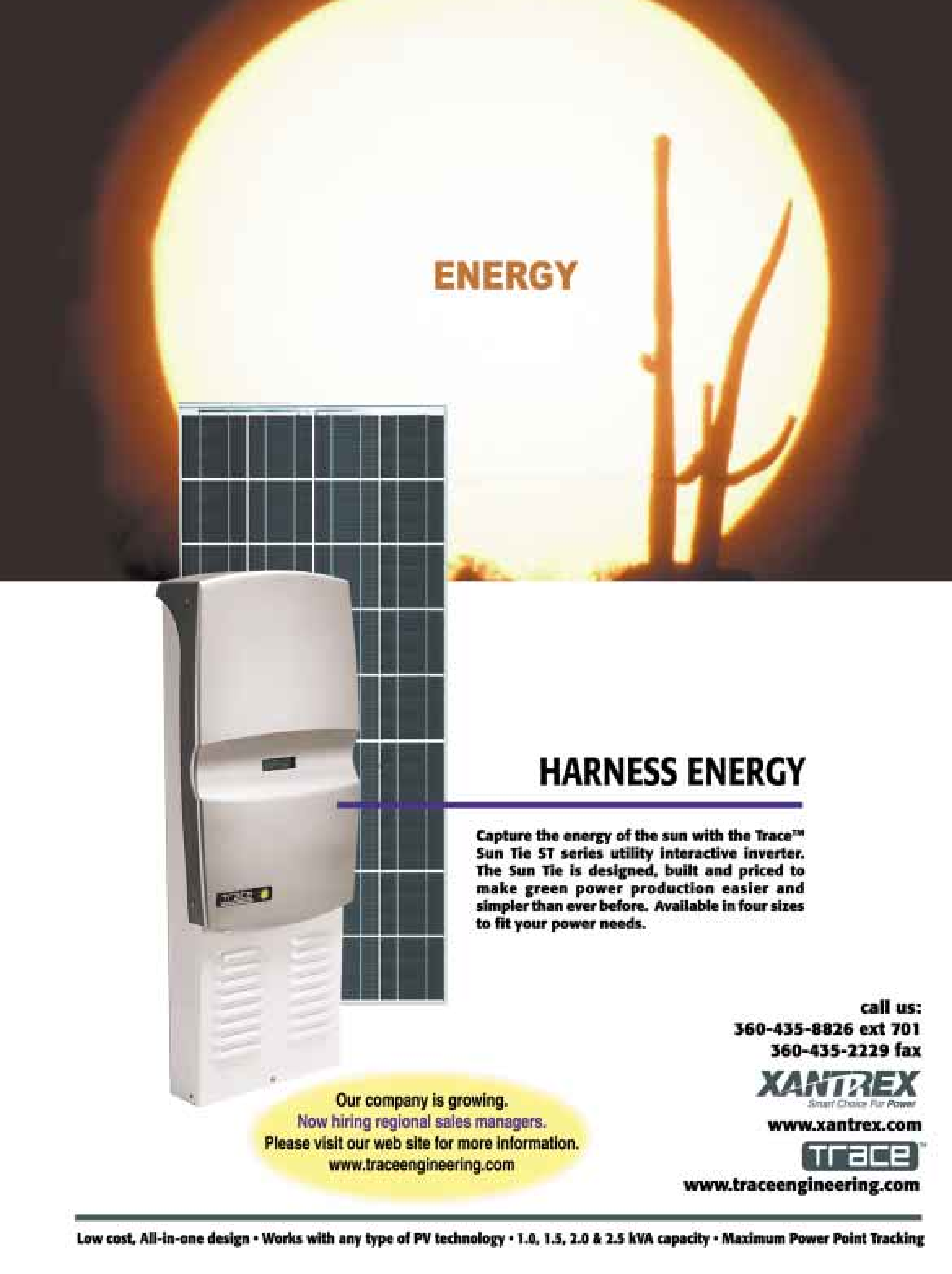
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THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #82 April / May 2001

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Features

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Things that Work!

Guerrilla Solar

Book Review

Columns

More Columns

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Your Energy Destiny

California's "energy crisis" is really a crisis of inefficiency and overuse. Soon the situation will spread to other states and countries, so don't feel immune. Our leaders are telling us it is a crisis of supply, so we cannot rely on them to do the right thing. We need to take it into our own hands. In fact, it is our *duty* as citizens and grid customers to do so.

How? For thirteen years, *Home Power* has been telling folks how. It has almost become a mantra. Compact fluorescent lighting, water heater blankets, solar hot water, efficient appliances, reducing phantom loads, and commonsense usage ("Emilly, please turn off the lights when you are through!").

Those of us with renewable energy systems in our homes know this well. The rule of thumb is that for every dollar spent on efficiency, you save three to five dollars on system costs. This rule has a lesson for California gridders too. When they invest in efficiency, they will save on their utility bills, and at the same time lessen the call for pollution-belching conventional energy sources.

The next step is replacing those belchers with clean, decentralized, rooftop solar and backyard wind. That's our job, not the government's. Your efforts turn each of you into quiet, unassuming energy activists, just by doing the right thing.

First we do what we can for ourselves. Then comes the question of how to pass this crucial information on to the masses of unfortunates who don't know much about energy efficiency and conservation. That's the hard part. We've been trying to get the government and media to help us do this for a long time, but with slim results.

Organize. Join like-minded folks in your community. Have meetings, and after you have helped each other, start helping other folks around you. Form buying clubs to get good deals on compact fluorescents. Ask your local retailers to start carrying the items you need. Then hit the media with what really needs to be done. And let them know what you have done on your own homes, so others can see. Example is powerful.

Fortunately, some of the media is coming around to our viewpoint. Lately, our crew has been doing quite a lot to spread the word outside our ranks. We have had a ton of calls from media as well as gridders seeing and hearing this publicity. You could be creating the same effect. Local media loves local response to the "crisis." Become a part of it by writing opinion pieces and offering your local TV stations the opportunity to see how you are addressing the problem. At least a portion of the media is starting to understand how important the mantra really is. That's thanks to you who are doing the right thing.

Keeping up the good work means that we can eventually control our own energy destiny.

—Michael Welch for the *Home Power* crew

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Richard Perez
Jason Powell
Shari Prange
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"Think about it..."

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–Kirby Spangler,
PV-powered in Palmer, Alaska

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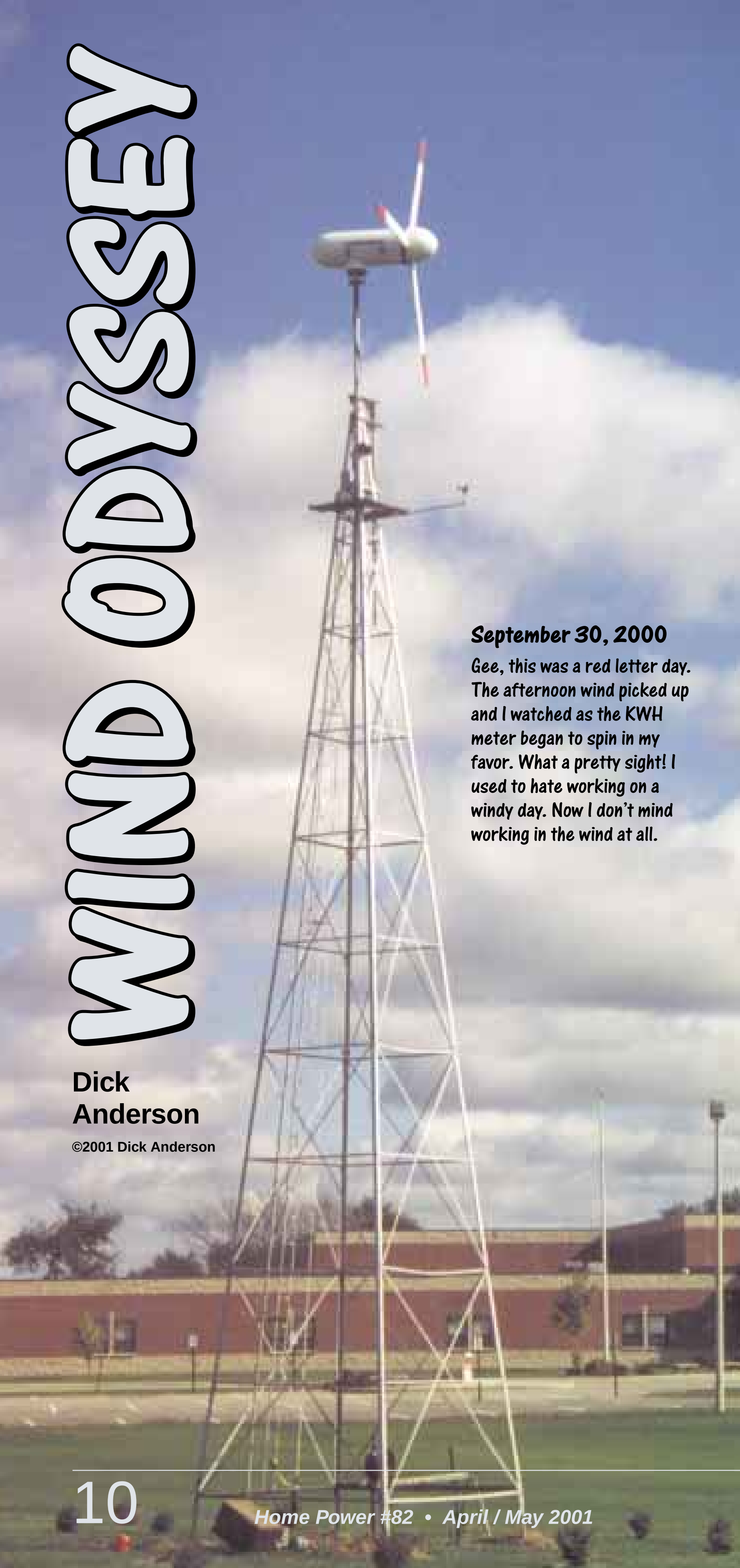


WIND ODYSSEY

Dick Anderson

In the seventies, I started getting *Mother Earth News,* and tried to introduce my high school shop students to wind energy. Twenty five years later, the dream is finally fulfilled!

In those twenty-five years, I made several experimental machines. None survived the test of time, but I don't consider them failures. As Thomas Edison commented when questioned about his five hundred failures with finding a suitable material for a light bulb filament, "These are not failures; we now know of five hundred materials that will not work." Well, I too had learned of several things in the wind generator department that would not work. I pressed onward.

In June of 1999, I took a three-day wind generator installation workshop put on by the Midwest Renewable Energy Association (MREA) and taught by Mick Sagrillo. Wow! We assembled an 80 foot (24 m) freestanding Rohn tower and installed a Jacobs wind generator and utility intertie system that helped supply power to the MREA fair that year.

I wanted to put together a system that would feed back onto the grid, without batteries, for demonstration and education, at a cost of less than US$2,500. Mick told me about a used Enertech 1800 unit. The rest is history. The photos and project log entries document the culmination of my twenty-five year journey into wind-generated electric home power!

September 30, 2000

Gee, this was a red letter day. The afternoon wind picked up and I watched as the KWH meter began to spin in my favor. What a pretty sight! I used to hate working on a windy day. Now I don't mind working in the wind at all.

April 8, 2000

I drove to Mick Sagrillo's place in Forestville, Wisconsin to pick up the used Enertech 1800 generator. It had been donated to the MREA, and my purchase was a contribution to them. I purchased it as-is, with no warranty. Pictured here are the fixed-pitch blades that make up the 13 foot (4 m) diameter rotor, and the fiberglass nacelle.

April 19, 2000

I designed and built a test stand for the guts of the Enertech unit. This was very useful during the testing and rebuilding process. The 1800 includes a control system, that in its normal or automatic mode turns the machine on only when winds are strong enough to make it behave as a generator. The controls turn it off when winds drop to the point where it would be acting as a motor.

April 22, 2000

I started cleaning up and testing the Enertech unit. I plugged in the motor and got no response. I cracked open the motor case, and to my surprise, the motor windings were fried! I checked with a local motor repair shop and they said they could rewind the motor for US$300. I dropped off the motor and went back to work on rebuilding the gearbox. New bearings and seals were ordered and installed.

May 22, 2000

After some discussions with Mick Sagrillo, I started to have some doubts about the strength of my 50 foot (15 m) water pumper tower. The Enertech manual stated that the tower top must be able to withstand 900 pounds (408 kg) of horizontal thrust. I built a one-tenth scale model and set out to pull on the model top with 90 pounds (40.8 kg). You can see the weights hung by a pulley and tied to the model tower. I determined that I would need to beef up the leg base anchor points, or the tower might overturn.

June 1, 2000

I had my first project for the summer—hand digging 1.5 cubic yards of dirt out from around each tower leg. I had many hours to reflect upon my folly as I dug.

June 30, 2000

With 6 yards of concrete in place, I felt that the tower was going nowhere. Mick was helpful as he wrote, “Now all you have to worry about is the tower folding over in a storm.” Well at least I was having a good time, and it was only money.

July 10, 2000

This unit had been out of service and stored for some time. The mice had munched on the plastic weather cap that goes over the slipring assembly.

July 4, 2000

I began by cleaning up the blade hub to get it ready to repaint. As I wire brushed more and more, the trouble began to loom, darker and darker. The three bolt holes where the blades mount to the hub (a major stress point) were horribly cracked. I called around and located a used hub plate for US$50, and I was back in business.

July 12, 2000

I decided that I would do a thorough job of rebuilding the unit, so I found a replacement cap. That was the easy part. Pulling apart the unit containing the sliprings and bearings just to replace that plastic cap was a big job, but very educational.

July 13, 2000

Unbelievable! In taking apart the slipring assembly, I discovered that one of the lead wires had melted off where it was supposed to be attached to its ring. It was touching but not soldered in place. A little wind, a little vibration, and I'd have had a nightmare to troubleshoot and fix after the unit was up on the tower.

July 25, 2000

Only one part left—I might as well rebuild the hydraulic brake too. I had no experience rebuilding hydraulic pumps, but that never stopped me before…. I was advised to keep a very clean work environment, and did so. A few seals later, the pump was done. I just hoped the slight drip would stop as the seals wore in.

August 4, 2000

In the early days, I had read up on the pros and cons of upwind versus downwind style units. Tower shadow effect in downwind systems was a factor that I had solved by designing and installing an adjustable pole mast that would extend beyond the top of the tower. I can lower it to work on the unit, and raise it to eliminate the tower shadow effect on the blades.

August 10, 2000

Mounting the repainted blades to the new hub plate was the next step. I installed a center point in the hub and checked the balance of the blades in one plane. Not leaving anything to chance, I read a service bulletin on balancing. The rotor had to be checked in a second plane of rotation. Shimming between the hub plate and blade was required if the blades were more than 1 inch higher or lower than another.

September 8, 2000

What a great way to start the school year. Students are always asking me what I did over the summer, so I showed them. Here the Enertech unit is being driven by a motor belted down to deliver 170 rpm to the gearbox. We then plugged it in to the utility, making the generator run and produce electricity. The students could see that the KWH meter was turning backwards and we were pumping some electrons onto the grid.

September 8, 2000

I even had the anemometer wired up to the control box. The anemometer is the brain of the system—we could watch the unit turn on automatically when the "wind" reached 13 mph (5.8 m/s). When the wind went down below 9 mph (4 m/s), the unit would shut off. We could also test out the high wind shutdown. At 40 mph (18 m/s), the unit shuts down, which protects it from overspeeding the motor and from wind damage. At 30 mph (13.4 m/s), the unit restarts. Seeing it in action really helped the students understand it.

September 15, 2000

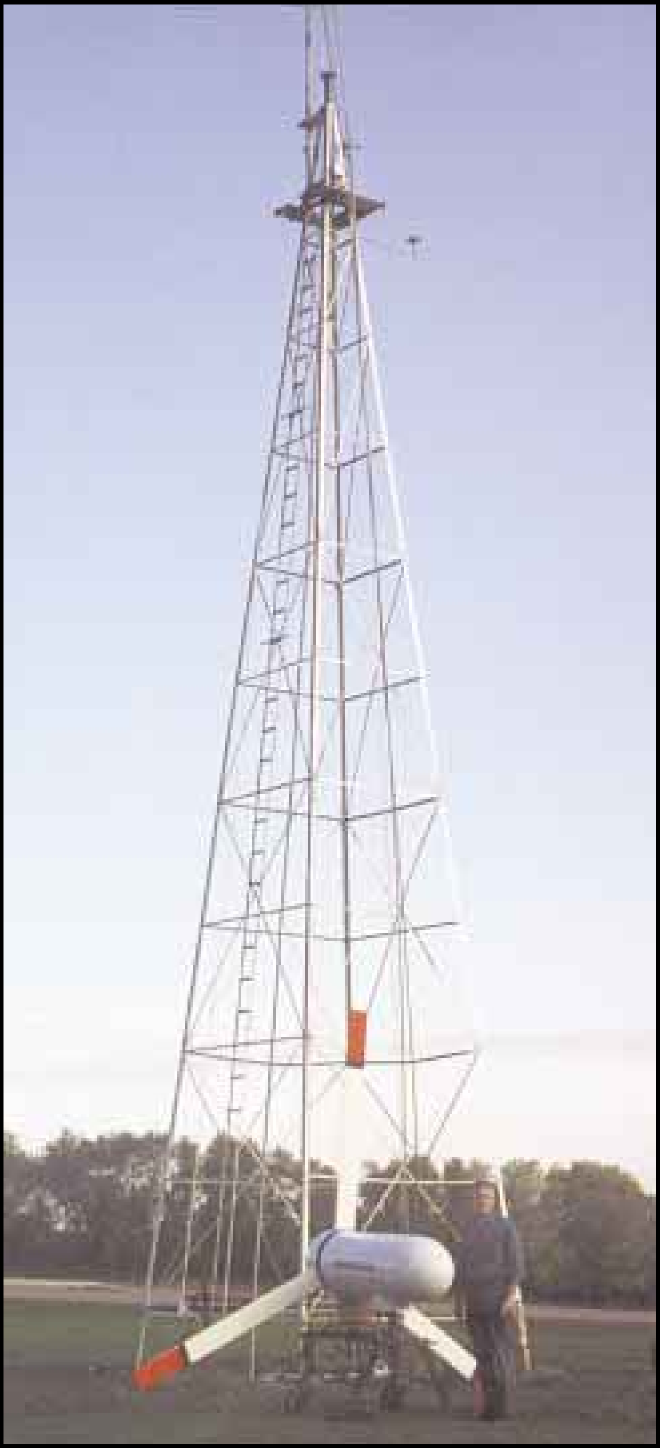
With a fresh coat of paint and new lettering, the ol' Enertech 1800 was looking fine. I wanted this unit to look nice when it went up, not like some cob job. So I had the local autobody guy apply a gel-coat automotive finish to the fiberglass shell. It really looks great in the sun, and was well worth the US$200.

September 18, 2000

The wire run is 250 feet (76 m) one way. Two THHN/THWN gas and oil resistant #6 (13 mm^2) copper wires, one #10 (5 mm^2) ground wire, and two #16 (1.3 mm^2) shielded communications lines were run in 1 inch PVC, underground. One #16 cable was wired to the anemometer, which tells the Enertech when it should turn on and off. The second cable was attached to a wind totalizer so I can measure the actual wind available and how the Enertech makes use of it.

September 22, 2000

With the wiring inside and the shop work all done, I was getting ready to go online. I had made contact earlier in the summer with the utility and they seemed pretty agreeable. Today they came out and looked over the system and gave me the green light and a 120 volt high speed KWH meter.

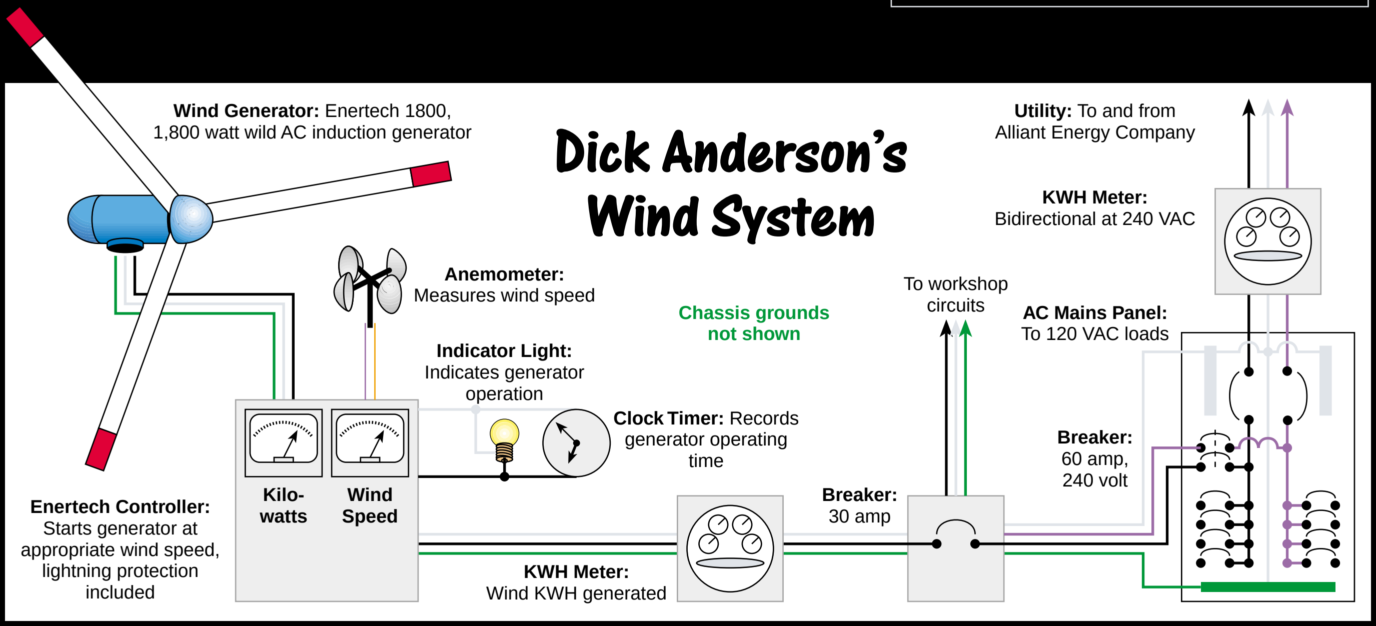


Enertech 1800 System Costs

Item	*Cost (US$)*
Enertech 1800 wind generator, used	$450
Cable, #6, 250 ft.	415
Concrete (6 cubic yards)	363
Rewind motor/generator unit	315
Safety rope grab unit	300
Repaint	200
Enertech control card for box	142
Crane rental	100
Bearing & seal replacements	85
Miscellaneous	81
Enertech control box	75
Top mount adaptor	60
Replace hub plate	50
Anemometer	40
Total	$2,676

September 30, 2000

This Saturday morning was the day. The crane was coming in and we were going to put the bird up on the tower. Here I am, the proud father standing next to my baby.



October 1, 2000

I decided to wire in a small light bulb and electric clock to the mercury solenoid in the control box. When the light goes on, I know the unit is running. The clock keeps track of the total time the generator runs. I check it every day, and by recording the hours of run time and the KWHs produced, I can see how efficient my production is. Later I'll use this data to fine tune the startup and shutoff wind speeds for the system.

October 2, 2000

The safety factor cannot be overemphasized when working on and around these things. I had a safety helmet and belt, but I also bought a rope grab and line with a shock cord for US$300. This device slides freely up and down a rope parallel to the tower. If I fall, the rope grab device locks onto the rope and catches me. I'm not looking forward to putting this thing to the test, but if it happens, I'll still be able to write about it.

Enertech System Fact Sheet

Item	*Description*
Enertech 1800	Fixed pitch, downwind, 60 Hz AC, 120 V
Generator	Heavy-duty 120 V induction motor, 1,725 rpm
Rotor	13 feet diameter, 3 fixed-pitch blades
Weight	265 pounds
Tower size	55 feet, 10 x 10 foot base, 2.5 by 1/8 inch angle iron legs
Tower leg anchors	6 yards concrete,18,000 pounds,
Horizontal thrust	900 pounds at 120 mph
Rated output	1,800 W at 24 mph, or 2 two-slice toasters
Wire	250 foot (one way) #6 copper #18 shielded signal wire
Protection	30 A circuit breaker
Wind speed control	Anemometer
Cut-in	13 mph
Cut-out	9 mph
Shutdown	40 mph, via electrically controlled hydraulic brake
Site analysis	70 days/yr., 10+ mph average wind speed 140 days/yr., 8 mph average wind speed
Energy production	Estimate of US$58 per year at $0.07 per KWH
Bottom line	Trust me when I say that it is easier to *conserve* energy than to produce energy.

