't know for sure that the market might be better on the coast than in the desert? Can you tell me of other addresses I can advertise the Titan. I hate to bother you, but I'm just not sure how I can sell it. It's a limited market. Thanks for your time again. Your Solar Friend in the desert; Christian Brunner, PO Box 1429, Moab, UT 84533

Alright, an up grade. You should write, Phred Tinseth, 101 Rainbow Dr #131, Livingston, TX 77351. Phred writes for a great RVers group called Escapees. Anyone looking for a good outfitted trailer should check out the article (HP#40, page 18) on Christians trailer and drop him a line. Karen

Historic EV

I am a long time builder and operator of electric vehicles and motorcycles. My electric Karman Ghia climbed Mount Washington in New Hampshire in 1976 at the 2nd Annual Alternative Vehicle Regatta. It's now in Boyertown Pennsylvania's Museum of Historic Vehicles. I built an electric 1914 Model T Ford for my Grandson, Andrew, and a 1911 Rolls Royce for Granddaughter, Amanda. I am now most interested in light weight EVs and am working on modifying my 4-motor electric MC to a 3-wheel Boat Tailed Speedster modeled after the 1934 Packard. I most enjoy all the articles on Elexctrathon racers — but my vehicle will be for street use. I would be happy to write about my Speedster when I get it finished. Edward C Proctor, New Holland, PA

Hi Edward, WOW, an electric Rolls Royce, I'm impressed! What I'm really waiting for is an electric 4-wheel drive that can do our 120 mile round trip to town, up and down two mountains, with several hundred pounds of stuff — my dream truck.

We're always grateful when good articles arrive. Hands-on, how I did it articles help everyone. Karen

Things That Don't Work

I recently purchased a new Bosch model 3054VSR, 12 VDC cordless drill. I plugged it into my Trace 2012 to top off the new battery. The indicator light on the charger indicated that the battery was in the "float state". I came back about an hour later to find the charger and battery smoking, stinking, gurgling, and extremely hot. I pulled the plug and set the unit outside to cool. After cooling, the battery and charger had fused together as one. Roached the darn thing before I drilled my first hole! Mickey-Wurl-Koth, Tomahawk, WI

Different Views
I've been reading the letters section in issue #43. I think it's just great that you print so many different views, nice job!

It seems obvious to me that we can be a strong united voice if we know what we want. The challenge before us is to create a level playing field. If the U.S. government wants to subsidize electricity then all should be given the same financial support.

Perhaps someone has done a study and knows dollar amounts that the RE industry should be getting.

I believe that the legislative process is the only possible hope for change. We know the results of sitting on the sidelines. Let's get in the game and take a swing.

I challenge Richard and the crew to come up with a petition in HP stating that we (RE) want the same finical breaks as nuclear, oil, gas, and coal.

The petition could be made so that each subscriber can get his & her friends to sign on. PS: United we stand, divided we fall, it's up to y'all. Jack (High Hopes) Montgomery, Murphy, NC

Thanks Jack, We definitely agree. Check this issue's Power Politics column for another plan. All input is very welcome. Karen

No Coverage
Subject: "Pubic Investment: Some Choices" News item — Number of years away scientists said a Nuclear Fusion power plant was in 1959....."another 25 years." Number of years away scientists said Nuclear Fusion power plant was in 1994 (ie 35 years and more than $10 billion later), after a major technological advance announced at Princeton University...." another 30 to 35 years." [the above "news item" quoted verbatim from the "Matter of Scale" feature in the 1994 May/June issue of World Watch magazine (Worldwatch Institute, page 39]

Second news item: Items from the editorial page of the December 3, 1994 Oregonian, referring to a new $150 million project by "Enron Corp of Dallas, Texas, the nation's largest natural gas company...(whose) officials believe that can inexpensively mass-produce large photovoltaic panels.... at a cost of 5.5 cents per kilowatt-hour (etc)..."

