HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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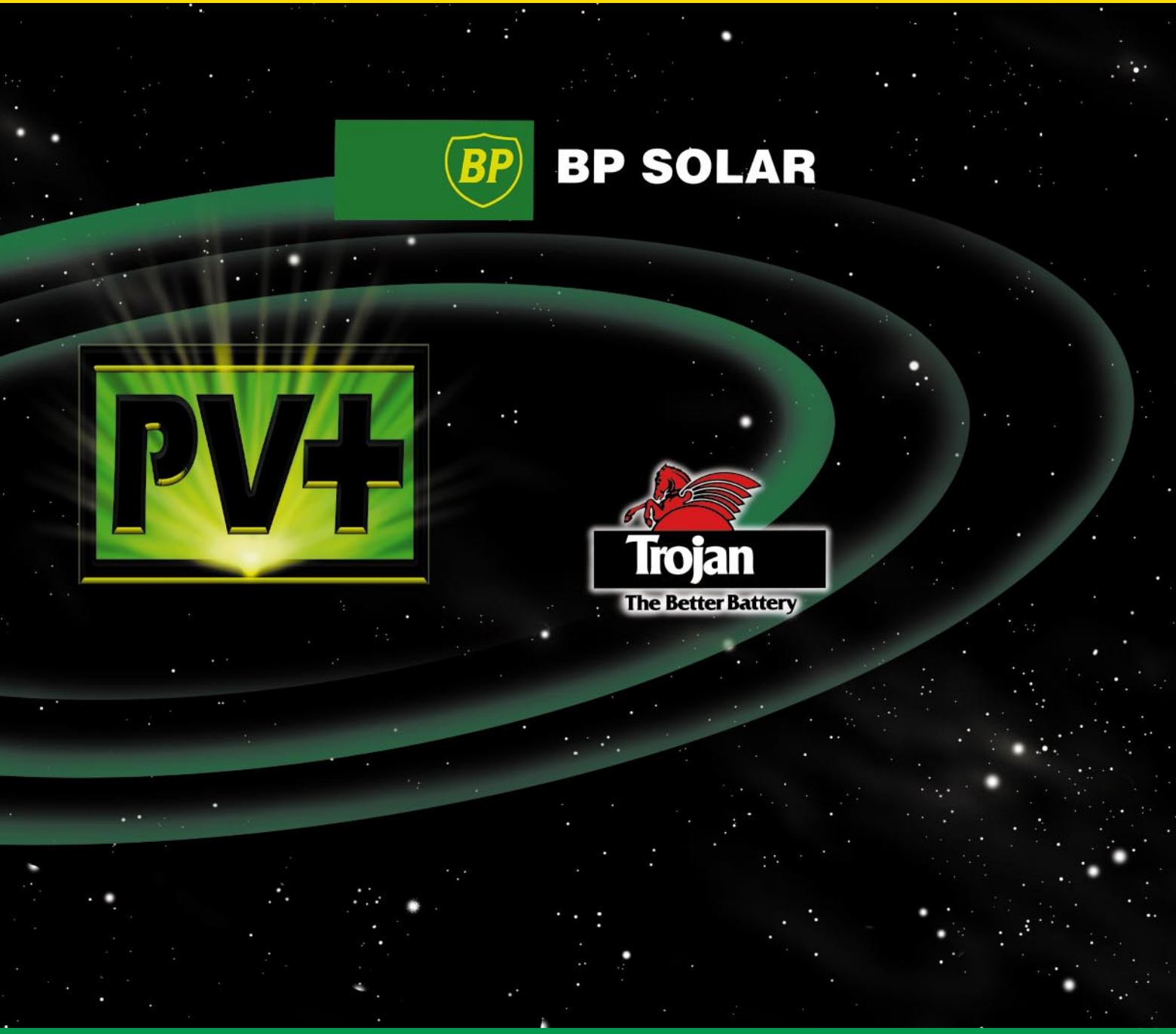

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #67 October / November 1998

Features

GoPower

Features

Cover: Ezekiel, Zoë, and Dawn Nesbitt prove that solar power is fun in Belize (page 8).

Things that Work!

Columns

Regulars

Access and Info

Access Data

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Recycled Paper

Recyclable Paper

For over one hundred years, America's utilities have made electricity and sold it to us. They make this electricity by burning coal and natural gas, by nuclear reaction, and by damming rivers. They want to continue to do this even though these energy production methods make air pollution, greenhouse gases, and radioactive waste. Utilities like the idea of centralized power. Only they can make it, and we can only buy it.

We have a better idea—let's use solar energy, wind energy, and stream power. Renewable energy resources are nonpolluting and sustainable. Renewable energy is inherently decentralized and freely distributed to everyone daily. And that's the problem….

Utilities are opposing small-scale RE on-grid in every way they can. They demand expensive "gold-plated" disconnects, and million dollar insurance policies. They want to either pay us nothing for our RE, or pay us a tiny fraction of what they charge us for their dirty power. Utilities want to hold on to their monopolies and their profits.

Guerrilla solar is our response. If America's utilities will not change their polluting, greedy ways, then they will have to contend with the solar guerrilla. See page 34 of this issue for the story of just one solar guerrilla. We are everywhere….

The sun is more powerful than any utility.

Richard Perez speaking for Solar Guerrillas everywhere

People

Joy Anderson
Mike Brown
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Anita Jarmann
Kathleen Jarschke-Schultze
Stan Krute
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Don Loweburg
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"Think about it…"

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– Leroy Eldridge Cleaver (c. 1968)

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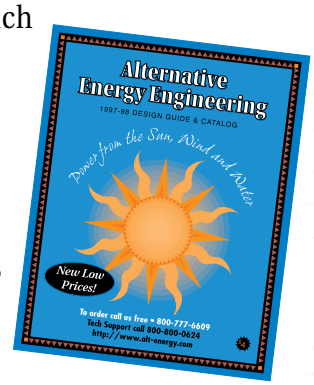

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Our Solar Farm in Belize

Christopher Nesbitt

Above: Ezekiel, Zoë, and Dawn Nesbitt.

Living in the bush more than a mile from the nearest road and electricity lines doesn't mean going without the basic amenities of modern life, such as running water and lights. A few years ago, I thought differently.

Belize is a beautiful country, filled with genuinely great people and an easy going melange of culture. It's a very nice place to live—I liked it from the first day I left Mexico and crossed into Corozal. I came here to escape the cold weather, and stayed because of the warm people.

I liked the pace of life here. When I reached the southern district of Toledo, I decided to make this peaceful nation my home.

Our Family and Life

These days, I work for Green & Blacks, a small organic chocolate company in England that makes a scrumptious chocolate bar called Maya Gold with Belizean cacao. I am their liaison with the organic cacao growers co-operative in Belize.

I live on a 70 acre parcel of land in the foothills of the Maya Mountains with my wife, Dawn, and our two children, Ezekiel and Zoë. I lived in this country for a few years, and looked at ten or twelve very nice pieces of land. In 1988, when I was 22, I bought my farm . I got it from a hard working old farmer who wanted to move to town to be surrounded by lights, excitement, and people.

Our farm is in a beautiful valley about two miles upriver from the predominantly Kekchi Mayan village of San Pedro Columbia, which has the nearest roads and electrical lines. We grow an assortment of organic fruits and vegetables, and we raise chickens for eggs. Until a few years ago, we had to use smelly, polluting, dangerous, non-renewable kerosene for our lighting. We also hauled our water by hand in buckets from the river. I lived without many concessions to the modern age for a few years, feeling virtuous about my low consumption of resources. However, part of me missed the simpler aspects of civilization, like fans, radio, electric lights, and water. I started looking into solar.

Solar Desire

In 1989, there were only two solar electric systems nearby. One of these was the Dem Dat's Doing Living Resource Center, a homestead/guest house built by some retired Americans. In addition to their solar panels, they also had a biogas digester. The second system was owned by some Mennonite missionaries who lived in San Pedro Columbia before the village had electricity. They have since moved on.

I saw both of these systems, and was duly impressed and more than slightly envious. However, the price for a comparable system was just too high for me. I didn't have sufficient funds to divert towards solar, so I did without. I hoped that someday I might also have solar electricity.

Reality

In the meantime, I continued burning kerosene and hauling water. The kerosene lamps gave a warm glow, but put out a feeble light. It wasn't very good for reading at night, and if the wick was not exactly correct, it gave an unpleasant smell. Using kerosene involved transporting it long distances. I burned it anyway, or sometimes used candles instead.

In retrospect, it sounds sort of grim, but it wasn't. I had only the vaguest idea of what I was missing. I enjoyed living primitively in the bush. My house was made in the local style, a simple thatch roof tied together with vine, resting on sapodilla posts. I sold my fruit at the market, and watched the cycles of the moon wax and wane.

Over the years, two things happened that changed the prospect of getting solar in my favor: my income level went up, and the price of solar went down. By 1994, I was married to Dawn, the love of my life and my best friend. We had a son, and we were all in Eugene, Oregon during an annual seasonal migration to greener economic pastures. We were selling jewelry, assorted doo-dads, and Guatemalan clothes on a summer tour with the Grateful Dead.

Solar RV

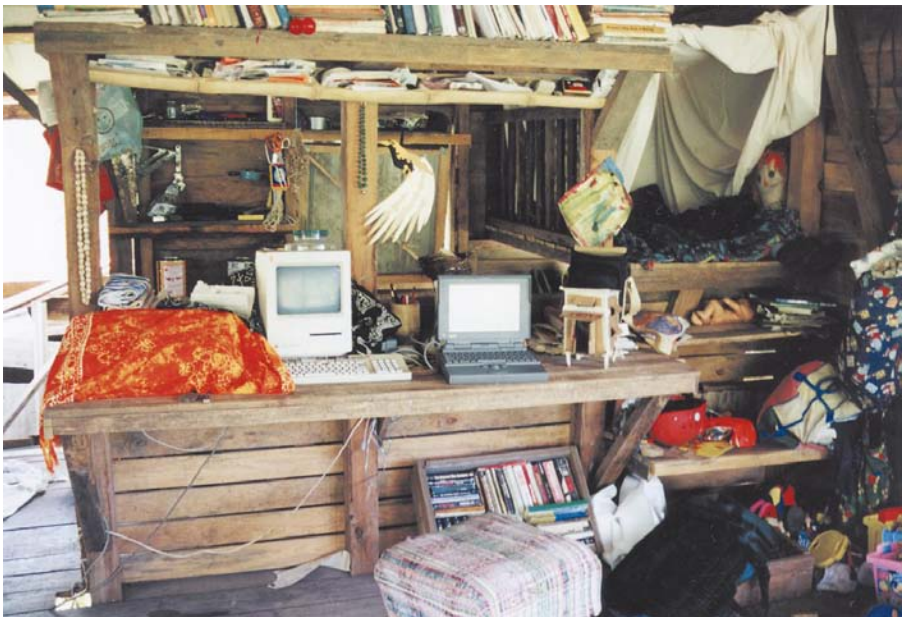
Dawn and I had talked many times about getting a solar electric system for the farm, but didn't know where to buy one. At one point, we saw some solar panels in the window of a store. This store actually turned out to be a promotional office for the local utility. According to the woman there, the utility had decided that it was cheaper to reduce demand for grid power than to build more dams. They weren't selling any panels, but gave us directions to a dealer's house instead. We drove over there, and some nice people mounted a 53 Watt Siemens panel on our motorhome. It all happened so quickly that I am ashamed to admit that I have forgotten their names.

The panel fit nicely in the DC electrical system. It charged the batteries and ran the lights and fans when we were parked for a few days. We hardly ran the generator and our batteries were kept charged. We could already see the benefits. We started thinking about the system we could build when we returned to Belize at the end of the season, using our new panel.

Solar Home System

We decided that we could build a small system for our home in Belize that would give us some conveniences. It would be a great introduction to PV and would cost

Below: Dawn outside the main house. The ground floor is open to admit cooling breezes.



Above: Area for work and play, showing the two computers on the system.

about $500 US, including the panel and charge controller that we had already bought for a little over $300. We designed the balance of the system around that premise. We ended up with a system that was easy on our budget and was a vast improvement on the past.

When the season ended, we returned to Belize with our panel, a Steca 4 Amp charge controller, a 12 V department store variety “deep cycle” battery, some Thin-lite 12 V fluorescent lights, and a fan. This was the beginning of our experience with solar electricity on the farm.

The Installation

We mounted the panel in the yard on top of bamboo poles, since it would have been difficult atop the thatch roof. We wired the house with two lights, one inside and one for our porch where the hammocks were. We used automotive inline fuses for every wire coming off of the positive battery terminal. It was very basic—sort of a training-wheels application. We learned a lot and it made us ready to try something a bit bigger.

That first night was great! After years of kerosene lamps and candles, it was disorienting to have bright electric light in our little thatch house. We sat there talking about all sorts of things late into the night, luxuriating in the light. We were filled with pride about finally stepping into the twentieth century on the cusp of the twenty-first. The house glowed, and the light passed out into the yard giving it a green halo. It was beautiful.

That year brought a lot of changes into our lives. We read more, stayed up later, had late night marathon two-party backgammon championships, and mounted a fan by the bed for those hot sticky nights in the peak of the dry season. We were very happy with the money we had invested in solar. We were also building a larger house to accommodate our expanding family. When it was finished, we wanted to outfit that with solar, as well.

New Information

On our way home, after we purchased that first system, we found a copy of *Home Power* for sale in Austin, Texas. Reading that issue opened our eyes to the large selection of products and dealers that are out there. Living here kept us out of touch with advances in RE. We had been under the impression that there was only one dealer out there, a large company that was quite expensive.

We contacted a few dealers in that issue of *Home Power* and they sent us catalogs. From this, we were exposed to the large variety of equipment that was on the market, as well as the substantial price variations from one dealer to another. This enabled us to figure out what we wanted for our new house.

The Next Incarnation

In 1995, we again went north for the summer to seek income. We were armed with a good idea of what we wanted for our system and where we could find the components. When the season was over, we returned with four more panels: a 48 and a 53 Watt Siemens, and two 90 Watt Solecs. We also purchased an SCI Mark III charge controller, two Trojan T-105 batteries, a Statpower 800 watt inverter, and a Flojet 2100 pump with linear current booster. We bought more lights and more fans.

The old house became our guest house. We took off the original 53 Watt panel and installed the new one rated at 48 Watts. Unfortunately, that panel put out 15.6 V, low for the hot tropical weather we have here. However, the house was seldom used since we don’t get as many visitors as we’d like. Even with the drop in voltage, the 48 Watt panel was adequate to keep the battery charged. Eventually, that system was dismantled. The panel is now in use with a second irrigation pump with low lift. The lights and fans have been put to work elsewhere.

Our new house has a zinc roof for water catchment. It also worked great for mounting the two 53 Watt Siemens panels. We lacked an appropriate mount for

the 90 Watt Solec panel, so we set it on a lawn chair in the yard.

All of these panels are wired for 12 Volts. This enabled us to fit the house with common 12 VDC lights, mostly fluorescent 30 Watt Thin-lites. We decided that using DC was better than risking our main source of lights to down time with a broken inverter. One of our neighbors has suffered through a broken inverter twice! Because the ballasts interfere with AM radio reception, we use an incandescent automotive taillight when we want to listen to our shortwave radio.

We bought the inverter for power tools like the drill, and for essentials like our blender and coffee grinder. The blender is so much better than the expensive DC toy variety that we have seen, and a very important device if you live where papayas, avocados, bananas and mangos are abundant and can be reduced to smoothies!

Antique Apples and Inverters

Now that we have an inverter, we have acquired a few older Macintosh computers from friends and family who have upgraded. One of those is this well loved antique Classic that I'm writing on right now. It runs fine with the modified sine wave power. In addition to the Classic, I have a Mac PowerBook 170 that I run using a 12 V adapter made just for this series of laptops. This PowerBook is equipped with a NiCd battery, and I've read that modified sine wave inverters might damage the internal charger. I don't know if this is so, but I don't take any chances. Instead of inverting 12 VDC to 110 vac and then stepping it down to 7.5 VDC, I convert 12 VDC to 7.5 VDC directly.

Having computers on the farm is crucial. Sometimes I climb into bed beneath the mosquito netting and work or write on my laptop. It enables me to do paperwork at home with my family instead of being stuck in town at the office. Having multiple computers enables the two of us to write our friends simultaneously. Last but not least, my handwriting is truly rotten. Some of my closest friends insist that they can't read a word of what I've written. My trusty old Macs enable me to communicate with those who are unable to decipher my cryptic scratches.

New Inverter

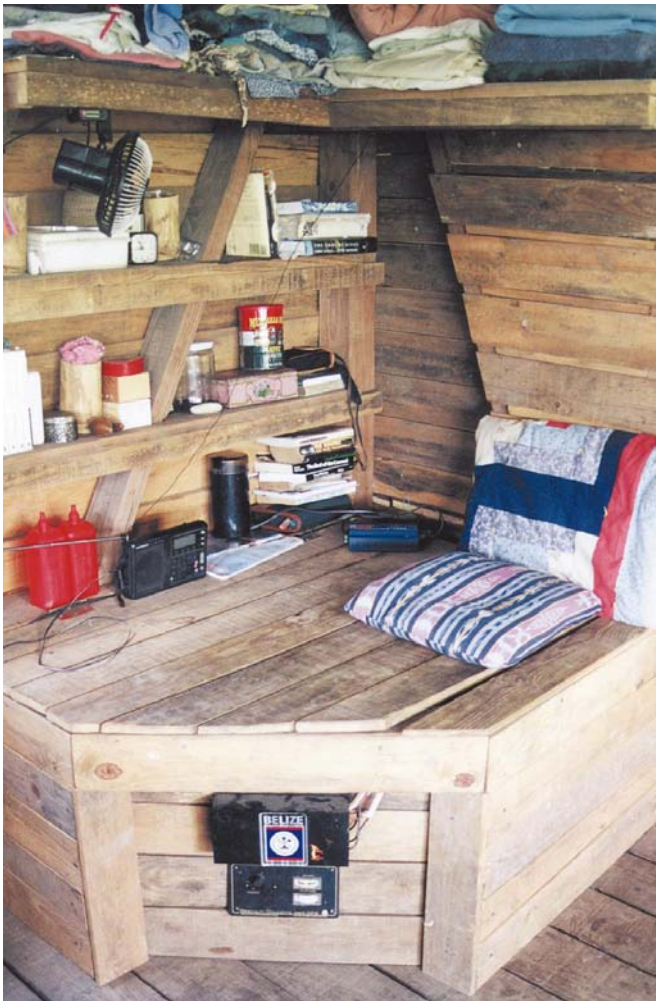
Recently, we had a little down time on our Statpower 800 watt inverter. We decided to buy a smaller replacement—a Statpower 300 watt Portawatt. The loads on the 800 watt inverter are high surging appliances like the drill and the blender. We use the new inverter for Dawn's computer, the ImageWriter II farm printer, and the smaller ac loads, such as the coffee grinder and sewing machine.

Batteries

The battery enclosure holds two Trojan T-105s and doubles as a late night reading platform and bench. Dawn won't let me mount even a small, non-invasive 5 Watt co-pilot reading light in the bed, claiming that the bed is for sleeping, not reading, and I bow to her concerns. The battery box is ventilated through the wall to the outside, and the charge controller and fusing are mounted on the front. The top is hinged for easy access to check the water level. It's big enough for eight T-105 batteries, but I doubt that we will ever use more than four. If our battery bank needs to grow, we will switch to four Trojan 395 Amp-hour L-16s.

We checked for a good source of deep-cycle batteries, but didn't have much luck. We found department store automotive deep-cycle wet-cell batteries, but they have a short life expectancy. We also found automotive deep-cycle gel-cells, which have some advantages, but they were still not what we wanted. Although they are

Below: The battery box doubles as a reading platform. The SCI Mark III charge controller and the 12 Volt DC fuse box are mounted on the front.



Above: A view from inside the open–air kitchen showing the wood-burning cookstove. Outside, the temporary “lawn chair” mount supports a 90 Watt Solec PV panel.

non-gassing, spill-proof, can be positioned anywhere, and never need watering, they are very expensive, easy to damage, and have relatively short life spans.

Many catalogs sell “golf cart batteries” and we wanted to avoid paying substantial freight costs for shipping to Belize. We looked for a local source before we left the United States, and found a golf cart dealership about twenty miles north of Austin. We called and told them that we were interested in buying some batteries for a PV system on a home. They had never had anybody ask for them for that purpose. I explained that golf cart batteries were the battery of choice for a starter home system. We purchased two T-105s. They were as cheap as automotive deep-cycle batteries, and have lasted the last two and one-half years without a hitch. They appear to be doing well.

Fuses

I doubt that our system would be up to code anywhere in the States, unless we put it on wheels. Because there are no electrical codes here for low voltage systems, our only guidelines were common sense and our budget.

All of the DC load wiring in the newer house was done with #12 duplex. Since it’s only a two-story 18 by 18 foot building, we weren’t worried about line loss. For circuit protection, we installed an automotive fuse block with 12 spaces. At this time, we are only using eight of them. We chose this setup because it was inexpensive and the fuses are easy to find locally. So far, we have burnt out only one fuse. This happened while rewiring a fan. Having seen wires burn in automobiles before, I was glad we had those fuses. I’ve read repeatedly that every wire connected to the positive battery terminal must be fused, and I live by that. It is simple to do, and you may never need it. But if you do short out a wire without protection, you could have a serious electrical fire.

Charge Controller

We chose the SCI Mark III charge controller for the meters and the price. Our neighbors bought one when their older controller failed, and they spoke highly of it.

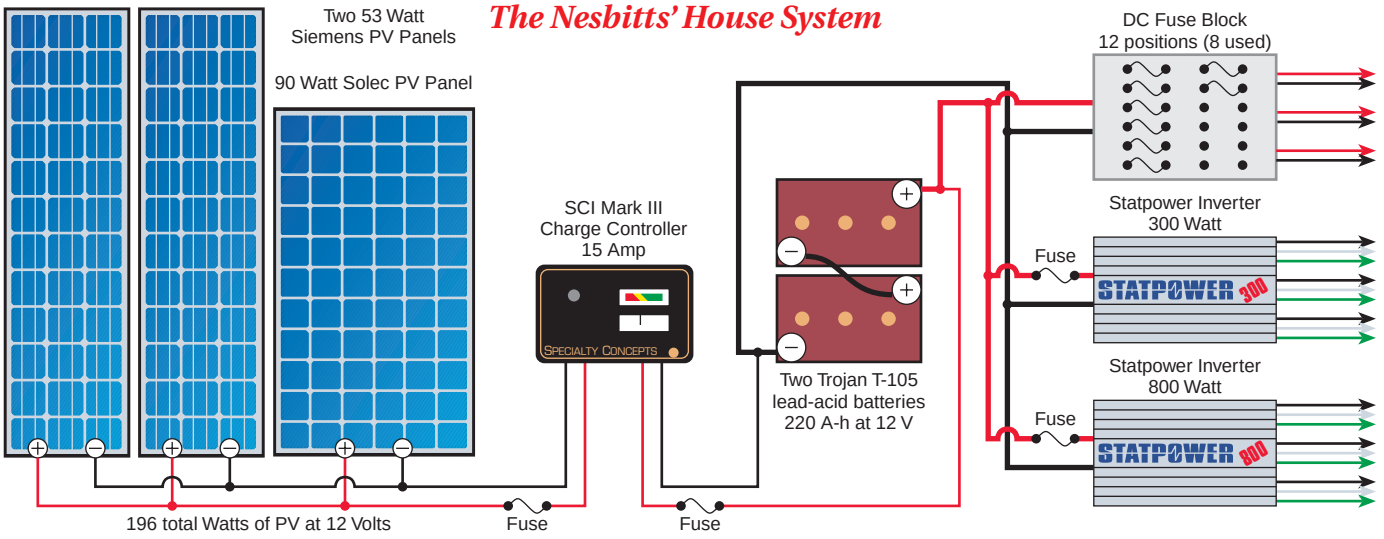
We got much of the system, including the charge controller, from Solar Electric, Inc. The meters give a good idea of what is going on with the system, showing what the state of charge is, and how much current is coming in.

In my enthusiasm and haste, I made an avoidable blunder during the installation. Zap! There was a small puff of smoke, and the sudden awareness of an irreversible tragedy. I sent the charge controller back to Specialty Concepts, Inc. explaining my mistake, and the nice people there repaired it free of charge. It was back in our hands in a few weeks.

Water System

We designed the house to catch water during the rainy season for drinking, cooking, and washing the dishes. The greywater goes to the garden. In the dry season, we pump water from the river for washing and irrigation using a 12 Volt Flojet 2100 pump powered by a 90 Watt Solec panel. The pump fills a 400 gallon tank up the hill from our house. From there, the water is gravity fed to the kitchen and the garden. This gives us plenty of pressure for the outdoor shower and for washing dishes.

We built a simple portable pumphouse out of a common Rubbermaid 10-gallon box with holes punched in the sides for the hose and cables to pass through. This enables us to move the pump if a flood threatens, while still protecting it from rain. The river can rise ten feet overnight in the rainy season, but usually we have dismantled the system by then. We only use the pump



in the dry season, disassembling it at the first flood of the rainy season.

Last year, I was down by the river hauling hose in a torrential downpour at 2:30 AM. Lightning was coming down, and the river was on the rise. With situations like these, I'm glad that the pump setup was easy to both assemble and disassemble. Backwoods Solar provided lots of extra diagrams and information. In particular, the trouble-shooting sections are invaluable. So far, we've had two years of mostly trouble-free operation. We have had to disassemble the pump a couple of times to clean it out, but twenty minutes later it's up and running!

Dry Season Gardening

We have a dry season garden on some rich alluvial soil up the river. The garden location gets flooded every rainy season, depositing more nutrients. We grow some monster vegetables there.

We bought another Flojet pump for this garden. The pump is powered by the 48 Watt Siemens panel from the old house. Irrigation enables us to have a green garden during the dry season when all of the surrounding neighbors' gardens turn brown. The garden is my favorite part of living on our farm. I keep puttering in the garden right through the dry season. I can spend two hours at a time walking from bed to bed watering the plants. I enjoy watering as a form of meditation, giving me time to think about life, the universe, and whether or not those beets are ever going to come up.

The House

The kitchen and dining area is on the first floor and is open to the breeze that blows in off the Caribbean, a short 25 miles away. The second floor has lots of windows. The view of the valley is beautiful and we take advantage of the prevailing winds. The windows close up quickly against the strong winds and heavy rains of the wet season. The house sits on the slope of a hill overlooking the river. We spend more time downstairs in the kitchen during the day, but if blowing rain threatens, we retreat to the dry upstairs.

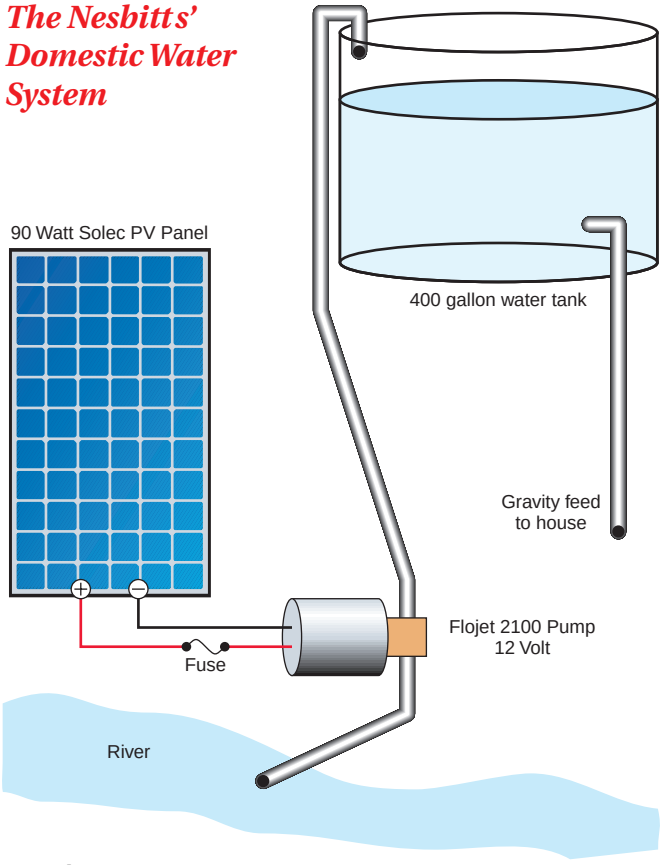
Adding Wind

Our most recent acquisition for the system is an Ampair 100 micro wind generator. I bought it from a departing yachtsman who wanted to sell off some of his possessions instead of dragging everything back to the States. I got the Ampair, an archaic Sovonics self-regulating flexible 22 Watt panel and some diving equipment for $200. I gave the solar panel to someone who needed it more than we did. I haven't set the Ampair up yet, because we haven't needed it. When I upgrade the battery bank with either four T-105s or two to four L-16s, I will add it to the system.

The Ampair wouldn't spin freely, so I sent it to Jack Rabbit Marine, the only Ampair retailer in the US. They specialize in marine RE systems. While we are confirmed landlubbers, many of the components suitable for a marine environment are also suitable for extreme humid tropics. Jack fixed it up and sent it back to me in a timely fashion. We still need to get the proper controller for it. When we do, we will talk with Jack again.

I like the idea of a hybrid wind/solar system. When we have our frequent rains, we often get wind, making the wind generator a prudent investment. When it is rainy and overcast for a few days, the wind generator will help to keep the batteries full. Lack of sun has not been a problem so far, as our loads have been limited. In the future, when the wind is blowing and the rain is falling, we will be sitting inside, working at the computers, happy in the knowledge that our batteries are being fully charged and maintained.

The Nesbitt's Domestic Water System



Local PV Systems

In the last few years, PV has become more commonplace here. In this watershed of the Columbia River valley, there are now eight solar-powered houses, ranging in size. Two small systems consisting of one panel and light are in one part of the village where the Electricity Board hasn't bothered pushing lines. On the large end of the spectrum, a big system runs a jungle lodge and butterfly breeding facility close to the Mayan ruins of Lubantuun.

Our system is somewhere in the middle in size. There are a couple of systems that are smaller, a few comparably sized, and one that is much bigger than ours. We trade information about our sources with each other. Some of us have also gotten our components from some of the same sources. For most of us in this watershed who have gone solar, the only possible way to have electricity at our homes was to generate it ourselves. In our case, it wasn't a question of time or money to bring in grid power. We are just too far for it to reach us. We all decided individually that solar was the way to go.

Dreaming Up New Systems

I think we have some nice systems. The first system on the old house was a big change from the days of the dreaded kerosene lamps. The larger system on the new house is an improvement on the first. Having the irrigation system is also a lot nicer than hauling buckets of water! It took a while to get where we are, and doing it like this has enabled us to really ponder all of our components.

When we upgrade the house system again, we'd like to get better overcurrent protection and a bigger battery bank to accommodate the larger loads we would like to have in the future. In the meantime, what we have now can serve us for a long, long time. However, we still have dreams. We would like a taper diversion regulator hooked up to an electrolyzer. This would create hydrogen gas with our excess power for burning in a modified propane stove. As my office is in town, two miles of river and twenty-three miles of bone rattling road away, we'd like telecommunications for the farm. A phone, fax, and modem would be great, but we will have to wait.

We would eventually like to have an efficient electric refrigerator and freezer, but it's not truly necessary for us at this time. There are many secondhand propane fridges around, with more becoming easily available every day as the rural electrification program continues. Some are very inexpensive, but the thought of lugging propane up the river is not appealing. The monthly expense of buying fuel is the sort of steady draining expense we are trying to avoid. The tropics provide food on a continuous basis. Fruits ripen daily, vegetables mature, but ice cubes sure would be nice.

To further improve our quality of life, a washing machine is first on our list. It is more important to us than other additional appliances, since we have two children and live on a farm. We have been dreaming of getting one since we saw a Staber that could do all of our laundry, wasn't power thirsty, and used little water.

Empowerment

Producing our own electricity has been an empowering experience for us, pun intended. We are very pleased. If we could get grid power, we wouldn't. We never get behind in paying our utility bills, because we haven't any. There are no power outages or brownouts to endure, which are problems that plague the electricity provided by the Electricity Board. There are no connection fees to pay, and no "administrative" costs. After the initial expense, we are free to do as we please.

We are our own little utility company, owned by those it serves. We like being responsible for the creation of our own energy. We enjoy turning sunlight into electricity. We aren't running a generator, so we don't create that noise or pollution. What's more, I like to watch the amp meter when the sun is out. The panels just push the electrons into the batteries!

We acquired our equipment from several different sources. As our budget was limited, with resources being directed towards other projects, we tried to find the least expensive sources for each component. There is a lot of competition in the industry and some companies are significantly cheaper than others. A potential tradeoff is that you may not get the service or assistance you'd like from a very inexpensive company. It would probably be better to build a whole system from components purchased from one source.

Give It a Try

If we were starting from scratch and knew what we've learned with this system, we wouldn't change much. We'd get a pulse width modulation charge controller, a low voltage breaker box instead of the automotive fusing, and perhaps a bigger battery bank. Even without these changes, the system is very satisfactory as it works now.

We love living here, and solar electricity makes it even nicer. I encourage anyone considering stepping off into the world of renewable energy to give it a try. It's a great feeling to supply your own power with the help of the sun. There are some great people out there in the RE business. Many catalogs are full of information. We read a few books, took our time, and did the design and installation ourselves. Practically anybody could set up a system like ours. Most of the dealers we talked with offer excellent service and advice. Having electricity is the best improvement in our quality of life since we moved to our farm. We can't figure out how we lived before we went solar!

Access

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Sources: Solar Electric, Inc., 5555 Santa Fe St. #J, San Diego, CA 92109 • 800-842-5678 • solar@cts.com
Web: www.solarelectricinc.com

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608-637-2722

Backwoods Solar, 1395 Rolling Thunder Ridge, Sandpoint, ID 83864 • 208-263-4290
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Web: www.backwoodssolar.com

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Fax: 203-358-9250
JackRabbitMarine@compuserve.com

Kansas Wind Power, 13569 214th Rd., Holton, KS 66436

AIR

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In 1995, Southwest Windpower designed a new generation battery-charging wind turbine, the Air wind module,™ "A brave new technology designed to make wind as simple and versatile as photovoltaics." The *AIR 303 wind module*™ quickly became the world's best selling wind turbine, selling 18,000 units. Now we have made it better.

AIR 403

The new ***AIR 403*** improves on the revolutionary features of the original wind module.

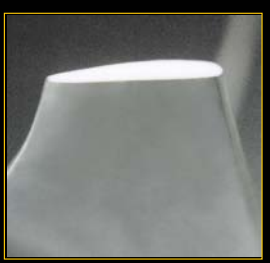
Refinement

An all new die cast zinc-aluminum alloy hub is designed for superior strength and easier assembly.

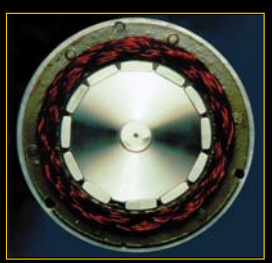
A new casting process refines the fit and finish. The new body design doubles the tip-to-tower clearance for greater reliability in high winds.

Performance

An airfoil so advanced it approaches the theoretical limits of efficiency. (Cross section of airfoil shown).



Redesigned brushless alternator using new high strength arced neodymium magnets, and new windings, increase power by 30%.



403

Air 403 Marine version shown

The stronger all carbon fiber reinforced blades and advanced airfoils achieve higher output and reduced noise. The passive-pitch speed-control system still has no moving parts.

The new alternator and more efficient windings enable the new ***403*** to deliver 400 watts at 28 mph and 20 kWh per month in a 9 mph average wind speed.

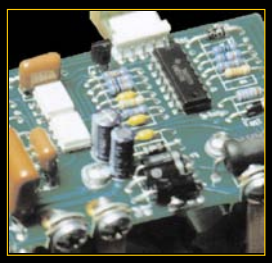
The state-of-the-art internal circuitry still incorporates safety features only possible with internal control and is now so intelligent it automatically slows the blades to a silent spin once the batteries are charged, then automatically restarts when the batteries need power.