The unit has now run for over 100 hours and all is well. I did have one scare though. It ran for about eight hours the first day, and I thought it would be a good idea to check it right away. As I reached the top of the tower, I saw a red-colored fluid on the mast and streaks of it on the nice white shell. My heart sank.

What could be wrong? Was it a disaster? Would this be the day that I dove off the tower in despair and gave my safety rope grab a true test? Not today. The problem was a blown O-ring on the fill plug of the hydraulic brake system. A big mess, but easily corrected, and a lesson learned about how O-rings are supposed to fit. I did check the tower and unit again at 100 hours, and now do it about every three months. I like to climb.

Living next door to the local high school and junior high school has generated a lot of interest. Several classes have walked over and asked a lot of questions. I have a fact sheet about the unit that answers many of the usual questions people have. Having the first wind generator in Darlington has caused a bit of a stir. The school buses pass right by it every day and the teachers I know tell me that the kids are keeping a close eye on it. But soon it will be just like another electric pole with a transformer on it.

The guys at the local coffee shop wanted to know why I had put up such a big fan, and would it be cooling off the neighbors this summer? Every day when I get my coffee and see it running, I just smile and think to myself, "If only they knew. If only they knew that it takes a 15 mph wind blowing for about six hours to make enough electricity to pay for my twenty-five cent coffee. If only they knew…"

Access

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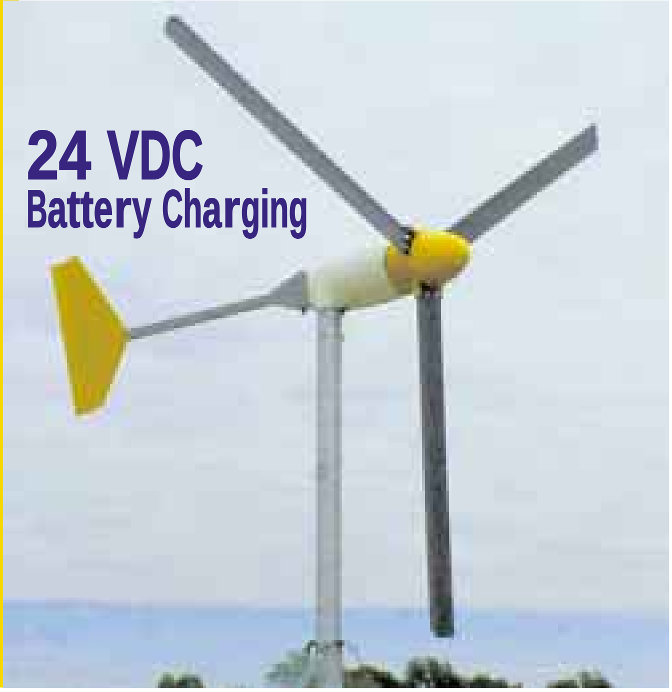

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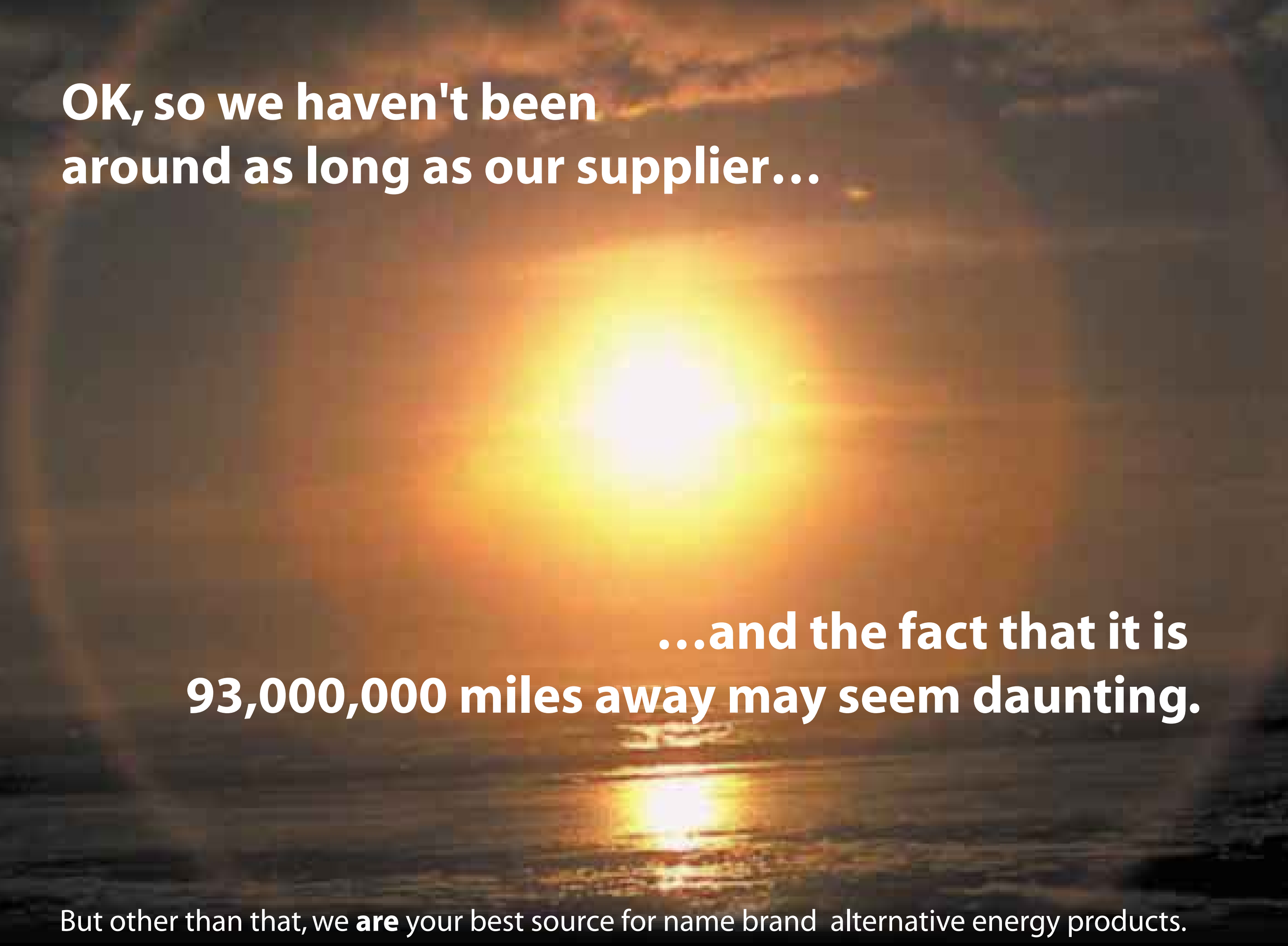

OK, so we haven't been
around as long as our supplier…
…and the fact that it is
93,000,000 miles away may seem daunting.

Introducing PV in a Somali Oasis Town

Photo by Pamela Collett

Mark Hankins
and Frank Jackson

Instructor Daniel Kithokoi (left) and student during a hands-on practical. Young women admire their school's new PVs.

Given the relentless violence of the past decade, Somalia's reputation as Africa's basket-case country is almost justified. However, much has happened since the fall of Said Barre and the American Blackhawk debacle of the early 1990s. Peace has come to the northern regions, now called Somaliland and Puntland, and elections in Djibouti are breathing fresh hope for peace in the ragged war-torn regions of the south. With all electricity infrastructure destroyed, and among the best solar resources in the world, many Somalis are committed to using solar energy as a new building block for their infrastructure.

Today, the three nominal regions that make up what was once Somalia (Somaliland, Puntland, and southern Somalia) have no central utilities, very little power generation, and no rural electrification programs to speak of. Energy Alternatives Africa (EAA) and Horn of Africa Relief and Development Organization (Horn Relief, for short) have taken up the challenge to get a solar industry started in the region.

PV Education in Puntland

In July 2000, Energy Alternatives Africa and Horn Relief conducted a basic solar-electric installation course in a Puntland desert oasis community hundreds of miles from the nearest grid. Working with fifteen technicians, we installed six photovoltaic (PV) systems that are now used for lighting and powering school equipment at the Buraan Rural Institute (BRI).

In 1997, Horn Relief sent one of their employees to an EAA Solar Training course at the KARADEA solar training facility in Tanzania. They immediately recognised the potential of solar electricity in Puntland and decided to introduce PV in their area of operation, Sanaag. It took three years to raise funding for equipment and a local training course.

NOVIB, a Dutch development organisation, provided funds for the purchase of PV power systems at BRI. Meanwhile, the British Lotteries and APSO (the Irish aid organisation) provided support to cover the costs of designing systems, running a two-week training course, and overseeing the relatively complicated delivery of equipment from Europe to the Somali outback.

Preparation

In January 2000, Mark Hankins, Fatima Jibrell, and Horn Relief Engineer Omar Irbad visited BRI to map out the school's PV systems and budgets. After this preliminary visit, EAA designed the systems, and Fortum/NAPS was awarded the contract to supply the equipment. In March, Frank Jackson of Green Dragon Energy, Wales, UK was hired through APSO as chief project contractor/electrician.

Shortly thereafter, the course and installation was set for July, and the delivery process was set in motion. In April, a violent hailstorm blew roofs off about half of the buildings at BRI. When we found out about this setback, we decided to use ground mounts for the three multi-module arrays.

Horn Relief organized participation of fifteen technicians in the July courses. Although they work with women as their primary target group, they decided to only involve men in this first course, since women electricians are virtually unknown in Somalia (a future course hopes to train a group of women to install systems in Galkayo, the capital of Puntland).

In early July, Frank Jackson flew from Nairobi, Kenya to Bosasso, to complete the preliminary tasks in the installation, before the course began. The trip involved a six-hour flight in a Beechcraft ten seater, ending up in the spectacular desert airfield, set between arid desert cliffs and Red Sea coral reefs. After spending a night in the heat of Bossaso, Frank and the students made the journey to the oasis town of Buraan, located in the high desert of central Somalia. They were accompanied by AK-47 toting "guards," grim reminders of the security problems of the past. Buraan, in the contested no-mans land between Puntland and Somaliland, has a spectacular scenery of mesas, rock outcrops, and sandy washes lined by green acacia trees. Somali nomads can be seen tending camels and herds of sheep along the rough track that leads to Buraan.

BRI, one of a few higher education institutions in Puntland, is sequestered inside a large walled compound. Outside, there is a town of under 1,000 inhabitants, who draw sustenance from their livestock and a few date palms and fruit trees adjacent to the oasis. The town is surrounded by picturesque yellow-brown cliffs.

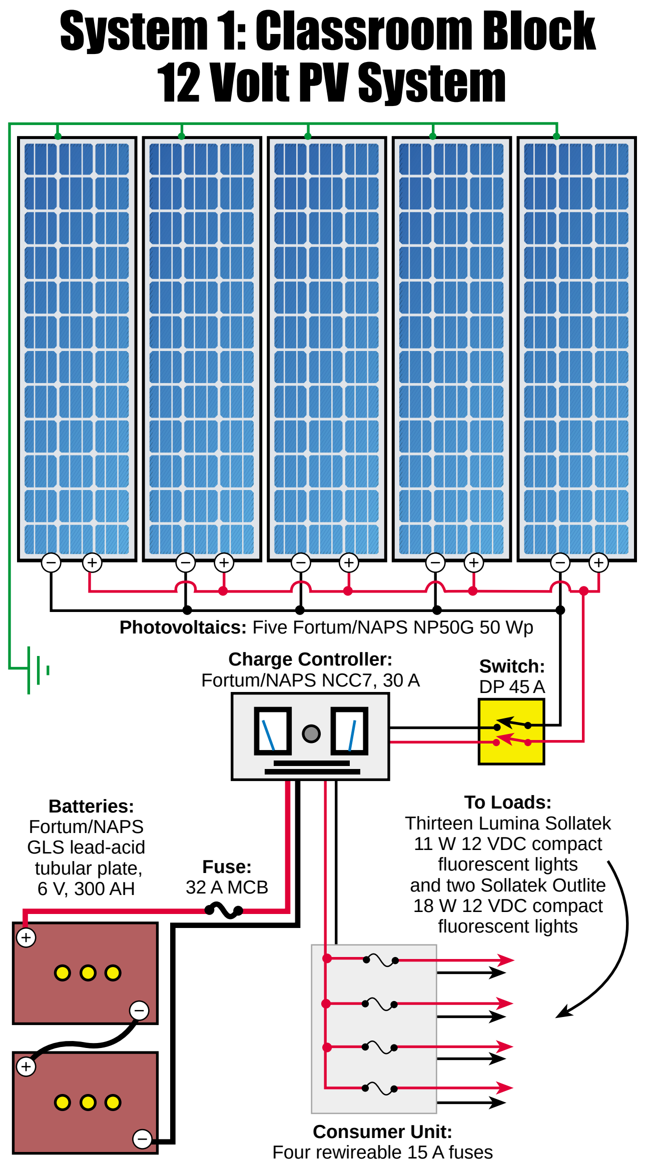
Map: Somalia 1992. Courtesy of The General Libraries, The University of Texas at Austin. Disputed borders have been added by *HP*.

With the help of the fifteen students, Frank unpacked and checked the equipment, began the installation work, setting up some lights and a basic AC power supply, and began holding introductory evening classes for the students.

Given that Somalia has largely been isolated from the rest of the world over the past ten years, it has not been exposed to the "solar revolution." People in rural areas have concentrated on simply surviving and avoiding conflicts. So an entire generation of people is without education and relevant skills. As bright as they are, our students have had little opportunity to access formal education. When Frank began holding introductory classes, he had to start with the basics, from DC electricity to solar energy.

Frank had detailed plans of the installation that he'd drawn up after EAA's preliminary visit earlier in the year. The Buraan school compound is a square-shaped, walled-in area of about 100 by 100 meters (328 x 328 feet), surrounded by a high perimeter wall topped with rolled barbed wire (a grim reminder of more chaotic times).

Running through the centre is a wall that separates about a third of the total area, the girls' quarters, from the rest of the compound. The main area consists of all the other buildings, including the boys' dormitories, classrooms, and teachers' houses. The yellow-painted



buildings are made of sturdy concrete/mortar and topped by tin roofs. The school was originally built about twenty-five years ago as a rural training institute, but was abandoned when the government fell apart. Horn Relief has taken it over.

Six PV Systems

The systems at BRI consist of:

- A 250 Wp DC-only lighting system for four classrooms.
- A 250 Wp system to provide AC lights and AC power for the dining hall, library, radio room, and boys dormitory.
- A 150 Wp system providing DC lights and AC power for the guest house.
- Lighting systems for the girls' dormitories—two 50 Wp, and one 20 Wp.

Since so few spare parts are available in Somalia, everything except the battery acid was flown in. We couldn't afford omissions. Frank had sourced student training kits and accessories like nuts, bolts, circuit breakers, and fuses in Wales, and then had them shipped to the Fortum/NAPS corporate office in Finland. They packed Frank's purchases with the modules, inverters, batteries, and regulators, and air-freighted the consignment to Dubai. Horn Relief picked up the shipment there and flew it to Bosasso. We were lucky—everything arrived in working order, and the local battery acid proved acceptable.

A week later, the rest of the training team arrived: Mark and Daniel Kithokoi from Nairobi, and Abdalla Kyezira from Uganda. The job was a big one, and the Somali students had no experience at all with solar-electric systems, hence the need for four trainers. There were fifteen students, all chosen beforehand by Horn Relief. Our trainees included an engineer (Irbad Omar from Horn Relief), several schoolteachers, three businessmen, two technicians, a radio operator, and a mullah (an Islamic clergyman).

Solar Training

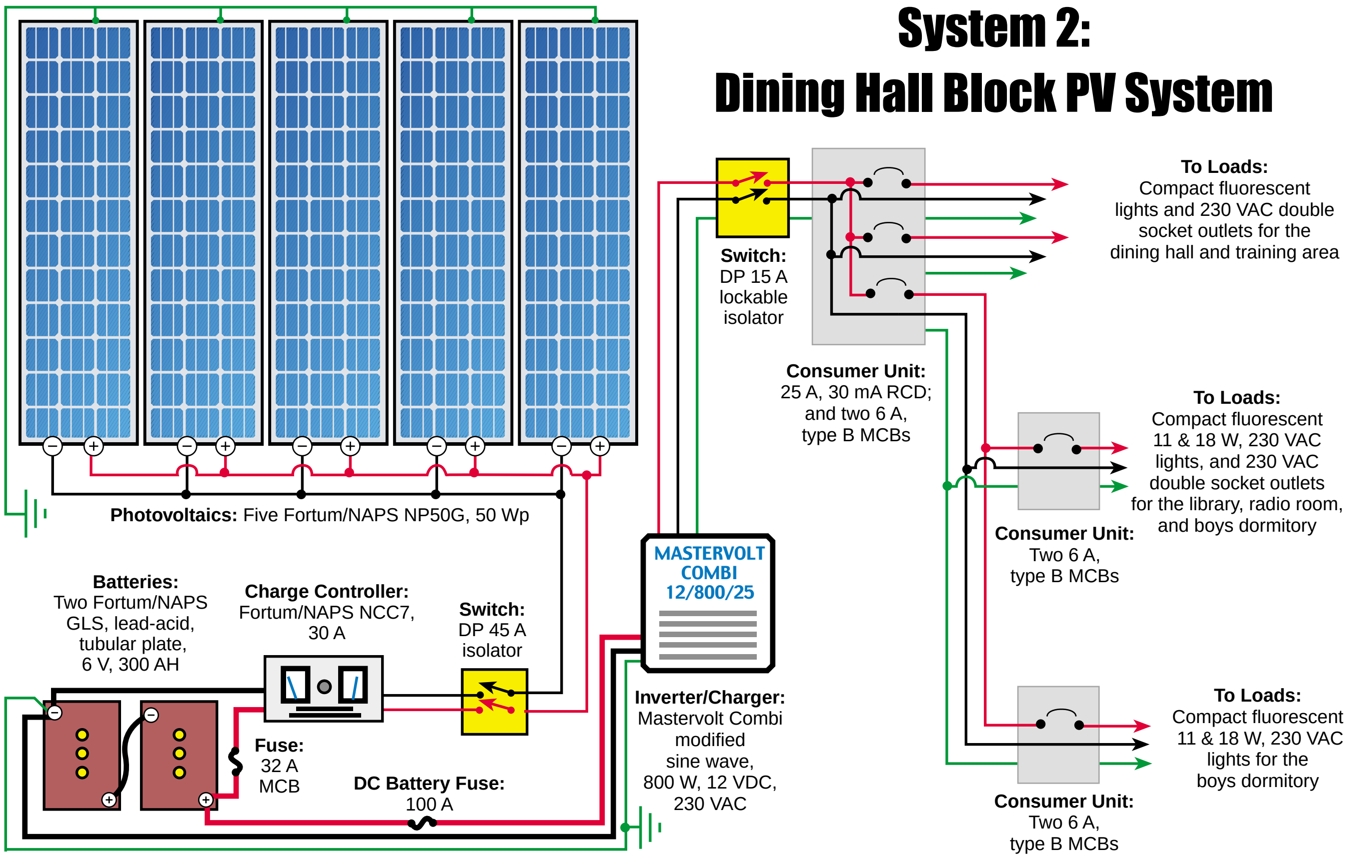
The course lasted ten days, with the theory work done by Mark and Abdalla in the mornings and evenings. After ten years, EAA has PV training courses down to a science. With a full set of detailed lesson plans and resources, we have been training East African instructors like Abdalla, who works for Incafex, a Ugandan solar company.

Daniel managed most of the practicals, and he and Omar oversaw teams of masons who built concrete ground mounts for the three multi-module arrays. Kithokoi also built aluminum roof mounts from extra pieces of ground mount frames.

Frank oversaw the general installation work and did the 240 VAC work in the dining hall, offices, and boys dormitories. Things took longer than expected, since there was much improvisation in the far from ideal working conditions. Still, the enthusiasm of the students was infectious, and ten-hour days were the norm. Classes began early in the morning, followed by prayers, practical work, prayers again, and an evening class in the solar-lit classroom.

For the ten days, students and teachers slept on mats on the ground. Food consisted of spaghetti (the Somali national dish—a legacy from Italian colonialism), delicious white bread rolls baked fresh every day, and meat (mainly goat, but sometimes camel) in spicy cardimom sauce. Tins of tuna fish appeared now and again, and fruit juice and fresh dates provided vitamin C.

System 2: Dining Hall Block PV System



AC Lights & Power

The trickiest installation was the 250 Wp system providing AC lights and AC power for the dining hall, library, two-way radio room, and the boys' dormitories—three buildings in all. It consisted of five ground-mounted Fortum/NAPS NP50G, 50 Wp polycrystalline modules; two GLS 6 V, 300 AH, lead-acid tubular plate batteries; a Fortum/NAPS NCC7 30 A charge controller; and a Mastervolt Combi 12 VDC, 800 W, 230 VAC modified sine wave inverter-charger.

The 230 VAC lights included energy efficient 11 W and 18 W PLs. Frank did most of the 230 VAC wiring himself, since no one else had the wiring skills. The students helped with hoisting and installing the overhead wiring, laying the cables, and installing the accessories (often bashing nasty holes in the soft plaster walls).

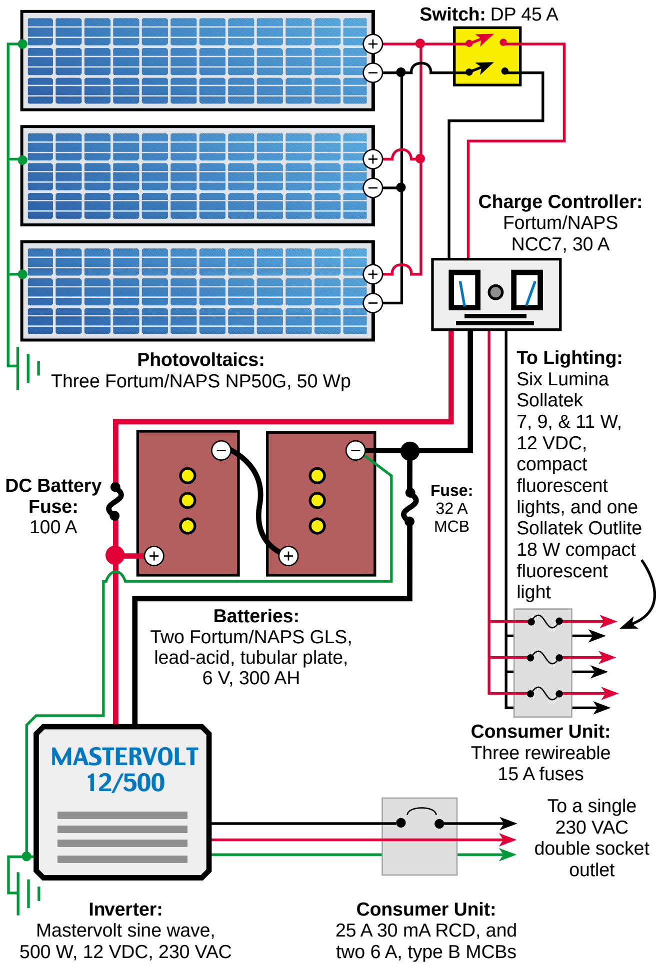
All AC distribution was protected by a residual current device (RCD or earth fault leakage circuit breaker). Each building had its own consumer unit (AC distribution panel) with 6 A circuit breakers, one for lighting circuits and one for outlet circuits. Socket outlets were of the 13 A UK type, and we brought a box of 13 A fused plugs along to fit in them. In total, only five double-socket outlets were installed, since we wanted to be able to control the number and types of appliances plugged in. (The non-adjustable low voltage disconnect on the Mastervolt Combi is only 10 volts, enough to protect the Combi itself but not the battery.) Battery state of charge is indicated by an analogue voltmeter in the NCC7 charge controller.

Distribution between buildings was with UV-resistant cable tied to an overhead stainless steel wire, installed to carry the cables. We decided against connecting the Honda 500 VA petrol generator on site to the inverter-charger, since it would be adding an unnecessary level of complexity.

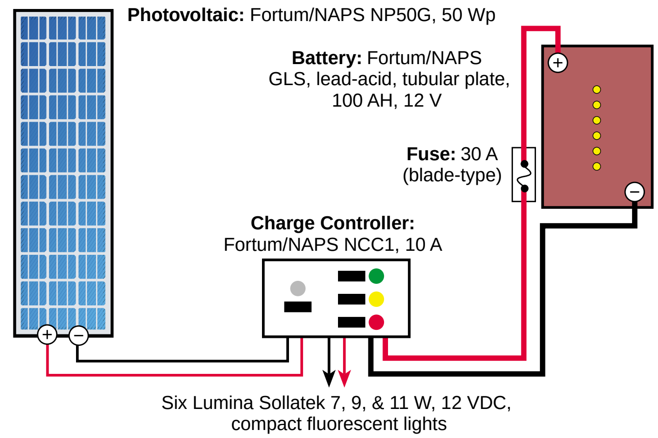
Besides, the output from the solar array at six peak sun hours a day is more than sufficient to provide all the energy needed. If necessary, the distribution system can be extended at a later date. In a remote location like Buraan, a system as complicated as this requires considerable user education, which is one reason why Frank stayed on for an additional two weeks.