Two observations/questions: 1) Guess what the two above "news items" have in common? 2) What specific (not to mention relatively "in depth") coverage has Home Power magazine given to this topic of the Great Photovoltaic Breakthrough, say over the e past 18 months? My impression? Very little, to none. Can you please provide me with specific HP page/issue number references proving me wrong? Thanks. Frazier (Nick) Nichol, John Day, OR

Well Nick, in a way you've answered your own question with your quotes from World Watch. Many breakthroughs are promised, few materialize. If we waited for the ultimate, inexpensive product we'd have long grey hair. Home Power's focus is helping folks do-it-now. Solar Industry Journal's focus is on the solar industry and the research being done. See their ad in this issue for subscription information. Karen

PV on the Road
We're in the middle of a bus conversion, outfitting it for a family of four to live in year round. There's lots of room on the roof for panels! We particularly interested in sizing our system correctly and pros & cons of various configurations. as they relate to a mobile environment. Any advise you or your readers can give would be appreciated. Shirley & Howard Carlberg, 8911 Acacia Ave, Garden Grove, CA 92641

Hi, Have you seen a magazine called Bus Conversion? It's just up your alley. They're address is 4517 Lavante St, Long Beach, CA 90815. Also, Phred Tinseth, an RV kinda guy, (see answer to 1st letter) might also be very helpful. Karen

Likes EVs
I very, very much have enjoyed your focus on electric vehicles. Your stand on decentralized power is also quite impressive. "The individuals freedom of choice is indeed the greatest home power of all." Jay Ames, Worldtime, PO Box 7322, Puyallup, WA 98373

Down the Road with Vegetable Oil
I have been experimenting with vegetable oil fuels in my diesel Volkswagen Rabbit for over two years and 20,000 miles. I've tried some different fuel blends including biodiesel (aka methyl soyate for Soydiesel) with varying degrees of success. The best arrangement I have found, in terms of cost, convenience, reliability, cleanliness and pollution reduction, is to use waste restaurant fryer oil (which is free!) thinned with kerosene (30–50% final volume — less in summer, more in winter). I use a second fuel tank (a five gallon jug) and separate, heated fuel lines to keep the vegetable oil fuel thin in winter.

From the start I had trouble finding other people with hands-on experience or knowledge of vegetable oil fuels. There was some research done in the early '80s, but virtually all of it studied large direct injection agricultural diesels running on new oil either neat or as a low percentage fuel extender. Small indirect injection engines, such as those in most cars, were ignored and no one was looking at waste fryer oil as a fuel stock or kerosene as a thinning agent.

To my knowledge there has been no formal research into long term practical operation of passenger cars on used oil. Perhaps you or some of your readers have experience, knowledge, or ideas in this area. Any input would be useful — there's still plenty of room for improvement in my system and the fewer wheels I have to invent, the better!

Here are a few vegetable oil fuel basics gleaned from journal articles and experience. Most concern fuel injector fouling (which, if neglected, can potentially lead to stuck rings and cylinder scoring).

1. The car must have indirect fuel injection. 2. High oleic cauola an peanut oil are best. 3. Store oil in topped-off plastic jugs in a dark place to reduce oxidative gum formation. 4. Clean injectors frequently, especially needle tips. 5. With a double fuel tank set-up start and warm up the car on diesel and switch back to diesel before shut down.

The double tank system uses a five gallon jug, which rides in the back of the car, and metal fuel lines run under the car along the exhaust pipe to keep the fuel warm in winter and allow switching between diesel and vegetable. To refill, I simply exchange the empty jug for a full one. The valves that join the vegetable fuel lines to the rest of the fuel system are operated by choke cables from the passenger compartment. Thanks! Power to the People! PS. I'm planning to drive cross country this winter making pit stops at restaurants along the way. Lee Connah, PO Box 104, Hood, VA 22723

Perfect

(Home Power is great bathroom reading.) I've got the perfect (and I mean PERFECT place) to incorporate an expandable RE system — perfect solar, hydro, and bit of wind located on the Bear River. I'm planning a system soon. I really am waiting for some type of utility or government help — (PG&E), tax credits or interest free loans etc. I really like the sections on RE law and governmental positions, Also, I'm an 8th grade teacher. You should see some if the solar ovens we constructed — a few are really efficient and useful. Keep up the good work and here's my $15 for another year. David Morehouse, Auburn, CA