Southwest Windpower's new tooling provides the highest quality turbine at the unprecedented price of $1.48 per Watt. The 13 lbs. ***AIR 403*** is modular to grow with your power needs, simple to install and requires no maintenance.

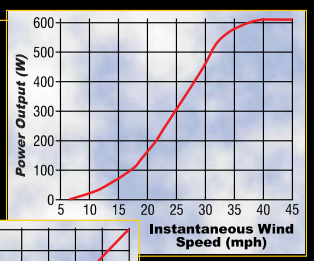
It is easier than ever to own the most advanced and affordable small wind turbine.

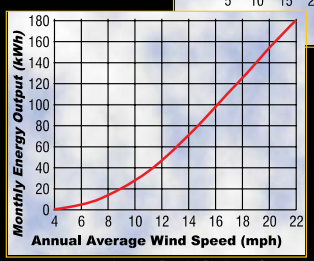
Control

The new internal regulator delivers peak power of over 750 Watts. To handle this, the new alloy body efficiently flows excess heat into the wind.



Power





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WET Lab Goes Solar

David Parker,
Bob Curtis,
& Bob-O Schultze

Above: Bob Curtis, WET Project Director, with solarized Mobile Lab.

Recently, in the news, Springfield, Oregon has been synonymous with school tragedy. It's time to tell a different story about Springfield that should have made the national headlines.

The WET Project (Watershed, Ecosystems, and Teamwork) is an educational partnership between Springfield Public Schools and the Eugene Water and Electric Board (EWEB). The goal is to promote environmental education and stewardship throughout Oregon's McKenzie Watershed in the southern end of the Willamette Valley.

The project provides Springfield teachers and students with curriculum support, teaching supplies, in-service opportunities, equipment, and a mobile laboratory. Teachers and students use the Mobile Lab for technological study and analysis of watershed, ecosystem, and energy topics.

The WET Project Mobile Laboratory visits schools throughout the year. Tours and lessons highlight the use of appropriate technology for scientific investigation. Visits include studies of ecosystems, birds, and the properties of water and electricity. Field trips are taken to local fish hatcheries, dams, diverse ecosystems, and watersheds.

An overnight outdoor school also uses the Mobile Lab to investigate aquatic insects, river topography, water quality, and aquifers. At the high school level, biology students study water quality along tributaries of the McKenzie River. These students report their findings to the Oregon Department of Fish and Wildlife.

Below: Some of the computers and A/V equipment powered by the new photovoltaic system.

The Lab

The Mobile Lab is a 33 foot Silverado fifth wheel trailer. It is fully equipped with four Macintosh 5400 computers, eight microscopes, an inkjet printer, propane heat, air conditioning, a slide out section, a wheelchair ramp, fluorescent lights, roof fans, a water pump, electric jack motors, a TV, VCR, and camera.

The system is powered by an Onan 6.5 kW propane generator. From there, power goes to a Sola Micro power conditioner for the ac loads, and to a MagneTek converter/battery charger for the DC loads. The Mobile Lab is wired for dual voltage, and carries two 100 Amp-hour (A-h) deep cycle coach batteries.

Out to Bid

In February of 1998, WET lab project coordinator Bob Curtis issued a request for quotation to upgrade the current system. Bob wanted a PV/inverter/battery system so that the lab could be operated for two to three hours without the generator vibration and noise. It would thus become a real demonstration of renewable energy technology. After all, in the course of a typical year, several thousand students and the public visit the lab.

Bob wanted to be able to plug into 120 vac shore power to maintain battery charge during inclement weather, rather than use the noisy generator. He also specified that a single 75 Watt removable module would be connected to the coach batteries. A voltmeter and ammeter would be visible outside, so that students could understand the importance of orientation and location to solar performance. The removable PV has 30 feet of cable and a quick disconnect plug. It can be used as a demonstration, either next to the trailer or in an indoor location.

Above: Joe Schwartz, of Electron Connection, installs the four Siemens SP-75s on tilt-up mountings.

The Energy Service Company (ESCO) was contacted to provide a bid. They decided to work jointly on this project with Bob-O Schultze of Electron Connection. Bob-O's experience with sophisticated wiring proved invaluable to the success of the venture.

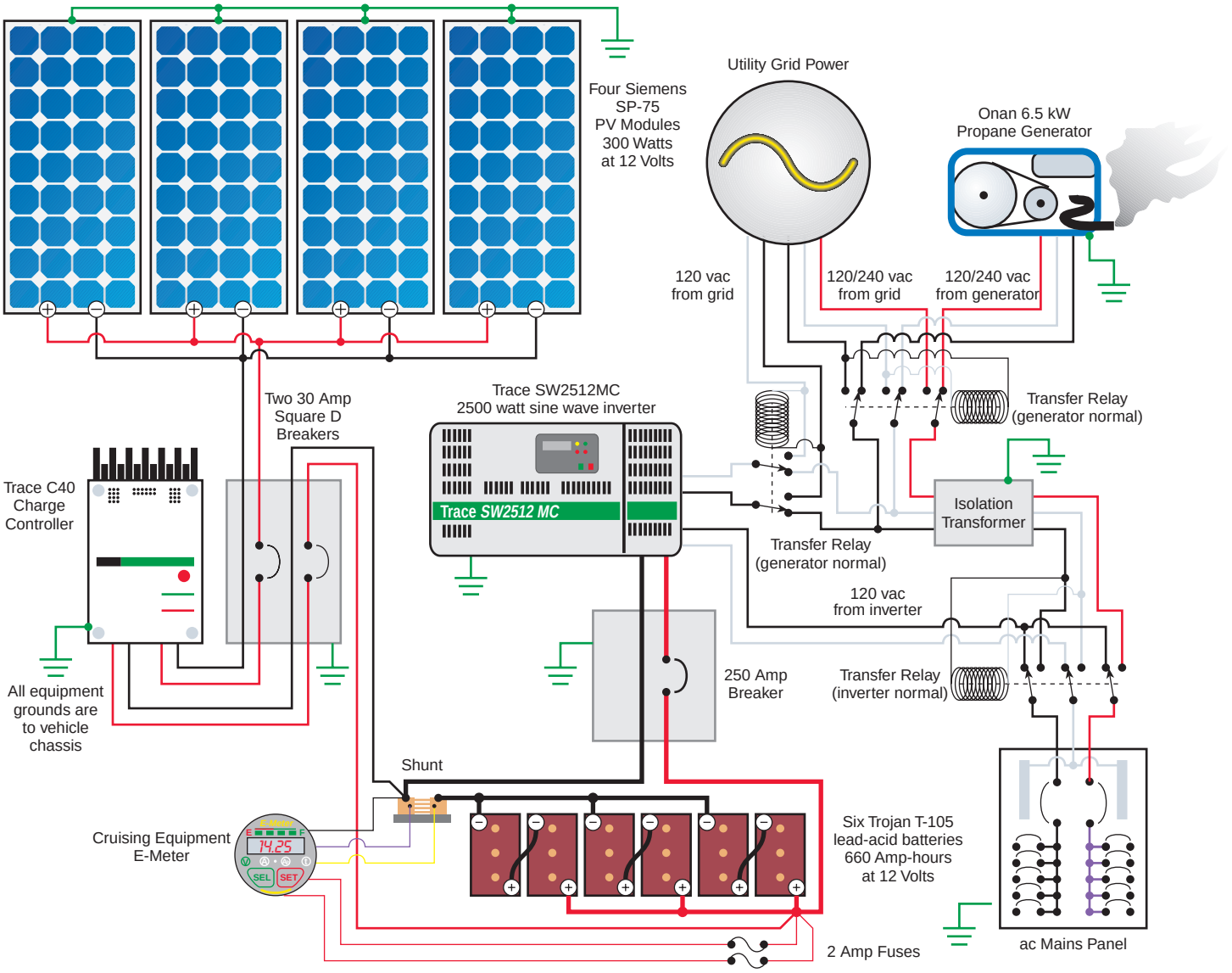
Below: Allen Hall, of The Energy Service Company, prepares the custom aluminum rack for installation of the batteries.

ESCO and Electron Connection made some upgrade suggestions to the original proposal. They suggested adding a Trace conduit box, a transfer switch, an extra module, and Hydrocaps for the batteries. They recommended using Siemens modules in place of those specified, and adjustable PV racks instead of fixed. They also advised changing the coach batteries from marine deep cycle to no-maintenance gel cell deep cycle. These upgrades were accepted. On March 15th, ESCO was awarded the bid.

The WET Lab System

A load analysis of the trailer showed that with all of the ac appliances

WET Lab's Main System



running, it would draw about 1200 to 1400 watts. A daily load would be in the range of 2400 to 3600 watt hours. The budget limited the purchase to only four 75 Watt modules, so the solar contribution would be up to 50% of the load, on average. Additional modules could be added later.

We sized the battery bank to provide 3 hours of autonomy at a 50% depth of discharge. Six Trojan T-105, 220 A-h batteries provide 660 Ah at 12 VDC. The batteries were installed in a Trace Power Module. It makes a fine battery box, with its internal tray and weatherproof locking door. To support over 400 pounds of batteries and their container, a welded platform was built under the tongue of the trailer. Aluminum 2 by 4 inch rails were welded and bolted to the trailer cross-members.

Above: The Trace battery box in place.

We chose a Trace SW2512MC pure sine wave inverter, due to the sensitive loads, mobile grounding feature, and the ability to power up to four more computers in the future. To complete the installation, we specified a Trace C40 charge control, E-Meter with shunt, Trace 250 Amp disconnect, and all of the appropriate fuses, connectors, switches, weather tight boxes, etc. We also used three automatic transfer switches, to choose between inverter, generator, and two options for shore power connection.

Below: Trace SW 2512 inverter, C40 charge controller and breakers inside the trailer.

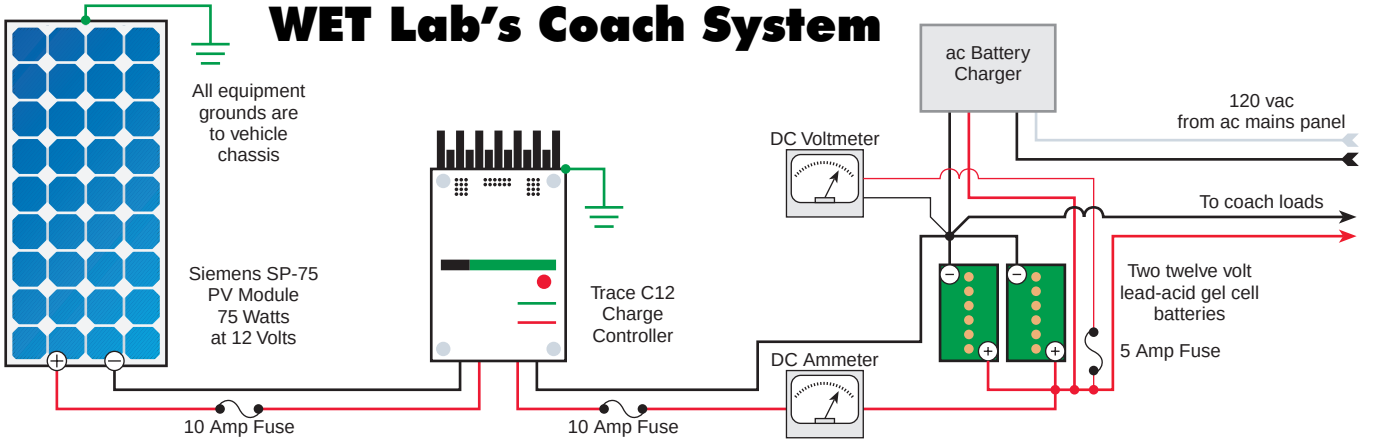
Above: The ac and DC fuse center. The Onan generator and Sola Micro isolation transformer are behind the grill.

Quick Install

Bob Curtis needed to have the system installed by April 8th. Much coordinated effort took place in a short period of time to bring together all of the materials required, including welding the custom battery support rack onto the trailer. Noon on April 6th was the time for the installation work to begin, and for the preparation to pay off.

By 5:15 PM the next day, the entire system was installed. With a flick of a breaker, it hummed to life. We

WET Lab's Coach System



WET Lab System Costs

117 vac System

#	Description	Cost	%
1	Trace SW2512MC Inverter	$2,627	23.8%
4	Siemens SP 75 watt PV Modules	$1,800	16.3%
1	Trace Power Module w/external kit	$715	6.5%
6	Trojan T-105 6 Volt Batteries	$474	4.3%
1	Welded Power Module Support Rack	$450	4.1%
1	Trace DC 250 Amp Disconnect	$285	2.6%
2	30 Amp Transfer Switches	$250	2.3%
1	E-Meter w/shunt	$190	1.7%
1	Trace C40 PV Controller	$185	1.7%
2	2 PV Adjustable Mounting Racks	$168	1.5%
18	Hydrocaps	$162	1.5%
2	4/0 Battery/Inverter Cables	$90	0.8%
1	Trace Conduit Box	$85	0.8%
7	2/0 Battery Cables	$63	0.6%
1	Square D PV/Controller Disconnect	$42	0.4%
	WET Lab 117 vac System Subtotal	$7,586	68.7%

12 VDC System

#	Description	Cost	%
1	Siemens SP 75 Watt PV Module	$450	4.1%
2	Gel Cell 100 A-h 12 Volt Batteries	$350	3.2%
1	Trace C12 PV Controller	$110	1.0%
1	1 PV Adjustable Rack	$60	0.5%
1	Analog Amp Meter	$19	0.2%
1	Analog Volt Meter	$19	0.2%
	WET Lab 12 VDC System Subtotal	$1,008	9.1%

Both Systems

#	Description	Cost	%
	Labor	$1,764	16.0%
	Misc. wiring, connectors & conduit	$380	3.4%
	Travel, meals and lodging	$202	1.8%
	Shipping	$100	0.9%
	WET Lab Both Systems Subtotal	$2,446	22.2%
	Grand Total	$11,040	100%

went immediately to the E-Meter to see 13 Amps of pure sunlight charging the battery. Not bad, for a flat mount of four panels in the late afternoon! Bob fired up the entire lab—lights, computers, microscopes, etc. The E-Meter showed a cumulative 87 Amp draw from the batteries. With the 13 Amps of sunlight, we had 100 Amps available going to the loads (87 + 13 = 100 A; 100 A x 12 V = 1200 W). It was right in line with the projected load.

Since the installation, Bob Curtis has reported that he can usually go all day with solar input, eliminating the need to run the generator. He is really enjoying conducting classes without the noise, vibration, and pollution of the original system. We will be using the system schematic created by *Home Power* inside the WET lab to show thousands of visitors how the system works. Bob is also planning to add a solar "module" to the curriculum.

Congrats!

Way to go, Springfield Public Schools and EWEB for funding this project! May this be an example to other school districts around the nation—go solar whenever the opportunity arises. This will provide a positive energy role model for the next generation.

Access

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Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 530-475-3402
econnect@snowcrest.net
Web: www.electronconnection.com

TRACE'S COMPLETE POWER SOLUTIONS

Solar DC Charge Controls

Now Trace brings microprocessor technology to solar (PV) charge controls, with pulse-width modulated C12 and C40 charge controllers. Ensure more power and longer life to your batteries. ETL listed. Meets NEC requirements.

DVM/C40 Meter C40 Controller

*C35, C40, *C50

Trace Engineering's most advanced alternative energy controller. The C40 brings microprocessor control solar, wind, at an affordable price. The C40 features an optional digital monitoring system that can be mounted on the controller or used remotely. The C50 is also designed for Solarx Millennium Panels. **List $145 to $225.**

C35R, C40R, C50R/50 OR 100

Remote display with 50 ft. or 100 ft. connector cord for remote installation in a dual outlet box. **List $115 to $135.**

DVM/C35, 40 & 50

Digital meter mounts into front of charge controller. Displays volts, amps, and cumulative amp-hours for solar array or DC loads. **List $90.**

C12 (Shown with cover removed)

C12

The C12 has an LED status light displaying both charging functions and battery charge state at a glance. This controller is used worldwide in a variety of applications. The DC disconnect function of the C12 will disconnect DC loads if batteries reach low-voltage conditions. Thousands in use worldwide. All controllers feature exclusive optional battery temperature sensor which maximizes battery life and charge. **List $110**

*Scheduled availability Sept. 1 1998.

DR Series

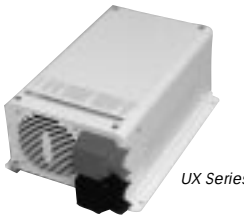
Simple & Expandable

High surge capacity, low idle current. Simple, powerful, reliable, and efficient, Trace DR-series inverters have set a new standard for inverters. Trace builds several models of DR-series inverters, ranging in size from 1.5 kW to 3.6 kW. All DR inverters have a built-in, automatic, three-stage battery-charging system (bulk, absorption, and float). Auto low battery protection.

DR Series

Fast auto switching for back-up power. Expandability is another unique feature of our DR-series inverter. Load capacity can be doubled by "stacking" a second inverter. A simple stacking cable kit (DRI) is all that is needed. When connected in series, a pair of DR inverters produces both 120 and 240 Vac power, enabling it to operate such difficult household loads as deep well pumps, heavy power tools and appliances. Battery temperature compensation option. **List $995 to $1,350.**

UX Series



UX Series

500 to 1400 Watts of Power
The new UX family is a powerful compact upgrade of the 800 Series. UX offers higher power with UL compliance. Automatic Operation Combination inverter/charger (StandBy) models include a built-in battery charger and automatic mode switching that provides true "set it and forget it" operation. ETL listed, UL standard 1741 - CEC approved. **List $550 to $940.**

NEW Tiger Series*

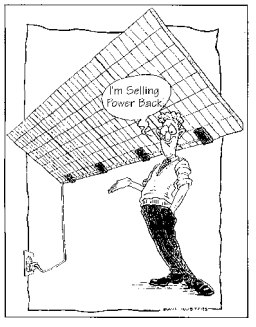
New low cost maxi-feature, modified sine-wave inverter with optional 3-stage battery charger & automatic transfer relay. More features, higher reliability and surge power than any other inverter in it's price range! **List $395 to $495**

Tiger Series

Micro Sine

Micro Sine Module

Trace Engineering is leading the way once again with our new miniature utility interactive inverter—the Micro Sine Module. Designed to fit on the back of an individual PV solar module. This totally weather proof inverter produces utility-grade power suitable for supply to a power distribution grid. Meets NEC requirements - ETL listing pending. **List $345.**



SW Series II

SW 4024 - List $3,410

New Series II Design

Don't settle for less! Used with utility interactive systems worldwide. Features include an easy to use programming system with separate "User" and "Setup" menus. Battery Charger with high efficiency, low current distortion design enables higher charger output from small generators. Output of these inverters is so clean that they are approved for utility interconnect. Meets NEC requirements. Approved by the California Energy Commission.
SW models are available in utility interactive and stand alone configurations. Auto generator start, battery voltage transfer mode, and PV power point tracking are all available. 54 microchip options. DR, UX, SW & MPS Series are ETL listed - standard UL 1741. **List $2,585 to $3,970**

Trace Power Modules

MPS shown with cover removed.

An **MPS** encloses inverters, charge controllers, wiring, disconnects and batteries in a lockable indoor/outdoor weatherproof cabinet. The modular design facilitates installation standardization and permits maximum flexibility. Meets NEC requirements. Approved by the California Energy Commission.

Ground Fault Protectors are now available for solar panels and can be installed in the MPS.

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this is page 25

Solar Electricity for a Remote Island Resort

Steve Willey

After ten years of planning, Kevin and Therese Wunrow had located a remote, 20 mile-long, coral ringed island. The island had 16 Fijian villages, no stores, no vehicles except a few powerboats, and no commercial development. Kevin determined that such a remote setting could become an educational eco-resort with snorkeling, scuba diving, and an inside look at the Fiji native culture and villages—powered by renewable energy.

The Resort Site
Fijian villagers live well on their own craftsmanship and bountiful gardens. The ocean and tropical trees provide plenty to eat, but they have little cash income for building or paying fees for their children's higher education. The boat or plane fees to the nearest city cost more than a day's wages.

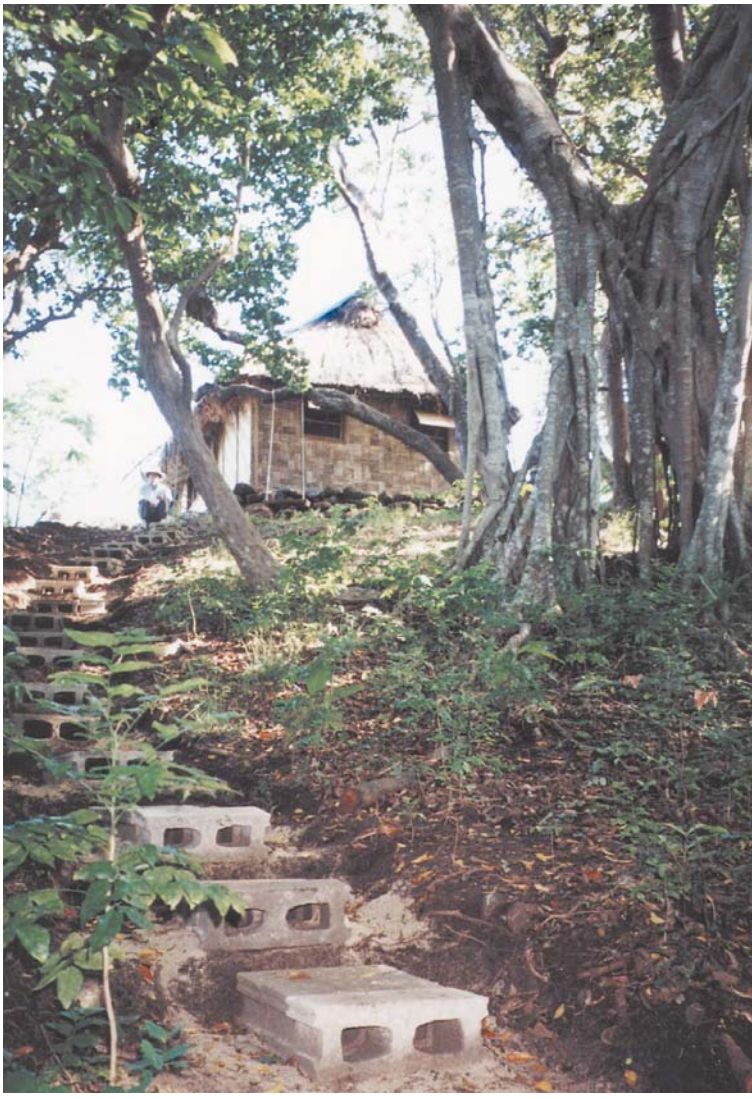
The people of one village, Somosomo, wanted to sponsor the eco-resort. One villager, Pita Bula, realized the great benefit of a resort close to the village. He leased some of his family property to the Wunrows, at the site of an ancient Fijian village that was described in Captain Bligh's logbook. In Fiji, usually only native citizens can own land, so the village shares in the resort construction, operation, and income. The Paramount Chief of the island, who had turned down several other offers, approved the Wunrows' eco-resort plan.

Estimated Power Needs
In the fall of 1997, the Wunrow family contacted us, seeking solar electric power for their planned Fiji Island eco-resort. They were ready to start building. There was no power on the island other than a generator or two, and one small solar module on a schoolteacher's residence.

They needed solar electricity for lights, ceiling fans, and incidentals in the guest huts. Three or four huts were planned, perhaps later increasing to nine or ten. A kitchen/bar and dining area would be a more serious power draw. They planned to run two freezers, many lights, and some other small appliances. Power tools would be used for building the resort, including a table saw, a small cement mixer, and cordless drills. In the future, Kevin intends to add a clothes washer. The daily power use projection looked very similar to a typical family home, at least for the first stages of operation. The list of electrical usage for both construction and the first phase totaled about 2.5 kWh per day.

The System Plan
We specified an expandable system starting with a 900 Watt solar array. The array consisted of twelve Siemens SP75 modules on Backwoods S-Mounts, and 600 Amp-hours (A-h) of 24 Volt deep cycle flooded batteries. We selected twelve Trojan T-105s, due to their size and weight. We wanted to make it possible to hand carry the batteries to the site.

We chose a Trace SW4024 inverter to supply 120 volt ac to all of the buildings via underground cable. Although public power in Fiji is 240 volt, the resort owners decided to produce 120 volt for the tools and equipment they were bringing with them from the US. If 240 volt capability was needed later on, they could add a second inverter.



Above: Kevin and Therese's traditional Fijian woven bamboo hut with thatch roof.

The balance of system equipment was fairly simple—we used an economical Backwoods Solar Power Center Kit. It includes a 24 Volt charge control, battery cables, inverter breaker, and adequate metering. The kit is based on components from the Trace Power Panel, simplified.

To set up a kit, we start with the Trace DC250 breaker box. We add a single C40 charge control and mounting bushings. We install a 500 Amp meter shunt, a 60 Amp solar circuit breaker, and two DC load breakers. All of this equipment conveniently bolts into the pre-punched holes in the Trace breaker box.

In the kit, we also include a TriMetric meter, wiring harnesses, wire entrance hardware, and installation kit. The installation kit includes a jumper cable from shunt to inverter, and a terminal lug for all other negative

Above: Installing the almost horizontal PV array of twelve Siemens SP75s.

connections in the box. With the Trace inverter cables added, everything goes together with just a screwdriver and wrench.

The resort already had a diesel back-up generator for use in case of extended cyclone weather or equipment breakdown. Since the location is 15° from the equator with mostly sun-filled days, there should be about 4 kWh charge received each day of full sun. This allows for some expansion of consumption, with little or no reliance on the back-up generator.

Batteries

We noted experiences that were reported in *Home Power Magazine* from other small resort and monastery installations. They indicated that a smaller battery capacity tends to give longer battery life, because batteries are assured of a full charge in a day's sun. With the anticipated initial power usage, we sized the batteries for three days of autonomy at 60% discharge. To allow for three days of autonomy, we did not size for total recharge of a dead battery in one day as might be done in a smaller system. This PV system can charge over 200 A-h per sunny day to the 600 A-h battery bank. To start, estimated daily usage will be in the range of 100 Ah per day.

Across the Equator

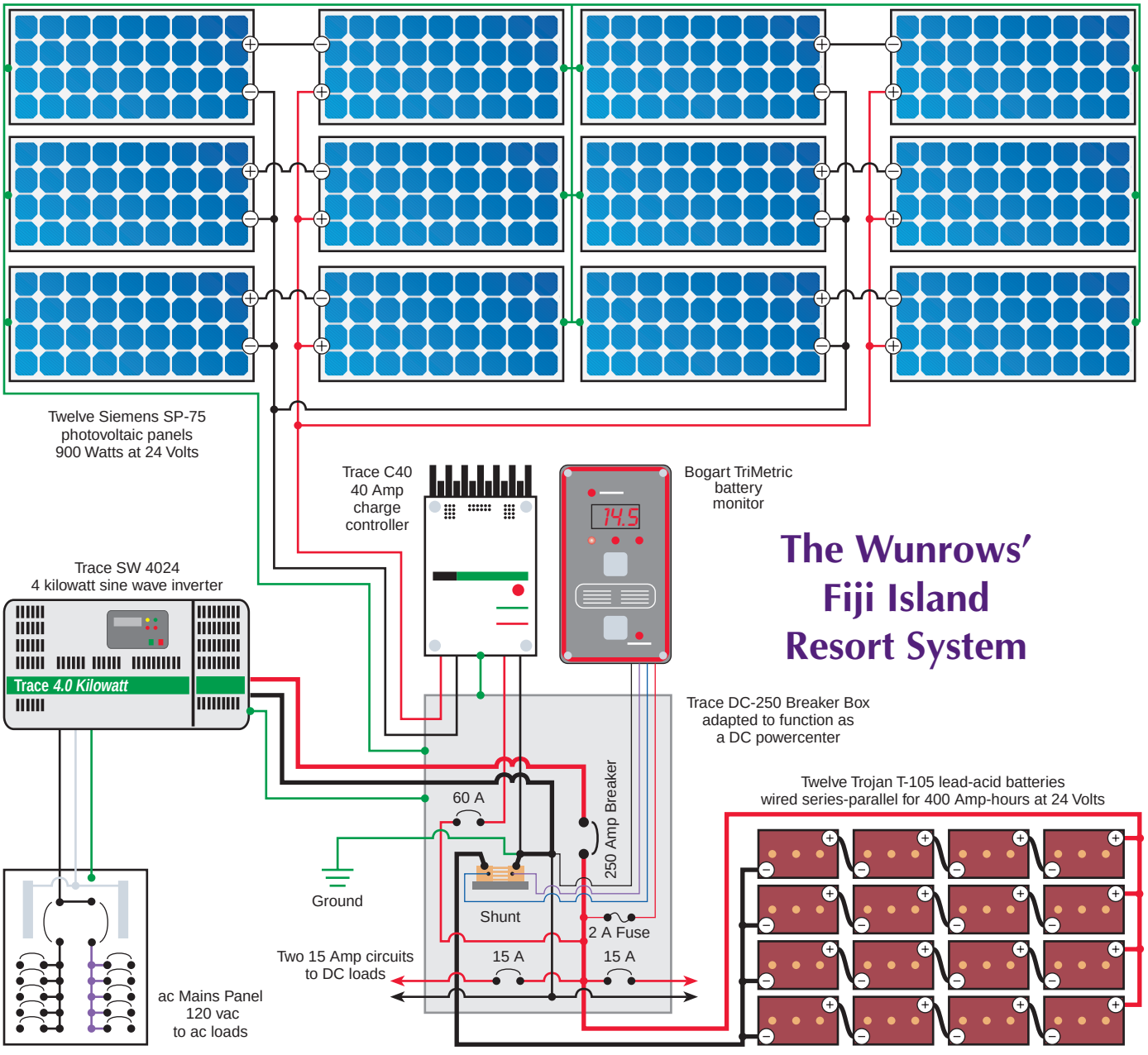
When Kevin asked if I was sure he would be able to install the equipment by himself, I joked that if he bought me a ticket to Fiji during north Idaho's winter, I would gladly go install the system. The next day, he offered to buy tickets. Elizabeth and I escaped some of our snow by taking a twelve-hour flight to Hawaii. Another twelve hours, and we had arrived in the South Pacific Fiji islands. We were 15° south of the equator, and across the international date line.

The local island hopping flight was repeatedly postponed. Apparently, the wet grass runway was too slippery for landing. We had to suffer several days wait in a deluxe tropical motel, eating eggplant parmesan and drinking fresh pineapple juice. Three days later, we landed on the anticipated island. We trekked through jungle paths to a beach where we began a long powerboat ride around the island. We sped by coral reefs and past numerous villages accessible only by sea. We finally beached in an isolated cove on the far side of the island. Here, the resort's first clients would find sandy beaches with mangos, coconuts, and huge crabs. There were opportunities for snorkeling and scuba diving in complete isolation from the commercial world.

Parts is Parts

But the resort was not yet built. The PV system equipment had been packed in a container and barged from Seattle, with piles of building supplies and all of

Below: Pita Bula (right), landowner and partner in the resort, and workers carry T105s up from the beach.



the Wunrows' worldly belongings. The day before, Fijian workers had manually pulled the barge onto shore. They unloaded mountains of supplies that stretched down the beach, covered under blue tarps.

This Sandpoint, Idaho family had brought lumber, office supplies, leaky tents, a gas stove, spools of underground cable—not to mention the sink. There was almost every tool that could be found at a discount store, and a six-month supply of food. Therese's piano and the harp she had played in the Seattle Symphony were also on the barge. First things first, we heard a classical piano recital. Then we had dinner accompanied by classical harp.

We were invited to the Fijian village several miles away by boat to visit their Methodist church, meet the chief, and hear their choir. Amazingly, Fijian villages each have a choir that sings religious and classical music, a cappella. It's of professional caliber, with singing competitions between the villages.

Mounting the PVs

Early the next morning, Elizabeth and I awoke with the sun. The solar electric system components were hiding somewhere among those piles. We located the modules and mounts, and carried them up the mountain. Before the others awoke, we assembled and wired the array. Then, we installed the modules on the

Above: The finished PV array with the South Pacific in the background.

S-mounts. These mounts are designed for a roof or wall, the intended permanent location for the modules. However, the building that was intended to house the PV system would not be constructed until next month.

To withstand local cyclone possibilities, we had to create a temporary power system structure. We found treated 4 by 6 inch posts among the building supplies, and designed a ground mount that would be secure. We made sure that it had a slight northern tilt, optimum for solar at 15° south of the equator.

Hard Workers

Shortly after Elizabeth and I had wired the array, we were delighted to see the village workers arrive. They joyfully began carrying the twelve batteries up the steep ridge. These folks can really get some work done fast. They used long machetes to clear five to six foot tall brush. They cleared half an acre of pathway and created a solar mounting site. Then they dug the holes and installed the eight posts for the solar mounts.

The huge spools of 6 gauge, three-wire underground cable seemed way too heavy to move by hand. While we calculated the lengths to cut from the spools still on the beach, two villagers just picked up a whole spool. While singing, they carried it up to the power site. In one day, the construction crew had a temporary screened kitchen and dining building set up. This included a gas stove, sink, ac outlets, seven compact fluorescent lights, and a Vestfrost freezer.

A temporary plywood shed was set up to house the batteries and inverter. We had the power center installed in the shed and functioning by the end of the day. At first, we could not find our TriMetric meter, so we temporarily bypassed the shunt to get the system functioning. By evening, someone had unpacked more of the piles. The TriMetric surfaced and was added to the system.

We laid power cables back down to the kitchen by rolling the spool down the ridge of the mountain. By dark, the freezer was operational. Compact fluorescent lights replaced candles and flashlights for our second evening meal, which included cold drinks.

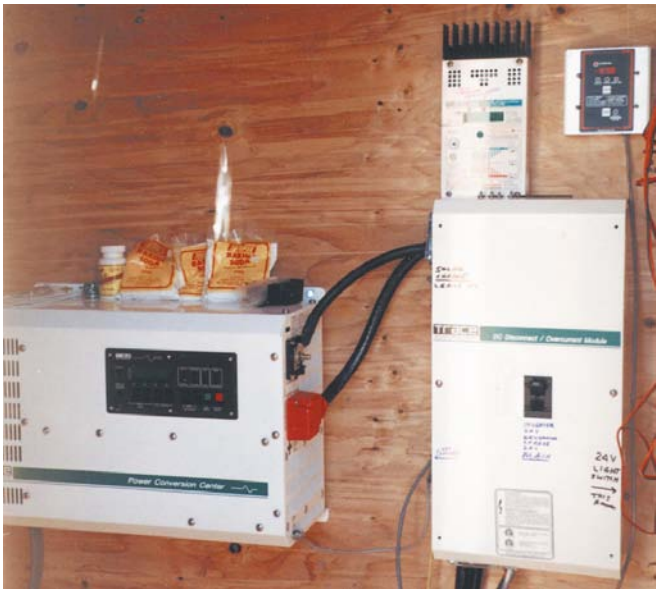
Freezer Performance

Though freezers would later become important for operation of the resort, the immediate need was for refrigeration of food and drink. Considering this, the owners selected two Vestfrost 7.5 cubic foot chest freezers. These have 4 inches of insulation with good energy efficiency. With a -5°F setting in the freezer, power consumption is 180 watts. Compressor run time measures 2.4 to 4.6 hours a day. This is between 430 and 828 watt hours per day consumption. Both the compressor run time and consumption depend on room temperature.

Makeshift Chest Refrigerator

One of the Vestfrost freezers was temporarily converted to a refrigerator, as the construction crew had an immediate need for cold beer and for keeping leftover food. We wired an industrial ac thermostat to an inverter-powered outlet for the freezer, with the thermostat in series with the hot lead. We mounted the thermostat on the wall above the freezer. We inserted the temperature sensing probe inside, through the gasket, on the rear hinge of the lid.

Below: The control center including the modified DC disconnect box.



Above: Therese Wunrow is jazzed by her new Vestfrost freezer.

The new thermostat was set to 38°F, a higher temperature than the built-in freezer control. This thermostat had first control as the unit cooled down, and kept the Vestfrost at refrigerator temperatures. Power consumption is much lower when functioning at refrigerator temperatures, rather than working as a freezer. Unfortunately, we did not have equipment to actually measure running time in Fiji.