The radio operator was to be responsible for maintaining batteries, taking daily readings of battery voltage, and seeing that lights are switched off when not in use. Engineer Irbad Omar was fully briefed on the operation of the systems. It would be his job to make sure basic maintenance was being carried out regularly, to deal with any problems that came up, and to extend any AC wiring if required. Complete wiring diagrams and manuals for equipment were handed over to him.

System 3: Girls' Block Guest House PV System



System 4: Girls' Dorm 1, PV System



Irbad has kept in touch with Frank, since Puntland has recently acquired email facilities.

12 Volt System

The classroom block was powered by a ground-mounted array of five 50 Wp Fortum/NAPS NP50G modules. We used two 6 volt GLS 300 AH, lead-acid, tubular plate batteries wired in series, regulated by a Fortum/NAPS NCC7 30 A charge controller. Each of the four classrooms used three of the 11 W Sollatek PL units. Two Sollatek 18 W "security" lamps provided outside lighting. The security lights were so good that some of the BRI teachers prepared lessons under them, outside in the warm night air.

We used the old type 230 VAC consumer units (AC distribution panels) with rewireable fuses for the distribution circuits. These are no longer available in the UK, and it was only with some difficulty that Frank and Daniel were able to find them in Nairobi. These days, most AC consumer units have 230 VAC rated circuit breakers, but these older units with their rewireable fuses work well for 12 and 24 VDC systems.

These fuses are basically a block containing a strand of fuse wire. If the fuse blows, it is simply replaced with another strand of fuse wire, which is readily available in 5, 15, and 30 amp sizes. The consumer units being used now have circuit breakers that are AC rated, not DC. The rewirable fuses work on 12 and 24 VDC without any problems.

Batteries and charge controller were situated in a central classroom that is going to be the BRI science lab. Solar electricity will be part of the curriculum (the head teacher attended all of the classes), and the NCC7 charge controller is a nice teaching tool. A flick of the switch and students can see charging current and current to loads in a clear analogue display. It's important when putting solar-electric systems into educational establishments that students are able to see how they work and gain some understanding of the technology, especially in Africa where solar is making great strides.

In all of the systems, the ground mounts were some distance away from the batteries. We had to double and treble-up on cables. The largest size we had or could find was 6 mm^2 (slightly larger than #10), but in all cases we got under 5 percent voltage drop. Although we considered the idea of making the system 24 VDC, we settled on 12 VDC to make it easier to find spare light fixtures, since all of the other systems are 12 VDC.

Guest House PV System

The third system was the 150 Wp system providing DC lights and AC power for the guest house. This consisted of another three ground-mounted 50 Wp polycrystalline Fortum/NAPS NP50G modules, two Fortum/NAPS

Buraan Rural Institute Systems Costs

System 1: Classroom Block	*Cost (US$)*
5 Fortum/NAPS NP50G modules, 50 W	$1,025
2 GLS 6/300 tubular plate batt., 6 V, 300 AH	630
Miscellaneous	600
13 Sollatek PL lamps, 11 W	351
3 Sollatek outdoor PL lamps, 18 W	225
Fortum/NAPS NCC7 charge controller, 30 A	198
Support structure	130
2 Sollatek PL lamps, 7 W	54
System 1 Total	$3,213

System 2: Dining Hall Block	
5 Fortum/NAPS NP50G modules, 50 W	$1,025
Mastervolt 12/800 inverter/charger	820
Miscellaneous	700
2 GLS 6/300 tubular plate batt., 6 V, 300 AH	630
Fortum/NAPS NCC7 charge controller, 30 A	198
Support structure	130
20 PL lamps, 240 VAC	160
System 2 Total	$3,663

System 3: Girls Block Guest House	
2 GLS 6/300 tubular plate batt., 6 V, 300 AH	$630
3 Fortum/NAPS NP50G modules, 50 W	615
Mastervolt inverter, 12 V, 500 W	600
Miscellaneous	600
Fortum/NAPS NCC7 charge controller, 30 A	198
Support structure	130
4 Sollatek PL lamps, 7 W	108
2 Sollatek PL lamps, 11 W	54
System 3 Total	$2,935

System 4: Girls Dorm 1	
12/100 GLS tubular plate batt., 12 V, 100 AH	$248
Fortum/NAPS NP50G module, 50 W	205
Miscellaneous	200
4Sollatek PL lamps, 7 W	108
Fortum/NAPS NCC1 charge controller, 10 A	65
2 Sollatek PL lamps, 11 W	54
System 4 Total	$880

System 5: Girls Dorm 2	
Korea lead-acid battery, 12 V, 100 AH	$120
Fortum/NAPS NP50G module, 50 W	205
Miscellaneous	200
4 Sollatek PL lamps, 7 W	108
2 Sollatek PL lamps, 11 W	54
Morningstar charge controller, 10 A (donated)	0
System 5 Total	$687

System 6: Girls Dorm 3	
Rocket lead-acid battery, 12 V, 50 AH	$60
Miscellaneous	100
2 Labcraft 8 W fluorescent & 1 Sollatek CF	81
Fortum/NAPS mini-kit charge controller, 5 A	30
Fortum/NAPS mini-module, 20 W (donated)	0
System 6 Total	$271

Training Materials	
Books	$320
Tools	250
Digital multimeters	230
Training Materials Total	$800
All Systems Total	$12,449

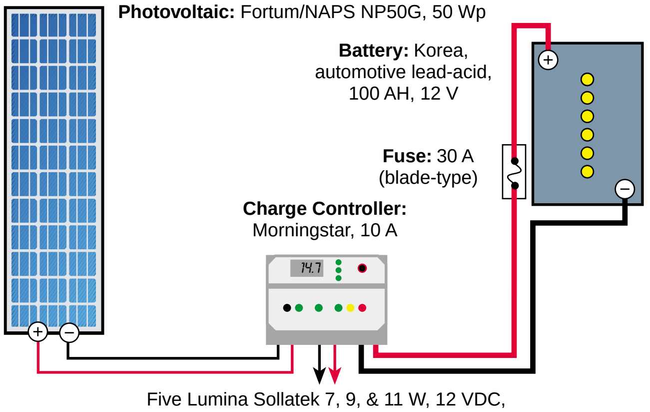
GLS, 6 V, lead-acid, 300 AH, tubular plate batteries, a Fortum/NAPS NCC7 30 A charge regulator, and a Mastervolt 12 VDC, 500 W, 230 VAC sine wave inverter. This system is probably bigger than it needs to be, but the excess power will be useful in the future.

The AC circuits are protected by a 30 mA 25 A RCD. We always install these on inverter systems, but it is not straightforward. Some RCDs will not work with some inverters, and even if they appear to work by tripping when the test button is pressed, you can never be sure if they are tripping within the specified earth leakage current value and specified tripping time.

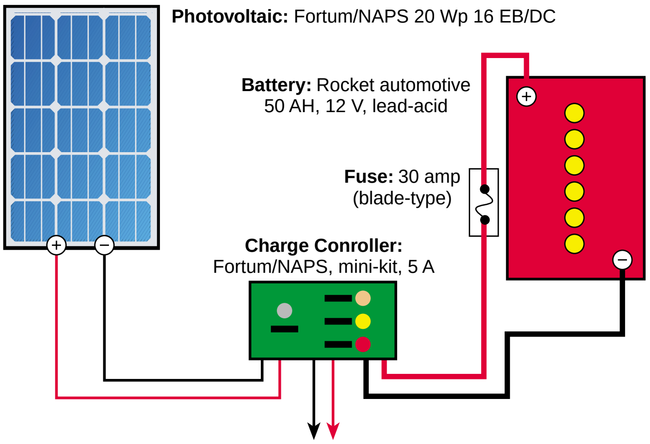
Three Small PV Systems

The three small single-module systems, installed in the girls dormitories, were all slightly different. They were installed completely by the students, with EAA trainers

System 5: Girls' Dorm 2, PV System



System 6: Girls' Dorm 3, PV System



watching closely. Two systems had single roof-mounted 50 Wp polycrystalline Fortum/NAPS NP50G modules. One of these had a 10 A Fortum/NAPS NCC1 charge controller. In another we used a 10 A Morningstar controller, kindly donated to EAA for test purposes. It arrived as a circuit board, and a wooden casing was constructed on site. One of these systems has a 100 AH automotive battery we bought in Bossaso, and the other has a 100 AH GLS lead-acid tubular plate battery.

Each of these systems had five Sollatek lights. The third and smallest system has a 20 Wp polycrystalline Fortum/NAPS module, pole-mounted, with a Fortum/NAPS 5 A charge controller and three lights—one Sollatek and two Labcraft 8 W fluorescent tubes. A locally available 50 AH automotive battery was used.

PV and Education

It was important to our educational mission that the systems were varied. Using different components gave the students an opportunity to see different designs, and using local batteries is probably the way most small solar home systems will be installed in the future in Somalia.

Horn Relief is now marketing some small solar-electric systems in the region. They are convincing local electric shops to supply the proper switches, junction boxes, cables, batteries, and other accessories. They will be using locally available components where possible, while importing solar modules, charge controllers, and lights (and batteries for larger institutional systems).

EAA will continue its training work in the region, holding two more courses in Somalia over the next year. One will be at a school in Hargeisa, the capital of Somaliland, and another (for women only) will be in Galkayo, in Puntland.

A Solar Future for Somalia

After more than a decade of war, the Somalia region is now moving into a season of peace. People are tired of conflict, and the ones we worked with are interested in rebuilding. Somalis are returning from all over the world to settle in their homeland. Others are sending contributions to their families back home.

With little infrastructure remaining, there is a fantastic opportunity for the country to use its ample wind and solar resources as a mainstay for the economy. Instead of running lines from diesel-fired power plants in major towns, many small settlements can economically generate their own power from the sun and wind.

However, for this to happen, a solar infrastructure needs to be built. In Somali towns, everybody knows about petroleum generators, and the sound of generators is heard through the night. Few people know about solar-electric systems, though the interest is there. Everywhere we went in Puntland and Somaliland, people are keen to go solar when they hear about it.

It is the local business and NGO community that will help solar power fill the niche that it can sustainably occupy in Somalia. For this group to gain information about viable solar applications, a strong effort needs to be made to train Somalis. With partners like Horn Relief, EAA continues to help develop the Somali solar infrastructure. Much more needs to be done. Please contact us if you are interested in participating.

Access

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Vanner

four color on negatives

full page

this is page 30


See BP Solar in a whole new light.
What you see when you look at BP Solar today is just as important as what you don't see. We're more than solar power. We're the power of experience, successfully providing solar electric solutions for applications in over 160 countries worldwide.
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Total Homebrew

Starting Small to Learn the Basics

Michael Lew

Above: Michael's 10 watt photovoltaic panel.

Right: A homemade power center with metering, fuses and disconnects, charge regulator, and low voltage disconnect.

Renewable energy (RE) has always been an interest of mine. But budget constraints have typically kept it out of reach on even a hobbyist level. Now, thanks to growing sources of information for homebrew projects, RE is becoming an increasing reality in my home.

I would like to note that *Home Power* magazine has been the single greatest resource for my research. With the wealth of information from this publication (sometimes complemented by outside sources), I have been able to construct a relatively sophisticated micro-system in an area where consumer RE is essentially non-existent—the suburbs surrounding Washington D.C.

I would like to thank *Home Power* and its supporters for providing such useful, applicable, and reliable information. The homebrew projects and articles provided by *HP* staff and readers alike have been invaluable in helping us build our micro-system and in learning about RE. In addition, off-line support for homebrew projects has been very pleasant—a testament to the camaraderie among members of this community.

Our micro-sized system contains all of the basics, including power collection, storage, control, and distribution. Power is generated from solar and wind energy, with solar being the primary source. Shunt regulation and low voltage disconnect circuits maintain battery voltage, while an electronic desulfator helps keep the batteries optimized. All of these circuits were based on designs published in *Home Power.* A 300 watt inverter is the only manufactured consumer electronics item in the system. It powers fluorescent lamps in the basement.

The beauty of this system is that it is teaching my wife and me the ins and outs of RE use. We plan to install a larger and grid-intertied system after we move to a preferred location, but as we have both discovered, there is much to be learned about RE, its use,

The fixed-mount wind generator with its 3 foot diameter hand-carved wooden blades.

The fixed mount bird produces almost 45 watts in a 25 mph (11 m/s) wind, using a surplus DC motor as a generator.

The protective cowling and nose cone are a creative use of plastic soda bottles.

application, design, and "care and feeding." In addition, this project demonstrates that the homebrew ethic can make use of RE under budget and environmental (neighborhood) restrictions.

Photovoltaic Module

The solar panel is a 10 watt single glass panel in a homebrew case. It was purchased on e-bay for US$60 plus shipping (I think that these solar panels are also available at www.solarsurplus.com, for slightly higher cost). The case consists of two layers of 3/4 inch (19 mm) plywood. The first is a backing with most of the solid portions cut out for venting. The second forms a perimeter around the panel, with 1/8 inch (3 mm) clearance all around. The panel is attached with adhesive silicon caulk around the perimeter and along the back. The whole unit is caulked and painted generously to protect it from the elements.

I used 1/8 inch (3 mm) plexiglass to protect the panel from the hailstorms that plague this area with increased frequency. The entire unit became quite hot before the vents were cut, causing the plexiglass to warp under the hot sun. It is mounted on the back deck where it is exposed to good light. It is accessible for occasional testing and tweaking.

Lessons learned: Keep PVs as cool as possible! With a solid wood backing, output voltage dropped from 17 V to 12 V in the summer before the vents were cut.

Wind Generator

More time was spent building the wind generator than any other component. Plans and books by Hugh Piggott were paramount in learning about blade and generator design, selection, and construction. The blades are carved from pine boards, painted with fiberglass resin, and then lacquered for color. A surplus DC motor that begins generating 12 volts at about 300 rpm serves as the generator, while trimmed soda bottles protect it from the elements.

Wind generator size had to be limited to avoid offending the local homeowners' association. Although the immediate neighbors have been supportive, the turbine was limited to a three foot (0.9 m) rotor and a fixed mount. The fixed mount (no yaw bearing) consisting of threaded, galvanized pipe was chosen due to the alignment of the townhomes. Good wind only blows in line with the buildings, west to east. It so happens that the best wind occurs during late fall through mid-spring, when the jet stream dips down to our area. Also, by using a fixed mount, a tail is not needed, and the wind generator maintains a smaller profile in the neighborhood.

With the efficiencies of a less-than-optimized design, total output has generally been about 1.5 amps at 13 volts with winds in the range of 25 mph (11 m/s). The rotor spins up to where it's hard to see the blades in strong winds and elicits a soft "chopping" sound. It's really neat to listen to and watch!

Lessons learned: These are extremely complex machines when one considers all of the different sciences involved (fluid dynamics, electromagnetics, materials, and construction). Limitations in tools and proper materials thwarted my attempt at building the generator unit from scratch.

The wind generator began as a learning experience, and the learning continues every time the wind blows. I recently constructed a two-blade propeller, but testing indicates that it will make the efficiency even worse. Feedback from homebrew wind generator expert Hugh Piggott agrees—the match is poor between the propeller and the generator. He concluded that there are too few blades for such a low speed generator. With more thought and planning, a better-matched propeller may be added in the future to improve its performance.

Design aside, the other drawback in this installation is placement. Much better wind could be realized if the wind generator was mounted above the home where the wind is smoother and stronger.

This winter has been wonderful for the wind generator, since we have had an abundance of strong, lasting wind. I have watched it spin outside for hours, producing current at the batteries at higher levels than expected. It has produced over 5 amps at 13 volts on several occasions. While this is not ideal for a wind generator of this size, it is more than I expected from my first attempt. I hope to improve on the design. One windy night provides as much charge as five days of sunshine!

Batteries, Regulator, & Desulfator

Our battery bank is 40 amp-hours total, either purchased used or recovered throw-aways. These are all gel cells. We will be expanding the bank as more surplus batteries are found. The batteries are kept in plastic marine-type boxes for safety.

Lessons learned: Batteries are extremely delicate and are as willing to teach as you are to learn. Time spent trying to maintain the batteries with the desulfator (and studying results) has been second to the wind generator construction. While gel cells have reduced risk of spillage, they are definitely less forgiving than flooded cells.

Inside the voltage booster.

The LVD is built from Forest Cook's design published in *HP60,* and the shunt-type regulator is a modification of that same design. The LVD is crucial in such a small system where a normal load can completely discharge the batteries in twenty-four hours. The shunt regulator is most effective here in the fall and winter when the wind increases.

Lessons learned: The LVD circuit works as designed with no problems. A simple modification to the circuit allows it to be used as a shunt-type regulator. Since the circuits can handle loads up to 30 amps, they can easily support expansion.

The desulfator is another homebrew circuit, designed by Alastair Cooper and published in *HP77.* It is proving to be quite useful for squeezing amp-hours from the aging batteries employed in the system.

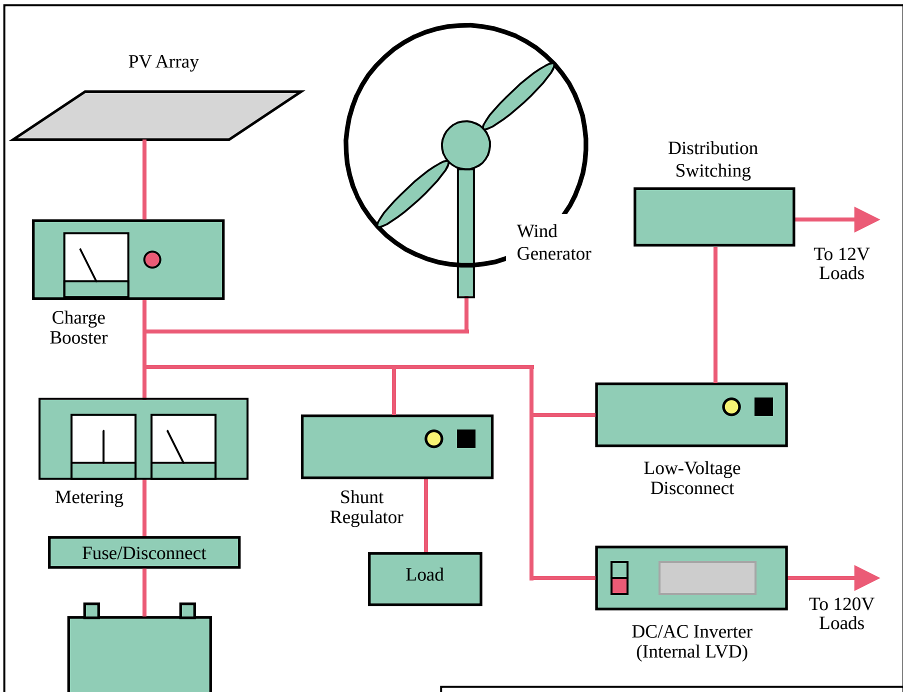
Lessons learned: This design is an adaptation of relatively new battery maintenance technology. It is a

The pulse desulfator is mounted in an old tin can.

very recent addition and is working to clean the plates of the used cells. Definite improvements were noted on smaller (7 amp-hour) cells after a couple of weeks of treatment; larger batteries take longer. Mr. Cooper has established a BBS on the Web to support the growing interest in this project.

The charge booster is an adaptation of the desulfator circuit. It is manually adjusted to optimize the output voltage from the solar panel.

Lessons learned: While the booster gains a few percentage points of efficiency in mid-day, bright light conditions, it loses efficiency in the early morning and late afternoon. I suspect that automatic adjustment is needed for it to be truly effective.



Total Homebrew – Logical Schematic

Inverter & Power Center

A basic 300 watt storebought inverter delivers enough power to support basement lighting and the TV. It comfortably powers several compact fluorescent (CF) lamps. It is a modified sine wave type.

The inverter is rated at 300 watts continuous, 500 watts peak. It uses a 140 volt modified sine wave to simulate 120 VAC power. It is fused at 30 amps on the 12 VDC input side. The inverter has a couple of nice features, including low-voltage disconnect at 11.5 volts, and an audible alarm if the voltage stays low after the LVD shuts the inverter down.

Lessons learned: Certain CFs are happier with the inverter than others. The "unhappy" ones give off a pronounced buzz and get warmer than they do on grid power. The Lights of America "twister" type lamps have worked the best so far.

The control center is a small, self-contained unit with power metering, fuse protection, and basic DC switching. It allows isolation of charging circuits for testing, and has switched outputs and an automotive power receptacle for added usefulness. The control center is designed to be as friendly as possible, especially since it is placed in a living area.

System Wiring

System wiring is best described as careful but temporary. The generating sources are located immediately above a basement window, through which the wiring is run. Ribbon-shaped cables were constructed for ease of fit by taking six strands of #28 (0.08 mm^2) wire sandwiched between packing tape for each conductor. This is clearly a temporary solution, but it has worked surprisingly well for the low current generated by the wind generator and solar-electric panel. A total of three conductors are used, with common negative and individual positive feeds for the wind generator and solar panel.

The indoor wiring is very simple. Since the basement is only 19 by 14 feet (6 x 4 m), no long runs are needed. The CF lamps either plug directly into the inverter, or use standard household extension cords. The 12 volt lighting uses #16 (1.3 mm^2) two-conductor "zip cord" attached at the terminal strip at the bottom of the control center. In addition, devices are plugged in as needed to the 12 volt DC, automotive-style power outlet on the face of the control center.

Lew System Loads

Item	*Watts*	*DC Amps*	*Average Hrs./Day*	*Average WH/Day*
60 W equiv. CF	23	1.75	0.43	9.86
100 W equiv. CF	28	2.50	0.21	6.00
DC lamps	12	1.00	0.29	3.43
Radio, fan, & toys	12	2.50	0.14	1.71
Laptop charger	30	3.00	0.04	1.07
			Total Average Watt-Hours Per Day	22.07

The wiring within the control center consists of stranded hookup wire ranging from #18 to #14 (0.8–2 mm^2). The control center uses fuses to protect the charge sources, outputs, and batteries. The switches provide individual charge source control (wind and solar), battery disconnect, and two output buses. Inverter aside, the only solid-state components in the control center are two Schottky diodes to prevent current from flowing back into the solar panel and the wind generator.

Lessons learned: Simple wiring such as this is suitable for a small room. It's not unlike running wires for stereo speakers. It does make rearranging the furniture more of a chore. I try to leave extra cable on each 12 volt lamp to avoid splicing longer leads on if we need to move something around.

The wiring through the window, while unique, is nothing that should remain long-term. Sheltered by the deck above, it has held up remarkably well, but in simple terms, it's clumsy. Future plans including purchasing a through-wall wiring tube, which I've seen at Radio Shack for TV antenna wiring.

Growing a System

The system was designed to start small and remain completely disconnected from the grid. However, as my wife and I have learned to use it, we find ourselves demanding more of the system than it is capable of producing, depending on the weather. In addition, some power-hungry experimentation with new devices, or activities such as introducing dead batteries to the circuit, have given occasional need for additional charging.

When needed, a 1.5 amp automatic trickle charger has been used to keep the batteries above a critically low state. The charger uses an on/off style regulator, with a 14 volt off-point and 13 volt on-point to maintain voltage. This US$20 charger has been great for periodic use, especially when reviving newly added weak batteries requiring a deep charge and weeks of desulfator use. The charger is not hard-wired into the control center.

In addition, a recent charging source has been added to the system. It was born of the combined need for exercise and the desire to do something productive with the energy spent. A Schwinn recumbent-style exercise bicycle was recently retrofitted with a belt-driven generator to provide a workout load while also charging the batteries. The electronics for the retrofit are not complete yet, but it produces 36 watts at 90 rpm at the pedals, and 60 watts at 120 rpm.

The friction band around the bike's flywheel was removed, and the groove in the flywheel readily accepted a belt sewn from 1/2 inch (13 mm) wide nylon webbing. The motor was purchased for US$20 from a surplus dealer. It is an Indiana General 24 volt, 0.75 amp, 1,200 rpm, permanent-magnet type.