Helpful

HP is my bible. I was spending many tedious hours in the library catacombs before HP. It has afforded invaluable assistance in building my passive solar, PV powered home and helped me towards an independent lifestyle. Thanks! Mac Shaw, Snowflake, AZ

Aw shucks, Mac. Thanks for the flowers. If we've helped out, then we're happy. Richard

Disappointing

It is disappointing to see off-grid living becoming entangled in our corrupt/governmental structure. I guess the fight for freedom never ends does it? Sometimes I'm tempted to ignore these "mainstream" issues, but I know to do so is at my peril. Thank you for your vigilance, especially Bob-O and Richard. Sign me up for another year. PS: Where can I find a book on repairing 12V/120v/propane fridges? Mark Whitaker, Portland, OR

Check out Jeff's Appliances (display ad this issue, see pg 96 Ad Index). Jeff is an expert on all this gas stuff.

As far as independence and corrupt structures go, ya pay ya money and takes ya choice. We choose what we do. I want us cleanly, freely, and quietly empowered. I'd talk PV to the Devil if he'd listen… Richard

Forward

I appreciate your realistic approach to energy solutions and common sense answers to problems. We as a country need to go forward to new answers, not backwards to ones we can no longer live with (or without). Dean & Gwen Kintner, Evergreen, CO

Links

I love Home Power! It is my link with other alternative energy users/makers. From new recipes for my sun oven to the latest in electric vehicles — you print it all. Keep it up. How & Kate Kuff, Pettigrew, AR

Good & Bad

What I like is the vast amounts of information in each issue. What I don't like is my inability to put the magazine down! I'd like to see more information on very low cost, small projects. Things like using RE to power just a lamp or TV/VCR etc. Don Alesch Jr, Menasha, WI

A Cadillac

Solar Chef ovens are great & are well worth the cost! The Cadillac of solar ovens. * Don't forget the small system folks. The super-slick-double-throw down stuff is fine, But the small all 12 Volt system still has its place. Thanx fore a great mag! Gene Milligan, San Macros, TX

Check out the lighting systems in Nepal page 6 this issue. Much can be accomplished with just a few modules and a battery. Richard Perez

Family Freedom
Freeing my family from the grid has been a hope of mine for years. Until I found your magazine I did not know how or even think it was possible. Now I see that the options are endless.

On the drawing board are plans for a hydroponic system and earth-sheltered home. With your expertise I hope to achieve a self-sufficient home and business.

I would like to see how brands compare in quality. How do I know I get what I pay for? Cindy Warren, Cleveland, TX

Survey Comments
These comments came in on surveys that arrived after our initial survey results were published. Check out HP#42, page 16 for the survey form, and HP#43, page 16 for the initial survey results. Many more surveys have been returned since HP#43. HP#46 will have a survey update. Karen

A generation scenario based on on-site, user-owned PV systems is preferable to one based on utility ownership from the standpoint of small-business opportunity only. The latter is preferable from the standpoint of PV penetration, PV vendors, reliability and cost. The reason is the number of American land-owners willing to be PV generators is X, while the number willing to be PV consumers is 100X. Why forfeit 99X growth in the name of small business opportunity? Is the goal multiple GW (sic: giga watts) of PV or is it $ and hubris? Newton, PA

I love being disconnected from the grid. When I started out with RE, I thought it would be for a few years (5–7) until I built my house. Now, there is NO way I would allow SCE (Southern California Edison) to enter my property for any reason! I will install a whole house system and live off-the-grid for the rest of my life. In SCEs district, CA

I would like to see utilities use RE in large scale production to wean us away from the nasty sources of power. If people want to sell it back (and put up with their BS), then the utilities should HAVE to purchase the energy at a FAIR price. I don't know why anyone would allow a utility to install, service and charge for a system, but if the choice is nukes or RE I say let people bend over for the utilities. Thanks for a great magazine, it has really helped me. Three Rivers, CA