Later, the Vestfrost may be converted back to a freezer just by plugging it into a different outlet. This was an effective and low-cost solution for flexible refrigeration needs. It might be a good solution for anyone who can use a low-cost, low-power chest refrigerator. Note that the unit cools from all sides internally, and cannot be made part freezer and part refrigerator. The thermostat we used is part number 2E740 from Grainger, and costs about $45.

Efficiency

We recommended using one-hour wind-up timer switches for the guest huts, so that fans and lights won't be left running when the huts are vacant. These have been used in many solar homes for both children's lights and outdoor lighting.

I noticed that some motels in Fiji have devised a better solution for energy savings. After entering your room, your room key is inserted into a slot inside the door which enables power to the room. When the key is removed by a departing guest, power to the room is disconnected.

Cordless Catastrophe

During the first night, the carpenters plugged in a Makita cordless drill charger. We know that these appliances tend to melt down with non-sine wave inverters. Since this inverter was sine wave, it should have worked. However, in the morning, the battery was melted! Unfortunately, it was only one of two drill batteries on the island. I noticed that the charger had caused the inverter to cycle on and off after the lights had been turned out, as it was too small of a load. At first, I thought that may have overridden the charge control built into the Makita unit. Then it was discovered that the night rains had completely flooded the circuit board inside the Makita charger. This was likely the cause of destruction of the battery.

Initial Resort Loads

#	Item	kWh/day	%
	Tools, construction, or first 4 guest huts lights/fans	1.00	41.5%
1	Vestfrost Freezer	0.75	31.1%
6	Compact Fluorescents,15 w for 4 hours	0.36	14.9%
1	Vestfrost Freezer converted to refrigerator	0.30	12.4%
	Total kWh Daily	2.41	

Above: Authors Steve and Elizabeth Willey suffering in Fiji.

System Performance

The morning sun began charging the battery bank at about 22 Amps, and had replaced the evening's power use before noon. This was rainy season, with sun coming and going, so I estimated that the balance would be close after the second freezer gets connected. It should support the construction tools as well as lights and refrigeration for the crew, but more modules might be needed when the resort begins receiving guests.

Our flight home left later that day, so no further observation was possible. I guess we will have to go back sometime to read those meters again, perhaps when snow begins falling here in Idaho.

Access

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It was a bright and calm spring morning. Two shadowy figures emerged from an unmarked van. It was so plain, so ordinary, that if anyone had been around, they would not have noticed the activity on the otherwise deserted city street.

One person was carrying a long case with a handle. The form quietly stepped across the sidewalk and glanced in both directions. In a graceful, practiced manner, a key was eased into the lock of the building. The figure slipped inside so quickly that it seemed as if no one had even been there.

The other person moved cat-like, gently closing the side door of the van. In through the unlocked door of the building, the second was soon behind the first—carrying a thin but somewhat unwieldy cardboard box about four feet square. It was carried as if it were precious cargo, like an expensive 17th century painting by one of the masters. The door clicked shut, and locked.

They were pros. This was guerrilla solar.

Chapter One

Earlier this year, we made a toll-free phone call to Alternative Energy Engineering (AEE) in Redway, California. A new solar product was on the market, and we were excited to check it out. We ordered the new "AC Module." This 108 Watt 24 Volt PV panel has Trace Engineering's Micro Sine inverter glued to the back. The inverter box on the module back is not much larger than the junction box itself. The inverter is pre-wired into the module's junction box, and has a long, thin, four-wire cable coming out of the side. A standard wall plug is wired onto the end of two of the wires, and then inserted into an ac receptacle inside the building.

Our intentions are honorable, but less than legal. We did not tell the utility that we were going to feed homemade electricity back into their power grid. This wasn't a decision arrived at lightly. Any revolutionary action should have all of the potential consequences weighed carefully before proceeding. In this case, we knew the risks would be minimal—unlike blockading a nuclear power plant where arrest was likely. We felt that the worst scenario would be the utility shutting off our power until we de-installed the illegal PV system.

Safety Isn't the Issue

Every utility puts high priority on making things safe for

their line workers. However, utility management has begun to use safety as an excuse to make it difficult for us to install intertie RE systems. The power industry doesn't fear lack of safety, they fear the revolutionary renewable energy movement. They fear that they will slowly lose control over their one-hundred-year power generation monopoly. They have good reason to fear people like us, but they can only delay the inevitable.

At a minimum, utilities require an expensive, lockable disconnect to keep your power out of their grid while they are working on it. The supposed problem is that a PV system feeding power to the grid could keep doing so when the grid goes down. This would put the line workers in jeopardy of being shocked when they are not expecting live powerlines. But modern intertie inverters are designed to sense the presence of grid power, shutting off when the grid does.

Imagine that there are two intertie systems in a neighborhood. When the grid goes down, what if they sense each other and continue feeding power? What happens if the load in the neighborhood is equal to what the inverter can put out? When an inverter continues to run when the grid goes down, it's called "islanding." PG&E, a California utility, ran extensive tests on Trace's SW series of intertie-capable inverters. They found no circumstances where these inverters would continue running when the grid went down—they do not island. Yet utilities, even PG&E, continue to require a disconnect on every intertie system installed. You know the real reason why.

Some utilities also require multi-million dollar insurance policies on the intertie. Those two requirements are often enough to discourage folks from installing on-grid systems.

Is this fair? Is it OK? No, and it rubs us just wrong enough to decide to do it without permission, without disconnects, and without additional insurance. Hence, guerrilla solar.

The Installation

Our installation was easy and fast. We lag-screwed a length of 1/4 by 2 by 2 inch steel angle iron straight up the side of our building. We left enough length above the roof line to be able to seasonally adjust the module tilt. Then, we bolted the backing from a pole mount rack to the AC Module, leaving out the part that would normally fit over the pole. Since our building faces nearly south, we were able to bolt the rack directly to the angle iron.

Not being engineers who can calculate wind loads on paper, we field-tested the mounting system. We wiggled it back and forth as if it was blown by a gusty wind. There was too much flex in the hefty angle iron,

Above: The Micro Sine on the back of the 24 Volt PV.

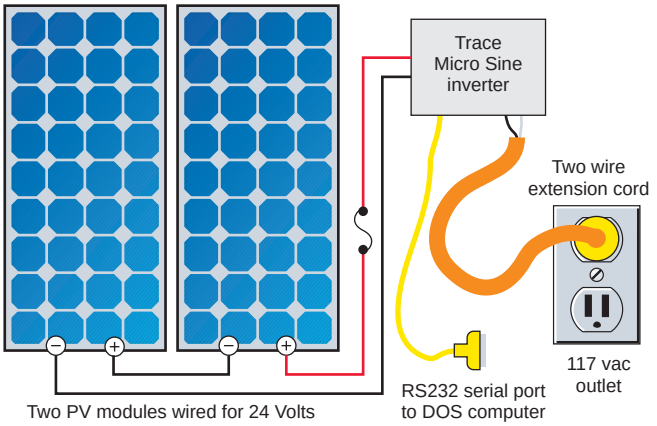
because it extended a fair distance above the topmost lag screw. We added a brace from the top of the post to the side of the building. This created a solid triangle supported in the direction of likely wind load. With the brace, the angle iron barely moved when we pushed hard against the module. We were satisfied.

Next, we cut the inverter output cable. We rewired it through a waterproof box mounted just below the module. This way, we can remove the AC Module without having to deal with the long cable that snakes down and through the outer wall. We put a standard household plug on the two ac output wires at the inside end of the long four-wire cable.

We (Kinda) Inform the Utility

As we were working on the installation, a utility line crew showed up to work on some underground cable in the alley below. The next time we had to go down to get more hardware, we stopped to say hello to the hardhats. We took the opportunity to point up to the newly-mounted PV module and said, "Look, friends, we are putting up a solar panel." Their reaction was predictable. They looked up with slight curiosity, while

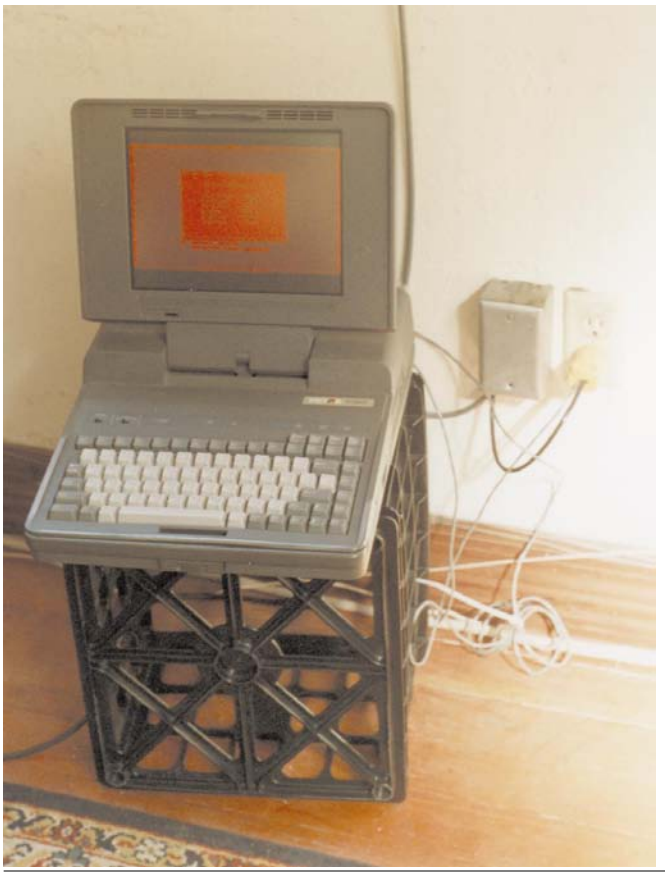
Wiring the Trace Micro Sine



some nodded and some grunted a minor interest. They looked back in their hole, went back to work, and left us to our task.

So, we had shown the utility our illegal installation. Would telling their worker bees be enough to satisfy the utility that we had done proper notification? Would word of our illegal system likely find its way back to utility management? No, but it was enough to give us a great anecdote while spreading the tale of our guerrilla solar electric system.

Below: Logging data.



Above: Just plug it in!

The Other Two Wires

We plugged it in, and our installation was fait accompli. We wanted to find out if it was working, but how could we tell? 100 watts peak, in a serious load like our building has, wouldn't show a noticeable reduction in the wheel speed of the utilitie's kWh meter. We could have temporarily put an amp meter in series with one leg of the wire, but there was another method available.

Every Micro Sine inverter has an internal data collector. It doesn't matter whether the inverter is mounted on an AC Module or not. It tracks real-time DC module voltage, ac output voltage, current, watts, and total watt hours. It also measures the temperature where the inverter is glued to the PV module. An optional serial port computer interface module is available with special software to access the data. The second set of two wires coming out of the inverter hook up to this interface module.

Tech Non-support

Unfortunately, the software that came with the module is only for PCs, and not for Macs. It runs under MS-DOS, but is not Windows-based. We installed it on a Pentium laptop and ran it in DOS mode. We hooked up the interface, but could not get the software to find the inverter. We had a bad experience calling and emailing

Guerrilla Micro Sine Data (Since April 10, 1998)

Date & Time	Aug. 12, 10 a.m.	Aug. 13, 1 p.m.
Weather	overcast	clear
Total watt-hours	46,896	47,354
ac volts	123	123
ac amps	0.074	0.601
ac watts	9	73.8
DC Volts	33.3	31.3
Temperature °C	18.5	49.2

Trace to find out the scoop. We asked the voicemail tech support to call back with information on the Windows version of the software that was supposed to be available. All in all, we left three messages in three different voice mailboxes, but no one ever called back.

Email was answered, but the person who replied didn't pay attention and answered the wrong question. Finally, the light bulb went on—a Trace rep told us that the software for Windows was not available. Trace, if only your tech support matched the quality of your equipment. Hopefully, under Trace's new owners, tech support will improve and the equipment quality will not suffer.

Contrary to what we were told, we had heard from a couple of other sources that Windows software *was* available. These inverters had been around for a while before Trace picked up the US rights. They are not Trace-designed inverters; they were designed and originally marketed by OKE-Services in The Netherlands.

We did a search on the World Wide Web. Soon, we had the software. We loaded the program on a Pentium laptop. OKE had delivered the US version of their software, but we still couldn't get it to work. We gave up on finding the Windows software.

In the meantime, we had successfully installed the DOS-based software on an ancient 80286 portable computer that belongs to a comrade. It ran like a champ, giving access to all of the inverter functions and information that can be had through the software. It turns out that the software and interface is capable of collecting information and managing the online status of lots and lots (127) of these inverters, not just our measly 100 watt system. Additionally, OKE publishes the information on how to access the data communication functions of the inverter, so that folks with technical capabilities can write their own software to do more and better data logging.

The Data

There it was on the computer display, proof that the guerrilla solar electric system was making power. And hang the utility—it was done safely for the line workers, and safely for the building.

After four months of use, the AC Module has offset 47,354 watt-hours of consumption in our building. It's a small amount—at ten cents per kWh, that's less than $5. It would take a lot of time to make up for our expenses, but we are not really interested in payback time. We are interested in contributing our fair share to a more just, distributed power system. Oh yeah, we also get a kick out of pulling one over on the utility.

Above: Freedom on the roof!

Yesterday started very overcast, and the inverter was putting out only 9 watts. Today after the fog burned off, we have seen close to 75 watts. On a sunny day with no haze, we have seen it put out just above 82 watts.

AEE says that the inverter will handle up to 130 Watts of PV, and that the UL listing should be complete and on any inverters manufactured after August, 1998. On the OKE website, it says that their 300 watt inverter "is" due out in 1997, but there is no indication of availability yet. In fact, that web site hasn't been updated since August, 1996.

Guerrillas Unite!

You can do this too. We hope you do—and we want to hear about your experiences. The Micro Sine inverter is not the only way. The same thing can be accomplished on a much larger scale. We'd like to try a Trace SW2512 inverter, an array of eight or more 100 Watt modules, a small battery bank and charge controller for when the grid is down, and, of course, the appropriate fusing and breakers.

Our flat roof is wide enough to hide the array from nosy utility employees and building inspectors on the ground. That brings up the last, very important point. Most legal

Guerrilla Solar Costs

Item	*Cost*	*%*
AC Module	$895	79.3%
OK485 Communications Adapter	$125	11.1%
Scavenged Mount	$65	5.8%
Angle Iron	$27	2.4%
Miscellaneous Hardware	$17	1.5%
Total	$1,129	

intertie systems are over-built in order to satisfy the rules of the utilities and the needs of building inspectors for unreasonably full NEC compliance. Our small system would satisfy neither, but is very safe with its built-in protection. It's up to any guerrillas installing larger systems to take the necessary safety steps, just like a well-designed off-grid system. Don't worry about the utility, these inverters are safe.

Access

Authors: (Hah! Did you think it would be that easy?) Send email to hp@homepower.com and HP staff will pass it on when we check in.

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Hydrogen Purification

Walt Pyle

Hydrogen gas (H_2) can be used for cooking, water heating, space heating, electricity generation, welding and cutting, and the synthesis and purification of other chemical materials. When hydrogen is made from water and renewable energy resources such as PV, wind, or microhydro, we refer to the produced gas as "solar-hydrogen."

Above: Electrolyzers driven by photovoltaics.

Solar-hydrogen is a sustainable carbon-free gas. It can release heat when burned with air or oxygen, or produce electricity when combined electrochemically with oxygen in a fuel cell. When solar-hydrogen is made or burned, there is no carbon monoxide, carbon dioxide "greenhouse gas," or hydrocarbon pollutants produced.

This article discusses hydrogen purification as a prerequisite to storage or utilization, and covers safety considerations in home power applications.

Where Does Hydrogen Gas Come From?

1. RE Electrolysis of H_2 Gas

We use PV electricity to run an alkaline electrolyzer to produce hydrogen gas. Unfortunately, we do not have a creek or other water resource nearby for micro-hydro electricity production. We could really use it during the rainy season when there is less solar insolation. Since we are located on a hillside in an urban area, a wind generator tower would not be a welcome addition to our neighbors' view. With this in mind, we use PV electricity as the exclusive renewable power source for our hydrogen plant.

Solec 50 peak-Watt PVs *(A, see diagrams on pages 43 and 45)* are arranged in eight panel arrays. They are wired in series-parallel for 24 Volts. Three of these arrays, totaling 24 panels, will produce sufficient power to run our Hydrogen Wind twelve-cell electrolyzer at nearly its rated 1 kW capacity.

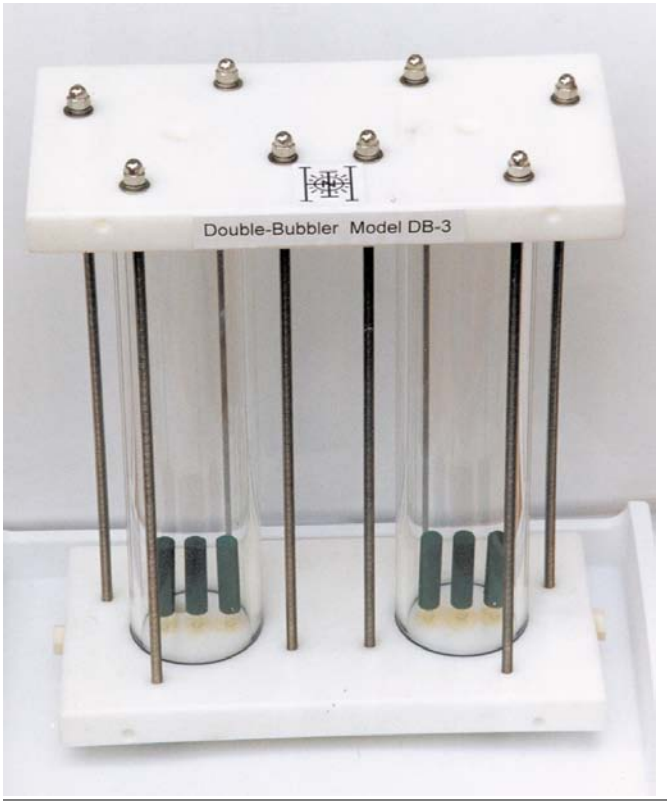
Our Hydrogen Wind electrolyzer *(B)* is shown in the diagrams with its associated purifiers and storage tanks. For more information on the production of hydrogen by electrolysis and hydrogen storage, see *HP39* and *HP59*, respectively.

2. Industrial Cylinder H_2 Gas
We can buy hydrogen gas in high pressure cylinders from a welding supply house. The industrial grade is about 99.5+% pure hydrogen. It may have a few parts per million of hydrocarbons, water vapor, helium, oxygen, and nitrogen contaminants present. These cylinders come in four volumetric sizes, and have 120 to 240 bar (1800 to 3500 psig) pressure ratings. The most common cylinder size is six cubic meters (215 cubic feet). Most industrial hydrogen is made by steam-reforming natural gas.

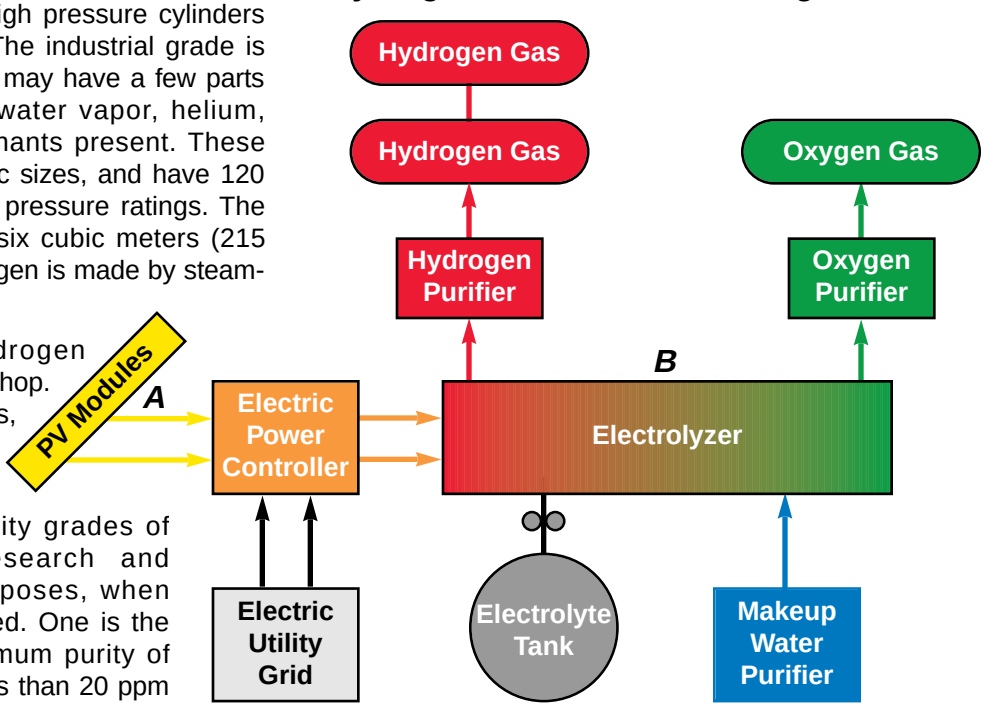
In the past, we bought hydrogen cylinders and used them in our shop. Now that we make our own gas, we rarely have to purchase it.

3. High Purity Industrial H_2
There are several higher purity grades of hydrogen available for research and metallurgical processing purposes, when contaminants must be minimized. One is the "pre-purified grade" with minimum purity of 99.95%. This grade contains less than 20 ppm oxygen with a dew point of less than -59°C (-75°F). This quality of hydrogen is often referred to as "3-nines."

Below: The Double-Bubbler™ removes particulate matter and KOH from the hydrogen gas by passing it through a column of water.



Hydrogen Production Flow Diagram

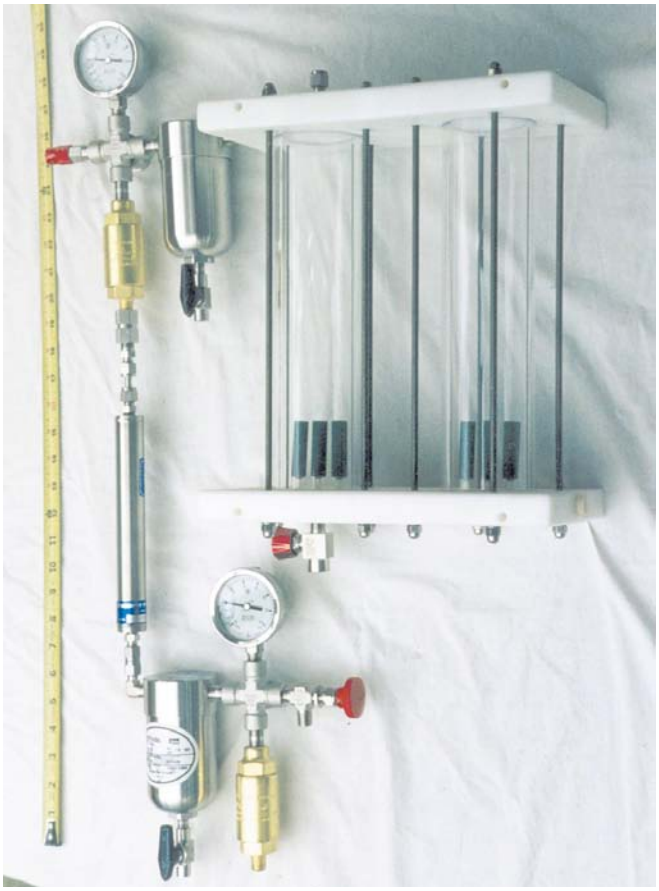


Another high-purity hydrogen, the "ultra-high purity (Gold Label) grade," provides 99.999% molecular hydrogen. Sometimes this is called "5-nines" purity. For those who demand the best, there is "Research Grade". This grade has even fewer impurities, and is available in small lecture bottles.

4. Cryogenic Liquid H_2
Liquid hydrogen is primarily used as rocket fuel or for large industrial sites. The only significant impurity is helium. We have never used liquid hydrogen for home applications, because special tanks are required. The cryogenic tanks have dual walls. The space between the walls is evacuated and filled with radiation reflective multi-layer insulation. Some experimental cars have been run on liquid hydrogen.

6. Common-duct Hydrogen-Oxygen
Common-duct hydrogen-oxygen welding gas is commonly referred to as either Rhodes' gas or Brown's gas. This gas consists of hydrogen that comes from a "common-duct" electrolyzer, mixed with oxygen. It is VERY dangerous. H_2 + O_2 mixtures should NEVER be stored. Common-duct electrolyzer hydrogen is not suitable for use in hydrogen fuel cells, catalytic heaters, or diffusion burners.

The only sensible application for common-duct hydrogen is to run welding and cutting torches. When it is used in this manner, there is no storage and the gas is consumed as it is made.



Above: The Double-Bubbler™ and purifier system.

What Contaminants May Be Present in H_2?

1. Solid Particulate Contaminants in H_2 Gas

It is possible to find entrained particles of dirt and rust in a hydrogen electrolyzer's product stream. Some electrolyzers have steel or iron alloy containers, valves, and piping. This metal may produce low levels of rust particles over time. Electrolyzers frequently use high surface area electrode materials such as nickel that may lose small particles into the electrolyte. Sometimes, particles of either plastic or sealant will enter the electrolyte system. This happens due to poor housekeeping during manufacturing or repair. These particulates can be removed from your hydrogen gas stream with an appropriate scrubber or filter.

2. Liquid Contaminants in H_2 Gas

Electrolyte is the normal liquid contaminant in an alkaline electrolysis system. In this case, it is water plus potassium hydroxide (KOH). A small amount of KOH and water escapes from the electrolyzer with the flow of hydrogen. An aerosol of fine electrolyte droplets is produced as bubbles of hydrogen gas rise to the surface of the liquid electrolyte and then pop. The same thing happens on the oxygen side of the electrolyzer.

In our Hydrogen Wind electrolyzer, there is another source of KOH/water aerosol hydrogen contamination: electrolyte-wetted float valves that control the discharge of gas from the unit. Any other liquid contaminant in the hydrogen gas would be unexpected. A coalescing filter can remove solids and liquid KOH/water aerosol droplets.

3. Gaseous Contaminants in H_2 Gas

Under certain conditions, we find gaseous contaminants such as oxygen, nitrogen, argon, and water vapor in our hydrogen gas.

Oxygen, nitrogen, and argon are present in normal air. When all three of these gases are present in the normal proportions, an air leak into the electrolyzer or its piping has occurred. However, this is rare. Usually, this is seen only at startup of the electrolyzer when purging or evacuation is imperfect. It also can happen when there are significant leaks in either the cells or in the interconnecting piping. Once the electrolyzer is operating above atmospheric pressure, no outside air will leak inside. However, some hazardous electrolyte may leak out if there are any poor seals. See *HP39* for safety information on handling alkaline electrolyte, as KOH is very corrosive to skin and eyes. Nitrogen and argon are not a safety concern, as they are inert gases. Oxygen is the contaminant of primary concern.

Water vapor is always present in a KOH/water electrolyzer. The gas vapor space of each cell is saturated with water above the electrolyte. The concentration of water saturation is governed by the temperature and pressure in that environment. The objective in a purifier system is to remove excess water vapor. This prevents condensation from occuring downstream, with subsequent flooding of other components. The presence of some water vapor in hydrogen that has been purified for storage in pressure tanks is not harmful—as long as a compressor is not used. The presence of water vapor in stored hydrogen gas slightly reduces its flammable limits in oxygen or air. Our electrolyzer produces gas under pressure, between 0.1 and 4 bar (1 to 58 psig), depending on storage tank pressure.

What are the Methods for Purifying H_2?

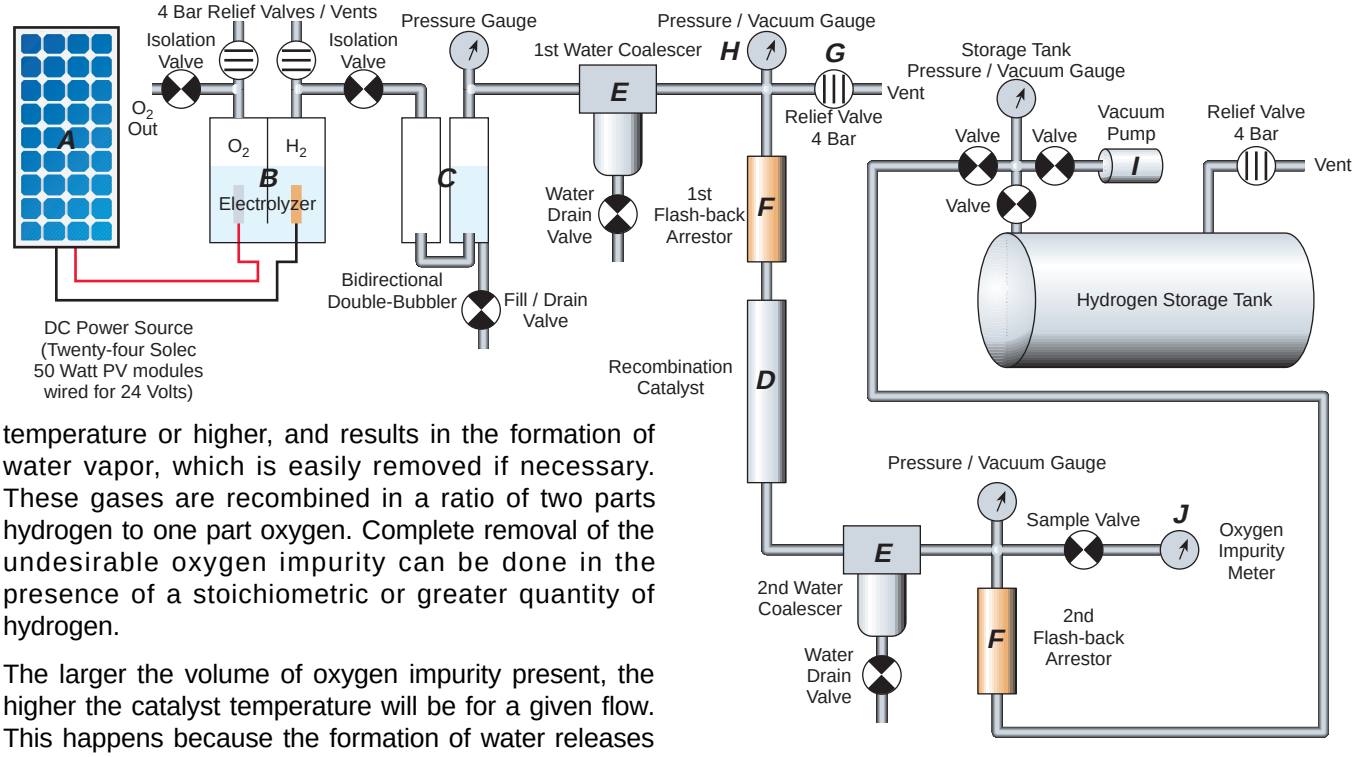
1. Scrubbers for Particulate and KOH Removal

Hydrogen gas that is contaminated by KOH/water electrolyte can be scrubbed by passing it through a water column in a Double-Bubbler™ *(C, see diagram on page 45)* to remove the KOH.

2. Catalytic Recombination Purifier to Remove O_2 Impurity

The catalytic recombination of hydrogen and contaminant oxygen is usually accomplished at room

Walt Pyle's Hydrogen Production System



temperature or higher, and results in the formation of water vapor, which is easily removed if necessary. These gases are recombined in a ratio of two parts hydrogen to one part oxygen. Complete removal of the undesirable oxygen impurity can be done in the presence of a stoichiometric or greater quantity of hydrogen.

The larger the volume of oxygen impurity present, the higher the catalyst temperature will be for a given flow. This happens because the formation of water releases heat.

Usually, the catalysts that are used for removal of the oxygen impurity from hydrogen (or vice versa) are based on platinum group metals (PGM). Thin films of PGM are supported on the surface of alumina pellets. The catalyst pellets are contained by screens in a section of pipe. The hydrogen gas flows through the pipe as it is being treated.

The catalyst will not work while wet. Care should be taken to avoid water condensation on the catalyst. If it becomes wet, simply dry it out before using. Removal of oxygen from hydrogen is called deoxygenation. Our catalytic recombiner *(D)* was designed to be capable of removing up to 3% oxygen from a hydrogen production stream, reducing the oxygen content to less than 1 ppm.

3. Polymeric Hollow-fiber Membrane Purifiers

Polymeric membranes employ the principle of selective permeation to separate gases. Each gas has a characteristic permeation rate. This rate is a function of the ability of a gas to dissolve and diffuse through a membrane. This allows "fast" gases like hydrogen to be separated from "slow" gases like oxygen. Some membrane separators use bundles of tiny hollow fibers inside a containment vessel or pipe.

During the process, a differential pressure develops across the fibers. This pressure drives the flow of the faster gas through the wall of the fiber. In this example, the faster gas is hydrogen. This results in the production of a purified hydrogen stream called the "permeate." To accomplish an efficient separation, the differential pressure must be 8 bar (100 psig) or greater. Monsanto makes this type of purifier for industrial hydrogen recovery under the Prism and Permea trademarks. At this time, they do not offer a purifier small enough to be used in a home-sized hydrogen plant.

4. Palladium-Silver Membrane Purifiers

Ultra-pure hydrogen can be obtained by diffusion through palladium alloys. Palladium is unique: it is extremely permeable to hydrogen, and it can store up to 1000 times its own volume of hydrogen! The mechanism of hydrogen diffusion through palladium alloy has six steps: adsorption, dissociation, ionization, diffusion, reassociation, and desorption. Johnson-Matthey, Inc. and Teledyne Wah-Chang manufacture membranes of this type.

Almost no hydrogen will flow through the membrane at room temperature. Operating conditions required for palladium alloy membranes include temperature of approximately 200 to 800°C (392 to 1472°F) and differential pressure across the membrane of 3 to 12 bar (44 to 180 psig).

In our renewable energy system, we did not have energy to spare for heating the purifier. In addition, our electrolyzer did not produce sufficient pressure to

Above: The relief check valve, pressure/vacuum gauge, and tops of a flash-back arrestor and coalescer.

operate a palladium membrane separator. A solar thermal source could be used to heat a palladium membrane purifier and reopen this option.

This a very attractive method for simultaneously removing water and oxygen from hydrogen. It is also the most expensive hydrogen purification option reviewed. We priced one for our 1 kW hydrogen generation plant and found a small lab-sized palladium-alloy membrane purifier for about $2000. This is the purest hydrogen gas available, 99.999999% purity. Yes, that's "8-nines." Oxygen cannot pass through the membrane, so safety is increased for hydrogen gas storage when these membranes are used for purification.

5. Hydrogen Dryers for Removing Moisture

Water contamination of hydrogen can be reduced by coalescers, refrigeration dryers, membrane dryers, molecular sieve dryers, and desiccant dryers.

Coalescers *(E)* are designed to cause combining of smaller aerosols into larger droplets, susceptible to the effects of gravity. Coalescers remove sub-micron solids and aerosols by three different mechanisms. First, particles in the range from 0.001 to 0.2 microns collide with the filter media and are subject to diffusion coalescing. Second, particles in the range of 0.2 to 2 microns are intercepted by 0.5 micron glass fibers. The efficiency of the interception mechanism increases as the pore size decreases. Third, particles 2 microns and larger are removed by direct inertial impacting, because of their larger mass and momentum. A coalescer is one of the most cost-effective water aerosol removers.

Refrigeration dryers cool the gas and dry it by condensation to a low dew point. These dryers use electric motor compressors and refrigeration fluids in a conventional Joule-Thompson expansion scheme. We did not choose a refrigeration dryer for our solar-hydrogen plant because of energy consumption, cost, and reliability concerns. Perhaps an absorption refrigerator could be applied to this process with solar thermal energy to reopen this option.

Membrane dryers utilize a hygroscopic ion exchange membrane to selectively remove water vapor from mixed gas streams. It can be thought of as a desiccant in tubular form. Tubes are bundled together inside a pipe shell so that the wet feed gas stream flows through the tubes and wets the inside walls. A counter-current dry gas stream flows on the outside of the tubes and purges water from the shell. A disadvantage of this type of dryer is that the dry purge-gas flow rate is greater than the wet product feed rate. Perma Pure Products, Inc. makes this kind of gas dryer.