System Use

While small, the system is well suited for running the CF lamps in the basement. Each 28 watt CF draws about 2.5 amps at the batteries. The storage capacity is

Lew System Costs

Solar-Electric Panel	*Cost (US$)*
PV panel, 10 W, make unknown	$75
Plexiglass for cover	30
Scrap plywood	0
Solar-Electric Panel Total	$105
Wind Generator	
Generator, 30 VDC perm. magnet motor	$70
Fiberglass resin	10
Mounting hardware	10
Propeller, scrap pine	0
Wind Generator Total	$90
Battery Bank	
Best battery, 12 V, 20 AH, gel cell	$20
Marine plastic battery case	10
3 Power Patrol SLA-1075, 12 V, 7 AH gel	0
EverStart Marine U1DC-6, 12 V, 34 AH	0
Battery Total	$30
Home-Built Electronics	
Desulfator, design by Alastair Cooper	$25
Low voltage disconnect, modified design	25
Voltage booster, from desulfator design	25
Home-Built Electronics Total	$75
Control Center	
Inverter, 300 W, brand unknown	$60
Switches & fuse holders	21
Meters from "junk box"	0
Case, milk crate, & scrap lumber	0
Control Center Total	$81
Other	
Wire and connectors	$30
Schumacker SE112S charger, 12 V, 1.5 A	20
Paint: wind genny, PV, control center	10
Fuses	5
Other Total	$65
Loads	
Two compact fluorescent screw-in bulbs	$28
12 V auto-style lamps from "junk box"	0
Loads Total	$28
Grand Total	$474

An old exercycle picks up where the weather leaves off.

enough to keep the room partially lit for several hours—perfect for watching a movie or writing email.

It is also capable of providing TV/radio news and lighting during power outages. Several of the radios in our home employ 12 volt internal power supplies, and I hope to bridge them over to the battery bank and pull them off-grid.

The use of hands-off circuitry, such as the LVD and charge regulator, minimizes complexity to the point where my wife is comfortable using the system without my presence. She doesn't worry about damaging anything, and even powers some of the children's toys from it. I am pleased to come home, read the lower voltage, and know that my family is using RE instead of the grid. Most of all, my wife and I are learning how to use RE, and how to increase its use in the future.

Access

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Alistair Cooper • www.shaka.com/~kalepa/desulf.htm
Homebrew desulfator circuit

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Hunting Phantom Loads

Intelligent Design Can Help You Eliminate These Costly & Frustrating Goblins

Dan Chiras

In 1996, my two sons and I moved into our nearly completed straw bale and tire home in the foothills of the Rockies in Colorado. Although the construction process had been difficult and frustrating, I was elated. My builders and I had succeeded in creating a state-of-the-art environmental dream home.

A fourteen panel photovoltaic (PV) array supplied electricity. A super-efficient refrigerator and compact fluorescent lighting, among many other energy-saving devices, helped to reduce electrical demand to about one-fourth that of a conventional home of similar size.

When we moved in, I imagined us sailing lightly into the future, virtually free of the tyranny of utility bills (we did bring in natural gas for cooking, heating water, and running the backup heating system). I felt as if I had nearly emancipated myself from the power companies and the long string of environmental problems for which they—and we as consumers of their product—are responsible. I was ready to sit back, play music, hang out with my boys, and enjoy my new-found freedom.

But shortly after I moved into my house, I found that the solar-electric system wasn't able to keep up with my modest electrical demand. In a panic, I called the electrician who had installed the system. "What's happening?" I asked. "There's plenty of sunshine and I'm running out of electricity!" She assured me that everything was okay. The system had been installed correctly. "The problem," she said, "is most likely that you are using a lot more electricity than you thought you would." I called Laurie Campbell at Alternative Choices, the equipment supplier, and she agreed. "It's a common problem," she said. "People just don't realize how much energy they use until they go solar."

Being an energy miser, I found it difficult to accept this prognosis. But I decided to look into the matter anyway.

The Chiras' off-grid, solar-electric and passive solar home, made of straw bales, tires, and numerous recycled building materials.

The phantom load of the LED light on this microwave is controlled by a combination switch and receptacle (pictured here).

The Trace inverter draws 5 watts when in search mode, and about 12 watts when operating.

A quick analysis of my electrical loads showed that both women were correct. I was using a lot more electricity than I thought. The problem was that the extra energy wasn't being put to good use. It wasn't being used by my appliances, lighting, or computer. It was being depleted by phantom loads.

Dastardly Phantoms

A phantom load is a tiny power draw created by many different types of electronic equipment, such as televisions, stereos, and microwave ovens. Small amounts of electrical energy are used to power those confounded and ubiquitous LED clocks, and to keep televisions in a ready state, so that when you turn on the switch, the set comes on instantly. We've grown awfully impatient these days!

Phantom loads are also created by voltage transformers (wall cubes) for answering machines, phones, caller ID boxes, and electronic pianos. Switches for automatic garage door openers, and sensors that keep children and small pets from being squashed by the closing doors, also draw small amounts of energy.

Unfortunately, the solar provider who sized my system hadn't said a word about phantom loads. Even the three top-selling books on solar electricity fail to mention them! As I began to become familiar with my solar-electric system, I uncovered a couple dozen phantom loads in my house. Together, they were conspiring to drain my batteries, even in the middle of summer when sun was in abundance.

The first phantom load I discovered was in the GFIs (ground fault interrupts). GFIs are electrical outlets that contain circuit breakers to protect against electrical shock. They are installed around sinks and indoor planters, in garages, and on outside walls.

Building departments love them, and require their installation anywhere a person using an electrical device might encounter standing water. They're protective devices, designed to short out before you do. Much to my surprise, I found that the code required installation of fourteen GFIs. Each one was drawing 2.5 watts, 24 hours a day!

The next phantom loads I discovered were my smoke detectors. As it turns out, many building departments require that smoke detectors in new construction be hard wired to an electrical circuit. These units also have backup batteries. Each of the three smoke detectors the electrician had installed drew about 12.3 watts. They too were operating 24 hours a day!

Inverter as Load

Next, I found what all solar-electric novices soon discover—the inverter uses electricity too. An inverter is an electrical device that converts direct current (DC) electricity produced by PVs and wind generators (and other renewable energy sources) into alternating current (AC), used by most conventional appliances.

Tiny phantom loads can activate the inverter, depending on the search mode setting. Search mode is a kind of sleep state for the inverter. When appliances and other electronic devices are off, the inverter automatically switches into search mode. Although homeowners can adjust the search mode wattage of an inverter to ignore individual phantom loads, small phantom loads add up, causing the inverter to run continuously. And when the inverter runs, it uses about 10 to 12 watts for its own operation, again 24 hours a day!

Phantoms Add Up

Some quick math revealed a stunning fact that explained the mysterious failure of my solar-electric system. The phantom loads in my house, including the inverter, were drawing about 125.5 watts, 24 hours a

GFIs like these draw about 2.5 watts.

day. In a grid-connected home, this kind of power draw is no big deal. Except, of course, when it is multiplied by the millions of other homes supporting similar phantom loads. In the United States alone, phantom loads from televisions, VCRs, microwave ovens, GFIs, and other devices consume as much as five large nuclear power plants produce, each with a 1 billion watt generating capacity.

In a solar-electric home, minuscule phantom loads can be a killer. In my home, equipped with a small, economical solar array, phantom loads created by my GFIs and smoke detectors were devouring a whopping 1.71 kilowatt-hours a day. Television sets, stereos, and other electronic devices were also adding to the phantom load, but they could be switched off or unplugged.

In my original PV system, the panels produced only 20 to 24 amps in full sunshine. Thus the modest 122 amp-hour daily phantom load required about five and a half hours of power output in peak sunlight. Thus, the modest 84 amp-hour daily phantom load required about four hours of power output in peak sunlight. That didn't leave much electricity to run the refrigerator, the lights, or anything else!

Banishing The Phantoms

My first step was to disconnect GFIs that weren't needed (I think the building department went overboard). Plates now cover those outlets, including the ones along my indoor planters. I also had to switch the smoke detectors to battery-only operation, using ten-year lithium batteries I purchased from Real Goods. These simple changes decreased my phantom load by 71.3 watts.

However, as noted earlier, there were other phantom loads I had to deal with. The television sets, which were super-efficient models, drew a small amount of energy when they were officially "off." The VCR and portable stereo also drew small amounts of energy when off, and so did the microwave oven and the gas stove (which had a clock).

Each problem required a different solution. To shut off the phantom load for my portable stereo, I installed a switch on the cord. The TV and VCR were plugged into power strips that are shut off when these devices are not in use. I replaced the electrical outlet for the microwave with a combination switch and receptacle. This allows me to turn the power completely off when the microwave is not in use.

The gas range, which is on its own circuit, is shut off at the breaker box. I tried disconnecting the clock, which was not needed, but that cut power to the electronic ignition devices. I now use a clock powered by rechargeable alkaline batteries. When I need to light the range burners, I use a match. When I need to light the oven, I turn the breaker on for a little while. The GFI in the garage, and others that I couldn't remove for safety reasons, are switched off at the circuit box.

Heating System Power Demand

These simple steps saved me an enormous amount of energy and got my solar-electric system up and running again. Well, almost. When winter set in, I discovered another problem in my solar-heated home—a major problem. My natural gas-powered backup radiant floor system consumed an enormous amount of electricity.

The system we had installed consisted of a super-efficient boiler with a fan for venting stack gases and drawing in outside air. Two pumps propelled hot water through plastic tubing in the cement slab beneath the tile floor to heat the house on cloudy days. Together, the pumps, fan, and other electronics in the system drew about 266 watts.

Making matters worse, the boiler also contained a glowplug to ignite the gas burner. This used an enormous amount of electricity too! Making matters even worse, the boiler cycled on and off every few

Audio/visual components are often phantom loads.

minutes. Each time it went on, the power demand peaked at about 50 amps at 24 volts.

Combined with the constant draw to operate the pumps and the fan, this power demand quickly ran my batteries into the ground. My calculations showed that I needed at least thirteen hours of peak sunshine a day to run the heating system for 24 hours.

Because of this excessive demand, I started running the backup heating system only when outside temperatures dropped. And even then, I typically had to run my gasoline backup generator to provide enough electricity to keep my batteries from running out. Many frigid January evenings, I found myself freezing in the dark. Temperatures in the house plummeted to 56°F (13°C) during the evening. My boys and I had to bundle up in blankets to stay warm. Even though it warmed up nicely during the day when the sun was out, the house was much too cold on frigid January nights and on cloudy days.

Needless to say, this situation required some additional attention. The contractor who installed the original backup heating system graciously agreed to replace the boiler with a regular gas-fired water heater with a pilot. A few more changes, like replacing the original pumps with a single, more efficient water pump, enabled us to decrease the load from 266 to 69 watts, a 75 percent decrease in electrical demand.

Although my solar-electric system still struggled a bit to keep up with the backup heat during cold, cloudy weather, my boys and I were a heck of a lot warmer. For the next year, I ran the gas generator from time to time to replenish the batteries. But my neighbors complained about the generator, so I added eight more PV modules. This winter, the backup heating system is working fine and we've got plenty of electricity. In the first three months of winter, I've only had to run the backup generator four hours. (In previous years, I was running it twelve hours per month!)

I'm hoping that the Air 403 wind generator I bought will add a little extra power too, further reducing my reliance on the gas-powered generator. But so far, the unit is only producing about a quarter of the electricity it's supposed to.

What Can You Do?

If you live in a house supplied by solar and wind power and find your solar-electric system isn't keeping up with your needs, phantom loads may be part of the problem. Many suppliers and installers ignore phantom loads when drawing up the specifications for a PV system! To calculate demand, they ask you to list all of the devices in your home. You list the watts drawn by a device and the amount of time it is used. From this data, they calculate the energy demand of your system. As I found out the hard way, if you don't include phantom loads, your system will fall short of expectations.

This power strip is shut off when the TV, stereo, and VCR are not in use.

If you are building an off-grid home, you can size your system to handle phantom loads. Of course, accommodating the appetite of your phantoms will add substantially to the cost of your system. In my system, which cost US$9,300, I would have had to double the number the panels to satisfy the hungry appetite of those pernicious phantom loads. The cost for the additional panels alone would have been about US$2,100!

Prevention Beats Cure

A far more cost-effective approach is prevention. One of the most convenient ways of avoiding phantom loads is to install wall switches. Plug in your appliances and electronic equipment that are phantom loads. A simple flick of the switch will deactivate the outlet and reduce your power demand. If you like to watch TV at night before falling asleep, for example, consider installing a switch on the wall next to the bed, so you can flip your television off right before the lights in your cerebral cortex go out.

Combination switch and receptacle units next to major appliances are also useful. They're more expensive than standard outlets, but they're easy to install. Cord switches like those I used on my portable stereo are a good idea, too. You can even purchase heavy-duty cord switches for larger cords.

Chiras System Phantom Loads Before and After Modification

Appliance or Device	*Watts*	*After Modifications*	*Watts*
14 ground fault interrupt (GFI) outlets	34.4	Removed or disabled	0.00
Automatic garage door opener, switch, & sensors	7.4	Disabled at circuit breaker	0.00
LED on the microwave oven	4.9	Switched off at switched receptacle	0.00
3 hard-wired smoke detectors	36.9	Battery-only operation	0.00
Clock on the stove	2.5	Switched off at circuit breaker	0.00
Television, VCR, & stereo (living room)	17.2	Turned off at power strip	0.00
Television (bedroom)	2.5	Turned off at power strip	0.00
2 portable stereos	4.9	Turned off at power strip	0.00
Power transformer for radiant floor heating	2.5	Turned off when not in use	0.00
Trace inverter	12.3	Search mode	4.92
Total Watts	125.5	*Total Watts*	4.92
Total Kilowatt-hours per Day	3.01	*Total Kilowatt-hours per Day*	0.12
Total Kilowatt-hours per Month	91.54	*Total Kilowatt-hours per Month*	3.59

If you need to, you can use power strips as I've done, or shut circuits off at the breaker box. But frankly, power strips are not very convenient. If they're tucked away out of sight, you may have to get down on your hands and knees to turn them on and off. Even if the power strips in your house are more accessible, you have to bend over to reach them. And you have to train everyone in your household to turn them on and off, too. A wall switch is much more convenient.

Some hardwired or plug-in electronic devices such as smoke detectors or clocks can be replaced by battery operated models. Use rechargeable batteries to avoid hazardous waste disposal problems.

Another option is to adjust the search mode of your inverter. When an inverter is in search mode, it shuts down if there is no load. Tiny bursts of electricity are sent through the system, searching for an active circuit. You can set the wattage higher on the inverter search mode so that it ignores the smaller phantom loads. But this can be a real pain, too. If you set it too high, some low wattage devices like portable stereos and compact fluorescent lights won't come on when you flip the switch.

The goal in all of this should be to be able to shut your house down, to let the inverter go into search mode. This is a kind of resting state when no power is being drawn from the batteries. (See *Phantom Loads,* by Richard Perez, *HP14,* page 13, for the phantom load detector homebrew, *A Beginner's AC Ammeter Project,* by Joel Chinkes, *HP33*, page 82, and *Phantom Loads Update,* by Michael P. Lamb, in *HP55,* page 36, for another homebrew phantom loads meter, as well as corrections to Lamb's article in *HP56,* page 100.)

In Tune

These steps can help you eliminate the anguish and frustration of discovering that your solar or wind-electric system isn't sufficient. These are simple measures that most people can do themselves, and they're a lot less expensive than installing a large PV system or expanding your PV system to accommodate phantom loads.

Even if you adopt these ideas, you may still have to do some fine tuning. Most people who live off-grid work around the sun—washing clothes or vacuuming when it's sunny, and cutting down on energy demand when the sky turns gray. It's just part of a lifestyle of living in tune with nature. It's a small price for creating a more enduring human presence on a planet well worn by years of human indifference.

Access

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www.chelseagreen.com/Chiras

The Natural House: A Complete Guide to Healthy, Energy-Efficient, Environmental Homes, Daniel Chiras, ISBN 1-890132-57-8, 468 pages. US$35 from Chelsea Green, PO Box 428, White River Junction, VT 05001
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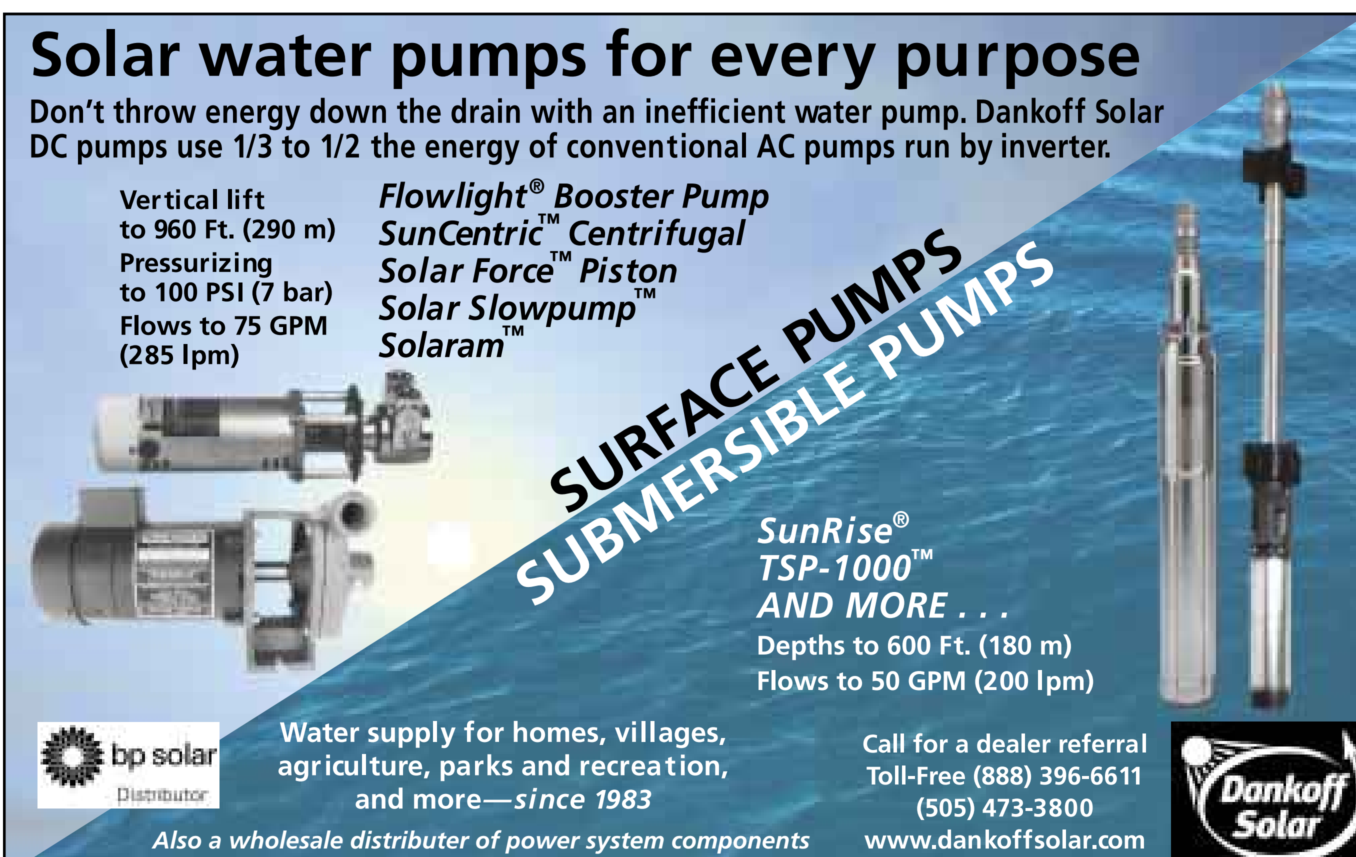

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State Funds Available for RE Systems in California

Eric Hansen

Norman and Janet Pease received US$31,000 in California buydown funds (43% of total system cost) for this 12 kilowatt grid-intertied PV system that powers their home and car (as reported on by Burke O'Neal and Jack West in *HP72).*

Can home-scale renewable energy (RE) help save California? Yes, and the state's putting money on it!

If you live in California and can utility-intertie your renewable energy system, the state would like to reimburse you up to US$3 per watt for your system (or a maximum of 50 percent of system cost). California is rallying for energy relief. Home-scale, decentralized RE generation can be part of the solution.

Assembly Bill 1890 (AB1890) allocated US$540 million to support RE in the state. Governor Davis and the California legislature have extended this funding with AB970, passed in September of 2000.

The buydown program has requirements to be met, so be sure to contact the California Energy Commission (CEC) before you purchase equipment or install your system. Participants need to reserve their buydown amount in advance. For more information on utility-intertie rebate money for homes in California, and to reserve a buydown amount, contact the CEC, or check out their Web site. All states' RE incentives can be found at www.homepower.com/education.htm on the *Home Power* Web site.

Tough Choice

In the face of the California energy crisis, the fix of choice seems to be natural gas-fired power plants. These gas-fired power plants, once constructed, will increase California's electricity generation capacity by 12 percent. This fix is inherently shortsighted—supplies are limited.

But there is money out there for home-scale renewable energy, and it can be installed and on-grid much sooner than building a gas generation plant. Sooo… What do you want, Mr. or Ms. California? Another gas-fired generation plant in your backyard, or solar panels on the roofs in your neighborhood?

Buydown Specifics

As you can imagine, there are many ducks to get in a row before the CEC will award you a buydown amount for your utility-intertied RE system. But the requirements seem very straightforward and fair.

For starters, contact the CEC and request their information and registration packet titled, "Volume 3: Emerging Renewable Resources Account." This guide is free and contains all the paperwork necessary to take advantage of the buydown program. Please keep in mind that your system must be approved before you actually purchase goods or services.

If your system is eligible, you could receive a buydown amount of US$3 per watt or 50 percent of eligible costs, whichever is less. No single project can receive more than US$1 million in total buydown payments. The program has no minimum amount or wattage for approved systems. Systems can be as large or small as the owner desires with one exception—the output of all wind machines installed at one site cannot exceed 10 kilowatts.

Requirements
Before you go any further, you should know that there are some requirements to participate in the CEC's buydown. First, you must be a grid customer, or be willing to connect to the grid of a participating utility. Currently, customers of PG&E, Southern California Edison, San Diego Gas and Electric, and Bear Valley Electric are eligible. If you'd like to participate but have a different utility in your area, check with the CEC—your utility may now be participating.

Second, you can only install eligible electrical generation equipment. These technologies include photovoltaics, solar thermal electric, fuel cells, and small wind turbines. The technology's make and model must be approved by the CEC. The list of approved manufacturers (most approved manufacturers on the CEC list advertise in *HP)* and their products comes with the information packet. Note that batteries, microhydro, and domestic hot water equipment are not included.

Third, your system must meet appropriate electrical codes. If you install the system yourself, it must pass inspection and have appropriate permits. If someone other than the homeowner installs the system, it must be a licensed contractor. The CEC will conduct random audits of systems that have received buydown payments.

Warranties are the last of the buydown's major requirements. Your RE system must have at least a full five year warranty. If a contractor installs your system, this warranty must include parts and labor. This warranty must be presented in advance in order for the system to be accepted. As an added bonus, the CEC has expert troubleshooting help for folks that participate in this program.

Reserving a Buydown Amount
After you receive your information and registration packet, read it thoroughly and follow the directions carefully. Again, you will need to reserve the funds for your system before you purchase any goods or services. Begin by filing the CEC-1890C-1 registration form, which is included in the packet, via fax or mail. Also, fill out the other forms in the packet that are applicable to your system.

When you have been awarded a buydown amount, you'll receive the CEC's official CEC-1890C-2 reservation confirmation and claim form. Reserved buydown amounts for systems 10 KW or smaller are good for nine months. Systems of 10 KW or more have their amounts reserved for 18 months.

An Example

From the California Energy Commission publication *Volume 3: Emerging Renewable Resources Account…*

An original reservation request was submitted for a 4,800 watt (4.8 KW) system with eligible costs of US$24,000. The proposed system was given a confirmed reservation of buydown payment of US$12,000, using program parameters in effect at the time of reservation of US$3 per watt or a maximum of 50 percent of system costs.

The purchaser eventually installed a system of 6,000 watts of rated output, with eligible costs of US$30,000. The buydown program parameters available for eligible systems at the time this customer submitted the second claim for a buydown payment had declined to US$2.50 per rated watt, or a maximum of 40 percent of system costs.

The buydown was recalculated by first applying the US$12,000 already reserved, and then determining the additional rebate. The calculation is summarized in the table below. Two real-world examples of California buydown systems are profiled in articles in *HP72,* (page 10), and *HP73,* (page 38).

California Buydown Program

Example System	*$ Per Watt*	*Amount (US$)*
Installed system, 6 KW	$5.00	$30,000
Rebate from reservation for 4.8 KW	2.50	-12,000
Rebate for additional PV of 1.2 KW	2.00	-2,400
	Total System Cost	$15,600

Go Big!
California utility customers will thank you for helping make green electricity and decentralizing generation. Your neighbors will thank you for helping keep gas generation plants from being built. And *Home Power* thanks you for being a utility-intertie trailblazer. Please write us and share your new system's story—we want to share it with the world.

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Things That Work!

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UniRac's U-PT, 4 Inch Series, Top-of-Pole PV Mount

Joe Schwartz

Last September, we installed a UniRac U-PT, 72S, 4 inch series, top-of-pole PV mount at *Home Power* Central. It's a nice stout PV mount that is easy to install and adjust seasonally for changing sun angles.