REliable?
It would cost about $25,000–30,000 to bring the grid in. Who are they kidding? Our power is safe, reliable, and beats what the grid has to offer hands-down. Grid power at my wife's office goes out on a regular basis — during winter storms as much as thirty times a day. They call that reliable. Silver Springs, NV

We support IPP! We don't trust the utilities although we support wise and fair use of the grid system. We are still building our system, hope to be complete by next summer. Wrangell, AK

Power Box
I am currently building a 28' x 32' shop and have used a "Power Box" that I built with the knowledge gained from Solar Energy International here in Carbondale, CO, help from Bob-O Schultze of Electron Connection and last minute question answering from Scott Ely of Sunsense. As always though, past articles on similar power plants in Home Power were my inspiration and guiding light, available at any hour of the day or night! I hope to write my own article for Home Power on the success of this power box. It sure impressed the construction pros on the site and several neighbors who did not have to listen to a generator. Sorry the survey is late, but construction sure does take up a lot of time! Carbondale, CO

Q&A

Simple Powerbook Solarizing
Appreciated your recent article about "Solarizing" the Powerbook, but it was overkill for me. Can I directly attach a solar panel (portable) to an external powerbook battery such as the VST Thinpack? (specs: 30 watt-hours @ 6 VDC). Or what HP article (I've got 'em all) would help me build a regulator for a 5 or 10 watt Solarex portable, eg.) Thanks! Dale Stancel, Winston-Salem, NC

Hello Dale. See HP19, page 18 for an article about using small PV modules to recharge small batteries. If the module is properly sized (in terms of current delivered to the battery), then a regulator is not necessary. PVs are constant current devices within their voltage operating window. It is unlikely that even a 10 Watt, 12 Volt module will overcharge your battery in a day.

We recently bought a charger/discharger for our aging PowerBook 160 battery. I was surprised to find that the charger/discharger was supplied by a wall cube power supply that converted 120 vac into 12 VDC at 1.5 Amperes. This charger can be powered directly with a small 12 Volt PV module. All that is necessary is to develop about 1.5 Amperes of current from the PV module. Quick charge takes two hours and then the battery floats in serene fullness. We got this Absolute brand charger/discharger from APS (800-947-8599, their part number 42112 for $64.95). This charger/discharger has been successful in rejuvenating our old battery. We bought the model (cat #42150 for $99.95) that included a spare PowerBook battery. This charger could be fully powered by two Solarex MSX-10 Lite PV modules. Richard Perez

Remote Telephones
We spend around $100 a month in order to have a cellular phone. The telephone company estimated $25,000 to put in a regular phone. Is there help on the way? Kurt Heyl, Cerrillos, NM

You bet! You can own your own radiotelephone (R/T) system. At Home Power we've been using an R/T for the last five years. The cost of the system is a one time expense of between $4,000 and $6,000.

Find a location near you with regular hardline telephone service. The distance between your location and this hardline connected location can be up to 50 miles, but under 10 miles is most common for these systems. Our particular radio path is six miles long with a large mountain — smack in the way. It helps greatly if the radio path is line of sight. At the hardline end, the telephone company's line plugs into a full duplex (talk and listen at the same time) radio transmitter/receiver. This radio broadcasts the telephone signal up to your remote location.

As far as the telephone companies are concerned, you are just another hardline phone and are billed at regular rates. No charges for incoming calls. No "by the minute" air time charges which are the bulk of cellular telephone expense. Our monthly phone bill would be over $3000 if we used cellular telephone here at Home Power.

Both ends of the R/T are easily powered with small PV arrays and a battery. For example, our hardline end is supplied by two Siemens PC4JF PV modules and a 12 Volt, 160 Ampere-hour Ni-Cd battery. The remote end of our system (located here at HP Central on Agate Flat) is supplied by two Solarex MSX-60 modules and a 100 Ampere-hour Ni-Cd battery. Both ends of our R/T system are stand-alone PV and use no other power source.