Another substance used for drying gas is zeolite. Zeolites are alumino-silicate mineral particles that absorb and desorb large quantities of water reversibly. Water absorption on these so-called molecular-sieve dryers is by way of a physical rather than chemical reaction. Zeolite dryers are regenerated thermally in their piping containers by heating them up to 550°C (1000°F) while purging with a dry gas. For continuous operation, two units are used. One is drying gas while the other is regenerating. RSI, Inc. makes small molecular-sieve zeolite dryers for hydrogen. We did not select a zeolite dryer for our solar-hydrogen plant because of concerns about energy consumption for the heat regeneration cycle. A solar heated regenerator would reopen this option.

Right: A flash-back arrestor.

Desiccant dryers absorb water vapor from the gas by contact with a chemical substance like calcium chloride. One popular lab gas desiccant is called Drierite. It includes a color indicator to show when the desiccant must be regenerated. The color turns from blue to pink when water is absorbed. The desiccant is dried by heating or evacuation for recycle.

Safe H_2 Storage

You are responsible for the purity of the solar-hydrogen to be stored. Hydrogen and oxygen mixtures are not safe to store. Make sure that your gas is at least 99% pure hydrogen before storing it in a tank. Measure your hydrogen gas purity with a quality instrument to be sure it is safe.

Oxygen is the impurity of concern, so measure for it in your hydrogen on a regular basis. The strategy for safe hydrogen storage includes using 99+% pure gas, and eliminating the oxygen impurity.

Homebrew Purification System

A hydrogen purifier was constructed for our 1 kW home-scale alkaline-electrolysis hydrogen production plant. We chose a catalytic recombination process to remove the oxygen impurity. Details are shown.

A Double-Bubbler *(C)* with water columns and sparger-frit aquarium-type bubblers can provide several useful functions. It can serve as a visual flow indicator, KOH scrubber, flame arrestor, liquid back-flow preventer (for intermittent operation), upstream or downstream leak detector, and imbalance detector (requires 2 units for comparison of O_2 and H_2 production).

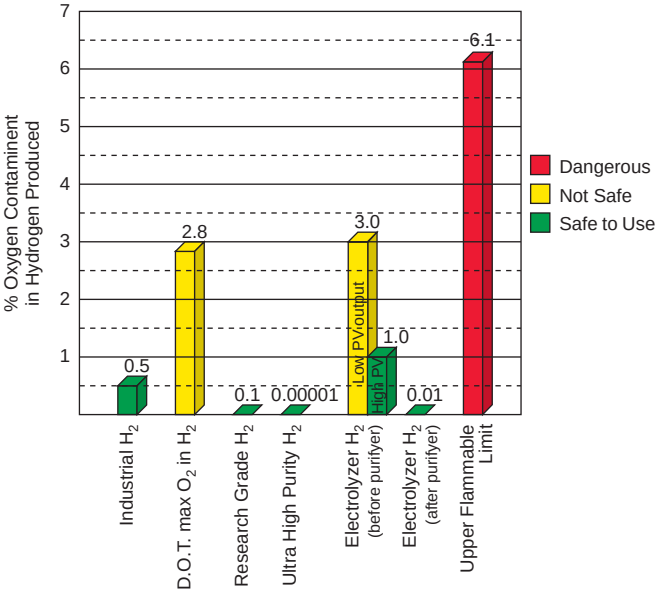
The water in the bubbler columns must be changed during regular maintenance servicing, as it becomes alkaline over time. Some operators have reported using cider vinegar instead of water for longer life between column liquid changes. A color change apparently occurs when the acidity of the vinegar is neutralized by the KOH/water aerosols. Soon, we're going to try it here to see for ourselves.

Water Coalescers and Water Drain Valves

Our coalescers *(E)* have stainless steel bodies, and bowls with replaceable filter elements inside. The coalescer filter removes rust, nickel, plastic, and dirt particles from the hydrogen gas stream. Coalescers also remove water vapor aerosols, known as fog.

The first coalescer removes bubbler aerosol. The second removes recombination-water aerosol, produced by deoxidation of the hydrogen as it passes over the catalyst beads. Our coalescer is a Finite unit manufactured by Parker Hannifin Corp. It captures water aerosols in the 0.001 to 10 micron size, using a glass micro-fiber element. We chose to use a type C filter media in the coalescers. It is compatible with hydrogen gas and can be used on the oxygen side as well.

Safety Levels of Oxygen Contamination



These coalescers are position-dependent, and must be mounted so that their water capturing bowls and drain valves face down. The coalescers require horizontal piping connections at the entrance and exit. With horizontal piping, the bowls will gravity fill with coalesced water.

Each coalescer is equipped with a small ball valve on the bottom of the bowl to allow regular draining of water captured from the hydrogen. The coalescers must NOT be allowed to fill up with water. We drain the water from the coalescers about once a week.

Flash-back Arrestors

Flash-back arrestors (FBA) *(F)* are used to isolate the purifier from other components upstream or downstream in the hydrogen system piping. An FBA will stop a flame from propagating through a pipe.

Hydrogen is flammable and easily ignited when oxygen is present. The FBA isolates flammable air and hydrogen, or oxygen and hydrogen mixtures, from any source of ignition. An open flame, spark, or hot metal surface can be a source of ignition.

A catalyst can also be a source of ignition, even at room temperature. By bracketing the catalyst with an FBA on either side, the upstream or downstream mixture will not be ignited. This is true even if there is a flammable mixture in the line due to a malfunction or mistake.

FBAs are made with a plug of fine silica sand restrained by screens in a wide section of piping. The sand

Left: The Panametrics XMO2 oxygen analyzer measures the amount of O_2 contaminant in the hydrogen.

quenches any flame-front and stops combustion. We prefer the FBAs that have an integral check valve to prevent backflow. Western Enterprises, Inc. makes an FBA appropriate for hydrogen and acetylene gas service.

Check Valve Pressure Relief
A check valve *(G)* for pressure relief is set to 4 bar (58 psig) to prevent over-pressuring the system by error. If this pressure is exceeded, the relief check valve "cracks" and hydrogen gas is released out of the vent line. When the pressure is reduced to the normal operating value (0.5 to 3.5 bar gauge), the valve closes once again. Relief valves are subject to drift over time, so check to be sure that the set pressure and the actual pressure are the same. This should be done at regular maintenance shutdowns.

Compound Pressure Gauges
We use pressure gauges *(H)* with all stainless parts to prevent corrosion failure. They are compound gauges measuring both vacuum and pressure. We use the vacuum gauge function to evacuate the system after maintenance, or before startup of the hydrogen plant. The pressure gauge monitors operation of the plant when making hydrogen gas.

De-oxo Catalytic Recombiner
Our catalyst *(D)* is packed in a stainless steel tube by the supplier and performs the key purification function: removing oxygen from the hydrogen gas stream. The catalyst tube must be placed so that the flow enters through the top and exits at the bottom. This will prevent lofting the particles in the catalyst bed and fluidizing them. Keeping the catalyst pipe vertically oriented helps to keep the flow uniform. Thus, the water formed during de-oxo purification flows towards the bottom in the same direction as the hydrogen gas. It can be removed from the purified hydrogen by the second coalescer before it reaches the second FBA.

Connecting the Purifier to the Electrolyzer
The hydrogen duct coming from the electrolyzer is first connected to the gas inlet port of the Double-Bubbler for KOH/water scrubbing. The scrubbed hydrogen gas is then fed to the purifier for oxygen removal. We used 1/4 inch stainless tubing with Swagelok fittings to connect the electrolyzer, bubbler, and purifier.

Purging the Purifier
Before starting the hydrogen plant, flush any possible flammable gas mixture out of the piping with an inert purge gas, like nitrogen or carbon dioxide.

An alternate method to remove flammable gas mixtures from the piping and other components is to use a mechanical vacuum pump *(I)*. It must be capable of producing a vacuum of at least 20 mbar (approximately 20 Torr). A vacuum cleaner will not work for this. A two-stage laboratory vane-type vacuum pump with a thermocouple pressure gauge will work well.

Compound pressure gauges are very useful, because you can see when the vacuum has reached less than 20 millibar (>29 inches Hg vacuum). It is also easy to check if the piping holds vacuum after the pump is removed. Vacuum measurement units have become more standardized in recent years. Unfortunately, many gauges are still on the market that register vacuum in inches or millimeters of Hg (mercury) below atmospheric pressure. This can be confusing to the uninitiated.

Startup of Electrolyzer and Purifier
Once the purifier is ready, we start the electrolyzer by closing the main electrical breaker to the DC power supply. Then, we wait twenty minutes or so for the float valves on the Hydrogen Wind electrolyzer to fill. Next, we close the vent valve on the electrolyzer. Pressure in the electrolyzer will begin to rise. Slowly, we open the isolation valve between the electrolyzer and the Double-Bubbler. Gas will enter the purged purifier. After the hydrogen flow through the Double-Bubbler has stabilized, we open the isolation valve all the way, and leave the valve open.

Measuring Hydrogen Purity
When production of gas is underway, we check the purity of the gas before storage. Several oxygen meters are available. We use a Panametrics XMO_2 oxygen

analyzer (*J*) that has a range of 0 to 5% oxygen. This meter has high accuracy and is reliable. A less expensive oxygen meter is available from Figaro USA. Our hydrogen has less than 0.01% oxygen after the purifier. We have used this catalytic purification system continuously for almost three years with no loss in performance.

Future Direction

We are now planning to store and use the electrolyzer's purified oxygen production for both fuel cells and a hydrogen-oxygen torch. The purifier has been operational for almost a year. Since we lack a suitable meter to measure the hydrogen contaminant in the oxygen, we still vent it to the atmosphere. Next month, our long-awaited hydrogen meter from DCH, Inc. is due to be delivered. The DCH meter is designed to measure from the ppm level to 100% hydrogen. In a future article, we will share our experience with oxygen purification and storage.

Acknowledgements

The author gratefully acknowledges the assistance of the following individuals in fabricating, testing, and documenting this system: Mark Hayes, H-Ion Solar, Inc.; Reynaldo Cortez, Shadowbox Construction Co.; Don Mackinder, H-Ion Solar, Inc.; Larry T. Pyle, Pyle Manufacturing Consulting; and Pat and Angello Scipi, A & K Machine.

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Web: www.hionsolar.com

Safety Information:
Air Products and Chemicals, Inc., "Safetygram 4" on Gaseous Hydrogen • 610-481-4911

Alkaline Electrolyzer:
Hydrogen Wind Inc., RR2 Box 262, Lineville, IA 50147 515-876-5665

Catalyst Suppliers:
Resource Systems Inc., Six Merry Lane, East Hanover, NJ 07936 • 973-884-0650 • Fax: 973-515-3166

GPT, Inc. • 732-446-2400 • Fax: 732-446-2402

Coalescer:
A.F. Equipment Co., Inc., 1273 Forgewood Ave., Sunnyvale, CA 94089-2216 • 408-734-2525

Parker Hannifin Corp., 17325 Euclid Ave., Cleveland, OH 44112 • 800-506-4261 • 216-531-3000

Complete Purifier System (Model PT-4) and Double-Bubbler (Model DB-3):
H-Ion Solar, Inc., see Walt Pyle above.

Flash-back Arrestor
(Western Enterprises Model FCV-3A):
Atlas Welding Co., 1224 6th Street, Berkeley, CA 94710 510-524-5117 • Fax: 510-524-9098

Hydrogen Membrane Dryer:
Perma Pure Products, Inc. • 732-244-8140

Palladium-alloy Membrane:
Johnson Matthey, Inc. • 44-1763-253306 (Great Britain) 610-971-3100 (USA)

Teledyne-Wah Chang, Inc. • 541-967-6904

Polymeric Membrane:
Permea, Inc. • 800-635-8842

Pressure Gauge:
Fluid Gauge Co., P.O. Box 881833 San Francisco, CA 94188 • 415-285-0648

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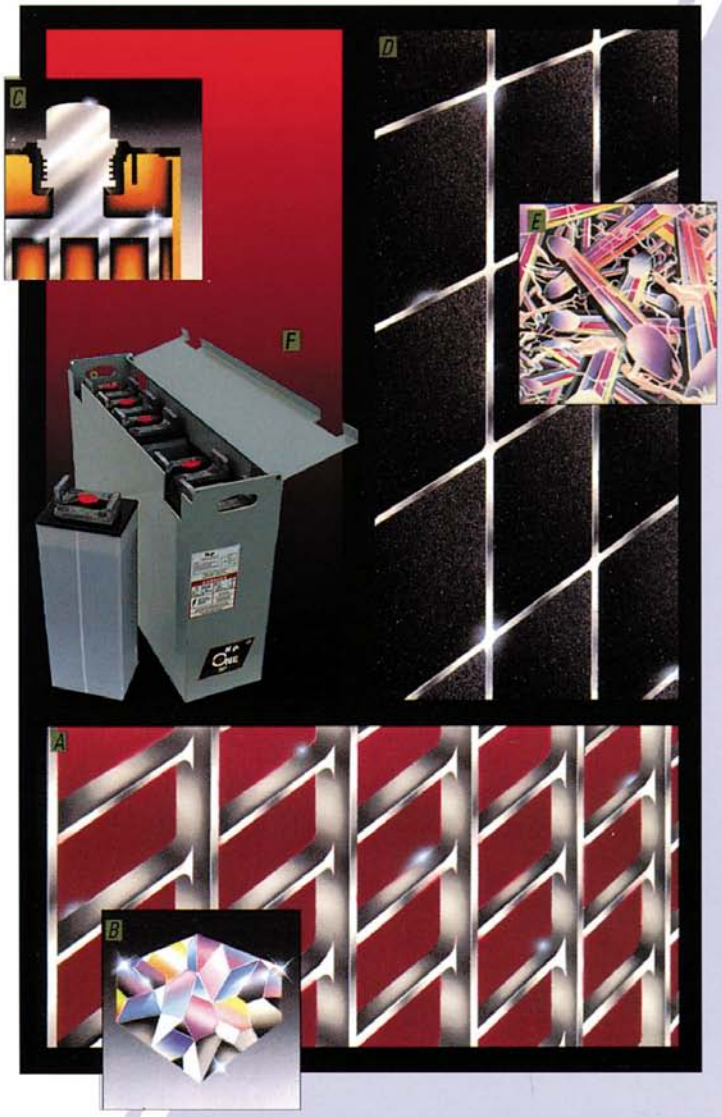

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Tehachapi Wind Fair '98

Above: A Zond 750 kw cutaway "bird" was trucked in for display.

On July 18th and 19th, well over 15,000 people attended the 1998 Tehachapi Wind Fair and International Music Festival. Folks came from nearby and from as far away as Africa to view the latest in wind power technology, solar energy technologies, and just to have a great time. If you didn't attend this unique energy fair, here's what you missed.

An RE Fair Specializing in Wind Power

I have always been fascinated with wind power. Wind power has a romance which PV lacks. Wind power is dynamic—you can easily see that energy is being converted by the wind turbine. PVs just sit there and smile at the sun.

When we were invited to this fair, we at *Home Power* were delighted at the chance to view big wind gennys up close. While we expected Big Wind, we were amazed at the variety of RE resources on display. We saw everything from utility scale solar thermal electric to electric transportation.

Getting There

Michael Welch, Karen, and I piled into a renta-van and drove the some 600 miles from Agate Flat, Oregon to Tehachapi, California. Don Kulha arrived under his own power and was there early to facilitate setting up the *Home Power* booth. As we crested the ridge of the mountains enclosing the Tehachapi valley, we instantly spotted the wind farm on the distant east ridges. Thousands of huge wind gennys were pumping out the watts! We couldn't wait to get up close and personal with these behemoths.

Driving into Tehachapi, we saw a wonderful picture of small-town America. This town of about 4,000 people plays a major role in wind power. Many locals make their living either at the utility scale wind farms or in the nearby Zond Energy Systems factory, manufacturing utility sized wind turbines.

Friday night, we checked into the motel. From our second story window, we were again treated to the sight of thousands of wind gennys dotting the Tehachapi Mountain ridges some ten miles east. The sight was fascinating. Karen and I were continually at the window watching the dance of these wind giants. The last thing we did at night was to look and see if they were all still turning—and again, first thing in the morning. The motel room was equipped with a TV, but

we found the view from the window far more fascinating. We became turbine watchers. They commanded our attention all throughout the weekend. Only for half an hour, early on Monday morning, did I view them not in motion.

Saturday Morning—Fair Time!

We really didn't know what to expect at this fair. We arrived early Saturday morning at Tehachapi City Park and began setting up our booth. By nine AM, fairgoers began to arrive. We met *Home Power* readers, solar bozos, wind weenies, and even a few hydro maniacs. These are our kind of folks! Before the day was over, everyone in the booth was hoarse from talking RE with hundreds of fairgoers.

I snuck off and visited most of the booths displaying RE technologies. On my sojourn around the fair, I met many RE people for the first time. Michael Bergey was there showing off his 10 kW Excel. I've always considered the Excel to be a big wind genny, but displayed alongside the 750 kW Zond turbine, the Excel seems tiny. Such is the magnitude of Big Wind!

We met Marianne Walpert of Pacific Solar. This lady does it all—utility-intertied PV systems from design to installation. We saw many old friends such as Don and Cynthia Loweburg from Offline Energy Systems. We met Josh and Kaia Tickell of Veggie Van fame—they were there sponsored by Green Mountain Energy Resources, complete with their vegetable oil-powered RV. We met with our old friends Phil and Richard Jergenson who helped to organize the fair. They were also there displaying their QuikStix building system. All in all, the exhibitors were an eclectic mix of solar and wind, from big to small. Even Southern California Edison was there, displaying an electric Toyota RAV vehicle.

Above: Salvaged nose cones make playground equipment at the city park.

The Las Vegas Electric Vehicle club attended in force with several electric street machines on display. Clark Beasley was there conducting Electrathon races around the fairgrounds. Electric bicycles zipped and zapped around the wonderfully green city park. At this fair, there was little doubt about the future of transportation—it's going electric!

All over town, multi-colored flags led folks to the fair. Even the barricades preventing vehicles from entering the grounds were huge wind generator blades placed across the city's streets. The kiddie slides and other fun kid-type things were made from the blades and nose cones of the huge wind gennys. Chicago may be known as the Windy City, but Tehachapi is really Wind Town, USA. Even the vegetation in downtown Tehachapi shows significant "flagging," i.e., deformation by the wind.

Below: Kaia Tickell at the Veggie Van booth.

Fun at the Fair
Workshops are the heart of any energy fair. This is where folks really learn how to use renewable energy in their own lives. The Tehachapi folks put major effort into the workshops and it really showed. No matter what your RE interest, there was a workshop for you—all presented by experts in their particular fields. It was impossible to attend them all.

If sitting through a workshop didn't appeal to you, then you could have enjoyed a bus tour of the local wind farm, a glider ride at the Mountain Valley Airport, or a bus tour of the Tehachapi Railroad Loop or local botanical gardens. Live music of all flavors flowed from the three music tents. Great munchies, even Ostrich burgers, were served at the many food booths.

The Science Tent was another exciting area of the fair. Inside, one could find interactive science projects and kiddie cars for smaller folks, as well as human-powered pedal generators, and the renewables history kiosk. Phil and Richard Jergenson did a great job organizing this area.

From Large to Small
Although we home power types focus on very small scale RE systems, both large and small were on display at the Tehachapi Wind Fair. The KJC Company showed off their solar thermal electric generators. These huge line parabolics have been up and running for over 12 years, making over 354 megawatts of power in the Mojave Desert—enough to run over 350,000 homes. These mega parabolics were displayed side by side with the same PV modules most of us already know and love.

Enron Wind Corporation had one of the most interesting exhibits. They brought one of their new Zond Z-750 wind machines mounted on a flatbed trailer. It is the size of a small RV and featured a cutaway nacelle (the generator's shroud) and transparent covers over the blade mount holes on the nose cone. Fairgoers could walk around the machine, while seeing and understanding the many different parts. Zond rigged up a moving, hydraulic-controlled blade feathering mechanism to make everything look workable.

Perhaps my most vivid memories of this fair are of the contrast between the small and the huge RE systems. I came away with a renewed appreciation of utility scale RE projects. After all, many of us are on-grid—if you are going to rent electricity from a power company, then it should come from RE resources such as wind and solar. Recent utility deregulation makes this choice possible. See Michael Welch's article on buying RE on-grid on page 64 of this issue.

Above: The Tehachapi Wind Fair crew worked hard, and it showed.

The People Behind the Tehachapi Wind Fair
Energy fairs happen because a group of people decides to put out the enormous efforts required to make them happen. This year's fair in Tehachapi was a success because local energy activists did this work. Kudos to Linda White, Executive Director of the Kern Wind Energy Association, Duana Pera, Tehachapi Wind Fair organizer, Carol Lawhon, Tehachapi Chamber of Commerce, Debbie Hand, Mountain Music and facilitator of the International Music Festival. Thanks to Jon Powers, the Jergenson brothers, Harvey Stevens and cohorts of KJC, Suki and Philip Crandell, and the many, many volunteers! You folks did a bang-up job!

We had a great time!
Perhaps the greatest compliment that can be paid to any event is to return to do it again. The HP Crew had so much fun that there is no way you'll keep us from the next Tehachapi Wind Fair in the year 2000. The situation and the theme of this fair is unique. If you weren't there this year, you really missed something special. We'll see you in Tehachapi for the next one!

Access
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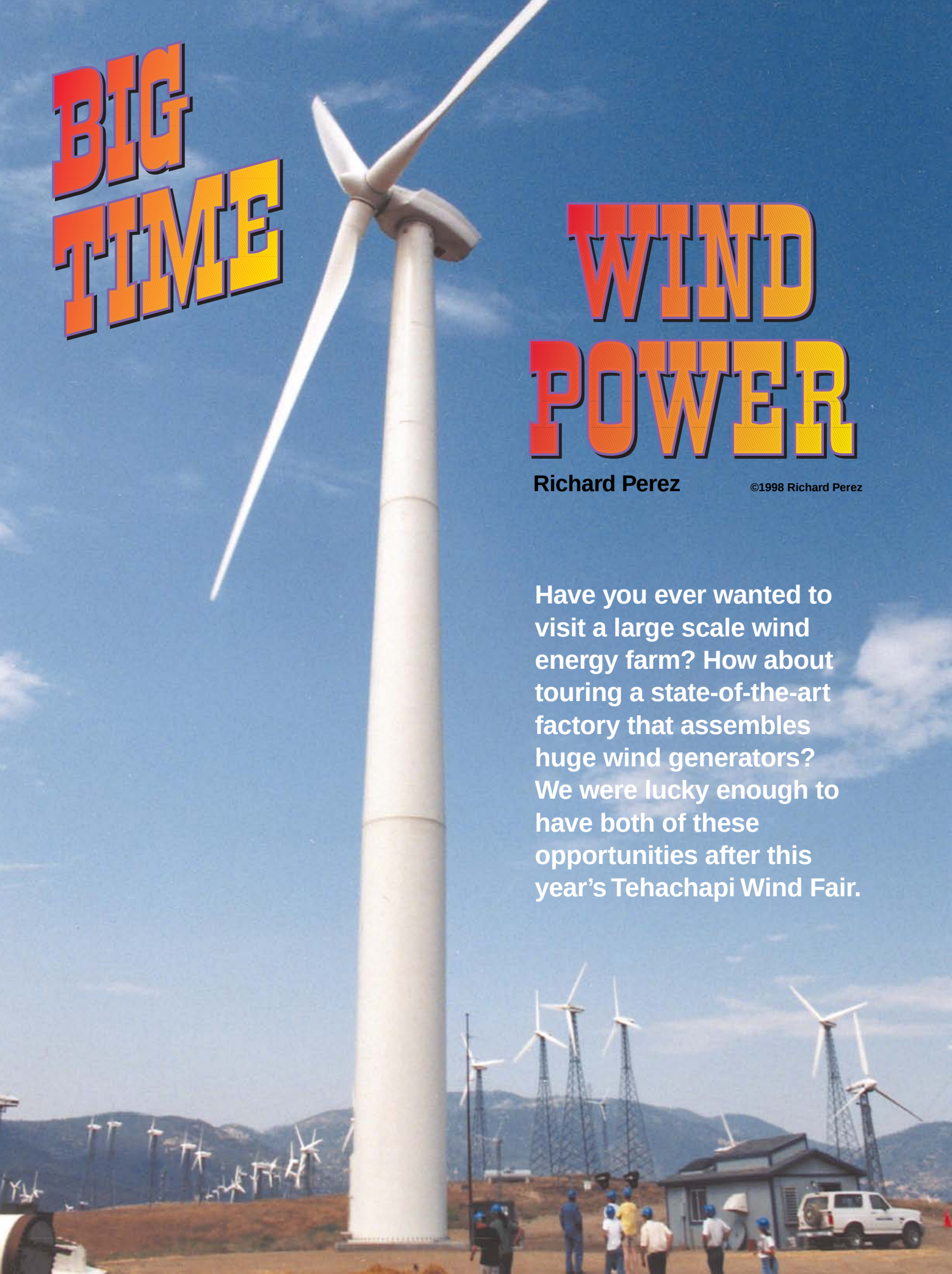
BIG TIME WIND POWER

Richard Perez

Have you ever wanted to visit a large scale wind energy farm? How about touring a state-of-the-art factory that assembles huge wind generators? We were lucky enough to have both of these opportunities after this year's Tehachapi Wind Fair.



Early Monday morning after the Wind Fair, a dozen of us met up with Linda White, Executive Director of the Kern Wind Energy Association. She gave us a tour of the wind farms placed on the east ridges of the Tehachapi Mountains. We also got to visit the plant where Zond Energy Systems assembles their monster 750 kW wind turbines. I was so excited about climbing one of the big towers that I was barely able to sleep the night before.

Safety First!

Before we were able to tour the wind farm, we were instructed in the required safety rules and issued hard hats. Those of us climbing towers were given a lesson in tower safety and also issued climbing harnesses. I was impressed by their commitment to safety. Also, not all dangers present were from the wind behemoths or from the high towers. It was rattlesnake season, and we all had to be on our toes.

We drove up the mountain, passing just a few of the 4,940 wind generators which populate these ridges. I'd spent all weekend admiring these wind giants from a distance. Viewing them up close and personal was an entirely new thrill. The biggest of these wind machines (the Z-50) has a 50 meter (164 feet) diameter rotor. Its center is atop a 65 meter (213 foot) tower. Overall, the machine is 90 meters tall (almost 300 feet). Even with these numbers, it doesn't begin to describe the experience of standing under one of the huge machines while it is operating. I was amazed at the low noise levels, as the blades whooshed around some 32 times a minute. The sight was mesmerizing—we just stood there and stared.

Above: A Vestas on a 140 foot tower. This one is just like the one I gathered the courage to climb.

Below: Going up! A climber's view of the Vestas' underbelly. This machine is rated at 225 kilowatts at a 25 mph wind speed.

Wind Farm Details

The wind farms on this ridge are operated by companies such as SeaWest, Enron, Oak Creek Energy, Cannon, CalWind Resources, Enron Wind Corp., FORAS, MHI, and others who sell the wind-made electricity to utilities like Southern California Edison. The wind farms around Tehachapi generate some 1.4 billion kilowatt-hours of electricity yearly—enough to power over 250,000 homes. The average price these wind farmers receive is 5 cents per kilowatt-hour.

Wind farms are an ecologically sound way of making electricity. They offset the production of over seven million pounds of sulfur dioxide, nitrogen oxides, and

Above: Just a few of the almost 5,000 wind gennys in the Tehachapi Mountains.

particulates. These pollutants would have been produced if the same amount of energy was made by burning natural gas. Wind farms displace the production of over 1.1 billion pounds of greenhouse gasses yearly. I don't even want to think about the pollution that would have been caused by burning coal and nuclear fuels....

Wind farms are constantly changing. Old, smaller turbines are being replaced with newer and bigger ones. Constant maintenance was going on all around us. The wind farms are a major source of income for the folks in Tehachapi. Hundreds of them work at maintaining and upgrading existing machines or making new gennys. That's one more advantage of renewable energy. It's locally produced and provides many local jobs.

Below: Scott Winneguth at the Zond factory shows us how they build wiring harnesses for their controllers.

Climbing the Big Tower

The newest and biggest of the turbines are climbed from inside an enclosed tower tube. We climbed one of the smaller, exposed towers holding a Vestas turbine. Even though this tower was shorter than some, climbing the 140 feet was a scary undertaking. I clipped my body harness into the safety cable and began my ascent. Now, I'm a lard-butted, 53 year-old office worker. While I've climbed both towers and rocks much taller than this one, it's been a long while. I had to stop four times on the way up to catch my breath at this elevation, which was over 5,000 feet.

Once safely secured to the work platform at the top of the tower, I took some of the photos you see here. Richard Jergenson of QuikStix began climbing once I had reached the top. Together, we shared the view. If these wind farms are awesome sights from the ground, they are twice as impressive when viewed from atop a tower. From this vantage point, I was able to view these wind giants at eye level. I saw many more wind generators populating the distant ridges. Almost all of them were spinning and pumping electricity into the grid. The tower under me swayed gently as the wind gusted. I was slack-jawed with amazement and misty eyed with appreciation. These folks are doing wonderful, important, and effective work! I descended to give Josh Tickell of Veggie Van fame a chance to do the climb. If you'd like to read an excellent account of Josh's wind tower climbing experience, check out www.veggievan.org/day17.html using your web browser.

I want to thank the wind folks in Tehachapi. Climbing that wind generator tower was an experience that I will never forget.

Visiting the Zond Factory

After climbing the big tower, I followed the crew, on wobbly rubber legs, to our next destination. Our mission: a tour through the Zond Energy Systems factory. A long-time operator and recent manufacturer of big wind machines, Zond was purchased by Enron in 1997. They created Enron Wind Corporation, a major player in the big wind market. Enron Wind Corp. has built over 3,400 turbines, with a total capacity of over 700 megawatts. Their plant in Tehachapi assembles the new Z-750 series turbines which have a maximum output of 750,000 watts. The current trend in commercial wind power is towards the bigger, more efficient, lower cost turbines. Let's take a look at Zond's new state-of-the-art turbine.

Above: The heart and soul of the Zond machine, its integrated gearbox.

The Z-750 series turbines are not only huge, but are also very cost effective. When we asked about the price, Scott Winneguth, Manager of Manufacturing, told us, "A buck a watt, installed!" While $750,000 sounds like a fair chunk of change to us home power types, this is inexpensive by big wind standards. That's why Enron is selling these turbines as fast as they can be made. Technically, the Z series has much in common with the smaller turbines we use in home power service. They generate variable ac (nominally at 468 vac) which is converted by a huge 750 kW inverter into synchronous 60 Hz ac for the grid. Oddly enough, these big inverters are made by a division of Trace Engineering, a company familiar to most *HP* readers.

Below: The tower-top collar and the servos that control yaw.

The Z series are variable speed, three-blade upwind turbines. Unlike most upwind machines, they have no tails. They are pointed into the wind with electric motors and planetary gear drives. Both turbine yaw (side to side motion) and blade pitch are electrically and hydraulically computer controlled. These turbines begin operating at wind speeds of 3 meters per second (6.7 miles per hour), and reach maximum output at 11.2 meters per second (25 miles per hour).

As we followed the assembly line, I was struck by the attention to detail evident everywhere in the manufacturing process. Every component is thoroughly tested before and after it is installed in the turbine. Scott told us that it's easier and cheaper to fix any problems *before* it goes into the air.

Above: Zond's circuit boards are built in-house.

Right: The factory floor full of the clean wind energy of the future.

Zond makes their own electronic controls. We visited the assembly room where workers were soldering components onto circuit boards. From there, they tested the assembled boards. This type of detail is probably why the Zond machines have a design life of thirty years.

Outside the factory, we saw dozens of the big wind gennys ready for shipping to wind farms all over the world. Over 300 megawatts of these turbines are being shipped to Iowa and Minnesota, where they will populate some of the biggest wind farms anywhere.

The utilities are the only thing delaying the Big Wind explosion. If the utilities and providers buy more wind power, then we will see wind farms going up everywhere. It's up to us, the consumers of electricity. When we demand renewable energy, then they will supply it. The truth is that if even a small fraction of America's wind sites were developed, then we wouldn't need any fossil fuel or nuclear power plants. The times are indeed changing, and the Big Wind folks at Tehachapi are on the cutting edge of that change.

The Road Home...

As we cruised up Interstate 5 on our way home, I looked at the high voltage power lines beside the freeway with a new perspective. How much of the energy they carry was made by wind power? If the folks at Enron have their way, it will be more and more with each passing year. While I love being off-grid and have a profound respect for our little wind genny, I must admit that the Big Wind folks in Tehachapi are on to something. If I was stuck on grid, I'd be buying my electricity from wind farms such as those in Tehachapi. See Michael Welch's article on buying wind power on page 64 of this issue.

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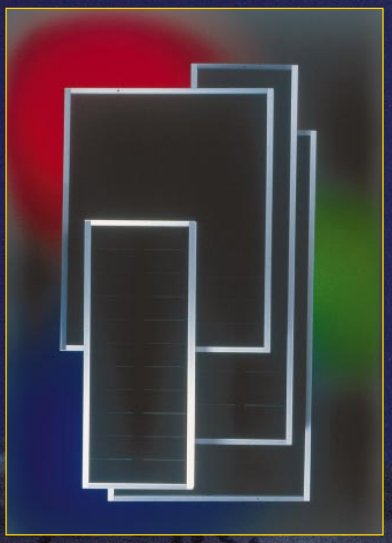

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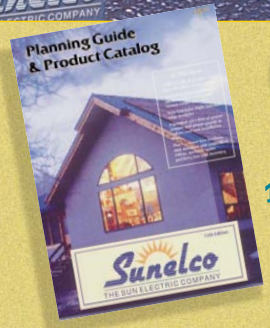

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Buying Big

Michael Welch

So, you live on the grid. You want to use renewable energy but aren't ready to purchase your own system. Although *Home Power Magazine* is about making your own electricity, we understand the circumstances that delay this for many of you. We encourage you to take steps as soon as possible that will help create the renewable energy future.

Obviously, it is important to decrease your consumption wherever possible. We have written many articles on this, and won't go into it here. This article details how you can use wind resources that are on-grid, or that will be in the near future.

Big Wind is the One

Some of the *HP* crew attended the Tehachapi Wind Fair, where we saw firsthand the growing use of our nation's vast wind supply. We were very impressed. Wind is probably our best resource for utility scale RE. Practically speaking, PV is cost-prohibitive on a utility scale. Using solar thermal for electricity is only somewhat cheaper. Biomass is not yet available in a large enough quantity. Large-scale hydro is cheap enough, but too destructive to our dwindling wild waterways and their ecosystems.

Restructuring

Electric industry restructuring (deregulation) is making it possible for consumers to choose supplier and resource. If you don't like what your utility is doing, or don't like its energy choice, then all you have to do is choose another one. We'd like you to choose big wind.

Restructuring will happen soon in most states. In the near future, it will probably also happen on a Federal level. For now, California is the only state with full implementation of restructuring, so we will use it as an example.

Nearly every California utility has some wind power contracts in its energy mix. However, when you choose a utility that sells some of their mix as green power, it only makes the power *less* green for the rest of the customers. Looking at the big picture, you might as well have done nothing. This would have been cheaper for you anyway, since utilities charge a premium for their green programs.

Wind Stats

Utility scale wind power is becoming increasingly prevalent in the USA. The American Wind Energy Association says that Texas winds alone could provide all of our nation's energy needs. In California, there are more than 12,000 commercial wind machines, ranging in size from 50 kilowatt (kW) to 1 megawatt (MW). The installed base of California machines is approximately 1579 MW. In the entire USA, it is 1780 MW. In 1997, the combined output was 3.5 billion kWh, enough to power 353,000 homes.

Of the nation's commercial wind contracts, most go into the power mix of the utilities. That leaves little available for resale to green energy providers. It doesn't much matter which consumers in the state it gets sold to—it's available anywhere deregulation laws allow it. California now, Pennsylvania shortly, and your state soon.

How Much Does It Cost?

Expect to pay 10 to 20% more for wind power or other RE sources. Keep in mind that these are energy costs only. They do not include the transmission costs that deregulated utilities bill for separately.