Documentation & Shipping

The 4 inch series UniRac U-PT mounts can be shipped via UPS. The mount we received was adequately packaged for shipping. A well written and illustrated one-page installation instruction sheet provides all the information needed to assemble the mount.

Stout—steel and aluminum construction.

UniRac Design Features

The retail price of the 4 inch series U-PT 72S mount is US$350. This makes it competitively priced compared to other top-of-pole mounts.

This mount supports up to eight 75 watt PV modules. UniRac mounts are compatible with ASE, AstroPower, BP, Evergreeen, Kyocera, Photowatt, Siemens, Solarex, and Uni-Solar PV modules. UniRac also manufactures a 6 inch U-PT top-of-pole mount that will support up to fourteen 75 watt PVs.

The UniRac top-of-pole mounts include rack framework and hardware, along with stainless steel PV module mounting hardware. All mount components are either aluminum, stainless steel, or galvanized steel, and therefore weatherproof. As with all pole mounts, the schedule 40 mounting pole is supplied by the user.

The 4 inch UniRac U-PT mounts use a supplied 2 inch galvanized schedule 40 pipe for the mount's strongback or cross-support. This is the framing member that runs perpendicular to the mounting pole. The strongback carries the weight of the PVs along with the remaining mount framework. It also must provide rigidity for wind loading.

UniRac mounts use slotted rails for mounting the PVs. I'm a big fan of racks using slotted rails, since there's a little built-in slop. This makes it easier to align the PV mounting holes to the rails during installation. UniRac's rails are reinforced with aluminum struts running parallel to the rails. The struts are centered on the rails, and run about half of their length.

Early 4 inch UniRac U-PT top-of-pole mounts had problems with the PVs shifting on the racks in high winds. The manufacturer changed the clamping system between the 2 inch pipe strongback and the rails. The new clamps are muffler-style and solve the slippage problem. I went as far as carefully hanging on the rack after the PVs were installed. Even with my 160 pounds on the rack, the PVs held their position with no problem.

Easy Installation

We installed the 4 inch schedule 40 mounting pole and waited twenty-four hours for the concrete to set. On the following day, we were ready to install the mount and the PVs. The array consisted of eight, ten year old Kyocera J-51 modules. UniRac had no problem coming up with the proper mount for these older modules. The 4 inch UniRac U-PT mounts are quick to install. It only took two of us about thirty minutes to assemble the mount and secure the PV modules.

Our 4 inch series UniRac U-PT mount divides the eight module PV array into two sets of four modules. Each set can be individually adjusted for elevation. This means a little less weight to handle while you're repositioning the PVs. This mount can be adjusted for any angle. This allows you to fine tune the angle adjustment seasonally for your specific latitude.

The design made installation and adjustments easy.

The 4 inch series UniRac U-PT mount is a good choice if you're looking for a top-of-pole mount for your site. It's rigid, quick to install, and easy to adjust seasonally as the sun's angle changes.

Access

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Wind System Installation: June 11 - 15 • Photovoltaic System Installation: June 16 - 20

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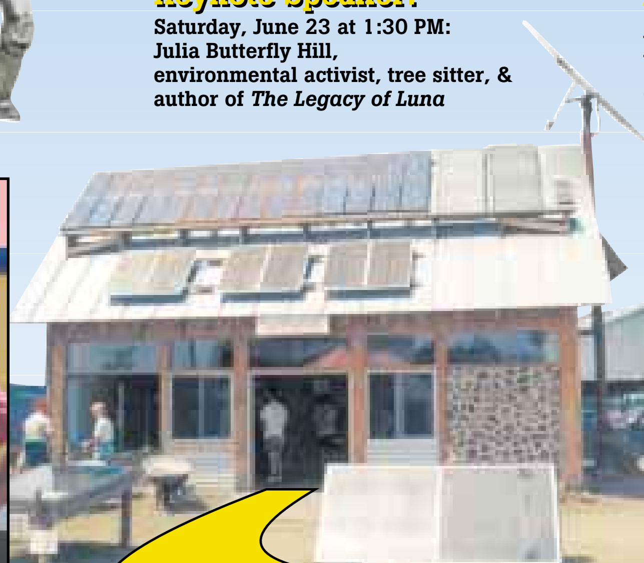
Bus Tours of Alternative Energy Homes, Silent Auction, Stuff for Kids, Evening Entertainment

Keynote Speaker:

Saturday, June 23 at 1:30 PM:
Julia Butterfly Hill,
environmental activist, tree sitter, &
author of *The Legacy of Luna*

Admission:

	1 Day	All 3 Days
Adult	$8.00	$20.00
Under 17 & Seniors	$5.00	$10.00
Children Under 12	FREE	FREE



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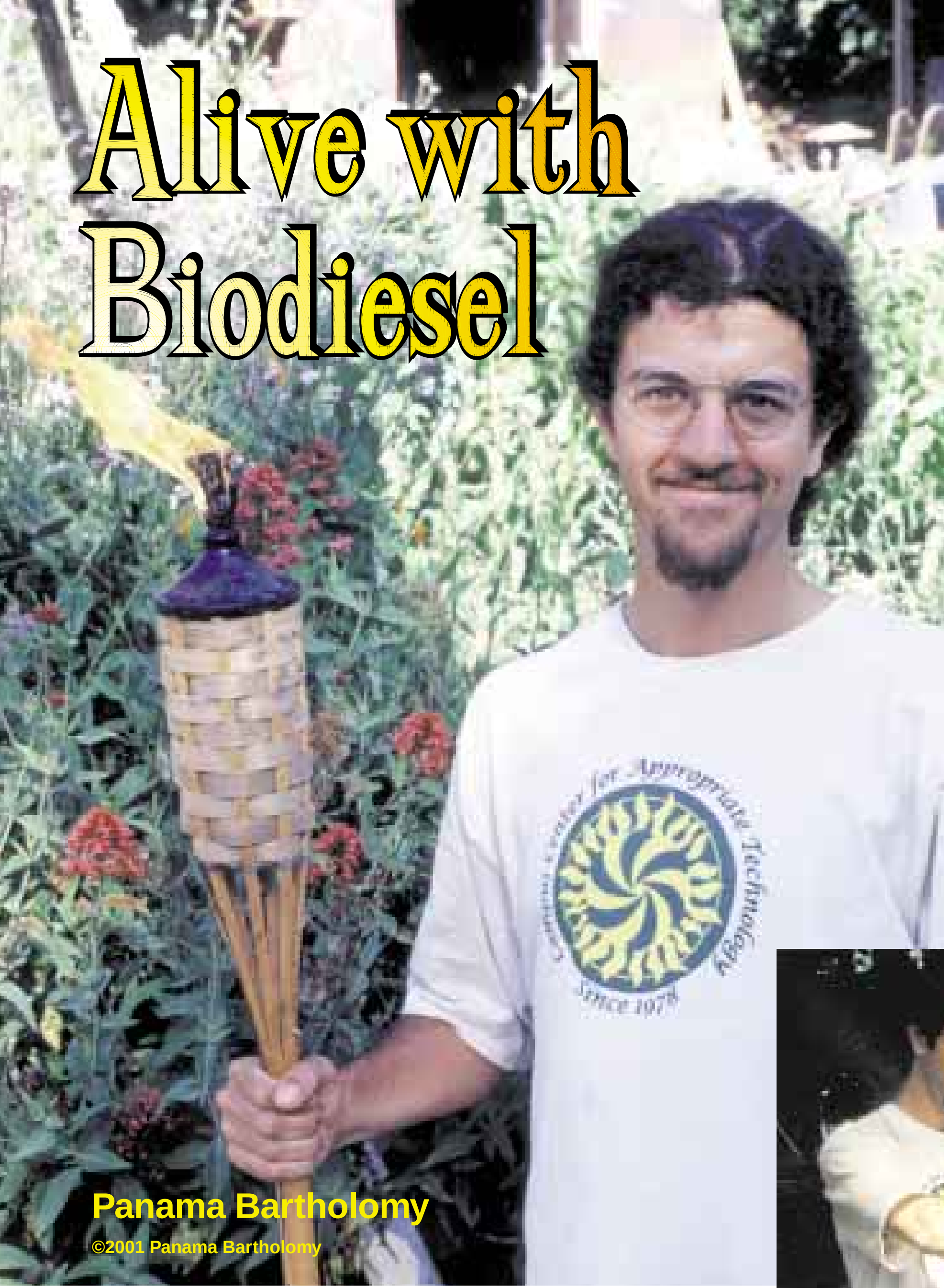
715-592-6595
mreainfo@wi-net.com

Alive with Biodiesel



Panama Bartholomy

"Don't ask yourself what the world needs. Ask yourself what makes you come alive, and then go and do that. Because what the world needs is people who have come alive."

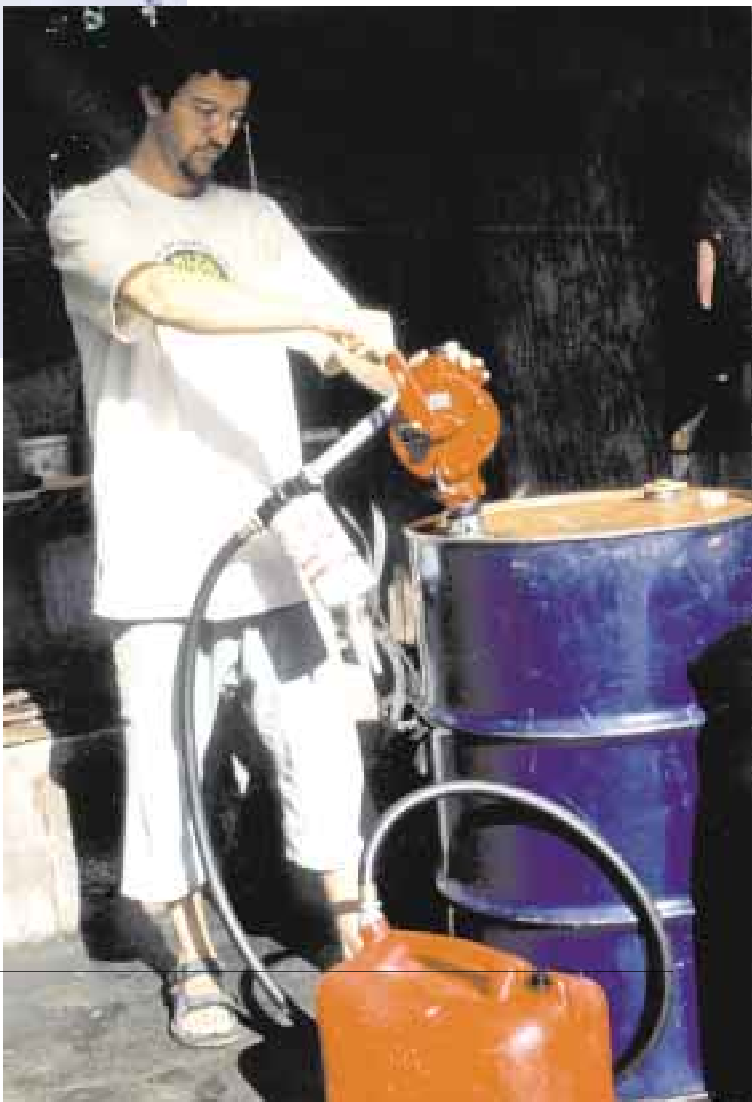
—Harold Thurman Whitman

The first time I heard of biodiesel, I was at the Health and Harmony Festival in northern California in the summer of 1998. On display was a van with sunflowers painted all over it and lettering explaining how many miles per acre the van got on a vegetable oil based fuel.

I was intrigued, and went over to see what this was all about. A young couple was near the van, explaining how they had traveled cross-country from Florida to get here and that they did it all on this fuel called "biodiesel." They didn't have to modify their vehicle, and any unmodified diesel engine could run on the stuff. They told the crowd that there is a 75 percent reduction in greenhouse gases from the tailpipe with biodiesel, and that the exhaust smells like french fries. The couple was Joshua and Kaia Tickell, and they were about to become my inspiration.

Left: Author Panama Bartholomy shows off biodiesel at Humbolt State University's Campus Center for Appropriate Technology.

Below: Finished biodiesel is pumped into a fuel can.



The Fuel for My Fire

I bought their book, *From the Fryer to the Fuel Tank,* and that fall, Andy Cooper, Anna Lee, and I built a mini-refinery (a blender) for our Appropriate Technology class at Humboldt State University. The folks up at the Campus Center for Appropriate Technology (CCAT)—on campus but off the grid since 1991—approached us about replacing their dying natural gas generator with a diesel generator fueled by our biofuel.

As another added benefit, Andy and I both have diesel vehicles, and we wanted to free ourselves from the greedy grasp of the Western Fuel Association. After a couple of months of researching, pricing, and planning, we made the ungainly leap from our blender to the home-scale refinery described below.

The System

The thing that surprises most people about biodiesel is how easy it is to make. You don't need a chemistry degree or access to a lab, and the setup can be cheap or expensive, small or large.

We wanted a setup that would allow us to produce, settle, and store multiple batches at the same time. To do this, we got three 30 gallon (115 l) barrels. One was the reactor, and two would be our settling tanks. Starting with 25 gallons (95 l) of reactants, we would be able to produce 20 gallon (75 l) batches three times a day.

We begin with oil recovered from local restaurants and the university cafeteria, the "J" (Our slogan: Now there's more than one way to get gas from the "J"!). We look for clean, thin oil with not many food particles, and we filter out any extra french fries through a small screen mesh filter.

Some restaurants are good about changing their fryer oil, while some are not. That makes a big difference in the acidity of the oil, which is determined with a simple pH kit. The acidity determines the amount of lye we have to add. We have looked into over eighty "waste" oil containers in the last year. My options for eating out in our area are very limited now due to the knowledge I've gleaned from these excursions.

We pour the filtered oil into a 30 gallon barrel, and light the propane burner underneath it. The oil has to be heated to about 125°F (52°C) for the "transesterification" reaction to take place, turning vegetable oil into biodiesel. Transesterification is the process of using an alcohol (such as methanol or ethanol) in the presence of a catalyst (such as sodium hydroxide or potassium hydroxide) to chemically break the molecule of the raw renewable oil into methyl or ethyl esters, with glycerol as a byproduct.

Panama uses a paint mixer to combine methanol and lye in a closed container to make sodium methoxide. In this posed photo, he skipped the usual protective gear.

As it is heating, we calculate how much lye to add (1–3% of the total mixture) based upon the pH test. We measure out the amount of methanol required to make the proportions of the mixture 80 percent oil and 20 percent methanol.

We get our methanol from a local petroleum distributor, and our lye from a janitorial supply dealer. We mix the methanol and lye together very carefully, since the combination, sodium methoxide, is very dangerous. Any time we deal with lye, we wear gloves, long-sleeved shirts, and safety glasses. Sodium methoxide will eat your nerves, so it may be too late to save your skin by the time you realize something is wrong. But after two years, all three of us still have all of our skin.

We isolate the sodium methoxide by making it in a closed container and using a paint mixer that attaches to an electric drill. After five minutes of mixing, we add the sodium methoxide to the oil.

In the reactor tank, ingredients are mixed with an electric outboard motor and heated with a propane burner.

In the reactor tank we now have oil and sodium methoxide. We turn on the small electric outboard motor (powered by a battery), and start mixing the batch. The outboard was by far the cheapest tool we found to mix 30 gallons (115 l) of thick oil. But with a little mechanical skill, you could easily make a mixer. We power our mixer with a deep-cycle battery that we will be recharging with our new diesel generator. For now, we are recharging it with one of our biodiesel vehicles.

After the first fifteen minutes, you can tell whether or not a reaction is taking place by observing the color change in the mixture. After about an hour and a half of mixing, the batch is ready to settle out.

We welded a bung into the side of the barrel so we can use gravity to get the mixture into 5 gallon (19 l) containers. Next we pour it into the settling tanks. Once in a settling tank, the mixture settles out over eight hours into 20 percent glycerin on the bottom and 80 percent biodiesel floating on the top. While it's settling, we start on the next batch, or, since we often make a batch in the evening, go to bed.

We had valves welded into the bottoms of the settling barrels (thanks to the local muffler shop!), and the barrels are lifted off the ground so that we can drain off the batches using only gravity. When the batch is done settling, we drain off the glycerin, which has separated out to the bottom of the barrel. The glycerin that comes out is dark and thick. So we can tell when it is all out and we are starting to drain biodiesel—both the viscosity and color of the flow change.

We close the valve and test the specific gravity of the biodiesel with a hydrometer. If the hydrometer reads below 0.90 and above 0.84, we know that we have successfully made a batch of biodiesel! We've only had a couple of failed batches out of the dozens we've made, and they were in the early weeks when we were still working out the bugs in our system.

At this point, some people wash their biodiesel with water to extract any residual glycerin, along with excess methanol, alkali soaps, waxes, and acids. But this greatly increases the time of the operation (three to four more days) and uses a lot of water, so we skip that part, counting on the filter on our storage tank to take out all of the leftover glycerin.

We like to keep our settling tanks freed for the next batch, so we pour the biodiesel into the 55 gallon

CCAT Biodiesel Production Facility Costs

Item	*US$*
Three 30 gallon barrels	$150
Minn Kota Powermax 36 outboard motor	100
Tuthill 112 pump, 80 gpm	100
Metal-Fusion propane burner	87
Three ball valves for barrels	48
Armor Plate DC27-15 battery for motor	47
Shelving (used)	25
Paint mixer (used)	15
Olive barrel for sodium methoxide (used)	10
Cim-Tek 200E filter,10 micron	9
Mesh screen for food particulates	6
Storage container, 55 gallon (donated)	0
Drill (donated)	0
Flame box for methanol storage (already had)	0
Hydrometer (donated)	0
Propane tank, 5 gallon (already had)	0
Setup labor (volunteer)	0
Thermometor (donated)	0
Triple beam balance scale (donated)	0
Welding (six-pack of beer per valve)	0
Total	$668

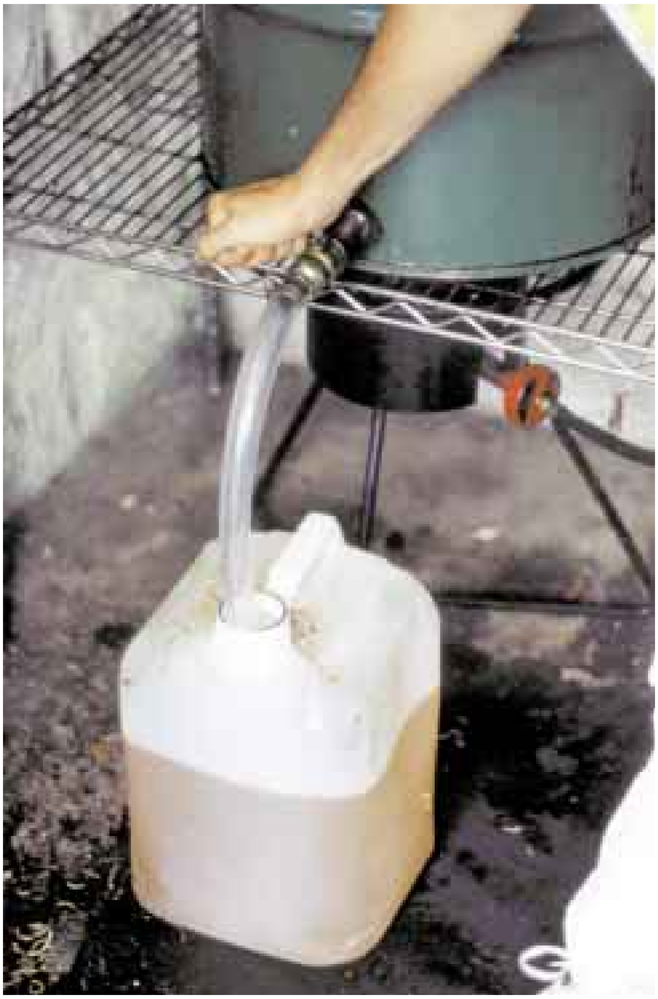
(210 l) storage tank. As we need it, we pump the biodiesel out through a large, 10 micron fuel filter to catch any food bits, glycerin, or other impurities. It is now ready to power an engine!

Biodiesel is also very good for other uses. We have used it as a paint solvent, a bicycle chain lubricant, and a heavy-duty cleaner. It's also great as a starter fluid for fires. In Japan, they use biodiesel's solvent properties to clean out car engines. They drain out the motor oil and put biodiesel in its place. Then they run the engine and the biodiesel cleans the inside of the engine. When they drain the biodiesel, a lot of old, gunky motor oil residues come out, and the inside is spic and span. They put motor oil back in, and off they go.

The Products

"What about the 20 percent glycerin?" you ask. Some people make the glycerin into soap or any of the thousands of products with glycerin in them. We would like to do this eventually, but for now we are composting it. It is non-toxic and completely biodegradable.

After mixing, the biodiesel and glycerin mix is transfered via 5 gallon jugs to a settling tank.



The glycerin, which is darker, settles to the bottom.

The biodiesel fuels an '81 Volkswagen Rabbit pickup and an '80 Mercedes stationwagon. CCAT just bought a Hardy 2.4 KW AC diesel generator specifically to use the biodiesel and to replace their gerry-rigged DC natural gas Honda generator. It will work strictly as a battery charger. Our Trace 4024 power center is about 70 percent efficient, so we shouldn't lose that much of the energy to the battery charger. Biodiesel is also non-toxic, biodegradable (composts in 28 days!), and safe to store due to its high flash point (325°F; 163°C).

When all is said and done, the cost of a gallon of our biodiesel, using recovered oil and not including labor and setup costs, is around US$0.70 a gallon (depending on your local lye and methanol costs). A "free" (not including pickup costs) gallon of oil + 1/5 gallon methanol at US$3 per gallon + 24 grams lye at 2.5 grams for US$0.01 = US$0.70 per gallon (US$0.19 per liter)!

History

When Rudolph Diesel created his diesel engine, it was able to run on pure vegetable oil. He got the idea from the fire starters of some tribes in Africa. While traveling in northern Africa around the turn of the century, Diesel witnessed tribes starting fires with tubes and a plunger device. The tubes would be sealed on one end and a bit of wood would be dropped in. Then the plunger would be pushed into the tube, forcing air to compress and heat the piece of wood. That piece would then be removed and used to start fires. Rudolf adapted the idea of the tube and created his engine, with veggie oil replacing the piece of wood.

He wanted to make an engine that a farmer could use without ever leaving his or her farm for fuel. But the car companies who have co-opted his creation designed fuel injection systems so that only a very thin, highly flammable waste product of the petroleum industry could be used—our modern day diesel fuel.

Now even CCAT's backup generator will be powered by renewable energy too.

How Does It Work in the Car?

What our whole process is really doing is slimming down the vegetable oil by removing its free fatty acids and making it more flammable by adding the methanol. The engines love it. They get the same mileage, and the same power and torque.

Standard diesels can be hard to start on cold mornings when the fuel will cloud or gel a bit. The same goes for biodiesel, and a winterizing agent will help with that. The exhaust smell is greatly improved—I can even talk people into putting their faces right up to the tailpipe.

Lessons Learned

First, both vehicles had problems initially when the biodiesel, an amazing solvent, knocked loose all the gunk (rust, algae, etc.) in the bottom of our twenty year old fuel tanks and sent it up to our fuel filters. That's apparently a common problem when biodiesel is first put in old tanks, and for us it simply meant replacing the filters.

Not only will biodiesel dissolve gunk in your tank, it will dissolve lastomir tank sealant. If you have already put that in your tank, expect to spend an afternoon cleaning sticky goo from the screen inside your tank. A similar warning goes for rubber fuel lines, which should be replaced with silicon lines after 10,000 miles (16,000 km) of biodiesel use.

Second, we bought some unnecessary things when we were first planning our system, but have since discovered that making biodiesel really isn't that complicated. We began with a setup where we filtered the oil while putting it into the mixing tank, requiring expensive metal shelving to support a barrel above the mixing barrel. But we discovered that we also wanted to filter it later to get out extra glycerin. Just filtering it at the end saved a lot of time, space, and mess.

Something that we already had that was very useful was a flame box—a flame resistant container, preferably metal, that can be locked and is safe to store flammables in. This is necessary, since we are located in a very public area. Since CCAT's function is educational, there are lots of people around. So for safety's sake, we keep the methanol, lye, and other stuff we don't want little ones to play with, in the flame box.

Third and last, we have learned the profound satisfaction of taking responsibility for making our own fuel for CCAT's generator and our own vehicles. We're also proud to be reusing a "waste" material, as well as making no net increase of carbon dioxide to the atmosphere. You can hold your head a little higher and feel a little more alive when you're driving with last year's soybeans, and your exhaust smells like donuts.