The particular brand of R/T we are using is called an Optaphone and is made by Carlson Communications, 655 Redwood Drive, Garberville, CA 95440 • 800-283-6006 • 707-923-2345. I figure we have about $5,000 invested in our R/T system, including radios, PV modules, batteries, wire, trenches, telephones, etc… Our system is the high-powered model because of the mountain smack in the middle of our radio path. Most R/T systems are lower in power (only three watts or so) and require a smaller PV array and battery. Typical systems cost less than $4,500.

Our Optaphone runs an entire office of telephone stuff. We use a Hewlett-Packard FAX 310 fax machine, three Panasonic telephones, one Panasonic cordless telephone, a Radio Shack voice answering machine, and two Hayes Optima 288 computer modems. All of this high-tech phone junk is plugged into a solar-powered Optaphone located six miles from the end of the phone company's hardline. Everything works like downtown except that the modems are very slow (2400 baud).

Designing an R/T system is a job for someone who knows radio work. Call Carlson for an Optaphone dealer in your neighborhood. If you can't find or afford a dealer, then get a local Amateur Radio Operator to give you a hand. Really, the R/T's installation is not much different than installing a CB radio. All R/T systems are licensed by the FCC, and an R/T dealer can be of great help here. It is essential to locate and license a free pair of frequencies for the R/T.

When you move to the country you don't get three things — power, phone, and a good road. We've solved the first two problems. If anyone has a solution to the bad road, please let me know. Richard Perez

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17. I certify that the statements made by me above are correct and complete. Karen L. Perez, Publisher and Managing Editor 9/28/94.

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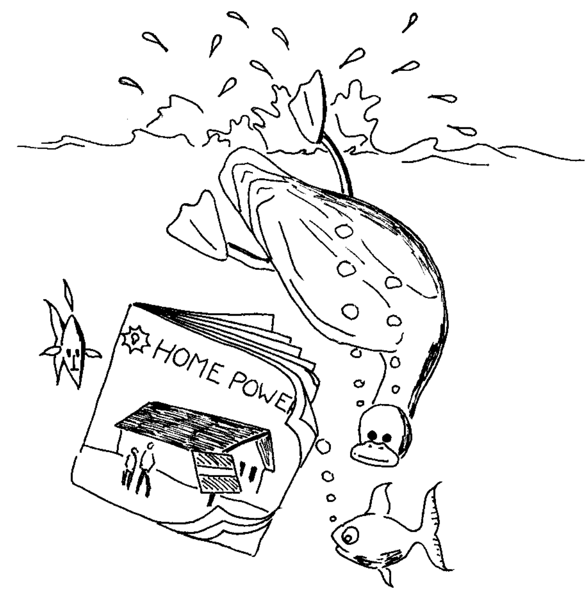

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Writing for *Home Power Magazine*

Home Power is a user's technical journal. We specialize in hands-on, practical information about small scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in *Home Power*.

Informational Content
Please include all the details! Be specific! We are less interested in general information, than in specific information. Write from your direct experience — *Home Power* is hands-on! We like our articles to be detailed enough so that a reader can actually apply the information. Please include full access data for the makers of equipment mentioned in your article. *Home Power* readers are doers. They want access data for the devices and products you mention in your article.

Article Style and Length
Home Power articles can be between 350 and 6,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short (less than fifteen words) and to the point. We like the generous use of Sub-Headings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power* . After you've studied a few, you will get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

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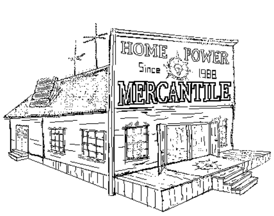

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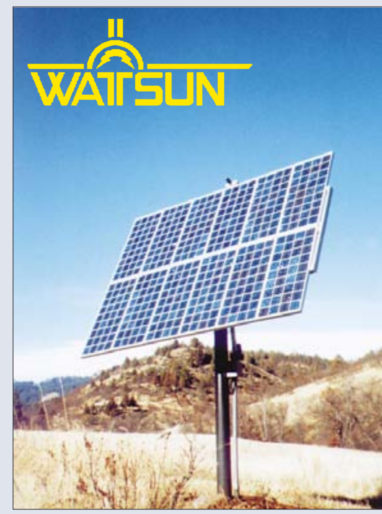

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