The cost of producing power varies widely, whether it is made conventionally or with renewable sources. Wind power falls somewhere in the middle of the range. Because utility bills are based on conventional power,

wind power, by comparison, will seem more expensive. In addition, many conventional sources also have significant subsidies that bring their cost down closer to average. Of course, we pay for these with our taxes. Unfortunately, that won't change based on choosing a renewable supplier. The new Zond 750 kW generators have an installed cost of $1 per watt. See page 56 for the article, "Big Time Wind Power."

Who Can Sell You Big Wind Power?

Here's the rub—most green energy providers offer a mix of renewables. This may be the only current way to get our hands on wind power, short of forming our own purchasing co-op or municipal utility. Either of these entities can contract with wind farms for specific amounts of power. They can also install their own wind turbines. For further information about forming municipal utilities and co-ops, contact me at your convenience.

At this time, there are no companies that can sell a residential customer 100% wind energy. Green Mountain Energy Resources has renewable energy programs that can contain wind power (approximately 10% of the mix). Their "Wind for the Future" program promises to buy a new Micon 700 kW wind genny for every 3,800 people who sign up. They have just contracted for three of these wind machines to be installed at Pacifiwest Wind Farm 1 in the California desert near Palm Springs. Both Redwood Alliance and I highly recommend this option (see *HP65*, page 86). Some other residential power retailers also have wind in their mix.

Commercial customers are a different story. Many electricity resellers who aren't interested in the residential markets compete to get these larger accounts, as they are much easier to service. Patagonia, Inc., a large, environmentally responsible outdoor clothing company, has contracted directly with Enron Wind Corporation for 100% of Patagonia's power. This amounts to approximately 1 million kWh of wind electricity annually. All that power will come from Enron's planned 16 MW wind farm, near Palm Springs. That farm has a lot more power than Patagonia can use, but Enron doesn't know yet what they will be doing with the excess. My hope is that some of it will find its way into residential markets.

Green energy providers are closely watching and testing both the residential and commercial power markets. Some believe that 100% wind is a possibility for the residential market if there is enough of a demand. However, the green energy market and its root cause, deregulation, are very new. Because of this, it will take a while for these fringe markets to be explored.

I like making predictions, and sometimes I am right. My guess is that by the fall of 1999, residential customers will be able to sign up for 100% wind at about 15% greater cost than a more standard green energy mix. This standard green energy mix will cost about 10% more than brown power.

The Doldrums

Where will your electricity come from when the wind doesn't blow? Most green energy providers purchase power from other sources for these times. If you are lucky enough, your green provider will have found a way to avoid "system power" because it almost always contains fossil fuel, nuclear, and megahydro. System power contains the leftovers from state generation facilities. In other words, power that hasn't already been contracted. Using system power for those no-wind times is forgivable, at least for now, while resellers are learning the ropes on managing their sources.

Conclusion

A growing percentage of the population can now buy renewable energy. You can too, even if you can't take the financial plunge into owning your own system. Over time, an increasing number of renewable resources will

become available to us. Every state will have some form of electricity restructuring that will allow its citizens to choose a supplier. Sometime next year, 100% wind power will be available for your home.

Access

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Microhydro is the most reliable and cost effective small-scale renewable energy source for charging batteries. It has drawbacks, however—microhydro is the least charismatic of the renewables. Cleaning the intake to the penstock, especially during fall leaf drop and spring runoff, can be a pain in the neck. Frequent rebuilding of alternators to replace brushes and slip rings that run non-stop is a less-than-wonderful part of the microhydro experience. ES&D's new brushless, permanent magnet (PM) field alternator is a new, exciting, and welcome product for the microhydro user. It should eliminate alternator maintenance for a long time. Now, if they could just build something to clean that darn intake….

A Quick Hydro History

Using falling water to do work has been around for a long time. How long? Since before Christ was a carpenter, before Buddha was a baby, before Mohammed knew his mom, before….well, you get the picture.

Making electricity from falling water, called hydroelectricity, has been around since the turn of the century. Since that time, there have been many improvements in both the wheels that convert the falling water to a rotary motion, called runners, and in the generators themselves. Most of the generator and runner design work was done long ago. Current manufacturers of microhydro equipment have built on what was already available, adding relatively minor improvements. Hydro system designers need to match the runner correctly to the hydro site and the alternator to the battery system voltage.

Hydro Primer

Every renewable energy site is unique, whether it's for photovoltaic, wind, or hydro. Within the scope of renewables, hydro is the most site specific. You probably can't make the hill any higher, or the water flow any more. In order to assess the site for small hydroelectric capability, there are four questions that need to be answered.

1. What is the head (vertical fall), from intake to hydro plant placement?

2. How many gallons of water per minute (gpm) will you be able to devote to hydro power? Keep in mind that water flow will vary from winter to summer.

3. What is the length, size, and type of pipe from the intake to the hydro plant?

4. What is the distance from the hydro plant site to the batteries?

The ES&D Stream Engine

The Turgo Runner

The Stream Engine is designed to operate over a very wide range of heads and water flows. The ES&D machine uses a Turgo runner to achieve this. The Turgo is a vertically shafted turbine-type runner with the nozzles pointed downward at a 20° angle from horizontal. The great advantage of this type of runner is its ability to digest a lot of water efficiently. This can give us the ability to use more water during peak winter flows. Depending on the head and number of nozzles, up to 300 gpm (1160 liters per minute) can be utilized. Quite an accomplishment for a wheel with a 4.5 inch pitch diameter!

Above: The underside of the Turgo turbine.

The PM Field Alternator

The ES&D alternator uses sixteen strong magnets embedded in a top plate which is spun by the runner. The twelve stator windings are stationary. Electricity is generated by passing the spinning magnets over the stator windings. The output is determined by the right mixture of rpm, configuration of the stator windings, and the distance between the magnetic field and the stator.

The field to stator distance is adjusted by a bolt within a bolt arrangement, which lowers or raises the spinning magnets. The stator windings can be configured into parallel, series, Delta or Wye wiring. The windings terminate on three studs for easy reconfiguration. The studs are before the rectifier, so it's easy to take the output as a higher voltage three phase ac for long transmission lines. This may be a little confusing, but either the manufacturer or your system designer will provide the machine with the right configuration for your site.

The beauty of this alternator is in its high efficiency and lack of moving parts. Since no electricity is required to energize the field, every watt generated goes towards output. The three ball type #6203 bearings supporting the shaft should last for years. They should be available from all bearing distributors. The machine can be disassembled for bearing replacement in about 15 minutes on a workbench. A bearing press and properly sized mandrel are suggested for removing and replacing the bearings. Any machine shop can do this very quickly.

New Nozzles

Older Stream Engines had the nozzles threaded into the bottom of the 1 1/2 inch nozzle holders. The new nozzle incorporates both the nozzle and the nozzle holder into one molded plastic piece. The new nozzles attach to the housing with four stainless steel Allen-headed screws. An Allen wrench is provided.

The new nozzle tapers all the way down to a 2 mm orifice. To get the right orifice diameter for your site, cut the nozzle back with a hacksaw. There are graduated lines and markings on the nozzle to use as a guide. The cool thing about this arrangement is that the end user can create virtually any nozzle size from 1/8 to 1 inch (3 to 25 mm). Wring the last watt from that water source!

Documentation

The Stream Engine owner's manual is a wealth of information on hydro siting, pipe friction loss, nozzle flow charts, and overall system design. Unfortunately, there are no page numbers and no index. This makes it very hard to find specific information. Still, all of the information you need for a successful set-up is in there—somewhere.

Test Site

The Stream Engine was installed on Camp Creek in Northern California. Camp Creek is a gradually falling watercourse that can range from 20 cubic feet per second during winter runoffs to drying up in the late summer or fall. The total head is 31 feet. The penstock is about 900 feet long. From the top, the pipe consists of 6, 5, and 4 inch PVC. The 4 inch PVC branches to two 3 inch PVC full flow valves. The outlet of each valve is reduced to a 2 inch insert adaptor. Each adaptor is then connected to a 2 inch flexible rubber hose. Each hose is hooked up to a bell reducer, which decreases the diameter of 2 inches even further to 1 1/2. The two bell reducers are connected to the two nozzle holders. From there, it feeds into the hydroplant.

Warts

I'd like to see the nozzle mounting flange a little wider for easier access to the mounting screws. As it is now, almost all of the plumbing needs to come off before a nozzle can be changed.

Above: The Stream Engine at work in Camp Creek.

The metal plate that covers the box containing the stator winding studs, rectifier, and output wire terminals is far from waterproof. Something with a gasket would be welcome.

As with all permanent magnet motor/generators or alternators, the maximum output is limited by the strength of the magnets. The ES&D machine uses very

Energy Systems & Design Stream Engine Test Data

Volts DC	Amps DC	Actual Watts	Theoretical Watts	% Efficiency	Net Head in Feet	Number of Nozzles	Nozzle Size	Gallons per Minute
28.0	11.6	324.8	560.4	58.0%	22	2	7/8"	135
28.0	7.6	212.8	358.1	59.4%	26	1	7/8"	73
28.0	2.7	75.6	141.5	53.4%	30	1	1/2"	25
26.4	3.4	89.8	141.5	63.4%	30	1	1/2"	25

strong magnets but still maxes out at about 850 Watts. This is more power than most watercourses can produce. For those with greater potential, the standard electrically charged field alternator will go nearly twice as high. This is not really a wart; it's just a fact until someone invents stronger magnets.

Operation

Turn the water on. Aside from adjusting the air gap between the magnets and the stator, that's about it. Unlike a regular alternator, there is no need for a diode between the battery and the field windings. Should the alternator stop due to nozzle clogging, the output will just fall off to nothing. There is no chance of the field staying energized and actually discharging the battery.

Adjusting the air gap is a trial and error operation. It involves stopping the machine, holding the rotor with the provided pin, and loosening or tightening the bolt-within-a-bolt. This moves the rotor closer or further away from the stator. It's a case of making an adjustment, spinning the machine up, letting the water flow stabilize, and observing the ammeter. It may take a few tries, but once you find the maximum output setting, it will not vary unless you change nozzles.

Conclusions

This is a very cool machine. It represents a major breakthrough in microhydro design. The probability of going four or five years between maintenance shutdowns is a BIG advantage. Over most of its power curve, it will outperform a standard alternator by 15-30%.

During peak flows at my hydro site, I got 280 W from a Turgo driven alternator fitted with a specially wound stator for low head. With the new ES&D PM field Stream Engine, output increased to 325 W. That's a 15% increase at a less than optimum hydro site. Can I find a use for those extra watts? You betcha!

Access

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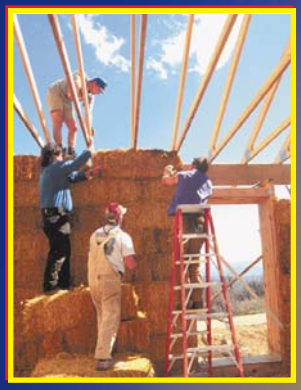

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Things That Work

Tested by Home Power

Brand Electronics'

Digital Power Meter

Tested by Richard Perez

This instrument makes accurately measuring the power and energy consumption of 117 vac appliances a snap! It's easy to use with "plug and play" connections, simple programming, and best of all, it's accurate and inexpensive.

The Brand Model 04-1850 Digital Power Meter

This instrument lives in a black plastic box, 2.5 inches high by 5 inches wide by 6 inches deep. It has a heavy plug and cord which is inserted into any 117 vac receptacle (wall socket). The appliance under measurement is plugged into the female 117 vac receptacle on the meter's back. Using this meter is very simple. Plug the meter into a 117 vac source, then plug the appliance into the meter. That's all, measurement begins automatically.

Brand Electronics calls this instrument a power meter, but it's really a power (watt) meter, an energy (watt-hour) meter, an energy cost monitor, and an elapsed time meter. The Brand Power Meter measures power in watts, energy in kilowatt-hours, and elapsed time in hours. The user can program the meter with their energy cost in cents per kilowatt-hour, and the meter will calculate the cost to run an appliance in both elapsed time mode and estimated monthly cost mode. Using and programming the meter is accomplished by four push buttons. Information is displayed by a 16-character alphanumeric LCD.

There is a lot going on inside this meter. A single chip microprocessor accurately measures voltage and current four thousand times per second (4 kHz). The microprocessor then takes this fine grained data and computes wattage, energy, and energy cost—all very slick and very fast. Since this meter is digitally based, it will accurately measure under any power factor and any ac waveform. This ability makes the Brand the only meter we know of capable of accurately measuring energy produced by modified sine wave and square wave inverters. The Brand meter automatically recalibrates itself every time it's plugged in or every time you push the reset button.

Brand Power Meter Specifications

Power Range	1 to 1850 watts
Power Resolution	2 watts
Power Accuracy	±2% of reading, ±2 in the least significant digit
Energy Range	1 watt-hour to 9999 kilowatt-hours
Energy Resolution	1 watt-hour
Energy Accuracy	±2% of reading, ±2 in the least significant digit
Power Supply Voltage	70 to 150 vac rms
Power Waveform	any (sine, mod sine, square, or triangle waveforms)
Power Frequency	3 to 100 Hz

Using the Brand Power Meter

I began testing the Brand meter in March of 1998 and have been using it for six months now. I started small, measuring the energy consumption of some of our office equipment such as fax machines, monitors, and computers. The instrument was so easy to use that I branched out into appliances I had never really measured before. The reason for this was the intermittent nature of the appliance's power

consumption. I measured the energy consumption of our washing machine, deep well pump, and home entertainment center. Since this meter is a recording watt-hour meter, it is ideally suited to measure the energy consumption of automatic appliances such as refrigerators, freezers, washing machine, air conditioners, and such—any appliance which automatically turns itself on or off. I became a Measurement Maniac. This meter is so easy to use, that I began measuring everything in the house and the office! And I got accurate, long-term data as a reward for very little effort on my part.

We've always known that our 117 vac entertainment center was a phantom load, so we use a switched plug strip to fully shut it off. But the Brand meter quantified these phantom loads—our Kenwood stereo, JVC VCR, and Sony 19 inch TV consume 23 watts when off. The switched plug strip on this entertainment center saves us about 460 watt-hours per day—the rough equivalent of the daily energy production of two PV modules.

Essential Solar Tool

Every RE system begins with a load analysis. The Brand Digital Power Meter is the instrument that takes all the guesswork out of load analysis. This meter will measure the power and energy consumption of any 117 vac appliance under 1850 watts. It will accurately measure difficult-to-meter loads such as refrigerators and freezers. The meter can take a couple of days of measurement and project this data into a monthly figure.

For those designing a system for themselves, or for RE dealers who design many systems for others, the Brand Meter is an essential tool. It's so simple to use that you can do a real load analysis on a home in just a few days. No guesswork, just real and accurate data. This meter is an essential solar tool. Why guess when you can know for real?

Cost of the Brand Meter

You get all of this for $149.95, shipped and delivered! In the world of electrical energy measurement, you can easily spend four times the money and get an instrument that doesn't even come close to the accuracy, simplicity, and performance of this Brand meter. The "lifetime" warranty offered by Brand is really a six-month free replacement or repair warranty with lifetime repair or replacement for a single $40 payment.

Who needs this meter?

We all do. Whether you live on-grid or off-grid, the first step to saving energy is knowing where it's being wasted. The Brand is the instrument that can tell you this at an affordable price. Look at it this way—if you are on-grid, use this meter, and act upon the data, it will easily save you the cost of the meter in less than a year. After you're done with your home, you can lend the meter to your neighbors.

If you are off-grid or designing a new system for off-grid use, then this meter can save you thousands of dollars in system components you won't have to buy. You will have already identified, measured, and eliminated all of the inefficient and inappropriate appliances in the system.

I've done dozens of "Things that Work!" reports for *Home Power*. This is the first time that I have wished for more than two thumbs.... Great work, Ethan Brand and Richard McGarth of Brand Electronics! You folks have created an accurate and effective instrument which is both easy to use and inexpensive. Both Thumbs Up!

Access

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Electric Sparrow Takes Wing

Above: Sparrows have many of the legal and practical advantages of motorcycles, including parking privileges.

"The sparrow is an urban bird," explains Tom Corbin. "You don't really notice them, but if you look around, they're everywhere. They're small and cute and friendly, and always very busy. They're very well adapted to life in the city." Tom is talking about a familiar bird, but he is also referring to an electric car, the Corbin Sparrow. He hopes that they will one day be as common in cities as the feathered variety.

The Hatchery

The Sparrow is a project of Corbin-Pacific, a strong company with an established business foundation. It looks promising for the Sparrow, as Corbin-Pacific already has the manufacturing expertise and tooling necessary to launch a new product.

Corbin-Pacific is based in Hollister, California. Hollister is perhaps best known for a large boisterous gathering of motorcycles in 1947, which inspired the movie "The Wild One" with Marlon Brando. The anniversary of the event was marked by a somewhat more sedate town-wide celebration last year.

Like the town of Hollister, Corbin's history is in motorcycles. Founded in 1968 by Tom's father, Mike Corbin, the company is famous for specialty and custom motorcycle saddles. Walking through the busy factory, Tom says, "Some people ask how we jumped from motorcycle seats to electric cars. We didn't. We make moulded composite structures. We just went from making small moulds to making bigger ones." Electric vehicles are not entirely new to Corbin, either. In the gas-crunch days of the 1970s, Corbin built an electric scooter.

Bird Of A Different Feather

The Sparrow is referred to as a Personal Transportation Module. Legally, it is a fully enclosed three-wheeled single-seat motorcycle. Unlike a "trike" configuration, this vehicle has two wheels in front and one in the rear. The legal classification as a motorcycle has many advantages, although specifics vary from state to state.

In many places, the Sparrow is exempt from rush hour tolls, has lower registration fees, and can use motorcycle parking areas and carpool freeway lanes. The Sparrow also avoids some motorcycle drawbacks. For example, in California, a Sparrow driver is not required to wear a helmet or have a motorcycle license. Also, with the fully enclosed body, the driver doesn't have to contend with rain in the face or bugs in the teeth. For some hardcore motorcyclists, this may not be considered an advantage, but to many people it is.

The Shape Of Things

Beauty is in the eye of the beholder, so it's hard to say whether the Sparrow is cute, or so homely it's cute. Either way, it's in good company with the original VW Beetle, the best-selling car of all time. Like the Beetle, the Sparrow has all smooth curves, but its profile is low and wide in the front, and tall and narrow in the rear.

The chassis is elegant in the engineering sense of functional simplicity. Rather than a body sitting on top of a frame, it is a monocoque: the structural members and the shell are of one construction. Steel support members are sandwiched into the reinforced fiberglass/rigid foam composite like bones inside muscles. They are out of sight, but provide strength and structure. Add to this the inherent strength of rounded shapes, and the result is good design.

Tom Corbin describes getting into a Sparrow as "putting your whole body into a motorcycle helmet". There are other thoughtful touches as well. The single door opens on the right. This means that the driver enters and exits the car on the curb side, away from traffic. It also means that the left front corner, the most collision-prone part of the chassis, is stronger by virtue of being seamless.

Above: Building the Sparrow.

It Runs On Chicken Feed

So what makes the Sparrow fly? It's powered by a rare-earth, permanent magnet, brushless DC motor. The motor is rated at 15 kW continuous duty, up to 11,000 rpm, and is expected to last through 100,000 hours of use. The drive system comes from SL-MTI, an aerospace company that was looking for a consumer market for its products. The motor drives the single rear wheel through a pulley and belt.

The motor is coupled with an integrated high frequency charger/controller also from SL-MTI. This ingenious and compact device controls the flow of electricity to the motor during driving, then serves as a charger when parked. It can charge from 110 volts, 220 volts, or even European circuits. It automatically recognizes what type of circuit is feeding it. At 110 volts and 15 amps, it gets a full charge in six hours. At 220 volts and 30 amps, it takes only two hours. After a finish trickle charge, the charger turns off. However, if the car is left dormant for a long time with the charger plugged

Left: Some of the thirteen sealed lead-acid batteries are stored under the seat.

Right: The controller, on top of the rear wheel, and the PM DC drive motor.

in, the charger will detect if the battery pack charge falls off, and will turn itself on again.

The 156 Volt battery pack is made up of sealed lead-acid batteries described as starved electrolyte or valve regulated. There are thirteen of the 12 Volt units, a blue-top model D900 manufactured by Optima. They are placed low in the car, below the axles, making the car very stable. Each battery is topped by a small yellow charger regulator, called a run-X. These regulators monitor the state of each battery during charging. As a battery reaches full charge, the current is shunted to bypass that battery while the others continue charging. This keeps the pack evenly charged, and enhances the battery life. The batteries are expected to last two to four years, depending on how they are treated. They cost about $100 each. Potentially, the car can be upgraded if better batteries are developed.

Good Things Come In Small Packages

Like its namesake, the Sparrow is tiny. Its maximum width is four feet in the front, and the total length is eight feet. Unlike some other micro-cars, it doesn't leave the driver staring nervously at neighboring hubcaps. The Sparrow sits nearly five feet tall, making it fairly visible for such a small vehicle. The entire car weighs 1,250 lbs. soaking wet, which is about what the battery pack alone weighs on many electric cars. About half of the weight in the Sparrow comes from the battery pack.

Its small size makes it environmentally correct three times over. It's quiet, emission-free, and makes a small footprint on the road. If large numbers of drivers switched to Sparrows, traffic congestion and necessary parking area would be reduced. Inside, the car gives conflicting impressions. There is a surprising amount of headroom, and the seat is comfortable for even a tall, well-padded person. However, the sides and sharply curved windshield seem very close. It is not a car for claustrophobes. People will have to determine its comfort rating for themselves.

Bells And Whistles

The Sparrow has most of the usual passenger amenities: retractable three-point safety belt and shoulder harness, adjustable seat, tilt steering wheel, electric windows, windshield wiper, air vent and heat, and an AM/FM CD player. Sorry—no air conditioning. Common to many electric cars, it has an E-Meter as a fuel gauge, and a 150-0-150 amp gauge. All of the accessories operate on 12 Volts. This is just like a normal car, except that the power is provided by a DC/DC converter that taps uniformly off the main battery pack.

The Sparrow shows its motorcycle heritage in a single headlight and high-mounted taillight, both flanked by turn signals. The headlight goes on automatically when the car is on, just like motorcycle headlights. There is a foot-operated dimmer switch on the floor. The rear has a tiny storage area behind the seat, big enough for a small briefcase, backpack, or a large shoulder bag. To access the storage area, you have to get out of the car—so don't leave your toll booth money in your purse.

Itty Bitty Birdy Feet

Even the tires on this car are interesting. Tom explains, "We needed a small, narrow tire, but we couldn't use motorcycle tires. Motorcycle tires are designed for a two-wheeled vehicle that leans into turns. Most of the tread is on the sides. If you tried to steer this much weight on motorcycle tires standing straight up, you'd just slide." By serendipity, Corbin discovered a tire that had been developed for a Mercedes product, then abandoned. The original design called for twin tires—two skinny tires side-by-side. Corbin uses the tires individually. Presto!—it's a perfect fit.

By The Numbers

Exactly what will this little bird do? In about 15 seconds, it can go up to 60 mph, and has a range of 40 to 60 miles. At 30 mph, the disk brakes and regenerative braking will bring you to a stop in 13 feet. At the end of the day, it will cost you about $0.75 to charge it up. The whole package comes with a 24 month warranty.

So, how do you get one? Corbin has been accepting $1,000 deposits on the $12,900 price, and has advance orders for almost 400 cars. Some people have been waiting up to a year and a half while production was being set up. Delivery of the first units is just beginning. Corbin expects to deliver 300 by the end of the year. Next year, they hope to build 300 per month with two new factories. Eventually, the one in Daytona Beach, Florida, will have the capacity for up to 7,000 units per year. If they catch on, the new factory in Hollister will produce up to 50,000 units per year.

Corbin is also making arrangements to license the technology for production and sale in Italy. This is a natural, since Europeans are already used to the micro-car concept. Also, the Sparrow transplants easily overseas because it has no “right-hand” or “left-hand” drive, and the charger accepts European electricity standards.

Will It Fly?

That’s the hard question, and only time will provide an answer. Many fine vehicles have failed in the marketplace because they were too far ahead of the curve, too different from the comfortable and familiar. The vast majority of the cars in this country travel short distances every day with a single person in them. The Sparrow is ideal for this kind of use.

But will the average driver spend over $12,000 for a car that cannot carry a spouse, child, or pet larger than a Pekinese? A lot of people spend that much (and more) on motorcycles with less comfort and safety. On the other hand, motorcycles also have more performance, a “thrill” factor, and can carry a passenger. What Corbin has is a new concept between a motorcycle and a car. As Tom Corbin says, its success will depend on the willingness of the buyers to “accept it for what it is, and not criticize it for what it isn’t.” Whatever the eventual judgement of the marketplace, the Sparrow represents a well-crafted and original offering that deserves some consideration, and a place in electric car history.

Access

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Mike Brown

My EV is very "jerky" starting off from a stop. What could be causing this?

The letter I received had all the elements of a good mystery novel: an unusual occurrence, multiple suspects, and no obvious villain. If the problem had been in a computer instead of in an EV, the technician would have scratched his head and said, "I have never heard of that problem before." (This happened to me the other day, but that's another story.)

Clues

The EV in question was a 1991 Ford Escort. It was converted by a company that is no longer in business. The 108 Volt battery pack was four years old and had about 20,000 miles on it. The controller was a Curtis/PMC 1221, and might have been the B model that came with the car, as there was no mention of a replacement. The motor was an Advanced DC 9 inch. The charger was built in-house by the conversion company and had a timer shut-off instead of an automatic shut-off when the battery pack reached its fully charged point.

The problem with the EV wasn't that serious. It was kind of a mild annoyance, perhaps backed up with with a sense of impending doom. The problem was a jerking motion when starting off in first gear in the morning when the EV had just come off the charger. This jerking would get less noticeable as the battery pack voltage went down while the EV was driven, and was hardly noticeable when the state-of-charge meter was under 60%. The driver also noticed more rapid than usual acceleration for the first few miles after charging. In addition, the owner found that if he cut back on the amount of time the batteries spent on charge, thus lowering the finish voltage, the jerking disappeared.

Circumstantial Evidence

Since the problem only occurred after the EV had been on the charger, charger malfunction was a possibility. This could have caused an overcharged battery pack, which might have led to problems in the controller circuitry. I didn't think this was the case for several reasons.

If the charger was the type with the automatic shut-off feature, a failure in the voltage sensing circuitry might lead to an overcharged pack. However, this charger was controlled with a timer. Judging from the excellent service the owner was getting from his batteries, he had learned how use the charger effectively and was not overcharging the pack.

The Curtis/PMC has an overvoltage cut-out circuit that prevents the controller from turning on if it senses an input above 160 Volts. If the charger was capable of getting the 108 Volt battery pack charged high enough to hit the cut-out limit, the battery pack would have been damaged beyond use the first time it happened.

With an experienced but innocent battery pack, and a simple but blameless charger, the only remaining "suspect" was the controller. The controller was mounted with the terminal end up. This could have allowed moisture from either condensation or road splash to accumulate on the potting material that seals the end of the controller and the terminals. If the potting had become cracked due to road vibration or mishandling the terminals during cable installation, moisture would have penetrated the controller where it could haved damaged the circuit boards.

My theory is that moisture damage had occurred in the circuit board. It was either in the area of the overvoltage cut-out circuit, or had affected some of the other parts of the controller's circuitry. This would be an unusual occurrence because water damage commonly results in complete failure.

The controller is frequently the first component blamed in the case of failure because it is one of the most expensive and least understood components in an EV. It is usually not the culprit. In this case, I feel confident of the verdict as it is based on personal experience. There is a history of a high rate of controller failures in cars converted by this company.

Diagnosis

The best advice I could give the owner was to remove the controller from the EV. I advised him to send it with a detailed description of the symptoms to Curtis/PMC for evaluation and repair. Even worst-case repairs on an out of warranty Curtis/PMC controller cost only a fraction of the price of a replacement controller.

I sent this diagnosis and advice to the gentleman with the problem some time ago. I haven't heard back from him, so I don't have confirmation yet. If I hear something from him, I'll publish it here.

In the meantime, send me more mysteries. It keeps life interesting.

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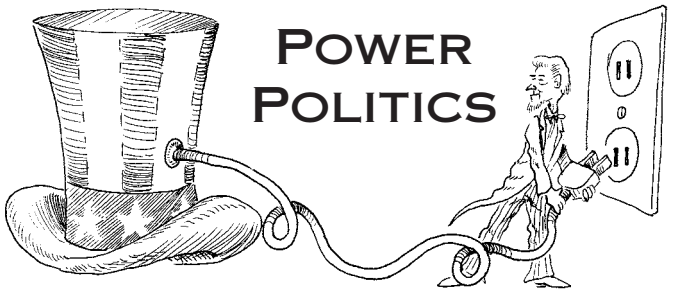

RAGE

Michael Welch

A new campaign has formed to help stop future utility deregulation problems. What happened with California deregulation, and what is close to happening in other states, is not OK. The campaign is called RAGE, or "We've Got the Power: Ratepayers for Affordable and Green Electricity."

Deregulation was supposed to turn electric companies into competitive businesses, bringing lower prices and customer choices. But across the nation, according to RAGE, the opposite is happening. Utilities are using their extensive influence to pass legislated bailouts that may cost customers as much as $300 billion.

The Bailout

Don's IPP column in this issue displays a California utility bill and touches on what is wrong with it. In another typical case, I saw a copy of a utility bill totaling $243.58. It is a common amount to be paying for electricity these days, especially if the consumer has not yet gotten into energy conservation. Included in that amount is the "Legislated 10% Rate Reduction," shown as -$24.57. Below is the "Trust Transfer Amount" showing +$35.20. This is the amount of money that goes to pay for the mandated rate reduction and its interest. In California, there have been no net savings to the small consumer. In fact, some folks' utility bills have gone up. "CTC Charges" of $79.31 are also on the bill. This money goes to pay off the utility's inappropriate investments, mostly in nuclear power.

It is interesting how the 10% reduction and the Trust Transfer Amount came about. At some point in time, California legislators realized that the bill they designed was "giving away the farm" to the utilities—basically everything they wanted. Legislators needed to throw a bone to the consumers, so they decided on a 10% rate reduction. But when it came time to put it in, the utilities said, "No way are we going to pay for that!" The lawmakers designed a scheme whereby the customers would pay for it themselves. Bonds would be sold to finance the reduction, and the customers would repay the bonds with interest. Such a deal.

California's Fix

More on RAGE below. As Don stated in his column, California Proposition 9, called "The Utility Rate Reduction and Reform Act," is designed to get deregulation straightened out. Fortunately, it did qualify for the November election ballot. It already survived a courtroom attack as the utilities tried to get it removed from the ballot. This Proposition is crucial to keeping the consumer viewpoint in the forefront of energy policy.

Please, please get involved in helping to pass this very important state law. This is a grassroots movement—it's not driven by wealthy special interests. As such, it requires all of us to get out there and help it along. The utilities are already mounting a multi-million dollar campaign against it. Citizen involvement is the only way to counteract this.

Proposition 9

Prop 9 will ensure that all residential customers and small businesses will receive at least a 20% reduction in their electric utility bills. This is a *real* reduction, not smoke and mirrors. It prevents the use of taxes and surcharges that force ratepayers to finance their own rate reduction.

Prop 9 protects ratepayers from being forced to pay for the utilities' past investment in nuclear power and other uneconomic investments. This amount represents close to 40% of the total utility bill. The total amount of the bailout is $28 billion, equaling more profits than Microsoft has earned since its inception.

Prop 9 ensures that consumers will have the information they need to obtain high quality, low cost electricity. Under current restructuring law, millions of dollars were handed over to the utilities for an advertising campaign that was supposed to inform California electricity customers of their new "choice" in electricity providers. The campaign was very confusing to consumers, and resulted in 99% of customers staying with the utilities. Prop 9 also prohibits the sale of private information about electricity consumers without their written consent.

Prop 9 provides for effective judicial review of Public Utilities Commission (PUC) decisions implementing utility restructuring. As it is now, the only recourse there is to try to change a PUC decision is to appeal to the California Supreme Court, which routinely refuses to hear PUC cases. Prop 9 adds effective appellate review of those commission decisions.

Utility CARES

The utilities are gearing up like they never have before to try to defeat the initiative. The wording and intent of Proposition 9 indicates a "no-brainer." We hope that people would automatically vote for something that is so strongly in their favor. But don't forget, the utilities involved are some of the most powerful companies in the nation. Their clout is incredible, and their resources nearly limitless.

They have already begun a disinformation campaign to try to sway voters to vote against the proposition. They formed a dummy front group called CARES to make it look like a grassroots effort to defeat the proposition. A closer look shows that 99.4% of CARES funding comes from PG&E, Edison, and SDG&E, California's three nuclear utilities.

They are deluging organizations and local governments with claims that Prop 9 creates more problems than it solves. As they did with the education money from the original legislation, they are working hard to confuse the issue. They are making far-fetched claims—they say that the initiative would force taxpayers to pay for $6 billion in bonds already sold, when state law already prohibits this. They claim that there will be a significant reduction in community services like police, fire, and education. They claim that it will eliminate customer choice and lower rates. They claim that it will harm the interests of utility workers and the environment.

And last, CARES claims that Prop 9 will result in years of litigation. That may be the only correct claim. If Prop 9 passes, you can count on the utilities trying to tie it up and beat it to a pulp in the courts. In fact, the other claims that CARES makes will come about only if the utilities *do* tie it up in court and win. It's hard to say what the courts would decide, but proponents think that the proposition will survive legal challenges. Let's make it so.

RAGE On

The whole point of RAGE is to give the consumer the say in their future, the say that got taken away from Californians. I've stated in this column about a gazillion times that the utilities and nuclear industry are powerful players in this political game. They are well organized, and prepared to go to great lengths to pry more and more money out of us. We need to be organized as well. In California's case, we left our future in the hands of a couple of huge environmental groups that had been dallying in the utilities' beds for a while. It was a big mistake. Now we have to go back, through Prop 9, to correct the error.

RAGE has high hopes that we can avoid those mistakes on a national level by having a pro-active agenda. Senator Paul Wellstone and Representative Dennis Kucinich are expected to introduce legislation that will support the RAGE tenets. Wellstone said, "We must have the courage and vision to put forward an agenda that protects consumers from rip-offs and cost-shifting, ensures that power generation is not harmful to human health or the environment, [and] shields low-income communities from degraded electric service…"

David Brower, of Earth Island Institute, is a supporter. He said, "The technologies exist to provide for our energy needs without sacrificing the future to pollution and climate change. We should be investing in securing a safer energy future, not in any attempt to bail out our past mistakes."

Consumers Must Be Protected

Citizens across the nation have long fought the installation of nuclear plants in our communities. In spite of decades of warnings, there are over 90 nuclear power plants that have been shoved down the throats of electricity consumers. Now, the utilities want consumers to pay for corporate decision-making errors. RAGE responds, "No more bailouts."

The whole reason that deregulation is taking place is that some larger corporate consumers wanted to buy cheaper electricity than they had been getting from the electric monopolies. They once argued in favor of the utilities building more, expensive power plants. Now they don't want to pay for those plants, and they can get out of it. Since many of them use vast amounts of electricity, they are able to bargain for the cheapest rates, leaving the rest of us to buy the more expensive power. RAGE would put an end to that problem, too.

Get Involved!

What we have here, are two organizations that desperately need our support. Call Californians against Utility Taxes (CUT) and find out exactly how you can make a difference in this next election. Even if you are not in California, help them out. As I said a long time ago, when the deregulation issue first started popping up—as California goes, so goes the rest of the nation. Be sure to support the RAGE tenets. Call your senators and representatives and ask them to support the principals outlined above.

This is an important call to action. Please be there for our renewable energy future.

Access

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Adopt a Library!

When Karen and I were living with kerosene lamps, we went to our local public library to find out if there was a better way to light up our nights. We found nothing about small scale renewable energy.

One of the first things we did when we started publishing this magazine eleven years ago was to give a subscription to our local public library.

You may want to do the same for your local public library. We'll split the cost (50/50) of the sub with you if you do. You pay $11.25 and Home Power will pay the rest. If your public library is outside of the USA, then we'll split the sub to your location so call for rates.