Access

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707-826-0298 • panamaredhat@hotmail.com

The National Biodiesel Board, 3337A Emerald Ln., PO Box 104898, Jefferson City, MO 65110 • 800-841-5849 or 573-635-3893 • Fax: 573-635-7913
biodiesel@sockets.net • www.biodiesel.org • Education and lobbying

From the Fryer to the Fuel-Tank, 3rd Edition, Joshua Tickell, ISBN 0-9707227-0-2, 176 pages. US$24.95 from BookMasters, Inc., PO Box 388, Ashland, OH 44805 • 888-822-6657 or 419-281-1802
Fax: 419-281-6883 • tickell@veggievan.org
www.veggievan.org

Pacific Biodiesel, 285 Hukilike St., B103, Kahului, HI 96732 • 808-877-3144 • Fax: 808-871-5631
info@biodiesel.com • www.biodiesel.com • Produces biodiesel fuel for diesel vehicles on Maui and does outreach to developing countries. They can build you a 200,000 gallon per year refinery.

The July/August 2000 issue of *Utne Reader* has a great article about rural farming with biodiesel in India.

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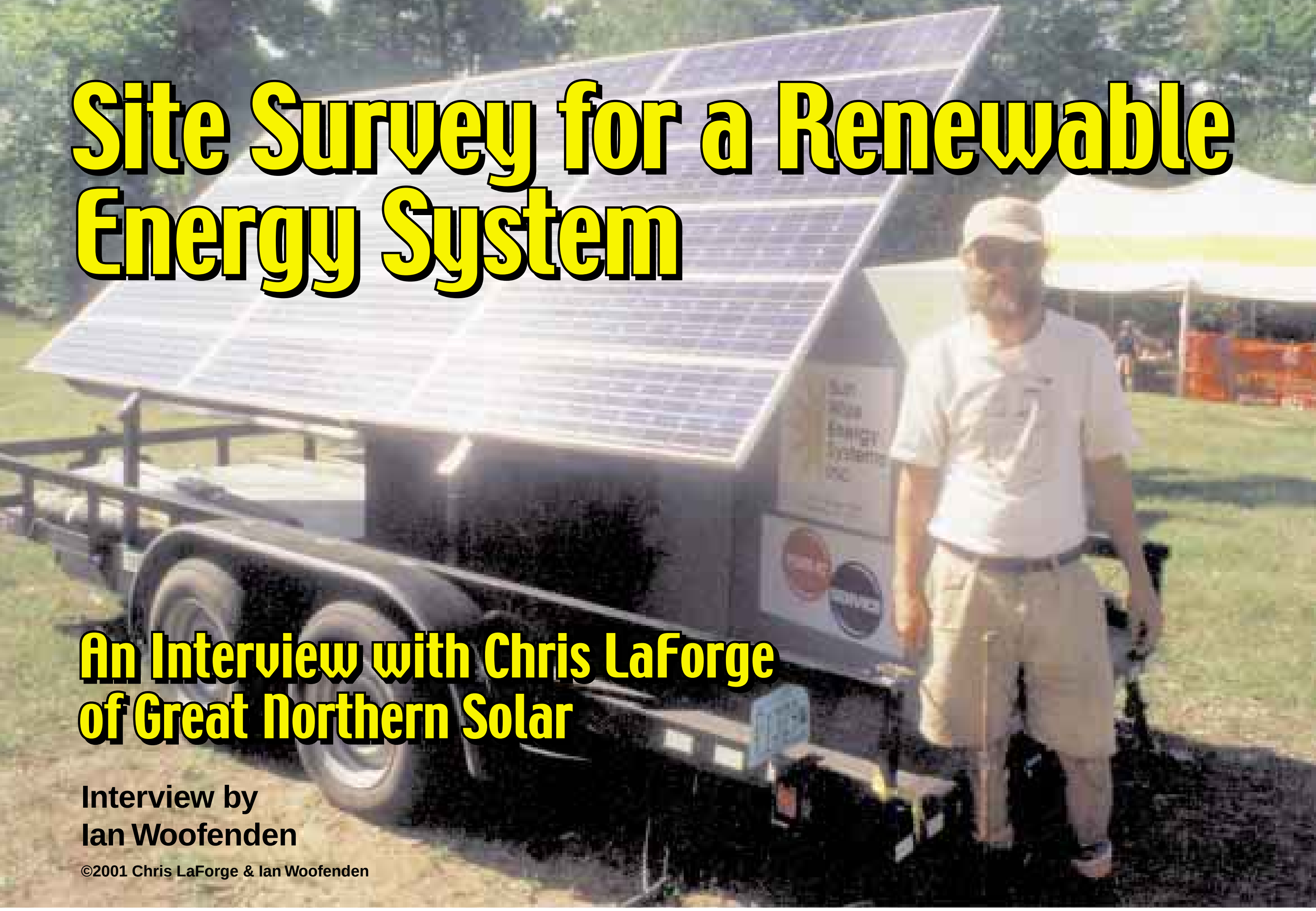
Site Survey for a Renewable Energy System

An Interview with Chris LaForge of Great Northern Solar

Interview by Ian Woofenden



Chris LaForge, owner of Great Northern Solar, energy activist, and RE educator.

Are you thinking about having a renewable energy (RE) system installed at your home or business? Perhaps you're wondering how to approach the project, and what to expect. You know that you'll need a site survey and a load analysis, but you don't really know just what an RE dealer will ask.

To get a clear picture of the process, I turned to Chris LaForge, owner of Great Northern Solar, in Port Wing, Wisconsin. Chris has been designing and installing renewable energy systems for over ten years. He lives off-grid with a photovoltaic (PV) and wind hybrid system, and has designed over 150 systems and installed over 100 systems for clients throughout the upper Midwest as well as other places. His customers have grown to trust his solid RE knowledge, and to appreciate his commitment to renewables, as well as his fine sense of humor.

What got you started in renewable energy?

In 1977, a proposed nuclear waste dump near Lake Superior got me angry enough to respond. Many of us in the Duluth area felt that before we started making a dump for something that lasts a hundred times longer than recorded history, we should first stop producing the waste. This suggestion required some alternative to nuclear power, which began my interest in renewable energy.

Tell us a little about your business.

We started the business with the motto: "We live with what we sell." We've found that that is a key to our success. By working and living with the systems we promote, we have much more knowledge, and we can honestly report on how things work.

Great Northern Solar has completed a very wide variety of systems throughout the country. We focus on the northern Midwest, but we have systems and students from Maine to California, Uganda, and Haiti. We have sold an average of about twelve systems each year since we opened over a decade ago.

What's the first thing you do when a customer contacts you about getting an RE system?

I start by talking about cost. No beating around bushes here. I identify roughly what size of system they need, and then give them the ballpark cost figure. If this does not inspire rage or coma, I know I have a potential customer, and we can start talking design and specification.

Being direct saves time, and weeds out people who have more curiosity than real desire for clean electricity. I send curiosity seekers information on the MREA workshops we offer. This is a kind way to get the word out, while not wasting a lot of time. The workshops are available from beginner to advanced levels, and serve as a great resource for most people who need to get up to speed.

What RE resources do you ask your prospective customers about—solar, wind, and hydroelectric? Solar thermal?

All of the above. Usually folks come to me with a wish list, but I fish around their plans to see if they are forgetting any potential resources available to them. This often leads to more plans for people doing new construction. I talk about how folks want to heat the site, pump and heat their water, do their laundry, you name it.

I always stress the primary unspoken resource—efficiency. People often just don't get it right away, but when you cost out a system for an inefficient load profile and compare it with the equivalent efficient system cost, they get very interested in conservation and efficiency.

When does a site survey happen, and how do you charge for it?

The site survey happens as soon as the people want to know what they have to work with. Some folks do this themselves, but they are the exception. Most folks who really are ready to get with it will have the survey fairly soon after the initial contact.

With residential systems, I often combine the site survey with a system design, and charge a fee (US$250 to $1,000), plus travel costs. Often the fee can be a part of the overall system cost. This depends on the trust developed in the relationship, and the owners' desires.

Tell us how a typical site survey goes.

I greatly prefer that the owner is with me as much as possible throughout the planning process. If the owners are a couple, it is very important to include both members, since both people will be using the system. So both need to know as much as possible about how it was planned, how it works, and what they can do to make it run well.

I go to the site and take a long walk around with my handheld compass. This takes about an hour, and is followed by pulling out my trusty Solar Pathfinder. With the compass and Pathfinder, specific potential PV sites are identified. Then several charts can be worked up to compare more precisely what production will come from each possible spot.

While this is going on, I am looking for signs of wind resource, obstructions to potential tower sites, and other RE resource potential. Once the best resources and site options are located, I start to talk with the client about their personal desires.

What questions do you ask the owners?

I ask at least the following questions:

- What resources do you want to use?
- How do you plan to use the site (full time residence, cabin, three season, occasional use, how much, etc.)?
- Who will also be using the system?
- What is your conservation/convenience quotient? Do you want to conserve and minimize your consumption and therefore system size, or do you want your power on demand without worrying about just how many amp-hours are still in the battery?
- How many people are in the household?
- Do you want the system to grow over time, or should it be full-blown at the beginning?

Chris LaForge is active in the Midwest Renewable Energy Association, teaching hands-on RE.

Chris designs systems to work—for the sake of the customer *and* the movement.

- Ideally, where do you want the PVs?
- Where do you want the balance of system components?
- What is your timeline?
- How flexible are you and the others who will use the system?
- Why are you interested in renewable energy? (Motivation is a significant issue in system design; Why is often more important than what or how).
- Do you want to participate in the installation? (I encourage people to participate as much as they are comfortable with. The more they help with the work, the better they will be at operating it. The time added to the install educating and instructing the participating owner is usually more than compensated for by having a qualified, educated, and confident owner/operator.)
- What is your desired budget? (I try to establish enough trust right away so that we can address the cost issue honestly and up front, though this does not always work).

All of the questions lead to discussions and more questions.

And how about wind power?

With wind, I am looking for the more hands-on operators (or at least "eyes on"). PV systems lend themselves to more carefree operation (within reason—you still must do your battery maintenance or hire someone to do it). Moving parts mean active participation.

I look for the obvious indications of wind potential (flagging on trees, documented average wind speeds, stories from local old-timers, etc.). I hunt for possible tower sites. I observe obstructions within 500 feet (150 m) of the potential tower sites. I determine if there is adequate room for a tilt-up tower, or if a freestanding tower is necessary.

I also ask at least the following wind-specific questions:

- Why do you want a wind power system?
- Will you really do the required maintenance or hire a technician to do it?
- Are you willing to participate in the ongoing research and development of wind power systems? (I have been doing more beta testing of wind system gear than I like. Products that are available often come with surprises that reflect the immaturity of this segment of the RE industry. If people are not going to roll with the punches, they need to consider systems with fewer moving parts. I look for their humor quotient, and discourage folks who can't laugh!).

I do strongly encourage the use of wind turbines for the right clients. They offer charging characteristics that other renewables don't (generation on cloudy days, generation at night, and high amp charge rates for extended periods that can be used to equalize batteries).

And do you deal with microhydro much?

I love microhydro, but it's difficult to implement. Local, state, and federal authorities all can have jurisdiction over your activities. Unless the client has complete ownership of the resource, you often end up right at the authorities' door.

That said, the constant charging output from the careful use of hydro is ideal. It works well in hybrids as well. To determine potential hydro capacity, I ask the following questions:

- Do you own the resource?
- What is the proximity of the resource to your balance of system components (BOS)?
- What is the available head (vertical drop from collection point to the turbine site)?

- What is the flow rate (available gallons per minute)?
- Is the resource year-round or seasonal?
- How will the gear affect the aesthetics of the site? (I describe the components of the potential hydro setup and suggest ways to mitigate physical and visual impacts.)
- What authorities have jurisdiction on the resource? (Is the resource a navigable waterway? Is it a registered trout stream or other breeding ground? Are any endangered species present, or does the potential exist? Did you know that the Department of Natural Resources wardens carry guns?)

How many of the systems you do are hybrids, and how many of those use engine generators?

Most systems (90%) are hybrids in the broad sense of having more than one energy source. Stand-alone systems have engine generators as a backup 90 percent of the time. Grid-intertied systems have the grid as backup and sometimes an engine generator as well.

I highly recommend solar/wind hybrids if the client fits the wind system profile. They work exceptionally well in many areas. These systems can reduce the use of non-renewable sources a great deal or completely. Solar/microhydro is another good combination if possible.

Grid-intertie systems get to use the grid for backup. This is a nice feature, although many RE folks do not like utilities. Grid-intertie systems that are battery-free are ideal. They can grow over time with the grid making up for shortfalls as the array grows. They are often more affordable than the more redundant grid/RE/battery systems.

How do you come up with a balanced system using more than one source of energy? And how does this affect your site survey?

This is very difficult without adequate wind resource documentation. Short of actual wind data from that site, accurate production calculations are not possible. If the area has other data, a general prediction can help.

I like to make hybrids rely more on the most predictable resource. Clients often have a different idea [wild laughter]. PV is very predictable compared with wind resources, and I use that fact to help make the system robust. Microhydro is a great addition in a hybrid, but as I mentioned, it's hard to apply in the real world.

If the wind resource is strong, I still try to incorporate at least a small PV component. This is important because it gives the system a greater level of resource availability and a good direction for system expansion over time. Sometimes the owners want only one resource (because they live near lake Superior, for instance, and they think it is very windy all the time—not true). I make sure that they understand the range of available options, and I remind them of this a lot. I like hybrids!

The site survey is a bigger event each time you add another resource. It takes more time. The planning requires more theoretical work than a simple PV design. I discuss the variables and their effect on system performance at length.

And is a load survey done at the same time as your site survey?

The load survey is usually done before I go to the site. I use a standard chart format listing *all loads* completely. The chart is divided into AC and DC loads. It has columns for these categories:

- Appliance
- Quantity (number of appliances of this exact type)
- Wattage
- Surge wattage
- Average "on" time per day
- Average number of days each week
- Load priority

The chart has a line for the largest load and largest combination of simultaneous loads. Both of these numbers affect inverter sizing.

Chris uses a Solar Pathfinder to do skookum site surveys—your installer should too.

What's your batting average? How do the finished systems end up—as far as energy production and use—compared to the projections you make in your initial survey?

I don't want to sound cocky, but I have a very high batting average—I'd say 950. I can't honestly list any serious failures. Now how do I do it?

First of all, I always try to be completely honest—up front and blunt. I explain all the problems we have experienced at our homestead over the years, and I try to make sure that the client is "getting it." I make the client do a serious load profile, or I tell them I have no way to make sure the system will work. I also tell these people that failures in the RE industry are very bad "black eyes" and I will be building a system for them that is probably more robust than conservative.

Second, I build robust designs. I de-rate modules 15 percent off manufacturers' ratings. I round numbers up and lean on the conservative side when estimating resource availability. I estimate how honest the load profile is and round it up if I don't trust it. I always build in expandability, and I underline the fact that *if the load profile grows, the system must grow!* Third, I pray on a regular basis.

How often is money the determining factor in system sizing, and how does that affect your site surveys, load analyses, and system designs?

In 90 percent of the systems, money is primary. It most often does not affect the survey, but it greatly affects the planning. Growing PV arrays over time and weaning engine generator use is a common way of dealing with small budgets.

There is usually a way to get the job done. If the owner is not ready to buy enough gear to do their job, I tell them that we can't skimp. If they don't believe me, I try to convince them. I plan for success, so I don't do a design unless I truly believe in it. Failures make a lot of news and are very bad for the growth of the use of RE (remember the 1970s?).

How is your site and load survey received by customers?

Clients generally don't get it until I tell them that a good survey leads to a good system in the same way that a cobbler looking at and measuring your feet will lead to comfortable shoes.

There are many people who get scared away by the fee for service. I've finally decided that my time is valuable. If people want something for free, they will get what they pay for. Skilled design makes all the difference in system performance.

Some people who have more money than time object to a detailed load profile. I tell these folks that if they don't want to be specific, they will buy a system that may be bigger than they will really need. Sometimes that's just what they want.

Very few people object to a site survey. The procedure just makes sense. If a vendor sells you a system without seeing your site, you are asking for failure. We had quite a noticeable number of instances where a well-known vendor in California was selling packages that might have worked out west, but were not appropriate for the Midwest. These failures put the wrong foot forward for renewables.

Packages can work when the task is very well defined. If you are powering a residence, you either get more or less than you need with a mail order package system. I sincerely hope that you buy the bigger one. Get more than you need, please. You will figure out how to use it.

From an installer's point of view, what's the advantage of doing these detailed surveys?

I build systems that work for the place they are installed. To do this, I need to know the daily watt-hour consumption of the client. I need to know the average and high and low solar insolation *where the PVs live.* I need to fit the pieces together correctly to avoid line losses. I need as much information as I can get and then some.

I hate callbacks. Site surveys allow me to bring all the gear I need and anticipate details that will save time and money. Making it work right out of the chute makes everybody happy. It leads to win-win situations.

And what advantages and disadvantages does it have for the customer?

Doing a good load profile will save you from one of two things:

- Spending more money than you need to on gear you don't need, or
- Getting a system that does not meet your real world needs, or worse—one that does not work at all.

Having a professional site survey will lead to a good design fitted for your circumstances and needs. It should lead to a smooth installation and avoid unnecessary costs. A good site survey may discover resources that you, as a novice, did not recognize. Having time with an experienced RE dealer should provide you with a lot of information about what you are trying to do and how it can be done. In some cases, it will convince you that it cannot be done (at least the way you may have first thought). Using these services should save you a lot of time and noticeable amounts of money.

Another advantage to having a survey is if you end up working with a crook. Time with this type of dealer should give you a chance to see through any schemes. Our network of IPP installing dealers can help people find qualified dealers who are in the business for the long run. I don't see many disadvantages for customers doing careful footwork during a major project.

Any closing sage advice for folks contemplating their first RE system?

- There are many reasons for using RE. Think about why you are doing it first. Helping improve our impact on the surface of the planet is a good reason. Saving money off your utility bill may not be.
- Shop around and ask questions.
- Take some workshops from the MREA, SEI, or other non-commercial centers of information.
- Take manufacturers' claims with a pound of salt.
- Watch out for big claims from glossy print material.
- Read *Home Power* magazine. Get the back issues of *Home Power* and read them.
- Good work costs money. Good work is worth its weight in gold.
- Respect the truth anywhere you can find it.

Access

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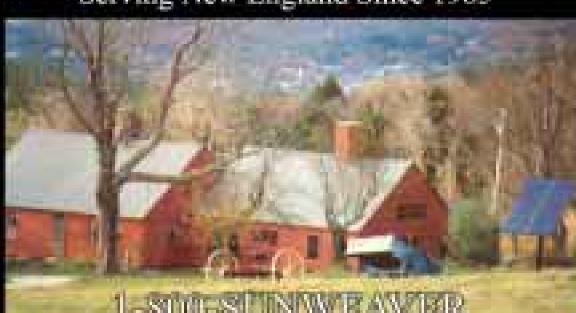
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How to Choose an Inverter for an Independent Energy System

Windy Dankoff

The inverter is one of the most important and most complex components in an independent energy system. To choose an inverter, you don't have to understand its inner workings, but you should know some basic functions, capabilities, and limitations. This article gives you some of the information you'll need to choose the right inverter and use it wisely.

Why You Need an Inverter

Independent electric energy systems are untethered from the electrical utility grid. They vary in size from tiny yard lights to remote homes, villages, parks, and medical and military facilities. They also include mobile, portable, and emergency backup systems. Their common bond is the storage battery, which absorbs and releases energy in the form of direct current (DC) electricity.

In contrast, the utility grid supplies you with alternating current (AC) electricity. AC is the standard form of electricity for anything that "plugs in" to utility power. DC flows in a single direction. AC alternates its direction many times per second. AC is used for grid service because it is more practical for long distance transmission. (See articles on basic electricity in *HP52 & 53.)*

An inverter converts DC to AC, and also changes the voltage. In other words, it is a power adapter. It allows a battery-based system to run conventional appliances through conventional home wiring. There are ways to use DC directly, but for a modern lifestyle, you will need an inverter for the vast majority, if not all, of your loads (loads are devices that use energy).

Incidentally, there is another type of inverter called grid-interactive. It is used to feed solar (or other renewable) energy into a grid-connected home and to feed excess energy back onto the utility grid. If such a system does not use batteries for backup storage, it is not independent from the grid, and is not within the scope of this article.

Not a Simple Device

Outwardly, an inverter looks like a box with one or two switches on it, but inside there is a small universe of dynamic activity. A modern home inverter must cope with a wide range of loads, from a single nightlight to the big surge required to start a well pump or a power tool. The battery voltage of a solar or wind system can vary as much as 35 percent (with varying state of charge and activity).

Through all of this, the inverter must regulate the quality of its output within narrow constraints, with a minimum of power loss. This is no simple task. Additionally, some inverters provide battery backup charging, and can even feed excess power onto the grid.

Define Your Needs

To choose an inverter, you should first define your needs. Then you need to learn about the inverters that are available. Inverter manufacturers print everything you need to know on their specification sheets (commonly called "spec sheets"). Here is a list of the factors that you should consider.

Application Environment

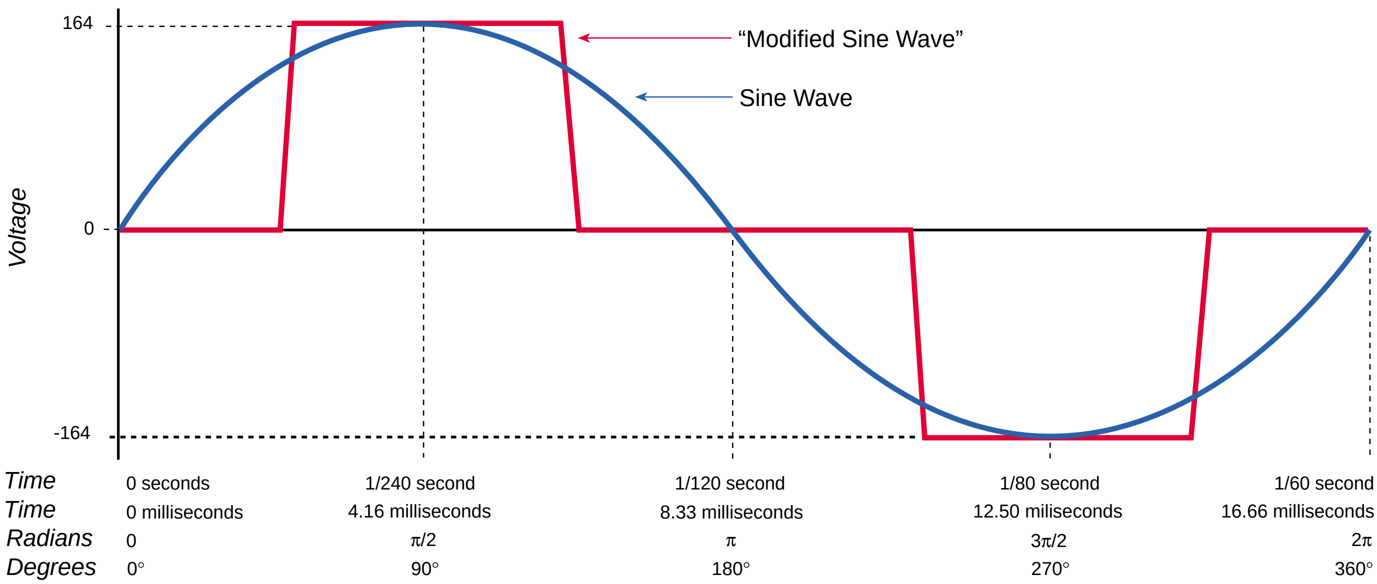
Where is the inverter to be used? Inverters are available for use in buildings (including homes), for recreational vehicles, boats, and portable applications. Will it be connected to the utility grid in some way? Electrical conventions and safety standards differ for various applications, so don't improvise.

Electrical Standards

The DC input voltage must conform to that of the electrical system and battery bank. 12 volts is no longer the dominant standard for home energy systems, except for very small, simple systems. 24 and 48 volts are the common standards now. A higher voltage system carries less current, which makes system wiring cheaper and easier.

The inverter's AC output must conform to the conventional power in the region in order to run locally available appliances. The standard for AC utility service in North America is 115 and 230 volts at a frequency of 60 Hertz (cycles per second, abbreviated "Hz"). In Europe, South America, and most other places, it's 220 volts at 50 Hz.

Inverter Power Quality (115 VAC, 60 Hz)



Safety Certification
An inverter should be certified by an independent testing laboratory such as UL, ETL, CSA, etc., and be stamped accordingly. This is your assurance that it will be safe, will meet the manufacturer’s specifications, and will be approved in an electrical inspection. There are different design and rating standards for various application environments (buildings, vehicles, boats, etc.). These also vary from one country to another.

Power Capacity
How much load can an inverter handle? Its power output is rated in watts (watts = amps x volts). There are three levels of power rating—a continuous rating, a limited-time rating, and a surge rating. Continuous means the amount of power the inverter can handle for an indefinite period of hours. When an inverter is rated at a certain number of watts, that number generally refers to its continuous rating.

The limited-time rating is a higher number of watts that it can handle for a defined period of time, typically 10 or 20 minutes. The inverter specifications should define these ratings in relation to ambient temperature (the temperature of the surrounding atmosphere). When the inverter gets too hot, it will shut off. This will happen more quickly in a hot atmosphere. The third level of power rating, surge capacity, is critical to its ability to start motors, and is discussed below.

Some inverters are designed to be interconnected or expanded in a modular fashion, in order to increase their capacity. The most common scheme is to “stack” two inverters. A cable connects the two inverters to synchronize them so they perform as one unit.

Power Quality—Sine Wave vs. “Modified Sine Wave”
Some inverters produce “cleaner” power than others. Simply stated, “sine wave” is clean; anything else is dirty. A sine wave has a naturally smooth geometry, like the track of a swinging pendulum. It is the ideal form of AC power. The utility grid produces sine wave power in its generators and (normally) delivers it to the customer relatively free of distortion. A sine wave inverter can deliver cleaner, more stable power than most grid connections.

How clean is a “sine wave”? The manufacturer may use the terms “pure” or “true” to imply a low degree of distortion. The facts are included in the inverter’s specifications. Total harmonic distortion (THD) lower than 6 percent should satisfy normal home requirements. Look for less than 3 percent if you have unusually critical electronics, as in a recording studio for example.

Other specs are important too. RMS voltage regulation keeps your lights steady. It should be plus or minus 5 percent or less. Peak voltage (Vp) regulation needs to be plus or minus 10 percent or less. Refer to *HP36,* page 34 for more about inverter specifications.

A “modified sine wave” inverter is less expensive, but it produces a distorted square waveform that resembles the track of a pendulum being slammed back and forth by hammers. In truth, it isn’t a sine wave at all. The misleading term “modified sine wave” was invented by advertising people. Engineers prefer to call it “modified square wave.”

The modified sine wave has detrimental effects on many electrical loads. It reduces the energy efficiency of motors and transformers by 10 to 20 percent. The wasted energy causes abnormal heat which reduces the reliability and longevity of motors and transformers and other devices, including some appliances and computers. The choppy waveform confuses some digital timing devices.

About 5 percent of household appliances simply won't work on modified sine wave power at all. A buzz will be heard from the speakers of nearly every audio device. An annoying buzz will also be emitted by some fluorescent lights, ceiling fans, and transformers. Some microwave ovens buzz or produce less heat. TVs and computers often show rolling lines on the screen. Surge protectors may overheat and should not be used.

Modified sine wave inverters were tolerated in the 1980s, but since then, sine wave inverters have become more efficient and more affordable. Some people compromise by using a modified sine wave inverter to run their larger power tools or other occasional heavy loads, and a small sine wave inverter to run their smaller, more frequent, and more sensitive loads. Modified sine wave inverters in renewable energy systems have started fading into history.

Efficiency

It is not possible to convert power without losing some of it (it's like friction). Power is lost in the form of heat. Efficiency is the ratio of power out to power in, expressed as a percentage. If the efficiency is 90 percent, 10 percent of the power is lost in the inverter. The efficiency of an inverter varies with the load. Typically, it will be highest at about two-thirds of the inverter's capacity. This is called its "peak efficiency." The inverter requires some power just to run itself, so the efficiency of a large inverter will be low when running very small loads.

In a typical home, there are many hours of the day when the electrical load is very low. Under these conditions, an inverter's efficiency may be around 50 percent or less. The full story is told by a graph of efficiency vs. load, as published by the inverter manufacturer. This is called the "efficiency curve." Read these curves carefully. Some manufacturers cheat by starting the curve at 100 watts or so, not at zero!

Because the efficiency varies with load, don't assume that an inverter with 93 percent peak efficiency is better than one with 85 percent peak efficiency. If the 85 percent efficient unit is more efficient at low power levels, it may waste less energy through the course of a typical day.

Internal Protection

An inverter's sensitive components must be well protected against surges from nearby lightning and static, and from surges that bounce back from motors under overload conditions. It must also be protected from overloads. Overloads can be caused by a faulty appliance, a wiring fault, or simply too much load running at one time.

An inverter must include several sensing circuits to shut itself off if it cannot properly serve the load. It also needs to shut off if the DC supply voltage is too low, due to a low battery state-of-charge or other weakness in the supply circuit. This protects the batteries from over-discharge damage, as well as protecting the inverter and the loads. These protective measures are all standard on inverters that are certified for use in buildings.

Inductive Loads & Surge Capability

Some loads absorb the AC wave's energy with a time delay (like towing a car with a rubber strap). These are called inductive loads. Motors are the most severely inductive loads. They are found in well pumps, washing machines, refrigerators, power tools, etc. TVs and microwave ovens are also inductive loads. Like motors, they draw a surge of power when they start.

If an inverter cannot efficiently feed an inductive load, it may simply shut down instead of starting the device. If the inverter's surge capacity is marginal, its output voltage will dip during the surge. This can cause a dimming of the lights in the house, and will sometimes crash a computer.

Any weakness in the battery and cabling to the inverter will further limit its ability to start a motor. A battery bank that is undersized, has corroded connections, or is in poor condition, can be a weak link in the power chain. The inverter cables and the battery interconnect cables must be big, and I mean *really* big, perhaps the size of a large thumb! The spike of DC current through these cables is many hundreds of amps at the instant of motor starting. Follow the inverter's instruction manual when sizing the cables, or you'll cheat yourself.

Idle Power

Idle power is the consumption of the inverter when it is on, but no loads are running. It is "wasted" power, so if you expect the inverter to be on for many hours during which there is very little load (as in most residential situations), you want this to be as low as possible. Typical idle power ranges from 15 watts to 50 watts for an inverter sized for a home system. An inverter's spec sheet may describe the inverter's "idle current" in amps. To get watts, just multiply this times the DC voltage of the system.

Low Switching Frequency vs. High Switching Frequency
There are two ways to build an inverter. Without diving into theory, I'll simply say that there are differences in weight, cost, surge capacity, idle power, and noise.

A low switching frequency inverter is big and heavy (generally about 20 pounds (10 kg) per kilowatt), and more expensive. It has the high surge capacity (four to eight times the continuous capacity) needed to start large motors. Beware of the acoustical buzz that low switching frequency inverters make. If you install one near a living space, you may be unhappy with the noise.

A high switching frequency inverter is much smaller and lighter (generally about 5 pounds (2.5 kg) per kilowatt), and also less expensive. It has less surge capacity, typically about two times the continuous capacity. It produces little or no audible noise. The idle power is generally higher. If the inverter is oversized for motor starting, its idle power will be higher yet, and may be prohibitive. Most homes that have a well pump or other motors greater than 1 hp will find a low switching frequency inverter to be more economical.

Both types of inverter have their virtues. Some people "divide and conquer" by splitting their loads and using two inverters. This adds a measure of redundancy. If one ever fails, the other one can serve as backup.

Automatic On/Off
Inverter idling can be a substantial load on a small power system. Most inverters made for home power systems have automatic load-sensing. The inverter puts out a brief pulse of power about every second (more or less). When you switch on an AC load, it senses the current draw and turns itself on. Manufacturers have various names for this feature, including "load demand," "sleep mode," "power saver," "autostart," and "standby."

Automatic on/off can make life awkward because a tiny load may not trigger the inverter to turn on or stay on. For example, a washing machine may pause between cycles, with only the timer running. The timer draws less than 10 watts. The inverter's turn-on "threshold" may be 10 or 15 watts. The inverter shuts off and doesn't come back on until it sees an additional load from some other appliance. You may have to leave a light on while running the washer.

Some people can't adapt to such situations. Therefore, inverters with automatic on/off also have an always-on setting. With this setting, you can run your low-power nightlights, clocks, fax, answering machine, and other tiny loads, without losing continuity. In that case, a good system designer will add the inverter's idle power into the load calculation (24 hours a day). The cost of the power system will be higher, but it will meet the expectations of modern living.

Phantom & Idling Loads
High-tech consumers (most of us Americans) are stuck with gadgets that draw power whenever they are plugged in. Some of them use power to do nothing at all. An example is a TV with a remote control. Its electric eye system is on day and night, watching for your signal to turn the screen on. Every appliance with an external wall-plug transformer uses power even when the appliance is turned off. These little demons are called "phantom loads" because their power draw is unexpected, unseen, and easily forgotten. (For more information on phantom loads, see Dan Chiras' article in this issue of *HP*, page 40.)

Another concern is "idling loads." These are devices that must be on all the time in order to function when needed. These include smoke detectors, alarm systems, motion detector lights, fax machines, and answering machines. Central heating systems have a transformer in their thermostat circuit that stays on all the time. Cordless (rechargeable) appliances draw power even after their batteries reach a full charge. If in doubt, feel the device. If it's warm, that indicates wasted energy. How many phantom or idling loads do you have?

There are several ways to cope with phantom and idling loads:

- You may be able to avoid them (in a small cabin or simple-living situation).
- You can minimize their use and disconnect them when not needed, using external switches (such as switched plug-in strips or receptacles).
- You can work around them by modifying certain equipment to shut off completely (central heating thermostat circuits, for example).
- You can use some DC appliances.
- You can pay the additional cost for a large enough power system to handle the extra loads plus the inverter's idle current.

Be careful and honest if you contemplate avoiding all phantom and idling loads. You cannot always anticipate future needs or human behavior.

Powering a Water Supply Pump
At a remote site, a water well or pressure pump often places the greatest demand on the inverter. It warrants special consideration. Most pumps draw a very high surge of current during startup. The inverter must have sufficient surge capacity to handle it while running any other loads that may be on. It is important to size an inverter sufficiently, especially to handle the starting

surge. Oversize it still further if you want it to start the pump without causing lights to dim or blink. Ask your supplier for help doing this because inverter manufacturers have not been supplying sufficient data for sizing in relation to pumps.

In North America, most pumps (especially submersibles) run on 230 volts, while smaller appliances and lights use 115 volts. To obtain 230 volts from a 115 volt inverter, either use two inverters "stacked" (if they are designed to be wired in series) or use a transformer to step up the voltage.

If you do not already have a pump installed, you can get a 115 volt pump if you don't need more than 1/2 hp. A water pump contractor will often supply a higher power pump than is needed for a resource-conserving household. You can request a smaller pump, or it may be feasible (and economical) to replace an existing pump with a smaller one. You can also consider one of a growing number of DC pumps that are available, to eliminate the load from your inverter.

Battery Charging Features

Backup battery charging is essential to most renewable energy systems because there are likely to be occasions when the natural energy supply is insufficient. Some inverters have a built-in battery charger that will recharge the battery bank whenever power is applied from an AC generator or from the utility grid (if the batteries are not already charged). This also means that an inverter can be a complete emergency backup system for on-grid power needs (just add batteries).

A backup battery charger doesn't have to be built into the inverter. Separate chargers are, in some cases, superior to those built into inverters. This is especially true in the case of low switching frequency inverters, which tend to require an oversized generator to produce the full rated charge current.

The specifications that relate to battery charging systems include maximum charging rate (amps) and AC input power requirements. The best chargers have two or three-stage charge control, accommodation of different battery types (flooded or sealed), temperature compensation, and other refinements.

Be careful when sizing a generator to meet the requirements of an inverter/charger. Some inverters require that the generator be oversized (because of low power factor, which is beyond the scope of this article). Be sure to get experienced advice on this, or you may be disappointed by the results.

Inverter Selection Table

	Inverter Characteristic			
	Waveform		*Switching Frequency*	
Criteria	*Modified*	*Sine*	*Low*	*High*
Power quality	Low	High	-	-
Motor-starting surge capacity	-	-	High	Low-medium
Low-load efficiency	-	-	Higher	Lower
Size	-	-	Big	Small
Weight	-	-	Heavy	Light
Acoustical buzz	-	-	Medium-high	None
Cost	Lower	Higher	Higher	Lower

Quality Pays

A good inverter is an industrial quality device that is proven reliable, certified for safety, and can last for decades. A cheap inverter may soon end up in the junkpile, and can even be a fire hazard. Consider your inverter to be a foundation component. Buy a good one that allows for future expansion of your needs.

Your Final Choice

Choosing an inverter is not a difficult task. Define where it is to be used. Define what type of loads (appliances) you will be powering. Determine the maximum power the inverter will need to handle. Is the quality of the power critical? Does size and weight matter? The inverter selection table will help you to determine what type of inverter is best for you.

Your next step is to learn what inverters are available on the market. Study advertisements and catalogs, or ask your favorite dealer. It is best to listen to professional advice, and to purchase your equipment from a trained and experienced dealer/installer. I hope this article helps you make the right choice.

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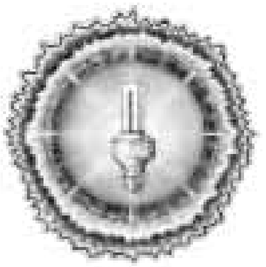

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TOP SECRET

GUERRILLA SOLAR: The unauthorized placement of renewable energy on a utility grid.

GUERRILLA SOLAR DEFINED: Energy is freely and democratically provided by nature. This century's monopolization of energy by utilities both public and private threatens the health of our environment. Solar guerrillas believe that clean renewable energy should be welcomed by utilities. But utilities and governments continue to put up unreasonable barriers to interconnection, pushing common citizens to solar civil disobedience.

Guerrilla systems do not endanger utility line workers (see HP71, page 58). They share clean, renewable energy with others on the utility grid, and reduce the need for polluting generation plants. When interconnection for small-scale renewables becomes fair, simple, and easily accessible to all, there will be no more need for guerrilla action.

PROFILE: 0014

DATE: January, 2001
LOCATION: Somewhere in the USA
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 120 watts of PV
TIME IN SERVICE: 9 months

Closer to the inspector's headquarters than most, this guerrilla solar-electric system is located in the heart of one of the largest metropolitan areas in the U.S. It consists of two 60 watt Solarex panels wired in series to a 100 watt Trace Microsine intertie inverter, converting the DC electricity to AC.

The inverter is skillfully wired to a handy extension cord, which is plugged into the wall outlet. Voila! A grid-intertie system, simple and easy to install. Notice the homemade frames on the panels, which had a short past life in an R&D lab as test panels. Now they live happily on the roof of our shed, sending their electrons to the utility grid.

This small solar-electric system is symbolic in relation to the total electrical energy use it offsets, but it is a concrete step we've taken to living sustainably in the city. As renters, it's hard to do big house alterations to change the way we live and decrease dependence on the environmentally destructive and wasteful infrastructures set up for us. But it's not impossible.

We can greatly reduce the electricity we consume. And solar-electric panels can be installed on shed roofs (out of sight of conservative landlords), or attached like planter boxes outside the windows of your house or apartment.

We're guerrilla energy producers, and also guerrilla energy savers. Our house is fully equipped with a greywater system. We re-use our shower water in the garden. This saves water stolen from dammed up river ecosystems, fosters water consciousness, and also removes the "waste" water from the evils of city wastewater treatment plants. At these plants, which consume vast quantities of electricity, the water is dosed with chemicals before being discharged. By saving water and returning it to nature's cycles, we're taking another step away from the environmentally destructive infrastructure so much of our lives are tied to.

Love,

The Revolutionary Photovoltaic Front (Frente Revolucionario Photovoltaico)

Passive Cooling

Part I — Basic Principles

Cliff Mossberg

Though the climate of Belize is hot and humid, residents can use various passive techniques to create a cooler, more comfortable living environment.

Much of my early adult life was spent homesteading in the Alaskan bush. Winters are the predominant force there, and like most others in a northern or temperate zone climate, my main concern was keeping my living space warm. My location colored my entire world view. It never occurred to me that in some places in the world, the problem was to stay cool.

Most of the residents of the United States have similar problems of perception. Because of this necessary emphasis on heating, there is not a lot of information available on alternative methods of cooling. In 1980, I was fortunate enough to "retire" to the Central American country of Belize where I routinely encountered temperatures in the eighties and nineties, and humidity in the upper 30 percent of its range. 95°F (35°C) at 95 percent humidity will quickly draw your attention to the need to cool down.

In the United States and most other industrial nations, cooling is dealt with by refrigeration. Air conditioners are predominantly powered by electricity, which is usually produced by burning fossil fuels. Affluence allows us to condition our living space using an expensive fuel of convenience. Most "third world" nations only allow this luxury to the very well-off. Where grid power is available in Belize, it costs 25 cents per kilowatt-hour. This is far too expensive for the average person to use for cooling on a regular basis.

Cooling for the Humid Tropics

Over the years, I've studied the problem of low energy input cooling in the tropics worldwide. There are two very different environments that demand solutions to the cooling problem. Hot, arid landscapes may require cooling as much as hot, humid areas, but the principles used to address the two problems are quite specific.

In this series of articles, I will try to pass on what I have learned about using sun, wind, and the basic principles of heat transfer to create a comfortable living environment. I am specifically targeting the humid tropics, but many of the principles I will discuss are relevant to arid areas as well. I will emphasize passive techniques here—things that can be done without using any technically derived energy to move heat, or techniques using devices to control heat flow automatically.

This will be a multi-part article. In the first part, I cover the basic principles of heat transference, and try to explain how they interact and what type of effects they produce. Later, I will discuss materials and environmental factors. Also, I will specifically apply the basic principles to building design and construction.

Heat Fundamentals

Heat is the motion of molecules in a substance. The hotter the temperature, the more energetic the motion becomes. There is no such thing as "cold"—there is only more or less heat. Cold is our own subjective reaction to a condition of too little heat for the body to be in its comfort zone.

This is an important concept because there is no one perfect temperature at which we are all comfortable. The human comfort zone depends on several factors,

Methods of Heat Transmission

Method	*Transmission Mechanism*	*Transmission Medium*	*Direction of Heat Movement*
Radiation	Electromagnetic radiant energy	Vacuum or transparent medium	Any direction, line of sight from source
Conduction	Molecule to molecule mechanical transference	Any substantial material in contact	Any direction into material in contact
Convection	Physical relocation of a heated substance	Usually movement of a heated fluid	Usually upward, unless forced

not least of which is the human acclimatization to the specific environment we live in.

While temperature is proportional to the energy of vibration in molecules of a substance, heat quantity is a measure of the numbers of these molecules and the temperature at which they are vibrating. A large pan of boiling water has more heat in it than a small one does, even though they are at the same temperature.

As matter heats up, the molecules move farther apart—they expand. Thus for the same volume of matter, there are fewer molecules if the material is hotter. This means that the same volume of our hypothetical material weighs less per unit volume when it is hot and more when it is cold and dense. This is true of solids, liquids, and gasses that are unconfined.

Three Modes of Heat Transfer

There are three ways that heat can be transferred between a source and a receiver body. They are radiation, conduction, and convection.

They all accomplish the task of imparting heat energy to a receiver body, and they do so in proportion to the difference in temperature between the sending source and the receiving body (called “delta t” and written “Δt”—Δ means “the change in”). The higher the difference in temperature between a heat source and a heat receiver, the faster heat will flow into the receiver and the faster its temperature will rise.

Radiation

When we talk about the electromagnetic spectrum, all we’re talking about is “radio” waves—waves of magnetic energy that can propagate through a vacuum in space, thus transferring energy from the sun, stars, and galaxies to our earth. We are familiar with AM radio and the higher frequencies of FM radio and TV, but the radio spectrum contains many other waves of much higher frequencies. Visible light is a series of radio waves that our bodies can detect directly.

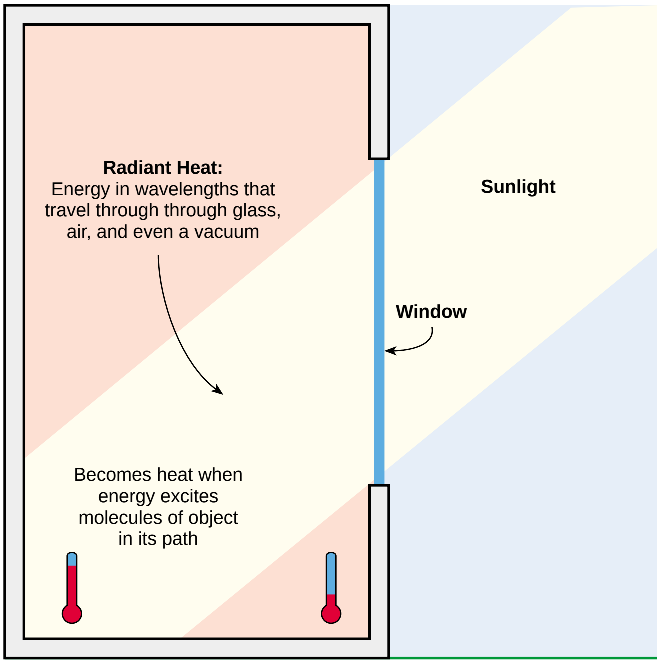
Other frequencies such as infrared (lower in frequency than visible light), ultraviolet (above the frequency of visible light), and x-rays (very, very high frequency) are undetectable by the human eye. Yet these frequencies transfer energy as surely as the visible light frequencies, and we are affected directly by them. Infrared radiation from the sun produces the feeling of heat on our skin when the sun’s rays hit us. Ultraviolet radiation causes sunburn, and x-rays can kill or mutilate our body’s cells.

Infrared radiation is the vehicle of heat transference that is most important to life on earth. It is heat radiation transmitted directly to the earth by the sun. It is one of the principles that allows a woodstove or a bonfire to radiate heat that warms at a distance.

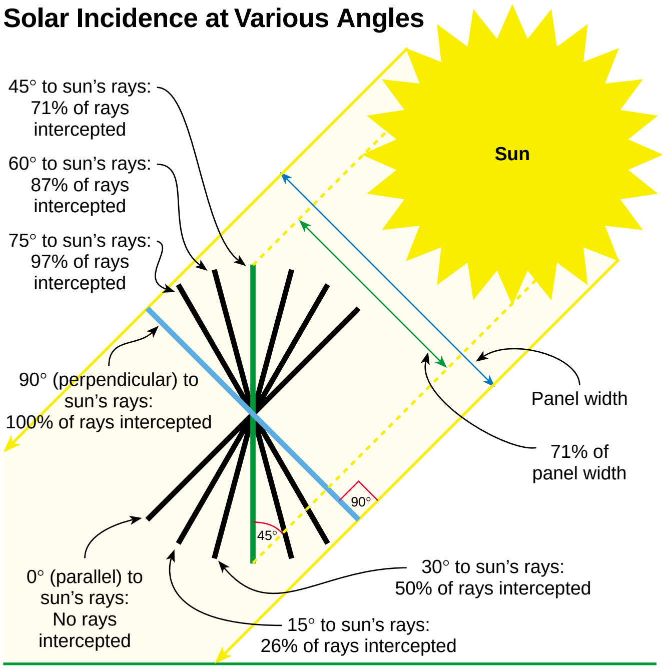
Visible wavelengths can be converted to infrared radiation when they fall on an absorptive surface, such as a roof or a photovoltaic panel. The energy in these light waves is absorbed by the surface, causing heating. This heating in turn causes re-radiation from the absorber as heat, or infrared light. This is the reason hot water collector panels are self limiting in their efficiency. The collector panel heats up the water until the water re-radiates as much energy back to the sky as it takes in. At this point, there is no further gain in collection of radiant energy possible.

A roof heats up in the sun’s rays until it re-radiates infrared heat energy down into the house as well as out

Heat Transmission through Radiation



Solar Incidence at Various Angles



Absorbtance Characteristics for Common Building Materials

Surface	*Solar Absorptance*
Asphalt Shingles	
Dark	95%
White	75%
Rough Wood	
Dark	95%
White	60%
Smooth Wood	
Dark	90%
White	50%
Glazed or Enameled Surfaces	
Dark	87%
White	37%
Stucco	
Dark	90%
White	50%
Unpainted Brick	
Dark	85%
White	65%
Concrete Block	
Dark	95%
Unpainted	77%
White	55%

into the air. If the ceiling has no barrier to radiant energy, this radiation will heat up the ceiling surface, which in turn will re-radiate the heat directly into the living area of the structure. Radiant energy is the principle vehicle for moving heat in a downward direction into a structure.

Effects of Solar Incidence

There are several factors that affect the ability of a surface to absorb or radiate infrared energy, and one of the most important is the angle at which the radiation hits the absorbing surface, known as the angle of incidence. If you want to absorb energy at the maximum efficiency, radiation should fall on a collection surface that is exactly perpendicular to that radiation.

The diagram above shows a variety of panel angles in relation to the sun's rays. When the panel is perpendicular to the sun's rays, the most energy is intercepted. When the panel is set at 45 degrees to the sun's rays, only about 70 percent of the available energy is captured.