Please check with your public library before sending them a sub. Some rural libraries may not have space, so check with your librarian before adopting your local public library. Sorry, but libraries which restrict access are not eligible for this Adopt a Library deal—the library must give free public access. — Richard Perez

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On the Conference Trail

Don Loweburg

Last May, I made a presentation at the Intertribal Council On Utility Policy (I-COUP) Conference in Rapid City, South Dakota. The conference focused on tribal utility policies regarding renewables, and on new opportunities with utility restructuring.

Our IPP presentation highlighted Residential Photovoltaics. We stressed the importance of building a delivery and support infrastructure *not* based on one-time grants and projects. With large off-grid populations, tribal communities offer many opportunities for residential RE systems.

IPP's emphasis on the sustainability of entrepreneurship was echoed repeatedly throughout the conference. For example, Debbie Tewa, director of Hopi Solar Electric Enterprise, reported on her work. Debbie is an excellent "Wrench." She has installed over 300 systems, and has established a revolving loan fund for financing. She outlined the importance of educating her customers about PV, in addition to a good technical installation. For more info on Debbie and Native Sun, see *HP62*, p. 16.

New Technology

At the conference, two presentations dealt with new technology. The first involved the exploitation of earth heat to make steam by injecting water into holes drilled into hot rock. David Duchane of Los Alamos National Lab reported on his method and presented the results of his first test project. The method involves boring two shafts deep into rock. Water is injected into one shaft, vaporizes in the deep hot rock, and exits out of the second hole as steam to run a turbine. David emphasized that this is a closed system. The used steam is condensed and re-injected.

Linear Flow Hydropower was the second presentation. This small-scale hydro technology is suitable for retrofits on many existing facilities. Dan Schneider of Schneider Engine Company explained his Linear Flow technology by comparing propellers and wings. A wing is linear—because Linear Hydro doesn't rotate, it can not harm fish.

Tribes Have Sovereign Rights

Policy was also on the agenda. Quoting a conference handout, "I-COUP was formed to provide information on rights and resources in matters relative to legislation, regulation and policy on utility operations in Indian country. …I-COUP is a vehicle for educating tribal governments about the economic opportunities available through public and private partnerships designed to provide utility services in a restructured regulatory environment."

Representatives of industry, government, service organizations, and tribal attended. This included Mohawk, Navajo, Hopi, and Lakota (our hosts). The vision and spirit of the conference was summed up by Lakota Councilman Don Lamoureaux. He said, "I see in the near future that people will come here from all over the country to see how to do renewable energy. We will be a model."

On the Ballot

To date, restructuring laws are good examples of the adage, "we have the best government that money can buy." Supporting this conclusion, last year Southern California Edison led all California utilities with $1.13 million in political contributions, according to the California Secretary of State.

The Campaign against Utility Taxes (CUT) had a signature drive to place an initiative on the California ballot for this November. The initiative, California Proposition 9, challenges the deal that the utilities struck with the legislature when the restructuring bill was passed. This bill, AB 1890, is known as the "midnight deal," because California utilities literally stole the restructuring process from both the Public Utilities Commission (PUC) and the California Energy Commission (CEC).

Actual California Utility Bill

Item	*Cost*	*%*
Electric Energy Charge	$14.56	12.5%
Transmission	$4.73	4.1%
Distribution	$41.89	35.9%
Public Purpose Programs	$4.96	4.2%
Nuclear Decommissioning	$0.65	0.6%
Competition Transition Charge	$44.97	38.5%
Trust Transfer Amount	$17.96	15.4%
Total Charges	$129.72	
Legislated 10% Reduction	-$12.97	
Net Charges	$116.75	100.0%

IPP supports retail energy competition and the recovery of legitimate stranded costs, but the citizens should not be burdened with the costs of poor corporate judgement and bad investments in nuclear power plants. To quote Dan Berman (co-author of Who Owns the Sun), "a nickel for renewables and a dollar for nukes."

A Case Study

Wenonah Hauter, co-author of a May 28, 1998 *Wall Street Journal* article, *A Shocking Giveaway to Utilities*, shares the above copy of an actual California utility bill.

Hauter stated, "Note that the price for electricity (i.e., the energy charge) in the market is extremely low, making it even more difficult for renewable energy and other independent generators to compete. On the other hand, note the high costs for distribution which is where the utilities are beginning to load costs as they move away from generation to become distribution companies. Similarly, the stranded cost bailout, which is comprised of the Competition Transition Charge and the Trust Transfer Account, totals $62.93. Moreover, the cost to pay the principle and interest on refinancing or securitization ($17.96) is more than the 10% reduction ($12.97) mandated by the restructuring law." Simply, the total bill is actually higher by about $5 after the 10% reduction.

IPP's Mission

IPP incorporated four years ago. Our corporate purposes are to promote and encourage the use of RE by "developing opportunities for end-user ownership of renewable energy generation sources,…encouraging a professional installation infrastructure, [and] adhering to recognized standards." Though the conversation on these pages has ranged far and wide over the years, IPP stays committed to those goals.

A Little History

IPP began in the summer of 1993, spurred by the revelation of utility plans. They were planning to install off-grid PV on customer rooftops, as a precursor to grid-connected utility-owned PV. Many did not understand the fundamental market abuse and legal issues involved.

IPP challenged California utilities and misdirected federal "commercialization" programs such as Project TEAMUP. These groups provided subsidies to regulated monopoly utilities, some well-meaning environmental groups, and elements within the PV industry.

The context shifted radically when restructuring came on the scene. It gradually became understood that generation would no longer be a regulated monopoly activity. In this light, people could more easily understand that PV was a competitive alternative to centralized monopoly generation, one of IPP's fundamental tenets.

IPP's Stand

At the 1995 Renewable Energy Development Institute (REDI) Conference in Willits, California, IPP presented commercialization plans for PV. We stressed the importance of using incentives for end-user purchases of PV, passing net metering laws, starting financing programs, establishing standards for equipment and installation practices, and developing a competent installation infrastructure.

An Interim Report Card

In the three years since that presentation, what has the industry done? Though far short of PV commercialization, we have definitely moved in the right direction. In California, about $30 million has been committed to end-use purchasers to help "buy down" the cost of PV and small wind. Even the DOE funded TEAMUP programs, initially directed to benefit regulated utilities, have shifted focus. They now provide buy-downs to end-user purchases of rooftop PV systems (more below, it's not all rosy). Over 20 states now have some kind of net metering law. PV financing is now available through at least one major distributor. Most hardware is now listed by Underwriters Laboratories (UL) or the equivalent. And IEEE P929, a simplified interconnection standard for small (<10 kw) grid intertie inverters, is nearing approval.

The Road Behind

Last issue, we reported some bumps in the road related to Photovoltaic Services Network (PSN), the regulated Colorado Public Service (PSC) utility, and Colorado Solar Energy Industries Association (CoSEIA). In that article, we heard from Lotus, an IPP member and

owner of Rocky Mountain Solar, and from Terry Schuyler, Vice President of Sales, PSN.

Terry Schuyler's response refers to PSN as a Limited Liability Corporation (LLC) but fails to mention that just a few weeks prior to this statement, PSN was, in fact, a non-profit corporation. As a non-profit, PSN received TEAMUP awards, including one for $700,000.

Now, as a for-profit corporation, Altair (new name for PSN) is mentioned in a press release, dated 7/28/98:

> *CO Utility Offers Solar as Power Option.* Public Service Company of Colorado and Altair Energy have teamed up to offer solar power to their customers through the "Solarsource" program. Through the program, customers now can choose to purchase photovoltaic (PV) systems to meet a portion, or even all, of their electricity needs.
>
> The utility pointed out that PV systems produce electricity that can be used by a home or a business or even sold back to Public Service. "Our company frequently gets requests from customers who are interested in buying electricity produced from renewable sources, like the sun and wind," said Andy Sulkko, product manager with Public Service. "This partnership with Altair Energy allows us to expand the portfolio of 'green power' options we offer our customers." The Solarsource partnership is a result of a tariff Public Service filed with the Colorado Public Utilities Commission (CPUC) last March to install up to 200 net-metered PV systems by the year 2001….

Strange Bedfellows

As renewables become a hot item in the marketplace, it's interesting to observe the feeding frenzy. In times past, companies grew by delivering better products and services, and by increasing their customer base. That was the accepted concept of competition. Today, acquisition is the rule. Companies grow by buying other companies.

Recent examples abound. Photocomm buys Sunelco and Utility Photovoltaic Group (UPG). Coors buys Photocomm, becoming Golden Genesis. Idaho Power buys both Applied Power Corporation (APC) and Solar Electric Specialties (SES), and then partners with Green Mountain Energy Resources to install rooftop PV systems in California. AMOCO-Solarex merges with Enron. Enron buys Zond Wind. BP opens a PV manufacturing facility and proceeds to vertically integrate all aspects of the PV industry (manufacturing, distribution, systems design, installation, and service). BP and AMOCO merge, becoming the third largest global petroleum company. As a holding company, they now control a significant portion of the global renewable energy industry (Solarex, BP Solar, and Zond Wind).

What our green petro colleagues don't want us to know, is that at this very moment, they are developing vast new fields around the Caspian Sea. According to a recent four part series of articles in the San Francisco Chronicle, these reserves will "surpass the output of the Persian Gulf and ensure an ample supply of low-cost oil for the developed nations and for the emerging Chinese market until the 22nd century."

Does the RE Customer Benefit?

The corporate movers who put these deals together tell us it's all about remaining competitive and lowering prices. Another perspective suggests that control and access are the goals of corporate aggregation. How does the customer benefit? Last issue, we discussed how the local RE company was circumvented with programs such as the PSCO-Altair alliance. By marketing TEAMUP subsidized systems directly to the customer, these corporate alliances weaken the local infrastructure. This is a disservice to the customer.

Knowledgeable RE companies do more than slap panels on the roof. At the very least, they do load audits, properly site the array, recommend conservation measures, educate about energy efficiency, and recommend the most efficient PV modules.

Contrast this with the corporate marketing programs. They don't care what your loads are, these are grid connected systems. Most likely, the customer is encouraged to use more power, since now they have "free" energy from the sun. Why would the utility or the Energy Service Provider want you to use less of the product they are selling? As for array siting—many utilities favor west-facing arrays. Definitely not to the benefit of the customer, but rather to benefit the utility's late afternoon load peak due to summer air conditioning. Do these programs promote the most efficient modules? No, in most cases, the TEAMUP subsidies apply to the less efficient thin film products. These products do not carry the usual 20 to 25 year warranties associated with more efficient modules.

A Glaring Public Example

I have a brochure promoting "The Solar Energizer," a packaged system that is being sold by several of the marketing alliances mentioned previously. It is clearly directed at the end user. Inside the brochure, we learn how quick and easy the installation can be. "A Solar Energizer is easily installed by a local contractor, and connected to your home's electric system by a local electrician, with installation typically completed in one day or less."

There is no mention of a qualified solar electric professional. Too bad—the installation pictured in the middle of the brochure could have used one! Judging by the shadow covering one-third of the array, it is about 1 PM. I would guess that in another two hours, the array would be 100% in the shade. Does this customer know they are only getting maybe 60% of full energy capacity from this system? Who is going to tell them? The contractor? The electrician? The petro-goliath that manufactured this taxpayer subsidized system? The utility-corporate alliance that marketed this package?

Support IPP

Member companies displaying the IPP logo are telling prospective customers that they agree with our statement of purpose. In many cases, IPP members are PV pioneers, having developed the demanding off-grid market. Customers can expect system design capability, knowledge of load auditing and energy efficiency, competitive pricing, service after the sale, and practical experience—most vendors use PV and renewables in their own lives. In short, customers can expect good service. Support IPP.

Access:

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Focusing On Fuses

John Wiles

Sponsored by The Photovoltaic Systems Assistance Center
Sandia National Laboratories

There are fuses and there are fuses. Using the wrong electrical fuse in the wrong circuit can produce results as explosive as those produced by the fuse in a large firecracker. In this Code Corner, information will be presented on the various types of fuses that can be safely used in a photovoltaic (PV) power system.

Why Use a Fuse?

A fuse is one type of overcurrent device that is designed to be a sacrificial element in an electrical power system. Fuses are designed to open circuits when excessive currents are present due to overloads or faults, and in this manner are designed to prevent further damage to the system that might result if the fuse were not present. Fuses are sacrificial in that they are generally good for one time use and are destroyed in the process of operating. The use of fuses in a circuit provides cheap insurance should there be an accidental or unintentional fault in the system wiring or components.

Properly used, fuses can prevent fires and other damage when accidents happen. Such accidents include: a cable coming loose in the battery-to-inverter circuit, a cable in a module junction box contacting a grounded terminal, a nail driven through unprotected wiring, a wrench dropped across the DC inverter terminals, or an animal chewing through insulation and causing a ground fault.

In general, fuses melt internally when subjected to currents above their rating, and if the fuse rating is below the rating (ampacity) of the connected cable, the fuse will melt before the cable melts or is otherwise damaged. There are resettable fuses, electronic fuses, and renewable link fuses, but these types are not generally applicable to direct-current renewable energy systems.

Fuse Ratings

Fuses are rated by current, voltage, interrupt capability, and whether they are designed to operate on ac or DC circuits. The current rating of a fuse is the current that it can carry for indefinite time periods without opening. The voltage rating relates to the ability of the fuse to function and extinguish internal arcs when it opens. The interrupt rating is how large a short-circuit or fault current the fuse can interrupt or stop safely without allowing a continuing arc and without damaging the fuse body or fuse holder.

Are ac and DC Fuses the Same?

Direct currents are very difficult to stop or interrupt when compared to alternating currents. Alternating-current sources reverse the flow of current 120 times a second (in some locations 100 times a second on 50 Hz systems). Each time the current reverses, it goes to zero in magnitude. A zero current is very easy for a melting fuse to stop or interrupt—it is already stopped, and there is no force trying to sustain an arc across the fuse element.

DC currents, as the name implies, are currents that travel in one direction only. They do not reverse. Fuses bear the entire burden (with no help from the current) of acting to stop these currents. The internal elements of a fuse must react to an overcurrent condition (usually by melting) and as they react, they must do so with enough capability to interrupt the current from flowing while extinguishing any arc that might form. DC fuses are relatively sophisticated devices that have many different internal elements that must work together. The complexity of DC fuses makes them cost more than ac fuses that may contain only a single, meltable link.

What about fuses marked for both ac and DC? Fuses that can pass the harsh Underwriters Laboratory (UL) Standards testing for direct currents are also able to pass the less rigorous ac testing standards. Some manufacturers elect to put both markings on the fuse. To illustrate the difference in the tests used to evaluate fuses, consider the type RK-5 fuse (discussed below) which, from most manufacturers, has both ac and DC ratings. For a 100-amp fuse, the ac rating would be 600 volts with an interrupt rating of 200,000 amps. The DC rating for the same 100-amp fuse would be only 300 volts with an interrupt rating of 20,000 amps—both significant reductions from the ac ratings. There are fuses with equal ac and DC voltage ratings, but the DC interrupt rating is significantly less than the ac interrupt rating. In normal operation, a properly-designed fuse must carry the rated current and not respond to short-term (2-10 seconds) current surges from motors that are 2-6 times the fuse rating. Time-delay fuses, like the RK-5 fuses, can resist even longer surges.

Which Fuses are Suitable for DC?
Fuses suitable for DC fall into several types. Any fuse used in DC renewable energy circuits should have the DC ratings printed on the fuse or be shown in the UL Listing information in the technical data for the fuse. The technical data is available in the manufacturer's catalog, data sheets, and even on the WWW. Beware that seemingly identical fuses from different manufacturers may not have the same DC rating even though they are given as exact replacements in the manufacturer's cross-reference data. The DC rating and UL Listing should always be verified.

The branch-circuit rated "class" fuse is the most robust of the DC fuses for use in renewable energy systems. While the manufacturer's exact catalog number may vary, these fuses fall into several classes, each having different performance characteristics and sizes. Some of these classes are: RK-1 and RK-5 (1/10-600 amps), T (1-1200 amps), and CC (1/10-30 amps). Many manufacturers have DC ratings for some of these fuses, but not all of them.

The RK-1 and RK-5 fuses are the types of fuses that fit in the fused, safety-switch disconnects available from all electrical supply houses and many home centers. These RK fuses are grouped in sizes by voltage with the shorter sizes having a 125-volt rating and longer sizes having a 250 or 600-volt DC rating. They are also grouped by current range (1/10-30, 35-60, 70-100, 110-200, 225-400, and 450-600 amps). The actual sizes on the commonly used fuses range from 13/32" x 1-1/2" for the Class CC fuses up to 3-11/32" x 13-3/8" for the 600-volt, 600-amp RK-5 fuses.

For each voltage rating of fuses, there are fused safety switches that are sized to accept the largest and smallest fuse in each current range.

The "midget" type of fuse (13/32" x 1-5/16") is similar in size to the class CC fuse, but is not listed for branch circuit use. They may be listed and have DC ratings for use as a supplementary fuse. Ratings are 1/10-30 amps. The NEC allows the use of supplementary fuses in the PV source circuits. The values available below 10 amps make this fuse easy to match up with the maximum series fuse requirement listed on the back of PV modules.

Bussmann Division of Cooper Industries has a DC rating (125 volts) and a UL Listing on their type ABC ceramic-bodied fuse in certain ratings up to 20 amps. The DC interrupt rating of this 1/4" x 1" fuse varies from 35 to 750 amps depending on fuse size. These inexpensive fuses can be used in the PV source circuits as supplementary overcurrent protection, but should be protected by a current-limiting fuse in systems with batteries.

What is a Current-limiting Fuse?
Many people are not familiar with the concept of a current-limiting fuse. They think that since a fuse opens a circuit, it must limit current to zero and therefore all fuses are current limiting. Current limiting actually refers to how fast a fuse can open under fault conditions. When a fault occurs in a circuit without a fuse, the current ramps up to the short-circuit value that is determined by the voltage and current characteristics of the power source and the resistance and inductance of the circuit. The time the current takes to get to the final value is very short, but not zero. A fuse that is not current limiting operates so slowly (still in fractions of a second) that it lets the current get to the final value before opening the circuit. The entire circuit, and any other components in the circuit, are exposed to the full value of the short-circuit current.

A current-limiting fuse, on the other hand, operates so fast under fault conditions, that it limits the current in the circuit before it has had time to reach the maximum. With this fast action, components in the circuit are not subjected to the full fault current, and are somewhat protected from the abuse of being subjected to fault currents in excess of their interrupt rating.

There are no listed circuit breakers that are DC-rated and tested to UL Standards that meet the definition of current limiting for DC circuits. Some distributors carry circuit breakers that are identified as current limiting, but these items have been tested to European standards that are not the same as the UL Standards for current limiting.

When should a current-limiting fuse be used? The National Electrical Code (NEC) requires that current-limiting overcurrent devices be used wherever the available fault current exceeds the interrupt rating of the other components in the system. In PV systems, this might happen when circuit breakers or fuses with limited interrupt ratings (i.e. 3,000-5,000 amps) are used with a battery having a 15,000-20,000 amp short-circuit current capability. If these circuit breakers or fuses were subjected to the full 15,000 amps of fault current, they would probably not be able to open the circuit and would more than likely be destroyed in the attempt with flames evident. A current-limiting fuse installed near the battery would limit the fault current at the second overcurrent device location to 3,000 amps that could be safely interrupted. The class RK-1, RK-5, and T fuses described above are current-limiting fuses.

Are current-limiting fuses required in all systems with batteries? There are two cases where current-limiting

fuses are not needed. If all of the overcurrent devices and switchgear used in the system have sufficiently high interrupt ratings for the fault currents in their respective circuits, then each device will have no trouble interrupting fault currents should they occur. In this case, current-limiting fuses would not be necessary. Some of the power centers and power panels on the market are designed this way.

In small PV systems, the conductors to the battery may be small gage conductors (i.e. 18-10 AWG) and these small conductors have a resistance per foot that quickly adds up in a very few feet. Since the resistance of the circuit determines the magnitude of fault current, the available fault current at the overcurrent device may be limited to a value that is less than the interrupt rating of the overcurrent device. The calculations required to make this determination are beyond the scope of this article.

What About Automobile Fuses?
Automobile electrical systems are designed to operate in a different manner from stationary PV systems. In an automobile, the electrical loads are designed to operate when the engine is running and the alternator is charging the battery and supplying the loads. The alternator output is in the 14–16-volt range and the radios and lights are designed to run at about 12.8 volts. A voltage drop is allowed in the conductors to reduce the alternator voltage to that needed by the loads. With the exception of the starting circuit, most conductors to the lights, fans, and other loads have relatively high resistance. This circuit resistance includes the resistance of the steel body parts used for the negative conductor. The system is not designed to power the loads for any length of time on the battery alone when the engine is stopped—the result would be a dead battery. This high-resistance wiring limits the available fault current from the battery and allows the use of automotive fuses with a very low interrupt rating.

A PV system, on the other hand, operates for extended periods of time on the battery without charging from the PV. Voltage drop must be minimized since the batteries start out at only 12.6 volts when fully charged. To minimize voltage drop, larger, low-resistance conductors are used in PV systems. These low-resistance conductors allow higher fault currents throughout the circuits. These higher fault currents are substantially in excess of the very limited interrupt ratings of automotive type fuses.

Another factor in the use of automotive fuses is that most PV systems (except the very smallest) have several batteries with high short-circuit current capabilities when compared to the single automobile battery found in vehicles. While there are a few UL-Listed automotive fuses, most are not listed. Even those that are listed are listed for use only in vehicles, and are tested to standards for use in vehicles. They have none of the conventional interrupt and voltage ratings. Automotive fuses do not meet NEC requirements for installation in PV systems that come under the Code. For these reasons, it is inadvisable to use automotive fuses in renewable energy systems to meet NEC requirements.

Who Makes the Proper Fuses?
UL-Listed, DC-rated fuses are available from a number of manufacturers. They include Littelfuse, Bussmann, Gould Shawmut, and Ferraz. These manufacturers will provide technical information on the correct fuse to use in renewable energy applications that require listed, DC-rated fuses.

Where Can I Get the Proper Fuses?
Many of the advertisers in *Home Power Magazine* carry the proper fuses and can advise a RE system designer on the correct fuse to use. Local electrical supply houses and home building supply centers also carry fuses. There are a few large mail-order sources, but some require minimum purchases that may run into hundreds of dollars. Digikey Corporation, Newark Electronics, and Allied Electronics are also sources. In every case, the UL-Listed, DC rating of the fuse should be verified.

Questions or Comments?
If you have questions about the NEC or the implementation of PV systems following the requirements of the NEC, feel free to call, fax, email, or write me at the location below. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work was supported by the United States Department of Energy under Contract DE-AC04-94AL8500. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

Access
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Sandia National Laboratories Sponsor: Ward Bower, Sandia National Laboratories, Division 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206
wibower@sandia.gov

The 1996 NEC and the NEC Handbook are available from the NFPA, 1 Batterymarch Park, Quincy, MA 02269-9101 • 800 344-3555 • 617-770-3000.

Distributors
Digikey Corporation • 800-344-4539
Web: www.digikey.com

Newark Electronics • 800-463-9275
Web: www.newark.com

Allied Electronics • 800-433-5700
Web: www.allied.avnet.com

Manufacturers
Littelfuse, Inc. • 800-832-3873
Web: www.littelfuse.com

Bussmann Division, Cooper Industries • 314-527-3877
Web: www.bussmann.com

Gould Shawmut • 978-462-2445/2456/2437
Web: www.gouldshawmut.com

Ferraz • 973-428-8400 • Web: www.ferraz.com

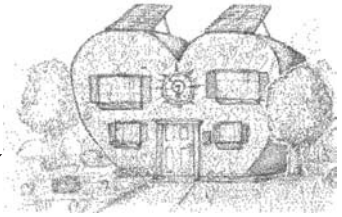
BACKHOME MAGAZINE

3.0 wide
5.8 high

b/w

camera ready

Home & Heart



Kathleen Jarschke-Schultze

Testing new solar cookers is always fun for me. My yard does look a bit strange, but I like that too. Some cookers do have a sculptural quality to them. Recently, I have been testing a couple of solar cookers that are different from the ones I use regularly.

Fresnel Fryer

The Sundyne Solar cooker is not the usual parabolic solar cooker. It is a Fresnel reflecting lens design. As with conventional parabolic cookers, there is a focal point of intense heat. The focal point is roughly spherical, about 6 inches in diameter.

It really looks like some sort of '50s-retro cooker of the future. I can just picture the Sundyne in an advertisment for the future family: an aproned and pearled mom cooks Sunday dinner on a Sundyne, while cowboy-costumed children frolic in the yard behind a white picket fence.

Assembly

The unit comes packed in a 24 by 24 by 10 inch carton, weighing about 50 lbs. The cooker is made in The Philippines. All of the parts are painted—even the screws. I guess they did this because of the salt air and humidity there. The instructions were not the best I've seen, but the last page had a very useful exploded view. I would advise assembling the unit in the shade, as the glare, by design, is bright and hot. It took me about two hours to assemble the unit by myself, without hurrying. It would have taken less time with a helper to "hold this" and "hand me that".

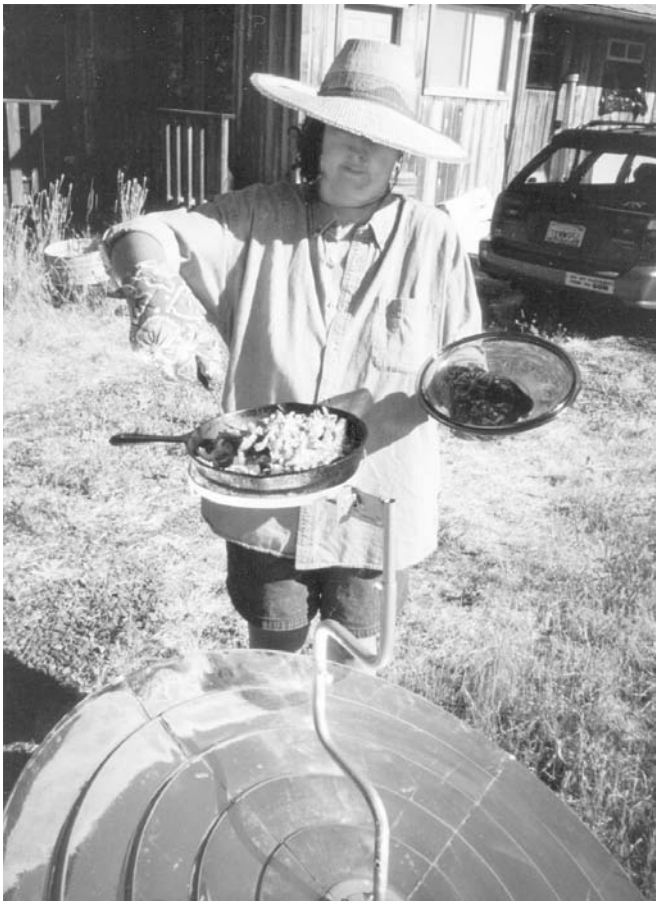
I was worried about stability of the cooker because of the near constant winds that blow through our canyon. I shouldn't have been too concerned—the Sundyne is fixed on a low tripod with long, sturdy legs. All of the parts were included. In fact, after I assembled the unit, I had some screws and things left over. Since they are duplicates of other parts, I figure that they're spares.

Testing, Testing, 1, 2, 3

After the assembly, I immediately checked to see if the Sundyne could boil water. I ran two quarts of water out of the cold tap into an amber-colored Visionware® pot that had a black non-stick coating inside. I placed it in the focal point and put a lid on it. I went inside, got a basket of laundry together and brought it downstairs to the washer. I took the clothes out of the dryer, transferred the other load from the washer into the dryer, then started the new load in the washer. Then, I took the dried clothes upstairs, went outside, and checked on the water. It was boiling. This was excellent.

Popcorn was the next test. I had this cool idea of putting a bag of microwave popcorn on the focal point, and having it work. Not a chance. I put the bag on the potholder. As I watched, it burst into flame. I got out a pot with a lid, and tried again. When the popcorn started popping, I shook the pot. Everything went fine, until the pot got hot—then I realized that I hadn't brought my cooking mitts. In that short time that it took for me to dash inside the house to grab the mitts, I burned the popcorn. It was totally my fault—I wasn't prepared.

Below: Kathleen fries with sunshine.



Versatility
Using the Sundyne, I found that I could start dinner after work, and still have enough sun to fix a Chicken Stir Fry. Earlier in the day, I cooked the rice. I set the rice in the focal point and left it, so that the focused heat would get it boiling. As the sun moved its position, the diffused light finished cooking the rice.

I even cooked pasta. This is something that other types of solar cookers have trouble with. I got the water to a good boil and added the pasta. These weren't flat egg noodles either, they were dried, cheese-stuffed tortellini. After I dumped them in, the water came back to a boil. Twenty minutes later, the pasta was done.

Notes on the Sundyne
I think that this solar cooker is going to be very useful, especially on those clear but cold days of winter when our canyon has abbreviated hours of sunlight. It's a different type of solar cooking, but it's very versatile.

When not using the cooker, keep the lens pointed directly up so as not to fry something by accident. Even if you don't move the lens, the movement of the sun will change the focal point throughout the day.

There are only fifty of these cookers in the USA. Blackhawk Solar has them for $199. This cooker has opened up some new cooking techniques for me.

Sun Toys
I have also been testing the Sun Toys Solar Panel Cooker. This cooker folds into a 14 by 14 by 2 inch packet, and weighs only eight ounces. It is patterned after Solar Cookers International's CooKit, highlighted in the *HP66* article on Solar Cooking in Africa. Instead of reflective cardboard, this one is made from bubble wrap with foil laminated to both sides. This makes it more weatherproof.

To cook with the Sun Toys unit, use a turkey roasting bag as the glazing around the cooking pot. Replace the bag after about 20 uses. The bags are commonly available at most grocery stores. Place sticks, stones or a trivet in the bottom of the bag, to allow the heat to circulate and to keep the pot and the bag separate.

Cooking
This cooker cooks quite well, although it's slow. I used it to make rice, vegetables, and a whole chicken, unstuffed. With the Sun Toys unit, use the old solar cooking rule of thumb: it takes twice as long in a solar cooker as in a conventional oven. The beauty of this cooker is in the portability, effectiveness and low cost—it was only $18.98.

Solar Pioneers
While we're on the subject of solar cooking, I was lucky to see and talk with Tom Burns and his wife, Betty, at the Midwest Renewable Energy Fair this year. This is a couple who have devoted years of their lives to promoting solar cooking on a large scale. Not only here in the USA—they've also worked in other countries around the world. These two people are the reason that seven villages in Haiti have fresh solar baked bread every week. It is highly inspiring to see that kind of dedication and commitment.

Solar Lard
Bob-O and I had occasion to butcher some pigs that were given to us. I highly recommend Carla Emery's *Encyclopedia of Country Living* and the inimitable *Stocking Up* for reference and recipes. See Emery's review in *HP42*, page 96. I used my Solar Chef cookers to render the fat into lard. Long slow heat with occasional stirring worked perfectly. I did not use the Sundyne—the heat would have been too intense.

Access
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530-475-0830 • kjs@snowcrest.net
kathleen.jarschke-schultze@homepower.org

Blackhawk Solar, POB 1468, Quincy, CA 95971
530-283-1396 • Fax: 530-283-4675

Sun Toys, 14837 206th Ave SE, Renton, WA 98059

Solar Chef, 220 Southridge Way, Grants Pass, OR 97527 • 800-378- 4189 • 541-471-6065

Burns-Milwaukee Sun Ovens, 4010 W. Douglas Ave, Milwaukee, WI 53209 • 414-438-1234
Fax: 414-438-1604

HAPPENINGS

AUSTRALIA
Oct 18–27: The biennial World Solar Challenge, the premier solar car race, contributing vital R&D for sustainable future transportation. New: Entry Competition open to school and tertiary entrants. Free entry to the first school and tertiary teams to register. Contact: Ray Wieland, level 7 178 N Terrace, Adelaide 5000, South Australia
+61 8 8303 2021 • wsc@saugov.sa.gov.au
Web: www.wsc.org.au

BELGIUM
October 1–3, 1998: 15th International Electric Vehicle Symposium and Electric Vehicle Expo, Brussels. Contact: EPE Assoc., c/o SRBE-KBVE, c/o VUB, Pleinlaan 2, B-1050 Brussels, Belgium
32-2-629-28-19 • Fax: 32-2-629-36-20
bsneyers@vub.ac.be
Web: www.avere.org/evs15

CANADA
The "Alberta Sustainable House" is open on 3rd & 4th Saturdays (except holiday weekends) from 1:00-4:00 PM free of charge. Emphasizes cold-climate features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc, 9211 Scurfield Dr NW, Calgary, Alberta T3L 1V9, Canada
403-239-1882 • Fax: 403-547-2671
Web: www.ucalgary.ca/~jdo/ecotecture.htm
jdo@acs.ucalgary.ca

The Institute for Bioregional Studies demonstrates and teaches recent ecologically-oriented, scientific, social & technological achievements for ecological, healthy, interdependent and self-reliant communities. Contact: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada • 902-892-9578

Vancouver Electric Vehicle Association, Call for meetings. Contact: 1402 Charlotte Rd., North Vancouver, BC, Canada V7J 1H2
604-987-6188 • Fax: 604-253-0644
rcameron@statpower.com

Electric Vehicle Society of Canada, Toronto Chapter promotes EVs to reduce the environmental impacts of conventional automobiles (and has fun!) are enthusiasts, inventors, Sunday mechanics and environmentalists who share the belief that EVs are a viable alternative. Meetings: 3rd Thursday each month, September-June. New members welcome! Contact: Howard Hutt, 21 Barritt Rd, Scarborough, Ontario, M1R 3S5 Canada • 416-755-4324

CHILE
Nov: SENESE X, the tenth annual Congress of Sustainable Energies, Punta Arenas, Chile. The progress of research from the academic sector of Chile & many Latin American countries, renewables/ technologies, discussions on promoting & reinforcing their application, & participation from NREL researchers. Paul Gipe invited. Contact: Arturo Kunstmann, Center for Energy Studies, University of Megellan, Casilla 113-D, Punta Arenas, Chile 56-61 207185 • Fax: 56-61 207184
cere@ona.fi.umag.c
Web: members.xoom.com/senese/

CHINA
Oct. 20-22, 1998: International Conference & Exhibition on Energy & Energy Conservation, Shanghai Mart, Shanghai. Contact: ICEEEC, Rm 1322 Bldg. 3, 1486 Nanjing Rd. (W), Shanghai 200040, P.R. China
Fax: 86-21-62049481 • wjyao@online.sh.cn.

Oct 14–16, 1998, Renewable Energy & Energy Efficiency Asia-Pacific '98 (REAP'98) Conference and Exhibition, Shanghai, China. Contact: Alternative Development Asia Limited, 1406 Leader Commercial Building, 54-56 Hillwood Road, TST, Kowloon, Hong Kong • +852-2574-9133
Fax: +852-2574-1997 • office@adal.com
Web: www.adal.com

INDIA
Nov 26-27, 6th Int'l Symposium on Renewable Energy Education, New Delhi, India. By Solar Energy Society of India, Int'l Assoc. for Solar Energy Education, and Tata Energy Research Institute.
091-11-462-2246 • Fax: 091-11-463-2609
akmisra@teri.res.in

MONACO
The 4th International Rendezvous Of Electric Vehicles will be held October 15–16, 1998. The focus: Helping increase electric vehicle usage in urban settings. Todays market, environmental regulations, policy and development will be covered. For more information contact: EPI Communication, 11 boulevard Albert-1er, MC 98000 Monaco
+377 97 97 60 00 • Fax: +377 97 97 60 30
e-mail: epi@monaco-monte-carlo.mc
http:www.monaco-monte-carlo.mc/EV

NEPAL
Nov 9 1998, March 1-9 1999, April 1-9 1999, 'Solar Sisters' install solar in Himalayan communities, giving women the opportunity to provide 'hands-on' solutions to energy problems faced by Nepalese communities. Volunteers contribute to the cost of a solar home system and come to Nepal for intensive installation training course. Participants will install the systems in buildings which exists for the benefit of the local community. Possible electrification sites include handicraft centers, health posts and classes used for women's literacy programs. Contact: Stephanie Davis, Himalayan Light Foundation, PO Box 9219, Kathmandu Nepal
977 1 418 203 • Fax: 977 1 412 924
hlf@mos.com.np

NEW ZEALAND
36th annual Solar '98 Conference, sustainable energy use and application in Australasia. By Australian and New Zealand Solar Energy Society. Attended by scientists, researchers, manufacturers, installers, government representatives, consumers and enthusiasts. Contact: George Hardy, ANZSES, PO Box 1140 Maroubra NSW 2035 Australia • +61 02 9311 0003
Fax: +61 2 9311 0004 • Web:
eureka.arch.unsw.edu.au/faculty/arch/solarch/anzses/anzses.htm

TURKEY
Oct 22-25, 1998: International Istanbul Energy Technology Exhibition, CNR World Trade Center, Istanbul. Trade show, professional contacts, & technical meetings toward informing industrial and government offices about new energy technologies. Contact: Center for New Relations, World Trade Center, Atatürk Havalimani Darsisi, Yesilkoy 34830 Istanbul • 90-212-663-08-81
Fax: 90-212-663-09-73-75 • ifnrg@ibm.net

NATIONAL US
National Summary Reports on State Financial and Regulatory Incentives for RE. Most current info on state and federal tax, grant & loan programs. To order contact: North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480
Fax: 919-515-5778
Web: www.ncsc.ncsu.edu/dsire.htm

Sandia's new web site. New material, organized better. Includes "Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices," "Working Safely with PV," & balance-of-system technical briefs, providing information on battery & inverter testing
Web: www.sandia.gov/pv

American Hydrogen Association nat'l headquarters: 1739 W 7th Ave, Mesa, AZ 85202-1906 • 602-827-7915
Fax: 602-967-6601 • aha@getnet.com
Web: www.clean-air.org

Solar Energy & Systems, a college credit course taught on the Internet using the latest technology. Covers fundamentals of RE for the homeowner or small village. Weekly assignments reviewing various texts, videos, WWW pages, weekly chat room, & email questions and answers. Mojave Community College. Tuition is $100 plus $10 registration.
800-678-3992 • lizcaw@et.mohave.cc.az.us
or chacol@hal.mccnic.mohave.az.us

American Wind Energy Association. Info about US wind energy industry, AWEA membership, small turbine use, and more
Web: www.igc.org/awea

Energy Efficiency & Renewable Energy Clearinghouse (EREC) BBS, free access to text files, share/freeware programs & utilities, & a free publication ordering system.
Web: erecbbs.nciinc.com
Modem: 800-273-2955

Energy Efficiency and Renewable Energy Network (EREN), Web: www.eren.doe.gov

provides links to hundreds of gov't and private internet sites & offers an "Ask an Energy Expert" online form to email questions directly to specialists. 800-363-3732

Energy Efficiency and Renewable Energy Clearinghouse (EREC) offers free info: 1998 Fuel Economy Guide (SD404), Insulation Basics (FS142), New Earth-Sheltered Houses (FS120), PV: Basic Design Principles and Components (FS231), Cooling Your Home Naturally (FS186), Automatic & Programmable Thermostats (FS215), & Small Wind Energy Systems for the Homeowner (FS135), reviewing site determination, system requirements, & costs of residential wind turbines. Contact: EREC, PO Box 3048, Merrifield, VA 22116 800-363-3732 • TDD: 800-273-2957 energyinfo@delphi.com Modem: 800-273-2955 Web: www.eren.doe.gov

The Federal Trade Commission offers free pamphlets: Buying An Energy-Smart Appliance, the EnergyGuide to Major Home Appliances, & the EnergyGuide to Home Heating and Cooling. EnergyGuide, Federal Trade Commission, Room 130, 6th St and Pennsylvania Ave NW, Washington, DC 20580 • 202-326-2222 • TTY: 202-9326-2502 Web: www.ftc.gov

Kids to the Country, an ongoing program to show at-risk urban children a country alternative. A project of PLENTY. Contact: PLENTY, 51 The Farm, Summertown, TN 38483 • 615-964-4391 • ktc@thefarm.org

The Interstate Renewable Energy Council (IREC), in cooperation with the SEIA and Sandia National Lab has a handbook to guide state and local government procurement officials and other users in the specification and purchase of RE technologies. Biomass, PVs, solar domestic water and pool heating, & small wind systems. Technology specs, RE equipment, photographs, and vendor contact info. Simple methods for estimating the pollution benefits of RE systems. Send $US15 ppd to Interstate RE Council Distribution Center, c/o ASES, 2400 Central Ave Ste G-1, Boulder, CO 80301 (make checks to ASES)

Oct 17, annual National Tour of Solar Homes. Solar energy is clean, quiet, and reliable. Homeowners open their doors to visitors for a first-hand look at practical uses of RE, featuring solar heating, PVs, and energy conservation. To find a tour near you, contact: American Solar Energy Society: 303-443-3130 • Web: www.ases.org/solar

May 22-29, '99. 11th Annual American Tour de Sol, US EV Championship. 50 EVs traveling from Waterbury, CT to Albany, NY and beyond. Contact: NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 Fax: 413-774-6053 • Web: www.nsea.org

Green Power web site, www.green-power.com, a forum for consumers, policy makers & green providers to discuss green power issues including electricity deregulation, "green" electricity choices, technology, marketing, standards, environmental claims & varying national and state policies. Links, articles & news. Launched by Global Environmental Options (GEO) & the Center for Renewable Energy and Sustainable Technology (CREST). GEOs other web sites include www.greendesign.net & www.greening.org • For more sustainable energy info: www.crest.org .

Non-profit Tesla Engine Builders Association (TEBA), info & networking for building efficient Tesla disk turbines. The 18" diameter, single stage steam version, operating at 9,000 rpm has been documented to consume 38 lbs of saturated steam per hp/hr @ 125 lbs inlet pressure & free exhaust. Send an SASE to TEBA, 5464 N Port Washington Rd Suite 293, Milwaukee, WI 53217-4925 • teba@execpc.com Web: www.execpc.com/~teba

ALABAMA

The Self-Reliance Institute of Northeast Alabama seeks others in the southeast interested in RE, earth sheltered construction, & other self-reliant topics. Contact: SINA, Route 2 Box 185A1, Centre, AL 35960 • cevans@peop.tdsnet.com

ARIZONA

Tax credits for all types of solar energy systems in Arizona. A technician certified by the AZ Department of Commerce must be on each job site. Contact: ARI SEIA 602-258-3422

Oct 18 - Nov 1, Permaculture Certification Course. How to best use natural resources, integrating built environment, and alternative economic systems. For planners, ranchers, home owners, educators, and others. $950 includes food, housing extra. Contact: 888-Permaculture

Dec 3–4: North American Electric Vehicle & Infrastructure Conference and Exposition, Phoenix, AZ. Contact: EVAA, 601 California St Ste 502, San Francisco, CA 94108 415-249-2690 • Fax: 415-249-2699 ev@evaa.org • Web: www.evaa.org

CALIFORNIA

Campus Center for Appropriate Technology, Humboldt State University, Arcata, CA has ongoing workshops and presentations on a variety of alternative, renewable, and sustainable living subjects. Contact: CCAT, HSU, Arcata, CA 95521 • 707-826-3551 ccat@axe.humboldt.edu Web: www.humboldt.edu/~ccat

Oct. 10, Solar Cookers International Annual Meeting. Sacramento, CA. Contact: SCI, 1919 21st St. #101, Sacramento, CA 95814 916-455-4499 • Fax: 916-455-4498 sci@igc.org • www.accessone.com/~sbcn

Siemens Solar Industries offers two levels of PV training: Basic PV Technology Self-Study Course, & Comprehensive Photovoltaic System Design Seminar (call for dates). Instructor: Mark Mrohs. Self Study program includes: 500 page training manual, 9 hours of video lessons, applications, w/exercises & examples. ($500 plus shipping & tax). System Design Seminar: 5-day intensive lecture, hands-on assembly, labs, & team system design problem solving. ($1000). Contact: Siemens Solar Training Dept, 805-388-6568 • Fax: 805-388-6395 cvernon@solarpv.com Web: www.solarpv.com

Rising Sun Energy Center presents ongoing Solar Energy Classes incl. electricity, water heating, cooking, & kids day. For schedule and info: PO Box 2874, Santa Cruz, CA 95063 • 408-423-8749 • sunrise@cruzio.com Web: www.cruzio.com/~solar

Oct 23, 24, & 25: Alameda International Electric Vehicle Exposition, at the former Naval Air Station, Alameda, CA. Electric, educational & entertaining family fun. Displays of experimental EVs, production & near-production EVs, EV equipment & transportation. EV races; ride & drive opportunities (Chrysler, Toyota, Honda, Ford, Nissan, GM and S-Lem). Looking for sponsors & exhibitors. Organizers : City of Alameda Bureau of Electricity, CALSTART, the Alameda Chamber of Commerce and Winnett Exposition Services, Inc. Contact: Cherry Hozian, 20, Winnett Exposition, Svc. Inc., 1090 Adams Street Ste. D, Benicia, CA. 94510 • 888-334-3976 • 707-747-6399 Fax: 707-747-6437 • cherryh@wes-scs.com Web: www.EVExpo.com

Nov 4-5: Power Matters '98, conference & exposition on California's deregulated energy market, Oakland, CA. Contact: Terry Bursztynsky • 510-464-7964 terryb@abag.ca.gov • Web: www.abag.ca.gov/services/power/pmconference/powermatters.html

COLORADO

Solar Energy International (SEI), a non-profit dedicated to the practical use of RE. Hands-on workshops on the practical use of solar, wind, & water power. The Renewable Energy Education Program features one & two week sessions: PV Design & Installation, Advanced PV, Wind Power, Micro-hydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Experienced instructors & industry representatives. For owner-builders, industry technicians, business owners, career seekers, & international development workers. Workshops may be taken individually or as a comprehensive program. $500/week. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org Web: www.solarenergy.org

National Wind Technology Center is operated by the NREL, near Golden, CO, assisting wind turbine designers & manufacturers with development & fine tuning. Computer modeling & test pads. Call in advance • 303-384-6900
Fax: 303-384-6901

Oct 11-14, '98: The 4th NREL Thermo-photovoltaic Generation of Electricity Conference, Adams Mark Hotel, Denver, Colorado. Contact: Heather Bulmer
303-275-4317 • Fax: 303-275-4320
Web: www.tpv.org

IOWA
Iowa Renewable Energy Association board meetings: 2nd Saturday every month at 9:00 am, Cooper's Mill Restaurant (Village Inn Motel) in Cedar Rapids. Everyone welcome. Call for schedule change. Contact: I-Renew, PO Box 2132, Iowa City, IA 52244
319-338-3200 • Fax: 319-351-2338
irenew@igc.org

The Iowa Renewable Energy Association (IREA) sponsors workshops this spring on straw bale houses, domestic hot water installations, & DC PV systems at Prairiewoods Nature Center near Cedar Rapids, Iowa. Contact IRENEW or Tom Snyder, 611 Second St. SE, Dyersville, IA, 52040 • tsnyder@mwci.net
or: Prairiewoods, 120 E Boyson Road, Hiawatha, IA 52233 • 319-395-6700

KENTUCKY
Appalachia-Science in the Public Interest has ongoing projects and demonstrations in gardening, solar, sustainable forestry, & more. Contact: ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • aspi@kih.net
Web: www.kih.net/aspi

MAINE
June 12-17 '99, Solar 1999: Growing the Market, American solar Energy Society's Annual Conference. Devoted to taking solar energy into the 21st Century. Growing strong and sustainable markets is our compass. Portland, ME Contact NESEA • 413-774-6051 or American Solar Energy Society
303-443-3130 • ases@ases.org
Web: www.ases.org/solar

The American Solar Energy Society's next annual conference, SOLAR 99, is devoted to taking solar energy into the 21st Century. Growing strong and sustainable markets is our compass for this June 1999 conference in Portland, Maine.

MASSACHUSETTS
Greenfield Energy Park needs your help preserving Greenfield's historic past, using today's energy & ideas, creating a healthy sustainable future. Contact: Greenfield Energy Park, NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051
Fax: 413-774-6053

MICHIGAN
Tillers International lists classes in draft animal power, small scale farming, blacksmithing & woodworking. For a class catalog contact: Tillers Int'l, 5239 S. 24th St., Kalamazoo, MI 49002 • 616-344-3233
Fax: 616-344-3238 • TillersInt@aol.com
Web: www.wmich.edu/tillers

MONTANA
Sage Mountain Center: Lifeskills Workshops, 1998. One day, comprehensive classes: Inexpensive earth-friendly home building, straw bale construction, making log furniture, cordwood construction, natural & non-toxic interiors, & more. $45 includes lunch & literature. Contact: SMC, 79 Sage Mountain Trail, Whitehall, MT • 406-494-9875

NEW YORK
Environment '98, Plug in to New York, featuring the Clean Air and Energy Summit, October 2–4, 1998. Contact: Environmental Advocates, 353 Hamilton St, Albany, NY 12210 • 800-SAVE-NYS • Fax: 518-427-0381

OREGON
APROVECHO RESEARCH CENTER is a non-profit educational institute on forty acres nestled in the forest of Oregon. Internship programs March 1, June 1, and September 1. Also, a six week winter internship in Baja, Mexico focusing on studying and researching appropriate technology applications, learning Spanish, teaching in a grade school, & working in fruit orchards & gardens. Contact: Internship Coordinator, Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198

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SEASUN, El Paso Solar Energy Association
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VERMONT
Free PV Workshops for beginners & experienced off-gridders. 9-3 pm, 1st Sat, most months. Topics determined by participant interest: site selection, system monitoring & maintenance, PV modules, batteries, charge controllers, inverters, lighting (ac & DC), system components, water, snow, ponds, living in cold climates, living with our woods, wood heat, & root cellars. Visit Vermont, meet people living with RE or considering it. Free! Bring your own lunch & coffee. Contact: David Palumbo, Independent Power and Light, RR1 Box 3054, Hyde Park, VT 05655 • 802-888-7194
indeppower@aol.com

WASHINGTON
GreenFire Institute: Workshops and Info on straw bale construction. Contact: GreenFire, 1509 Queen Anne Ave #606, Seattle, WA 98109 • 206-284-7470 • Fax: 206-284-2816
wilbur@balewolf.com
Web: www.balewolf.com

Solar, Wind & Water Power Workshops Presented by Solar Energy International in the San Juan Islands, USA. Renewable Energy for the Northwest, Fri-Sun Oct. 16-18 $200 Overview of producing your own electricity, including solar, wind, and microhydro systems, hybrid systems, system design and siting, energy conservation and efficiency, and resources for further study. Photovoltaic Design and Installation, Mon-Sat Oct. 19-24 $500 Learn hands-on how to use solar electric technology including basics of electricity, solar site analysis, pv system components, energy efficient appliances, pv system sizing, component specification, electrical wiring, safety procedures, solar water pumping, pv for lesser developed countries. Contact: Ian Woofenden
970-963-8855 • 360-293-7448 (home)
Fax: 970-963-8866 • ianw@pacificrim.net or sei@solarenergy.org
Web: www.solarenergy.org

Oct 20-22, Environmental Forum for Business, 9th annual conference and trade show. AE for the next century, one of 7 conference tracks. Contact: 509-358-2073
Fax: 509-358-2179 • enviro@sirti.org
Web: www.environmentalforum.org

WASHINGTON, DC
Oct 28-31, Excellence in Building Conference & Expo, Sheraton Washington Hotel. Building science, construction practices, marketing, utility, & gov't. programs. Contact: EEBA, 2950 Metro Dr. #108, Minneapolis, MN 55425 • 612-851-9940 • Fax: 612-851-9507
Web: www.eeba.org

WISCONSIN
Midwest Renewable Energy Association (MREA) Workshops. See ad in this issue. Call for cost, locations, instructors & further workshop descriptions. MREA Membership & participation: all are welcome. Significant others 1/2 price. Contact: MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166
Fax: 715-824-5399

Bioenergy '98, 8th Biennial Conference, Oct. 4-8, 1998, Madison,WI. Contact: Great Lakes REgional Biomass Energy Program, 35 East Wacker Dr. #1850, Chicago, IL 60601
312-407-0177 • Fax: 312-407-0038
Web: www.cglg.org/bioenergy98

The University of Wisconsin-Madison will offer, Principles of Effective Energy Management, incorporating energy and environmental considerations into your facility and how to benefit from utility deregulation. November 16–20, 1998. December 1–4 1998, Power Quality Problems in Industrial Environments. A course covering basic analysis techniques, solutions to voltage disturbance problems and monitoring for harmonic and transient disturbances. Contact Katie Peterson, Department of Engineering Professional Development, University of Wisconsin-Madison, 423 N Lake St, Madison, WI 53706
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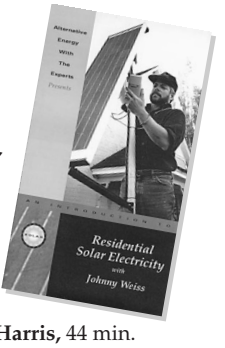

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the Wizard speaks...

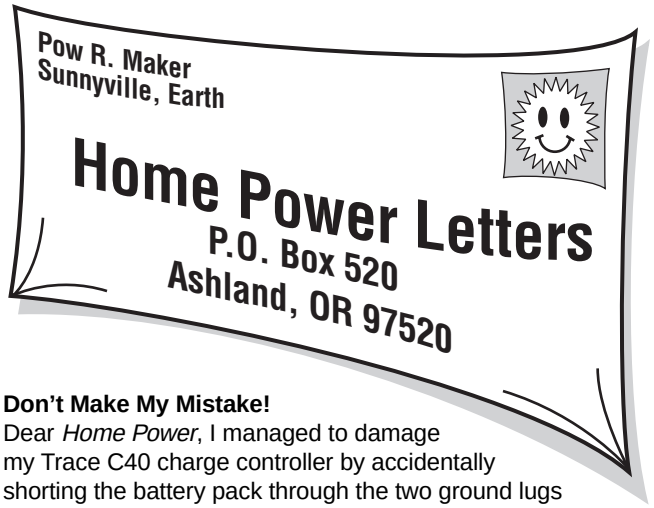
Origins

It is said that our universe resulted from a massive explosion called the Big Bang. Before this, there was no space, no time, and no matter. What existed before the Big Bang? Where did the energy and space that comprise our universe originate?

From a synthesis of many disciplines, I have surmised that we exist in a metaverse of *n* spacial dimensions, where *n* is greater than ten. There is an ever-existent, infinite, and unbounded superior three-dimensional universe. The other (*n*-3) dimensions are curled up in tiny neighborhoods of this superior universe. Due to the actions of the superior universe and/or internal self-organization, these (*n*-3) dimensions form bubbles on the surface of the superior universe.

One of these bubbles represents the singularity that gave birth to our physical universe. From this bubble of (*n*-3) dimensions, the three dimensions of our universe began to unwind and expand. This unwinding and expansion of the dimensions released the stored dimensional energy which resulted in matter. This was the big bang. It is still going on at the boundaries of our universe, where the dimensions continue to unwind.

Some of the other (*n*-6) dimensions are probably still curled up in the original bubble. By virtue of their structure and organization, these (*n*-6) dimensions may be responsible for the general laws of the physical universe. Even if still curled up in small neighborhoods, these (*n*-6) dimensions exist at every point of our three-dimensional universe.



Don't Make My Mistake!
Dear *Home Power*, I managed to damage my Trace C40 charge controller by accidentally shorting the battery pack through the two ground lugs on the C40 board. In repairing the board I found that there is a weakness in the layout of the PC board. The electronics on the C40 board require a connection to the ground taps. What I found is that there is a ground 'loop' where a PC trace comes off from one ground lug, routes throughout the PC board, and returns back to the other ground lug. Normally this wouldn't be a problem since the two ground lugs themselves are shorted between each other with shorter PC traces, but what happens when the traces between the two lugs gets blown out? The current flow then flows through the longer ground trace in the electronics portion of the board causing many burned traces, and taking out electronic parts. True, there is not much Trace could have done to handle hundreds of amps of current between these two ground lugs, but their electronics should only have been connected to one lug. In this arrangement any overcurrent would only blow out the traces between the lugs, and not take any electronics out with it. The repair for this damage would be easily fixable by bolting a fusible strap between the two lugs.

You may be wondering how I managed to short the battery through the charge controller? I was wiring up heavier gauge wires from the C40 to my fused disconnect, and although I had the fuses pulled, the new wire I was installing accidentally brushed up against a live wire block inside the disconnect. Instant poof.

I was able to repair my Trace C40 myself, ordering the needed parts from Digi-key. I did leave an email and voice message with Trace to inquire about having my C40 repaired, but both messages have gone unanswered. I doubt they could have repaired the unit in the 3 days it took me to wait for parts to come in anyways.

In the meantime, I would recommend that if you have a Trace C40, and your gauge of wire is small enough that you can put both ground wires into one ground lug, do that instead of putting each in their own lug. Also, always disconnect your battery pack at the battery before working on any portion of your system. I mistakenly thought I was safe to pull the fusible disconnect! The C40 is built well, and has overcurrent and overvoltage safety features, but not between the two ground lugs!

As a side note, the front panel label of the Trace C40 reads that there is an audible alarm that will sound if the polarity at the lugs is reversed. THERE IS NO AUDIBLE ALARM! There is not even an audible transducer either! Trace says this is a misprint. Dave Schmidt • dschmidt@silcom.com

Rail is Better and Cheaper
I noted your remark in the most recent issue of *Home Power* about the huge amount of gasoline used in the motorhome rented to transport your group to the Midwest Renewable Energy Fair.

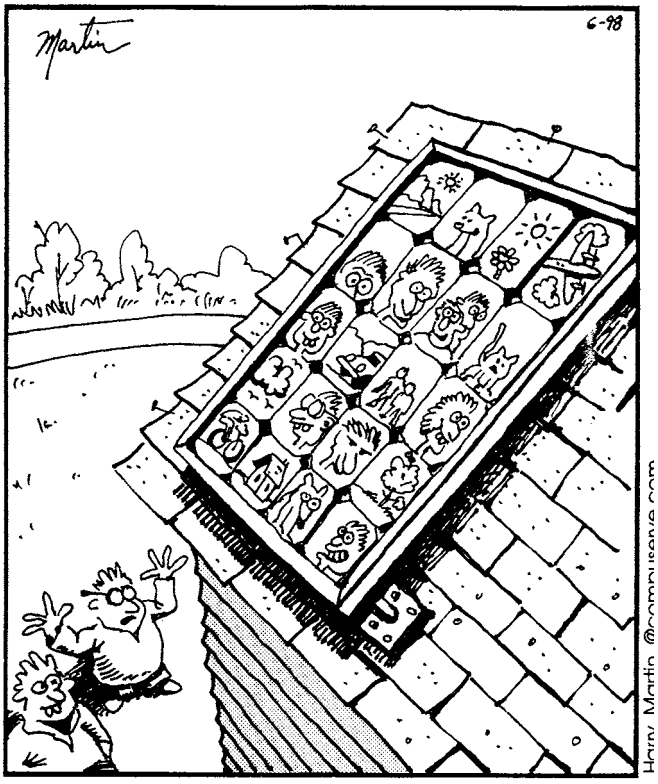
Besides being a *Home Power* subscriber and owner of a small PV-based system in my apartment, I am also a rail fan. Once in the reading I do on that subject it was stated that it takes half the BTUs to travel inter-city by rail as compared to air travel, which you were considering for your next trip.

How about it? Is Amtrak a viable alternative for that next trip to Wisconsin?

Also I wanted to say, "Thanks!" for your recent tip about point-of-use electric water heaters. You pointed me to a 2.5 gallon model in the Grainger catalogue which I successfully plumbed in for a friend last weekend. It works great!

Keep up with the good work on the magazine, Stanley Ames 76010.2202@compuserve.com

Hello Stanley. It was a disgusting amount of gasoline—about 650 gallons. To be sure, there were six of us in the vehicle but this still seems like too much fuel. We considered a smaller van, but driving straight through like we do requires that the crew whom are off-duty must sleep well. Sadly enough, the rented motorhome was cost effective. It saved two days of driving time by moving 24 hours a day. This saved everyone's



"No no...I said photovoltaic, not photographic panel!"

time. We were able to haul hundreds of pounds of magazines, books, CD-ROMs, and booth equipment rather than shipping, saving about $400 alone. And the RV rental was far cheaper than buying six plane tickets.

Karen has tried to route us by rail for the last four years. We are some two hours by truck from the nearest railhead—Klamath Falls, Oregon. Oddly enough, even though Medford, Oregon has an "international" airport, it has no passenger rail service. Medford is also two hours from us by truck. In the past, the rail route was not continuous. We would have had to rent a car and drive between rail terminals to complete the trip by rail.

On your suggestion Karen called our local travel agent to see if the rail picture had changed. Here is what she found out. The journey is now possible entirely by rail from Klamath Falls, Oregon to Milwaukee, Wisconsin. Travel time is 54 hours. A seat is relatively inexpensive, $339 round trip. This is about $225 cheaper than round trip airfare. The only problem is that we'd have to spend 54 hours sitting up. One of my big objections to driving is that we arrive worn out. I suspect that rail would be more comfortable. After all, no one has to drive. We'll see how the crew feels about sitting up for 54 hours....

Thanks for the flowers. We like our little point-of-use water heater too. We originally added it as a diversion load. Now system demands have grown and we no longer have much surplus to divert. I think we are going to add some more modules and upgrade the wind genny. Richard Perez

The Dutch Way

I have just discovered your mag on WWW, following links from Mr. Solar's site! Downloading the latest mag took less than a quick morning coffee-break: 5 minutes! But that may also be influenced by the time zone difference: I live in Holland, so it was night at your site. I very much like the concept: bringing power to the people by creating awareness, by education, and by practical installation advice. I want to comment on recent letters:

(1) The result of the "free download" is that the message is spread to ALL interested people, who are surfin' following their search queries. (mine was "solar power PV") If I had to pay before download, I wouldn't be in touch with you—I would have clicked the next link.

(2) "Armchair readers" who are dreaming or waiting for an opportunity to start their solar project: you can make a big difference, even before starting on your solar power! I am in the designing phase myself, so still 100% on-grid. However, I bought an inexpensive 230 vac power meter and connected it between every appliance in my house and the wall outlet.

This gave me two things: I now know the total power I am using today, one input for designing the solar system; and I stumbled across some surprises: my hi-fi set consumes 40 watts while in standby mode! My VCR uses 25 watts just to pass the antenna signal to the TV set! So the hi-fi and VCR waste 1.5 KWh each day, 20% of my electricity bill!

I checked every appliance that has its transformer or power supply connected to the grid 24 hours/day, to find the tiny bits that add up to a significant bill every month. After building up this knowledge, I changed the behaviour of myself and my family to use the power switch instead of leaving the hifi in standby mode. I installed a simple 230 volt switch on the VCR. I had to split the antenna signal to feed the TV set directly, so the VCR only needs to be powered when we actually use it.

Another great saving is replacing incandescent light bulbs with fluorescent ones. I had to modify two lamps, some mechanical engineering because most 'folded tubes' are still a little longer than bulbs. I enjoy the 7 watt PL-S tubes every day, giving more light than the 40 watt bulbs they replaced. The saving seems limited, but becomes impressive when I tell you this equals at least 2 solar panels at my latitude! Together with the other savings and some small adjustments to habits (children now turn off the light when leaving the bedroom...usually) this means using around 700 kWh less each year. I could have equally lowered my bill by installing 10 solar panels, but I know which is easier and cheaper—yes, I am Dutch.

All of these are simple actions, due to the awareness that I built up. Measure, and you know! Each of you can afford a power meter and it takes just a few minutes to check the power leak of a device. By calculating the total power you also know how much you have to cut back before becoming self-supporting at a limited budget. By the way: I do not intend to go off-grid, for the following reasons:

(3) I am astonished about the Net Metering discussions when I compare the situation here with yours. I will describe my experience with the local utilities, it might bring you new positive ideas for discussion. After I called the utilities, they sent me a letter with confirmation that they not only allow, but also support de-centralized RE power generation (no guerrilla needed, it's legal here). Up to 5 kW they only require basic safety specifications from the inverter, so I can connect it safely to the grid. Under 400 watts peak you can simply plug the inverter into any wall outlet, above this you have to provide one (or two) new 'group' fuse and wall outlets to separate the generator from your installation (Max on one fuse is 16 amps, 3600 watts here). They don't require UL listed gear, because it is your own installation (beyond the wall outlet) and your own safety. They expect you to use common sense.

The electricity meter is allowed to run backward, without any further action the power bill will be based on the yearly net consumption. Net surplus is not paid back, unless you install a second meter. When I install a grid-connected PV system and send the proof of purchase to the utilities, they refund 3 guilders for every connected Wpeak, approximately $150 for each 100 Watt panel connected to the grid! They supported me with advice and information on panels and installers, so these utilities are truly customer-oriented! They only asked me to report my installation to their office in my town, so they would know in case of maintenance to the grid. In theory they could disconnect power for maintenance while my inverter keeps the "island" at 230 vac, causing a hazardous situation to the workers. By the way, power outages are seldom here, I only know one occurrence in the last 5 years, so that too is no reason to go off-grid.

(4) Off-grid (i.e., battery) operation means inherent power loss due to the difference between the voltage delivered by the PV panel (about 16 V), the charging voltage of the batteries (14 V), and the battery voltage when discharging (depending on the current 12 to 13 V). This means that you lose approximately 25% power, even before reaching the inverter. Of course I will not be self-supporting during blackouts when I skip the batteries, but I can run the inverter from 100% of the power delivered by the solar modules. This consideration made me decide for a grid-connected system without batteries. Now I am designing my own inverter, because the ones in the catalogs are beyond my budget—and for the fun of it! The panels I already purchased will deliver 2.5 kWp, but I want my inverter to be configurable for a larger system as well. Expandability is a designer's flaw.

I had some trouble viewing your mag after downloading when I clicked on the link for immediate viewing it. Acrobat as plug-in couldn't display anything after downloading succeeded. Solution: downloading to file (click right mouse button) and start Acrobat manually!

Keep up the good work, positively biassed by the sun! Cor van de Water, The Netherlands, Cor.vande.Water@ex1.dsn.ericsson.se

Hello Cor, you are indeed lucky to have a utility which accepts RE input from its ratepayers. Here in America, we have to fight most utilities into accepting our RE on their grid. You are correct in assessing the greater efficiency of a utility-intertied system. A batteryless system allows the modules to work at, or near, their maximum power point, whereas a battery-based system forces the PVs to operate below their maximum power point. One fact in the favor of a battery based system is that your lights stay on when the utility goes down.

I hear you on the phantom loads! If everyone in the USA were to clean up their phantom loads, we would save enough electricity to power the entire countries of Greece, Peru, and Vietnam! Check out the review of the Brand Power Meter on page 72 of this issue—it's just the instrument for finding and quantifying those phantoms. Richard Perez

The Revolution Continues

Dear Richard, I want to thank you, Laurie Stone, and the *Home Power* crew for the article "Revolutionary Health Care" (*HP66*). In the wealth of negative images of Cuba presented by the mainstream US media, I found it refreshing to read an article that focuses on the advances in Cuba, particularly in the fields of heath care and solar energy.

I found the quote by Luis Berriz, President of CUBASOLAR, particularly moving. Luis is a beautiful person. I got to know him through his cousin in Boston and later spent some time with him and his family in Havana. While the US government and right wing Cubans seek to demonize Cuba and equate the revolution with an evil image of Fidel Castro, Luis is an example of what revolutionary Cuba really is. Luis fought in the revolution and continues this fight through his efforts to promote the research and development of solar energy in Cuba for "the true economic and social development that humanity needs."

It is an example of their hypocrisy that those who claim to be struggling for "democracy" in Cuba will use economic pressure, intimidation, threats, and violence against those of us who offer alternative perspectives. In this context, I am grateful to you for publishing the article. While the US government maintains its brutal and inhumane blockade of Cuba, people like you, Laurie Stone, and the *Home Power* crew are helping to break the blockade of ideas and dialog.

Thank you, y pa'lante, Steve Fernandez, Jamaica Plain, MA, chango@gis.net

HPEE

Dear *Home Power*, I wanted to drop you a note expressing thanks for the PDF version of *HP* available on your web site.

I've had a bit of difficulty finding it in the local magazine racks but the web is easy. And it reduces inks, paper, and other byproducts of the printing business, which I am completely in favor of, being rather concerned about the environment.

Keep up the good work and tell your advertisers I am still reading (and responding to) their advertisements. Kyle R Hearn • kyle@nstar.net

Hello Kyle, Thanks for the flowers! Hey, we love the Home Power Electronic Edition (HPEE)*. I originally started it as a favor to friends in the solar biz in Kathmandu, Nepal. They were getting printed issues very slowly (over five months), or not at all. After about a year of posting the* HPEE*, this mode is making up about 2/3 of our readers.*

No paper, no transportation, and no printing mean we can give it away. We're right back to where we started 12 years ago, giving HP *away. Richard Perez*

Hello Richard!

Just found your magazine yesterday in a Barnes & Noble bookstore and devoured it (a little salsa, some espresso—not bad!) Called Anita this morning, had a pleasant conversation and ordered the "Quick Start" subscription pack, Solar 2, and Solar 3 (Don't worry about losing paper subscriptions by giving away the mag on the web—ain't gonna happen, we still want hard copy!).

The best part is the schematic/how to descriptions of people that have put in installations. Second best part (believe it or not) are the ads! I kept going to the next page to see what kind of suppliers were available! Man, I'm inspired! I have already started thinking about what I have around that I can start experimenting with to get back into RE! The plan is to "check out" in three to four years and move to central Washington state (good sun and wind). The idea of being power independent has tremendous appeal to me—stress on the "independence" aspect. (By the way, I never thought I would read a mag for the advertising, since I was a communications major in college, but, its happened. 'Tis a "sad" but true state of affairs.).

Speaking of which, when I finally got around to graduating from college in 1975, I was very interested in alternative (RE) energy ideas but the technology was primitive and somewhat limited to certain geographical areas. It just wasn't "there" yet technologically. Actually seeing the availability of technology that *works* and is *in daily use* is GREAT!

One last thing re: the inquiry about towers for generators in the current issue: Don't forget the Amateur Radio handbook. The first thing that popped into my mind was a how-to article for a 40 to 60 foot, non-guy wired, tilt-over tower made out of steel irrigation pipe that I remembered from an old issue from the 60s (been a "ham" since '64). Very cool! No guy wires to maintain and no need to climb the tower for antenna (or generator) service—it comes down to you! And, if you want innovative tower ideas (both low budget and hi-tech) for safe, guyed tower construction, nobody tells you "how" better than Amateur Radio publications.

Well, keep 'em flyin'! Keep up the good work!! Best of 73's, too (Anita told me both you and Karen are amateur radio operators). Looking forward to hunkering down with the computer and your Solar CDs and actually DOING something with RE! Steve Toth • SToth@enpointe.com

Green-e Clarifications

Dear *Home Power*, I was happy to see the "Green-e Renewable Electricity Program" get mention in *Home Power* (*HP64* and *65*, Power Politics), but it looks like a few facts need to be clarified.

To gain Green-e certification and the right to use the Green-e logo, an electricity product must be based on AT LEAST 50% renewable electricity. A tag line accompanies the logo which identifies the exact percentage of renewable energy used to supply the certified product.

I am happy to report that half of the certified residential products offered in California have 75% or greater renewable electricity. Of course, even products that are 50% renewable utilize four times more renewable energy that the traditional system mix, which effectively cuts greenhouse gases by at least half.

Some extremely exciting news is that four of the 11 products currently certified under the Green-e program are based on 100% renewable electricity. In addition, companies participating in the Green-e program are required to make full disclosure of the sources of electricity used to supply their electricity products. Products that are Green-e certified cannot use differentiated purchases of nuclear energy, and the non-renewable portion of a Green-e certified product must be as clean or cleaner than California's system mix for SOx, NOx, and CO2, which effectively also eliminates the use of differentiated coal.

The Green-e program is designed to protect customers by ensuring they get what they pay for when they purchase renewable-based electricity products that meet our minimum standards. It is a transparent program based on objective standards, clear definitions, and was created with the input and involvement of experts and stakeholders from the environmental and consumer protection community, as well as renewable energy advocates.

We hope that gaining large numbers of new converts to green power will boost the creation of new renewable facilities and create new, dynamic markets for renewable energy technologies. In the process, many customers will become well-informed about renewables and the types of products regularly featured in *Home Power*.

To learn more about the Green-e program, you can check out our web site (www.green-e.org) or call our toll-free number (888-63-green). I hope this helps clear up some of the confusion! Cheers, Kirk Brown, Green-e Program Manager, San Francisco, CA

Thanks for your clarifications, Kirk. I agree entirely with what you said about the importance of creating new green energy facilities. But where we differ is in how Green-e relates to this. Nothing Green-e has done has helped create new green energy resources. Certifying utilities and the APX that split out their green sources and then charge a premium price only lines their pockets while making the other customers' electricity more brown. There's little good in that.

Additionally, certifying a product as green and then allowing up to 50% brown power to be mixed in is an insult to other successful and popular certification programs. Imagine buying canned tuna certified as Dolphin-Safe only to find out that it still allows Dolphin kills, although 50% less than before. Or how about buying Certified Organic produce that allows 50% of pest control to come from unhealthy pesticides? Would you have a problem with that?

Sorry, your program stands out as an inappropriate compromise in favor of the utility industry. It gives consumers a false sense of contributing without making a significant difference. It is unfortunate that your program got a foothold before a better certification alternative came along. I stand by my recommendation that people use the Green-e logo only as an indicator of possibility, then look into whether a particular company is truly green. Michael Welch

Up and Coming Ukrainian Dealer

I've been reading your magazine nearly one year. Katcha Sanderson from California helps me to receive your wonderful and very interesting magazine. We have nothing like your magazine in Ukraine.

I think we need so much new technology here because we have economic and power crises. And we have the biggest pollution in the world—radioactivity from Chornobyl. We live in Chervonograd, the town of lots of pollution from coal mines and boilers. I think that alternative energy will have a big perspective in Ukraine and our 100,000 inhabitants town.

I was in USA in 1994 for about a year and I know English. I am an electric engineer and I would like to know more about solar panels and other alternative energy. If some firm would help me to open a USA visa I would like to learn and work without salary, only bed and firm. Afterward I plan to open my own business or represent this firm in the Ukraine. I hope you will print my letter and we shall find one another.

Sincerely, Alex Korsun, v. Molotshna G/1, Chervonograd, Luivska obl, Ukraine 292210 • tele: 9-79-41 info@astra.gal.ukrpack.net

Hello Alex. Here's your letter, I hope we can hook you up with an internship or partnership with someone. We would recommend sending a similar letter to some of our advertisers, as well. The Crew

Wants Mini-Wattz Column

Like *HP* very much, especially the layout—whole articles kept

together makes very good reading. Would like to see a corner devoted to very small, low cost systems (Mini-Wattz?). Being a senior on a fixed income, I enjoy reading about the big systems that have everything, but they don't really relate to me. I have two UPM 880 solar panels and two deep cycle marine batteries and everything is 12 Volt. Even with this little cabin system I have lights when the grid is down! I don't really understand all the complicated systems and would appreciate a corner with tips and advice for us "mini-wrenches!" I'm sure there are a lot more than me. Keep up the good work, CS Sternberg, Mt. View, MO

Hello CS, I hear you regarding small systems. Check out the articles on pages 8 and 34 of this issue. Both are about small and inexpensive systems. One of the advantages of RE is that you don't have to buy more than you need. After a few years, if you do need more, then the RE system can easily expand to meet your new needs. Karen and I began in 1983 with a single PV module. Now we have over fifty modules and we're planning on adding at least sixteen more. In the early days of our system, we used all of the power as 12 VDC. Now we only have a few 12 VDC appliances left and almost everything is powered through the inverters. Even if a system starts small, it can grow without wasting the gear already purchased. We'll keep the information about small starter systems coming! Richard Perez

Solar Hot Water

I'm pleased that you have been featuring more articles on solar water heating but I wonder if systems such as the "Solar Gravity Siphon" (*HP63* and *64*) might tend to turn people off because of their complexity.

Solar water heating is really a pretty simple technology. Looking at the index in *HP65* I see that you have covered the really simple and easy to use stuff like batch heaters, passive thermo-syphon systems, ABS plastic, and the like. These systems are easy to build and very effective but usually aren't freeze protected and gravity problems have to be dealt with.

I believe that in trying to reach maximum efficiency a point of diminishing returns is reached and the various drain down, drain back, and gravity syphon systems with their switches, tanks, and complex piping are probably past that point.

For someone who wants to build or have installed a system that is fairly simple, very efficient and reliable, and easy to understand I recommend a PV-powered glycol system. Mine consists of a liquid collector (panel), PV panel, 12 Volt circulation pumps, and heat exchanger, all purchased from AAA Solar Service and Supply of Albuquerque, New Mexico. The rest of the components were obtained locally. Rigid copper tubing and the expansion tank are common hardware store items. I used a new 52 gallon electric water heater for a storage tank. No complex valves, switches, or controls are needed. When the sun shines the collector heats the glycol and the PV panel runs the pumps. Simple as that!

The folks at AAA Solar sold me good components and advised me on how to put them together. This system was easily tied in with my existing wood-fired water heating system and downstream of both is a gas fired demand heater (Aqua Star) for backup.

This system has operated for six years with no problems. It has long since paid for itself. Northern Minnesota doesn't see much sun in December and January so I just shut it off. The wood fired system heats the house and makes all the hot water we can use. I've found a system of this type to be very reliable and adaptable, and if you're on grid power will really take a hunk out of your electric bill.

A few years ago at MREF I jokingly stated to an old hippie that a shower under solar-heated water seemed to feel better than fossil-fuel heated. He got real serious and said, "It does feel better. Nature is rewarding you for doing the right thing." Maybe he's right. Bill Thiessen, Bermidj, MN

Hi Bill. We are happy to hear that your solar/glycol DHW system is treating you well. Yes, many of the solar hot water systems covered in Home Power *are the build-it-yourself-out-of-bits-and-pieces type. Here on Agate Flat, we have had many a pleasurable shower from funky, low-tech systems. The 2 by 6 foot collector was thermosyphon and the shower head was hung from a tree. We do understand your feelings that these systems may be overly complex to build and maintain in relation to their performance and cost savings. But many of our readers enjoy the hands-on process of harnessing simple physics.*

We have now graduated to a pump and glycol system on the new bathhouse. But there are pros and cons to every invention. Yes, this system is less demanding of our attention, and was professionally installed—that is easy. However, the two pumps draw 150 watts all day long—quite a bit of energy for an off-grid system. Also, we may have overheated and damaged the glycol while we were away at MREF because no hot water was being used.

What we are trying to do with Home Power *is provide information on the full spectrum of RE options, but that takes time. Look for future articles on our glycol systems, flat plate and Thermomax, once we have collected more data and experience. Of course, you too are invited to write an article about your own system since it works so well. If you have questions about our author's guidelines, just ask us. Ben Root*

Look It Up Yerself

We are currently in the planning stages of a monolithic dome home and plan to be totally off the grid using wind and solar power as our sole energy sources.

Since we are new to the RE field, we are in need of guidance as to how to select a reputable local (or regional) company to assist us with design and installation.

Can you help us? Any and all information is welcome. Thank you for your attention and effort, Lorenzo and Donna Trujillo, Denver, CO

Hey, are you trying to get us in trouble? If we recommend one, then the others get mad. Actually, you can use any of our advertisers. We do not accept ads from known weasels. If there is not an advertiser nearby, then we have a database of almost 2,000 RE businesses that you can download yourself from our web site's download page. For example, the database shows two installing dealers in Denver proper and a whole bunch in Colorado. We don't filter the database for

weasels, however. Anyone can get in. And if you STILL can't find a dealer nearby, then we have several companies that you can do business with that will help you through the design and purchasing process, but you will still have to find someone to install it, or do it yourself. Michael Welch

Dirty Laundry

I have enjoyed your magazine for five years or so. I've been building my off-grid home here in Waimen, Hawaii for close to four years. The last three have been using wind and sun for all my power. We will be moving in soon and I read the letters about the Neptune and Staber washing machines. Could I please get some info on where I can contact these companies for info and pricing on these products?

Keep up the good work, Scott Hudgins, Kamuela, Hawaii

Hello, Scott. We tested the Staber and gave it a thumbs up for Things that Work! in HP47*. Home Power Central has one of them installed in our new bathhouse, and we love it. On average, it uses about 235 watt-hours of electricity to do a load of wash. Many of our advertisers sell the Staber. You can contact Staber Industries, Inc. directly at 800-848-6200. I think you will find the Neptune available at any big department store that handles Maytag products. We have not tested them, but our readers report that the Neptune uses about twice the energy of the Staber. The web address, neptune.maytag.com is the only info we have. Consider this: every watt-hour of energy you don't consume is a watt-hour that you don't have to produce, process, and store. In terms of money, every buck spent on an efficient appliance saves about three bucks in system components. Richard Perez*

This 'n That

Dear folks at *Home Power*, please sign me up for another year and thanks again for not bombarding me with renewal notices. And thanks for allowing pricing in your advertising. Now if we could encourage more advertisers to post their prices—the joys of competition.

I've enjoyed visiting your web pages, but I'm confused as to why you are being charged for downloads. I only know two owners of commercial web sites and neither is charged for downloads by their service. Why is *Home Power* being charged so much? Perhaps you could move your site. But whether you move or stay, nothing is free and I think it reasonable to charge a fee for access.

On another issue, I feel John Wiles and his Code Corner brings bureaucratic nonsense to your magazine. I've worked enough as an electrician to realize he is nit picking under the guise of safety. There is enough real opposition to solar power without getting blind-sided by such "constructive" criticism. It looks like his influence on the next National Electrical Code update will cause solar installations to be more expensive and needlessly complex. Do we thank him or his money from the masters of war at Lockheed Martin? One of the best parts of *HP* is that it is preaching to the choir. Let's leave Mr. Wiles and his "what if" theories behind and use the space for projects like the recent solar water heating series. Solar is change. Peace, love, and good vibes, Bill Hennessy, Mertztown, PA

Hello, Bill. Thanks for the kudos about the web site. We've had quite a bit of mail and email about our high cost for giving away the magazine. We really can't blame our Internet Service Provider for charging us extra for what they call "excess data traffic" which they consider to be above and beyond their Professional Web Site product. We chose our ISP because they keep their machines and network well maintained, they are close to the internet "backbone," and they keep a favorable ratio of number of T-1 (a special connection that handles lots of digital traffic at once) phone lines to the amount of traffic going through them. Like you say, nothing is free. When they see some 40,000 people (each HP *issue) trying to download our 6+ megabyte files, and when that is combined with their other customers having similar impact on their servers and network phone lines, they have to look at adding infrastructure which costs money.*

We came up with an alternative, though. We have a second ISP that charges us a small flat rate for a web site and we moved our big files to that site. Unfortunately, our files are now not as close to the backbone as optimum, and not as much attention is paid to the amount of traffic allowed on their T-1 phone lines. That translates to a little slower and slightly less reliable downloads for people wanting our files. This allows us to continue giving the electronic edition away for free. Our main web site remains close to the backbone for quick and reliable service. Michael Welch

Hello Bill, I thought I'd respond to your comments on Code Corner. We keep this column in HP *for a very good reason. We want these systems to be safe, and able to be financed and inspected. If RE is going mainstream (as it is doing right now), then we need to deal with the banks and electrical inspectors. Both of these organizations require National Electric Code (NEC) compliance. We can't comply if we don't know the rules. To be sure, I think that some of the new requirements are expensive nit-picking disguised as safety. This is why we also run the Wrench Realities column as counterpoint. Look at it this way—the powers that be (the NEC, the banks, and the electrical inspectors) are going to make these regulations whether we like it or not. If we keep the dialogue open between the NEC and the Wrenches, then at least we can have some input on the rules and regs. In the past, our input has produced positive changes in the NEC—more reasonable grounding requirements and the use of shunts in the negative leg of DC circuits, for example. Richard Perez*

When?

Dear Richard Perez, Many moons ago you announced that with the modern technology and growing competition the price for solar would come down. The new technology is here, but the prices aren't. It seems the little guy is kept out of the picture.

Respectfully yours, "Bill on the Hill" Dyro, Bethel, VT

Hello, Bill on the Hill. The price of PV has come down. While we're paying about the same for a module, the amount of energy the module makes is up from five years ago. The warranties for modules are longer than they were several years ago. And the prices have decreased slightly in the face of inflation. Consider this—last year the worldwide PV

industry made and sold 45% more modules than the year before. The prime reason why we haven't yet seen radical price reductions is that PV module production worldwide is not even close to meeting the demand for solar electricity. Every PV manufacturer that I know of is building new plants as fast as they can. There are new thin-film technologies poised to come on-line. Cheer up, the situation is gradually improving! Richard Perez

Bias Towards Advertisers?
This magazine is excellent! Practical knowledge on all forms of RE is what's needed to transform a hobby into a movement, and *HP* is doing just that. Holistic, yet focused, *HP* is a true resource for the grassroots.

Ads are good. Bias towards advertisers is bad, however. Please continue to reinforce the fact that there is room for everyone. Thank you, Cory Snavely, Ashland, OH

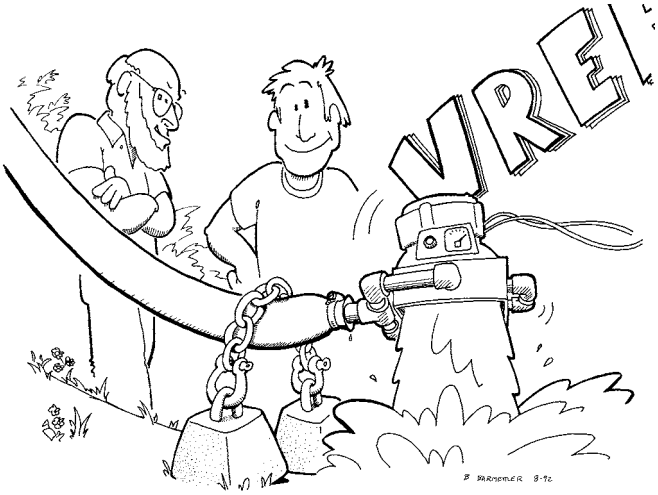
Hello Cory. We have about one hundred advertisers in every issue. These companies are the heart and soul of renewable energy. If a company doesn't advertise in Home Power*, then they are not serious about home-scale RE. We often praise and mention products from companies who do not advertise—for just a single example, the Staber washing machines. Our advertisers offer the finest products and the best deals. Karen and I, and the rest of the* HP *crew, use these products in our own homes—what greater compliment can we pay these companies? If this is bias, then we're guilty as charged. Richard Perez*

GoPower
Shari Prange and Mike Brown's Go Power articles are always very informative. We just took part in one of Electro-Automotive's EV conversion workshops, and it was GREAT! Highly recommended and worth it, even though we're on a serious budget (like most folks, of course). Keep up the good work, Mike and Shari, from The VW freaks of Boston. C. Parker, Somerville, MA

Mom, I think Our System Has Periwinkles…
Bob-O, are you working on any more microhydro projects? From the articles it looks like people are only interested in solar these days. I'd love to see an article comparing (pros/cons) a Pelton wheel vs. a crossflow, or tips on how to keep periwinkles out of your flow. You may not have this problem in the northwest, but these little snails are really thick any time there is a clear stream current. They are not fun to walk on barefooted, either. Take care, Eric Johnson, Alpharetta, GA • ejohnso4@vanstar.com

Hiya Eric, I'm still doing microhydro installations, you betcha! I generally take pictures and will write some of them up one of these days. Time, time, time, ya know? You'll find a review of an exciting new machine from ES&D in this issue. I hope that will hold you for now.

As to a comparison of different types of runners, it's an interesting concept, but I don't see how you could do it fairly. All runners perform differently at different Head/Flow combinations. What is optimum for one runner will be less-than-wonderful for another. Hydro is the most site specific of all the Renewables. While there is some overlap, just one runner/alternator combo will usually be the RIGHT one at a



given site. What we could and probably should do someday is write a comprehensive article listing the virtues and warts of all the microhydros on the market, ala Mick Sagrillo's "Apples & Oranges" wind machine articles.

No, we don't have periwinkle problems out here, but we DO have crawdads. Dang creepy-crawler critters that get past your screening and clog your nozzles no matter how hard you try. I generally tell folks that there are two times of the year when keeping a microhydro system generating is a pain in the butt. Leaf drop in the Fall and flood runoff during big winter storms. Guess I'll have to add a third–periwinkle season! Best, Bob-O Schultze

BioDiesel
Hi Richard, I help run a vineyard and renewable energy centre in the south east of England. We've subscribed to *Home Power* for about four years now (through Steve Wade at Wind & Sun, Leominster, Hereford) and now we've launched ourselves in to the e world I thought I'd get in touch.

Well, the biodiesel article you recently published was totally inspiring. I have since ordered the book from the Tickells and I can thoroughly recommend it to any of your readers. Since then, I've been zipping around fast food joints here in Colchester England and scavenging as much old cooking oil as possible. They did make a small mention in their article that the diesel engine was originally intended to run on peanut oil. So, I jumped in at the deep end and poured several pints of filtered, but otherwise unchanged oil, straight into our tractor! After a few minutes, the smell of the exhaust did change, and that was all. The smell was the only give away that the tractor was now partly running on old cooking oil. Since then, I've added more and more oil to the fuel tank and I can now say that the tractor has been happily running on nothing but old cooking oil for about a month. Starting is just as reliable as with petroleum based diesel although I guess that this is because the engine has a high compression ratio and never needed and glow plugs in the first place. Thank you Josh and Kaia Tickell! We now have an R.E. tractor! Tom Mudd • tom@carters.prestel.co.uk

Aw Reet, Tom! This is the way the world changes—a home at a time, a tractor at a time.... We recently got to meet Josh and Kaia Tickell at the Tehachapi Wind Fair. They are truly great

humans and I'm proud to be on the same planet with them. They are working on more articles for HP*, and are now touring California in the infamous VeggieVan. I've been having a great time following their RE adventures on their web site (http://www.veggievan.org). Josh and Kaia really have the electronic publishing act down cold. What happens one day is on the web for all of us to enjoy on the next day! Richard Perez*

Colorado Solar Energy Industries Association Comments
To The Editor: The Colorado Solar Energy Industries Association (CoSEIA) wishes to comment upon issues presented in the *HP66* IPP story. The CoSEIA board of directors takes exception to a number of the points raised by the contributors to the story. Our efforts regarding the "tariff" matter discussed were initiated and carried to culmination on behalf of the CoSEIA membership. Our membership, of approximately 75, represents a variety of renewable energy ventures and interests. Manufacturing, wholesale and retail distribution, engineering, and installation and consulting services form the basis of our group.

Our state's predominant utility had requested, from our Public Utilities Commission (PUC), authority to extend its regulated business activity to include photovoltaic services. We took action. We called upon a cross section of our membership to consider the proposed action and to formulate an appropriate strategy for CoSEIA. We appointed a consultant from outside the group, familiar with energy issues and the PUC process to coordinate our efforts. Our preliminary meetings brought a consensus that led us to formal intervention in this matter.

Our intervention group continued to consider the best course of action and kept our membership up to date on CoSEIA's position. We solicited, from our entire membership, participation in this effort. We also had the opportunity to receive legal counsel, courtesy of our national trade group affiliate. We believe we assembled and made available the most reliable information possible prior to polling our membership for consensus on what we would carry forward as the CoSEIA position.

CoSEIA's position was carried into discussion with the principals in the PUC process. CoSEIA was among several parties engaging in formal intervention. As talks continued the opportunity for resolving our concerns became available to us in the form of stipulations to the PUC filing. Upon consideration of the advantages and disadvantages of a stipulated agreement, our membership electing to be involved in this process chose to seek an agreement.

CoSEIA hoped to achieve the best possible outcome for the majority of our members. Our membership has not been duped by anyone. We realize the stipulated agreement is not everything each individual member may have hoped for. We believe we have positioned our group to have some opportunities that may not have existed if we had chosen another course of action. In addition this tariff is valid for only a little over three years (it expires on 12-31-2001). CoSEIA anticipates much more radical changes in our energy regulations within the next three to four years. The environment for solar business may become so changed as to render our recent efforts moot.

CoSEIA takes exception to the commentary on the IPP page for the following reasons:

1. The focus of the articles is on issues outside the scope of the tariff action we were involved with.

2. CoSEIA couldn't resolve the general competitive issues discussed in the articles by our action in this tariff proceeding.

3. The articles seem to use the tariff discussion only as a springboard to implicate CoSEIA as party to matters for which it has no control.

4. Presentations lack detail, sound conclusions can't be drawn.

CoSEIA encourages widespread involvement in the discussion and formulation of policy related to energy matters. Our membership is composed of a number of concerns to which competitive regulation is extremely critical. We will continue to work towards a successful marketplace for all of our membership. We do not limit any members' access to benefits of affiliation within our group. To the contrary, we continue to encourage participation in all aspects of our activities. We hope to keep building and invite contribution from all engaged in our industry.

CoSEIA board of directors: Jeff Brady, Kerry Kalarney, Jon Klima, Pat Osborne, Kirk Smith, Rick Hubbart, and Mike Tierney

Ozonal Notes

Richard Perez

On the Road for Renewable Energy

We've been putting *Home Power* on the road lately. Since last issue, we've traveled to the Tehachapi Wind Fair in Tehachapi, California, taught a Successful Solar Business class at Solar Energy International (SEI) in Carbondale, Colorado, and visited the new BP Solar plant in Fairfield, California. Later this month, we are off to the Southwest RE Fair in Flagstaff, Arizona, so expect a report on this event in the next issue. This latest round of road trips for RE have ended our three year hiatus on traveling. The HP Crew is having a wonderful time meeting folks and seeing what they are doing with RE. We're back to flying once again. So far, so good—not a single close shave!

If you are interested in our experiences in Tehachapi, then see the articles on pages 52 and 56 of this issue. The Successful Solar Businesses class at SEI in Colorado was a pleasure, once again. This is the third time that Karen and I have given this class and it's working. Two of the 25 students in this year's class got jobs before the class was even finished! We even had two large RE companies send "headhunters" to the class looking for employees. Six of the members of last year's class now have their own solar business and are up and working! It's always a pleasure to visit with our old friends at SEI, but the real benefit of this class is bringing new people into RE as a profession. The students at SEI are the cream of the crop. They are motivated, well educated (thanks to SEI), and serious about making a career in renewable energy. We will be giving this class again next summer, so if you are interested in a career in RE, be there!

Our trip to the new BP plant in Fairfield, California was a real eye opener. BP Solar workers hand assemble each and every module. I was impressed with the care and quality control going into the BP Solar products. We got a tour of BP's new thin-film PV process which promises to deliver solar power at low prices. While all the hardware was fascinating, what impressed us most was BP Solar's approach to the business of solar energy. We sat in on meetings with the BP distributors and dealers. BP Solar is the first large manufacturer of PV modules who seems truly interested in the welfare of their rank and file dealers. Their dedication to RE system integration and dealer support is unique. We are not used to seeing a very large, multi-national, energy corporation actually concerning itself with the support of its dealers. BP has realized that the dealers who actually sell and install the RE systems are as important as their corporate profits. While this seems pretty obvious to me, it's a new idea for big corporations in the RE field. Good work BP Solar!

Right: Richard Perez uses a bogus press pass to sneak his way into a top secret wind facility in the Tehachapi Mountains of California.

Photo by Josh Tickell

No Sniveling, Please!

Over the last ten years, the common topic at energy fairs and RE gatherings has been how to "mainstream" renewable energy. Everyone, from distributors to dealers to end users, realizes that RE must spread if it is to have any real impact on our energy and environmental problems. Right now, renewable energy is finally becoming mainstream. More and more folks are using RE not only off-grid, but now also on-grid. Every RE dealer we talk to reports greatly increased sales and installations. The major question asked by many RE dealers these days is, "I'm swamped and need to hire folks—where can I find help?" Last year the major question was, "Business has been slow—how can I find new customers?"

With this explosion in RE sales, comes the inevitable. Big fish are eating little fish. Large corporations are buying out smaller RE businesses. Over the last two years, many old and established "Mom & Pop" solar businesses have been sold to larger businesses, which in turn have been adsorbed by even bigger corporations. At *Home Power*, we have been hearing quite a bit of complaining from some of the smaller businesses. They bemoan the loss of the smaller companies and express distrust of the larger corporations which are now becoming major players in the RE field. I, myself, have no great love for large corporations. I've seen the effects of unrestrained corporate greed. I've also seen the wonderful and beneficial work which the resources of a large corporation can accomplish. To be sure, it was the smaller "Mom & Pop" businesses which pioneered the RE industry. It was their work which has raised this industry to the point where the big fish are now interested. In every case where a "Mom & Pop" solar

business was sold to a bigger company, they wanted to do so. To the best of my knowledge, there have been no hostile take-overs.

What all of us in this industry need to realize is that this transition is a natural result of everything we have been working for over the last ten years. As RE becomes commonplace, then the industry will grow. And with this growth comes the merger and buy-out activities we are now seeing. Oddly enough, the biggest complainers are small solar businesses which refuse to expand and change, but instead complain about now having competition. Nature abhors a vacuum. If these businesses will not meet the rising demands of thousands of new customers, then other businesses will.

So I say to those who fear the current explosion of RE, "No more sniveling, please!" We're just getting what we all have worked so very hard to attain.

Oregon Net Metering

Well, it seems like we Oregon energy activists working for a net metering bill may have done our job too well. We have raised such a public ruckus about net metering that Oregon's utilities are running scared. They are mobilizing and lobbying against our bill before we have even had a chance to introduce it into the Oregon legislature! So this is shaping up to be an interesting political battle with RE supporters on one side and utilities on the other. I am mentioning this because we need your help and support. If you live inside Oregon and want to see our state have a net metering bill for renewable energy systems, then please contact me. We have a lot of work to do. We need folks in every neighborhood to circulate petitions supporting the bill. We need folks to attend public meetings concerning this bill. Even if you don't live in Oregon, we need your support. All of our efforts are costing money. We need to hire a full-time lobbyist to push the bill through. We need to place advertising in Oregon's newspapers. We could use some financial donations to help pay for all of this.

I have predicted an easy victory for this bill, but now I'm not so sure. Oregon's utilities have a powerful lobby and they are mobilizing faster and heavier than we anticipated. We assumed that if we presented them with a reasonable bill that they might just do the right thing. Now it seems like they are placing their profits ahead of our environment. If we're going to make Oregon net metering happen, then it seems we have more work to do. I console myself with the thought that even if this bill fails, we still have RE options. There is always Guerrilla Solar, and even beyond that, we can just tell the utilities to "take that power line and shove it," by going off-grid entirely. Let's all work together so that Oregon can join the 23 states who have already adopted net metering bills for RE systems.

Find the Schwartz…

Have you ever noticed that some folks get their pictures into *Home Power* all the time? One particular fellow always seems to have his mug in our mag. In fact, this fellow had been sneaking his picture into *Home Power* for years before we actually met him. In this issue, this solar bozo has his picture appearing multiple times. Now, we didn't plan this or do it deliberately—it just happened. So we thought we'd have some fun with this serendipity. If you can find all of the pictures of the Schwartz, you can win a free *Home Power* T-shirt and a one year subscription. Write us (via snail mail or email) specifying the page numbers. The winning entry will be selected at random from all correct responses on All Hallow's Eve, 31 October, 1998. May the Schwartz be with you!

Access

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Q&A

SW Stands for Stepped Wave?

Please clarify the difference between a square wave, modified square wave, stepped wave, quasi-wave, sine wave, and pure sine wave inverter.

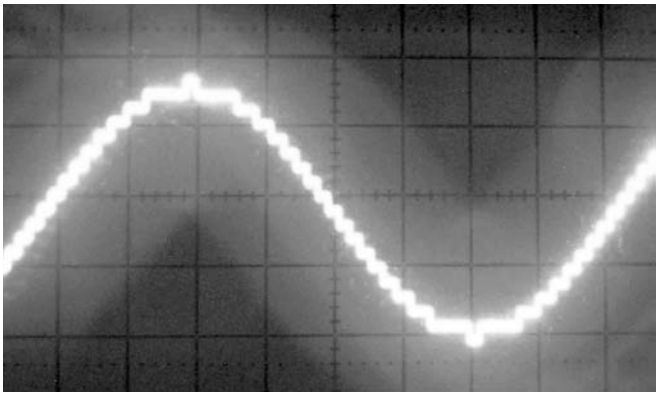
We have been using the Trace SW4024 inverter for about two years. This is our third one, as we have had trouble with the other two. At last year's MREF, other inverter manufacturers told us that our SW4024 was not a sine wave.

When I got back to New Zealand, I immediately acquired an oscilloscope. I tested the inverter, and guess what…I found a step wave. In *HP48*, p. 26, you call this waveform a "Mayan temple". Trace says it's a "stepped approximation of a sine wave". I'm confused. Does this mean that SW stands for stepped wave?
Barry Hillis, Invercargill, New Zealand

Don't feel bad, Barry, most folks are confused about the actual waveforms generated by inverters. The purity of any alternating current (ac) waveform is measured by Total Harmonic Distortion (THD). Ideally speaking, the ac power waveform should be a pure sine wave with 0% THD. Sine wave power began by being generated with rotary motion in generators. Since the magnetic field in the generator is rotating smoothly, the resulting power output is a smooth and pure sine wave. With inverters, the ac waveform is electronically synthesized, as there is no mechanical motion.

In the very first inverters, the waveform was a square wave of two steps with a THD of well over 60%. As the inverter industry grew and the technology blossomed, the modified sine wave inverters using four steps became available. Now, I'm not really sure who coined the phrase "modified sine wave", but I suspect that the

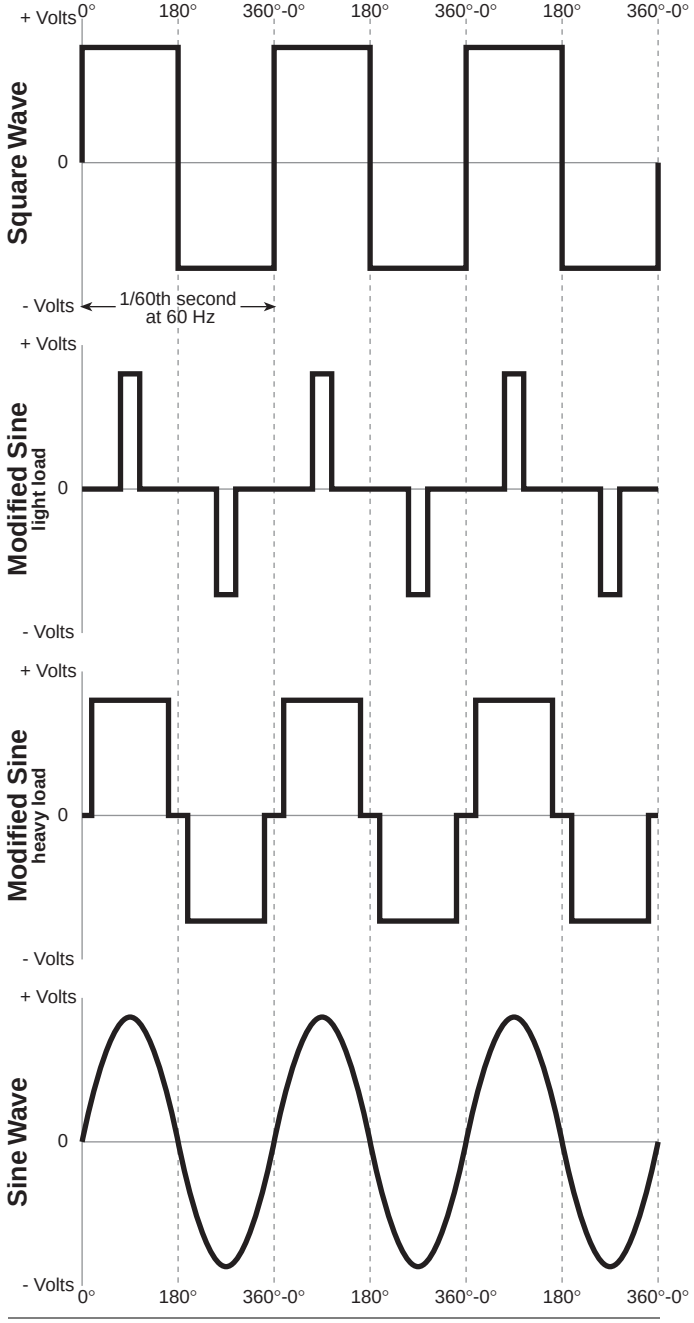
Below: an oscilloscope photograph of a multistepped waveform from a Trace SW series inverter.



Marketing Department had its way with the Engineering Department in this nomenclature. The modified sine wave is actually a modified square wave. The modified sine wave inverters have a THD of between 30 and 45% depending on the model inverter and on the load it is powering.

Within the last five years, "sine" wave inverters have become available. All sine wave inverters synthesize the sine wave in steps. The big question is how many steps. Although the actual number of steps varies with amount of power output, The Trace SW models use about 50 steps to synthesize the sine wave form. They

Various Inverter ac Waveforms



have a THD between 3 and 5%. The Exeltech sine wave inverters use 416 steps and have a THD of 1.5 or less. We have done long-term measurement of grid power, and found THDs from 5 to 17% at the outlet.

Grid power is a very pure sine wave when it is generated at the power plant. But, after it leaves the plant, goes through the high voltage lines, is stepped down by your local substation, is distributed to the local neighborhoods, and is stepped down by the transformer feeding your home, the THD will vary widely. When it comes to grid power, the whole neighborhood shares the power. If your neighbor is welding, or has a refrigerator with a marginal motor/compressor, then it effects the quality of your power. When you have an inverter, then you have a power plant making electricity just for you.

How much THD is too much? Well, it depends on the appliance. Incandescent light bulbs don't care at all about THD, and neither do electric heaters. In general, this is true for all resistive appliances. Other devices do care—running cooler, better, and more efficiently on low THD sine wave power. Such devices include most electronics, TVs, stereos, computers, fluorescent lighting, microwave ovens, most induction motors (found in everything from refrigerators to table saws), and many others. The reason is simple and straightforward—that's what the appliance was designed to operate on. In general, if your 117 vac power source has a THD of less than 10%, then all appliances will run well and efficiently.

Total Harmonic Distortion (THD) is not the only criteria for choosing an inverter. You should also consider such things as rms voltage regulation (should be 117 vac rms ±no more than 5%), peak ac voltage (should be 164 vac peak ±no more than 10%), and frequency stability (60 Hz ±0.5 Hz or less). For people using 240 volts at 50 Hz the ±% tolerances are the same. Richard Perez

How Many Amps?

What is the maximum number of Amps you can charge a 6 Volt, 220 Amp-hour golf cart battery when it is discharged fully, to bring it two-thirds of the way back? I know the last part of the charge must be slow. Howard Clunn, Auburn, CA

Hello, Howard. The maximum recharge rate for a lead-acid battery is C/5 if you want it to last. This C/5 rate should only be used when the battery is between 20 and 80% State Of Charge (SOC). For your battery of 220 Ampere-hours, this rate works out to 44 Amperes.

You mentioned that your battery is fully discharged. This is an SOC below 20%. When a lead-acid battery is fully discharged, its electrolyte becomes water. All of the sulfate ions are in chemical combination on the plates and the electrolyte is depleted of sulfuric acid. At this point, the electrolyte has much higher resistance than at 20% SOC. Use a C/20 rate of recharge (that's 11 Amperes for your battery) until the battery reaches 20% SOC. At this point, you can move to the faster C/5 rate.

Using the C/5 rate on a fully discharged battery, or on an almost fully recharged battery (over 80% SOC), will reduce the life of the battery. Most of the energy will be converted to heat instead of breaking the chemical bonds. This heat expands the plates in the battery (thermal cycling) which will lead to early battery demise. In general, I'd recommend using rates no faster than C/10. It's a matter of efficiency—the faster you recharge, the more energy is lost to heat and water electrolysis. Richard Perez

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