Absorption & Reflectance

Another factor that affects the amount of radiation converted to thermal energy on a hypothetical earth "panel" is the color and texture of the surface. This is so fundamental to our experience that the concept is understood intuitively. Dark surfaces absorb heat and energy, while light surfaces reflect them. Rough surfaces absorb energy, while smooth surfaces reflect it. What is not so intuitive is that colors and textures that absorb energy well, also radiate energy well.

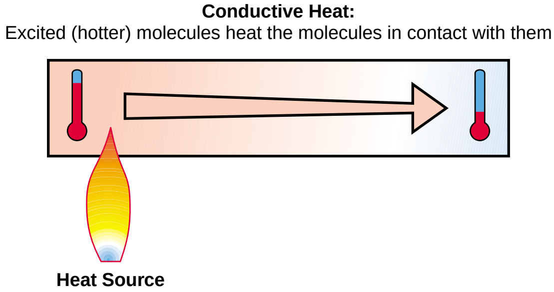
Reflective metallic foils take advantage of this. They are actually conductors, but when specifically engineered into buildings to control radiant energy, they are as much as 95 percent effective at blocking radiant energy absorption. They are also very resistant to re-radiating absorbed energy.

To be this effective, a radiant barrier must be installed with an air space on one or both sides of the material. Its mirror surface will then reflect any infrared energy rather than absorbing it and conducting it as heat.

Conduction

Conduction is the most intuitively understood mode of heat flow. For conduction to occur, materials must be in contact with each other. For example, imagine a copper bar one foot long, two inches wide, and half an inch thick (30 x 5 x 1.3 cm)—a rather substantial piece of copper. If we support this bar, and place a candle or a Bunsen burner under one end, the bar will slowly heat up from one end to the other. Soon the whole bar will be too hot to touch. Heat is being transmitted by conduction throughout the bar.

Thermal Conduction



What is happening here is that the heat source is exciting the molecules in the copper to vibrate more enthusiastically, becoming more and more energetic as the temperature increases. As these copper molecules pick up physical motion from the heat energy, they continuously "bump" into the molecules next door.

This physical disturbance imparts energy to the adjacent molecules, causing them to increase their vibrational energy—they warm up. Heating progresses down the bar, away from the heat source, until the whole bar has reached a state of equilibrium based on the amount of heat supplied by the source.

Conductive Heat Flow

Radiant energy is one of the loss factors that draws heat from the bar. Another factor that allows the bar to lose heat is conduction to the medium surrounding it. This is a loss by physical contact with the fluid—air—surrounding the bar.

Different materials will move heat at different rates. Based on these rates, materials are classified as "insulators" if they retard the flow of heat, or "conductors" if they facilitate the movement of heat. These are far from absolute definitions. Most insulators are designed to retard heat flow in conduction, but there are some exceptions such as metallic foil radiant barriers.

Air can be either an insulator or a conductor. For example, air is used as an insulator to slow down the transmission of heat in homes. It is the "dead" air space in fiberglass batt insulation that does the work. But air is also a cheap and relatively effective conductor of heat in electric motors, vehicle cooling systems, and many other applications. So while it is important to understand how material properties affect heat flow, you should also realize that these properties can be applied in many ways to achieve an engineering goal.

Materials and their Conductivity

Material	*Conductivity (Conductance)**
Copper	220.000
Aluminum	122.000
Steel	25.000
Concrete	0.600
Water	0.350
Brick, red	0.270
Rubber, soft	0.100
Wood, pine	0.070
Corkboard	0.025
Rock wool	0.023
Air	0.014
Vacuum	0.000

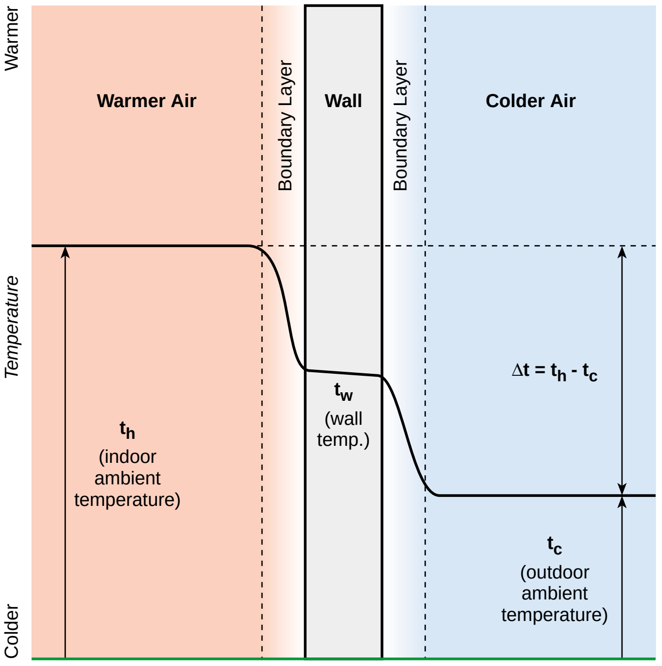
*BTU per hour per sq. ft. per degree per foot thickness

Boundary Layer

In conduction, heat flows through a substance because of tangible physical interaction between molecules. These same forces allow heat to flow between any substances that are in contact with one another. The boundary where one substance stops and another begins (between the copper bar and the air, for example) is known as the interface. Heat flow across an interface can be complicated by factors that are not obvious. The first of these factors is the variable rate of conduction by different materials. The second factor is the mobility that a fluid has, which results in convective flow.

Conductive heat flow is impeded when a fluid such as air is in contact with a heated surface such as a wall. This impediment is caused when a layer of stagnant air is changed in temperature and density by heat moving across the interface. The air in the layer next to the wall

Conduction through a Boundary Layer



will heat up more that the air some distance away. When this situation exists, the change in temperature (Δt) between the warm wall and the warm layer of air is reduced. This cuts back on heat flow.

The existence of the boundary layer and its removal is the essence of "wind chill." This is when it feels colder than the real ambient temperature because of the extra heat loss when the wind blows away the boundary layer around our bodies. This is undesirable when we are trying to keep warm, but very desirable when we are trying to cool down.

The conductivity of any material can be measured and quantified so that the relative qualities that make it an insulator or conductor can be examined in absolute terms. The conductivity table lists some materials and their conductivity. Even without knowing how to use the "soup" of units with which these materials are labeled, it is obvious that copper has a very high conductance value (220), while air is very low (0.014).

Convection

In its most generic form, convection involves the movement of heat by transporting some hot substance. Convective heat movement is usually associated with the movement of fluids. There are two common forms of convection—"forced" and "free." In forced convection, power is used to move a heated fluid from the source of heat to the heat destination. Vehicle radiator type cooling systems and hot water or hot air home heating systems are common examples of this.

Since we are interested in heat flow that occurs without any energy input from us, we will be concentrating on free convection to move our heat. Free unpowered convection happens due to the difference in density or molecular concentration per unit volume that occurs when a fluid is heated.

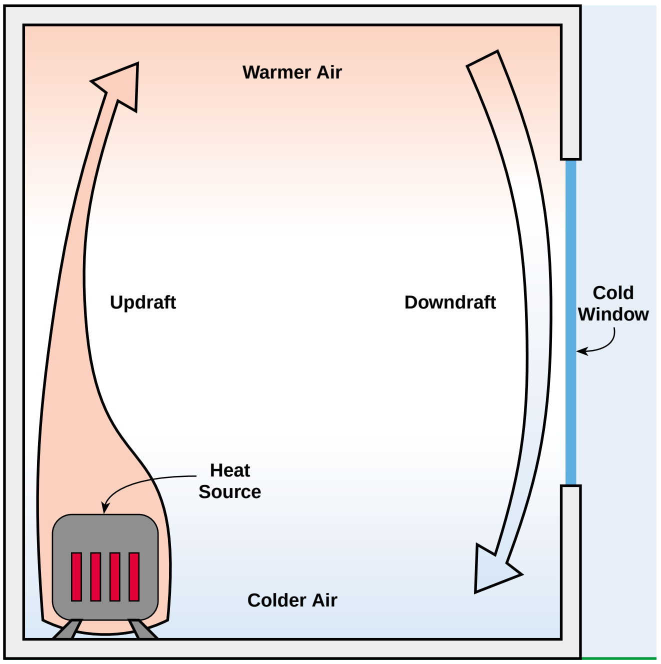
Molecular Density & Weight

The same volume of material weighs less per unit volume when it is hot and more when it is cold. Thus a "cold" (less hot) fluid packs more matter into the same volume than the same amount and type of fluid when it is heated.

The practical result of this change in density is that a hot fluid, being lighter, will "float" on a colder fluid. Conversely, a cold fluid will move downward under the pull of gravity until it finds the lowest level possible. These are dynamic processes. The fluid actually physically flows from one position to the next as its thermal status changes. Such flow results in the movement of heat.

If you put your hand over a heated stove burner, you can feel air rising off the burner. A hot air balloon

Thermal Convection in a Fluid



depends on the change in density between the hot air inside the balloon and the cooler air outside it to rise into the sky. On a warm summer day, the lake you swim in will have a warm layer at the top and cooler water underneath. These are all examples of fluid movement caused by a change in density that causes convective heat to rise.

Convection is the movement of the heat rather than the movement of the fluid. But the two are inexorably intertwined, so much so that we also call the fluid movement convective flow.

Stratification & the Greenhouse Effect

Hot air flows up; cold air flows down. This causes several familiar effects such as stratification. The warm water on the lake surface in the example above is a case of stratification. Water in the lake is heated by sunlight and rises to the top level, where it cannot go up any farther. Here it forms a layer. It gives off some of the sun-induced heat to the air above it, becomes more dense, and eventually sinks again.

Depending on the amount of solar energy available, this convection loop will stabilize so that approximately the same amount of water is constantly heated, rises, gives off its heat, and sinks back into the cold depths. Thus solar heat is moved from the lake to the air.

The conversion of visible light energy into re-radiated radiant energy contributes to what is called the "greenhouse effect." That's the label for the tendency of heat to build up in a greenhouse so that the air inside is much warmer than ambient outside temperature.

This happens because glass that is transparent to visible light waves impedes the re-radiation of infrared wavelengths. The trapped radiation heats the structure, fixtures, and air inside the building. This heated air is trapped inside the greenhouse by the glass (probably causing stratification), and cannot move the heat away by convection.

Chimney Effect & Boundary Layer Disturbance

Convection directly affects the comfort of our living space, and even the clothes that keep us warm. It also affects the boundary layer, which is made up of stagnant air that acts like an insulator.

If the Δt between the ambient air and the boundary layer is anything but zero, the boundary layer will attempt to rise or fall of its own accord, inducing convective heat flow. This can be the boundary layer around our own warm bodies on a cool day, chilled air flowing down a cold windowpane to create floor drafts in a dwelling, or heat rising off the inside of a solar heated wall.

Another convective phenomena commonly encountered is the “chimney effect.” In most furnaces, exhaust gasses exit the combustion process under the influence of convection. The heated gasses are lighter than the ambient air, so they rise up the chimney, pulling air into the furnace or stove through cracks or through a controlled draft regulator. The hotter the flue gasses and the longer the chimney (within limits imposed by conductive heat loss), the faster the gasses will exit, so the stronger the gas column flowing up the chimney will be. Most stoves and furnaces would simply not work if this convective flow was not possible.

This chimney effect is not limited to chimney flues. It can be used in a building as a tool to move hot air out of the living space. The rising hot air can be supplied by solar energy. The resultant air movement is used to induce whole house ventilation where it might otherwise be difficult to achieve passively.

Wind as a Heat Mover

Under the right circumstances, warm lake water will heat the cooler air above it, inducing another fluid convection cell in the air. This air is heated, rises, cools, and circulates back down to the surface to be heated again. This process is much the same as the drafts settling off a cold window. It is much greater in volume, and we call this movement wind. Anything that can affect the heating of the air mass is important.

Wind is our ally. We have limited ourself by definition to creating comfort passively in our living environment. We have cut ourselves off (or been cut off by circumstances) from the use of highly concentrated fossil fuel derived energy. Yet to move heat around to our advantage, it takes energy—sometimes large amounts of it. Wind is the one source of energy readily available to us that can do this job.

The differences in reflectance of the earth’s surface is important to heat absorption wherever we are. Black basalt rock will absorb more solar energy than light silica sand. A farmer’s pasture will absorb less heat energy than the concrete streets and building walls in a city. This brings us back to the basics of material, surface texture, and color.

We don’t usually think of something like a parking lot affecting natural breezes. Yet such a man-made feature can have a vast effect on the microclimate that we are subjected to in our living spaces. A large black parking lot will absorb a lot of solar energy. This solar energy will be transmitted into the soil through conduction, re-radiated into the surrounding environment as radiant heat, and will heat the air above it, which can then rise convectivly.

This convective flow may induce local breezes where there would be none, or it may disrupt natural wind flow. The radiant energy will distribute itself outward from its source to all the surrounding areas adjacent to the lot, causing local heating and possibly destroying any benefits a locally induced breeze might produce. Conductive heating of soil will create a reservoir of heat that will continue to radiate to the surroundings long after the ambient air temperature should have become naturally cooler. All three factors as well as terrain and vegetative cover are interactive and each affects the other.

Humidity & Evaporation

No discussion of wind and weather would be comprehensive without understanding the role of humidity and evaporation. Wind and weather are formed as part of a large heat cycle driven by solar energy. One of the principle forces acting on this cycle is the addition or subtraction of heat through evaporation.

It takes one BTU (British thermal unit) to raise the temperature of one pound of water from 211 to 212°F (99.4 to 100°C), but 970.4 BTUs are needed to turn it to steam at 212°F. Those 970.4 BTUs are known as latent heat, measured under standard conditions of one atmosphere of pressure at sea level.

Water does not have to boil to absorb this latent heat. It will slowly evaporate at room temperature, requiring the same latent heat. Evaporation requires heat, and this heat, coming from surroundings, cools the environment considerably. The heat taken in or given off as this process occurs creates a very complicated thermal dance in everything from deserts to hurricanes.

Unless it is artificially dried, air contains water vapor suspended in molecule-sized droplets. The amount of water air can hold is determined by its temperature and density. Hot air can hold more moisture than cold air. So that there will be some common point of reference when talking about air moisture or humidity, figures for the water content are given as "relative humidity."

Relative humidity measurements are given in the percent of moisture that air holds relative to its maximum possible moisture content at a given temperature. The range runs from 0 percent for absolutely dry air to 100 percent for air that holds as much moisture as is physically possible. This is known as the saturation point. Anything greater than 100 percent relative humidity will lead to free water condensing out of the air as mist, fog, clouds, rain, or snow.

The amount of moisture that air can absorb under any condition is dependent on temperature and the amount of moisture it already contains. Thus air measuring 70 percent humidity can only absorb the equivalent of the remaining 30 percent moisture capacity. The lower the air humidity, the more potential moisture the air can still absorb.

The more moisture that can still be absorbed, the more potential there is for heat removal through evaporation. By evaporating moisture into the air as humidity, cooling can be produced. And the more moisture that can be absorbed, the more efficiently you can cool with evaporation. Humidity bears directly on the creation of the human comfort zone, since the body depends on evaporation through perspiration to rid it of excess heat.

Vegetative Cover

The black surface of an asphalt parking lot is a very good absorber of thermal energy. The dark green surface of vegetation is also a good absorber of thermal energy, yet the plants cool their microenvironment. How can this be?

Plants are designed to effectively trap solar energy. But instead of absorbing light and producing heat, they produce plant sugars through photosynthesis. Much of this solar energy has no chance to be turned into excess heat. It is directed to the plants' needs instead. Because of this, the use of green foliage to block sunlight striking a building is very effective. The advantage of such shade is obvious when it comes from trees, but the use of vining plants on trellises covering roofs and walls also works effectively to lower temperatures.

One of the products plant leaves give off is water vapor, a vegetative "breath" that is transpired from pores in the leaves. Transpiration is the process of taking in gasses (mostly CO_2) and sunlight, and giving off oxygen and water vapor. This evaporating water absorbs heat from the leaves and the surrounding air, cooling the local microclimate. The combination of transpiration and evaporation is called "evapotranspiration."

Local Breezes

Transpiration can also play a significant role in local breeze generation. The figure on the facing page is a scale cross section of the Barton Creek valley where I lived in Belize. The east side of the valley and the adjacent hill was cleared for pasture when the original settlers moved in. It is covered with low bushes and a dense fern covering that is locally called "tiger bush." It faces squarely into the afternoon sun, and the rate of vegetative transpiration is poor.

The west side of the valley was too steep to be cleared, so it is mostly covered with undisturbed jungle canopy. Direct morning sun hits this slope and is cooled by the vegetation, but late in the afternoon when the east slope is hottest, this west slope is taking the indirect (non perpendicular) sun's rays and is cooled still further. Air is heated on the east slope and rises, while it is cooled on the west slope by the tree canopy and sinks down into the valley.

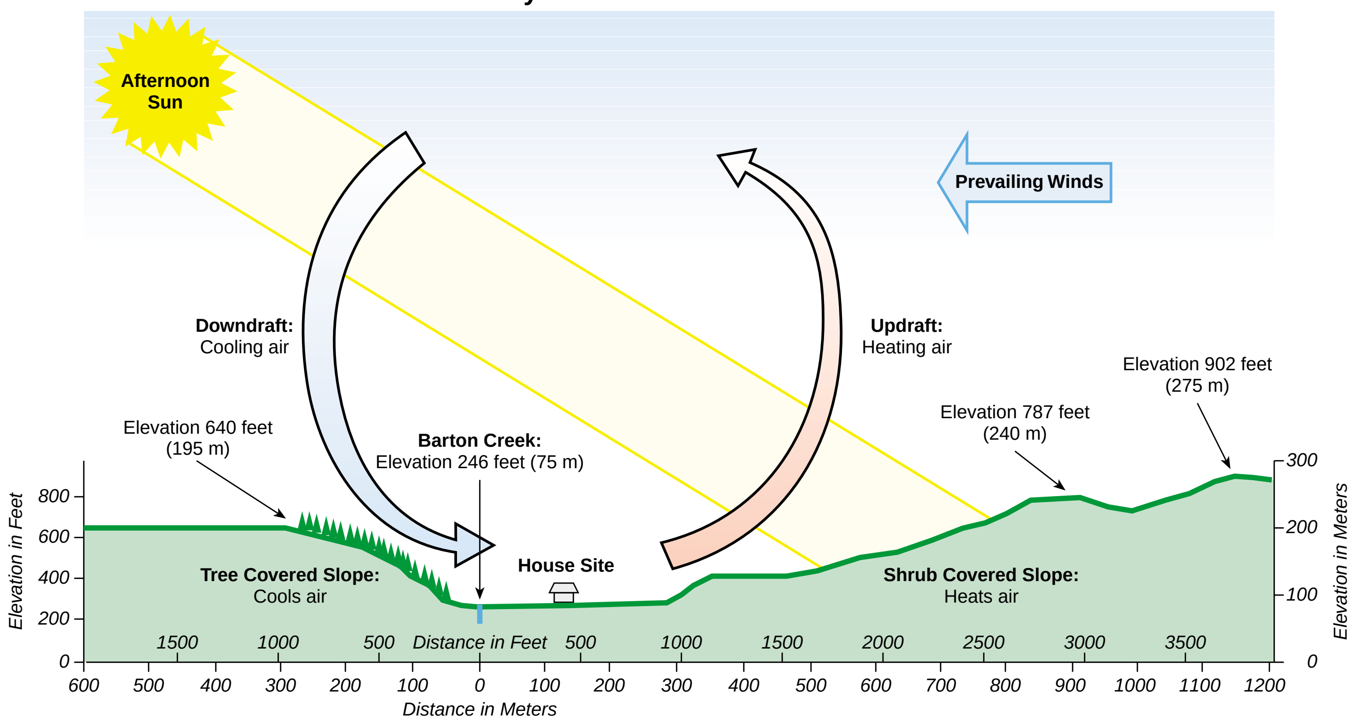
The net result of this differential movement is a strong afternoon breeze that blows straight across the valley in the hot dry season, contrary to the direction of the prevailing Caribbean trade winds. The existence of such a wind is completely counterintuitive, but very much appreciated because it is much more local and intense than the prevailing breeze. This illustrates how much significance local and regional factors, both natural and man-made, can have on ventilation and heat flow.

Terrain such as hills or mountains can act as deflectors to re-route prevailing winds, either creating a wind shadow or augmenting wind velocity. Up to a point, when you are trying to get cool, more is better, so astute selection of a house site with an emphasis on maximizing (or minimizing) local wind is important. A good site for wind will provide the energy needed to deal with uncomfortable temperatures either passively or actively.

Human Heat Physiology

In spite of any surplus heat from the environment, the body must maintain an internal temperature very close to 98.6°F (37°C). There are a great many mechanisms that we have evolved to effect this precise temperature regulation. All three mechanisms for transferring heat are at work—radiation, conduction, and convection. In addition to those three, the body also uses

Localized Winds in the Barton Creek Valley of Belize



perspiration—shedding excess heat through the latent heat of evaporation.

The high relative humidity typically encountered in the humid tropics (around 95–98%), will severely interfere with the ability to lose heat through evaporation. The air is already saturated and cannot hold more moisture. This is the great difference between a hot humid environment and a hot arid environment.

Where the humidity is low, the body has the cooling mechanism of evaporation at its disposal and the low air moisture considerably increases the efficiency of the process. This makes the designer's job much easier in such an environment.

Since I am targeting passive cooling in a hot humid climate, my emphasis will be on techniques for the humid tropics and subtropics. For those readers who are fortunate enough to have dry desert conditions as their design criteria, I direct you to two books by the Egyptian architect Hassan Fathy. These books are superb, clear, well illustrated, and relatively non-technical.

Acclimatization

When I moved from Alaska to Belize in 1980, I was adapted to the subarctic environment of interior Alaska. Winter temperatures plunged to -60°F (-51°C) routinely, while summers were "oppressively hot" at 80°F (27°C). I could work in shirtsleeves at 35 to 40°F (1.6–4.4°C) and be comfortable.

In five years in Belize, the coldest temperature I ever encountered was around 55°F (13°C). The typical high temperatures were 75 to 80°F (24–27°C) in winter, 90 to 95°F (32–35°C) in the wet season, and 95 to 108°F (35–42°C) in the hot, dry season. Getting used to these temperatures so that my body could regulate itself was difficult. I acclimated about 80 percent in the first year, and by the end of year two, I was 90 to 95 percent acclimated. I never reached 100 percent in the five years I lived there full time.

If you live in Phoenix, Arizona where the temperatures go to 125°F (52°C) in August, and you are used to a 72°F (22°C) air-conditioned environment, you will never acclimate to the heat because you are not forced into it. But if you are out in the heat as it gradually increases over the spring and summer, you will find yourself growing accustomed to an environment that would have seemed impossibly hostile before. If you are acclimated to the local climate, whether hot or cold, it will take much less energy input to remain in the comfort zone under adverse conditions.

The Comfort Zone

The comfort zone is defined as those combinations of conditions of humidity, temperature, and air motion under which 80 percent of the population experiences a feeling of thermal comfort. In temperate zones, this is from 68 to 80°F (20–27°C), and 20 to 80 percent humidity.

Different conditions can redefine this zone of comfort. Air motion or breeze can extend it to almost 98 percent humidity and 90°F (32°C). Evaporative cooling can extend the highest comfort temperature up to 105°F (41°C) at lower humidities. High thermal mass (such as rock or concrete) acts like a thermal flywheel, remaining cool into the day, and warmer at night than ambient air. Thermal mass alone can extend the comfort zone up to 95°F (35°C), while thermal mass cooled by nighttime ventilation can extend this zone all the way up to 110°F (43°C). Combinations of techniques are even more effective.

Evaporation (Perspiration) & Air Motion
At higher humidity and temperature, most of the excess body heat is lost through perspiration. Air motion can increase the boundaries of the comfort zone up to 98 percent humidity. This boundary would be 80 percent in still air.

Research with a large sample of people shows that comfort can be maintained at 100 percent humidity and 82°F (28°C), if air velocity across the skin is maintained at around 300 feet per minute. This is the approximate velocity of a good ceiling fan on high speed. At lower humidities (50 percent or less), temperatures of around 90°F (32°C) are comfortable at this velocity. Because of this relationship, the designer's goal is to create or preserve air velocity in the dwelling whenever possible.

A breeze blowing against our bodies removes heat through two mechanisms—convection and latent heat transfer. When convection occurs, the skin heats the air and this heated air is carried away by the breeze. With latent heat transfer, perspiration evaporates, soaking up heat from the skin in the process. Moving air aids the process of evaporation at higher humidities, as well as removing the boundary layer on the skin. This dead air layer acts as an insulator to block thermal transfer from the skin to the air.

The boundary layer also blocks evaporative transfer from the skin to the air. This layer heats up and reduces the Δt between the skin and the air, slowing down heat exchange. It also absorbs moisture from the skin, but is unable to immediately pass this on to the surrounding air. The boundary layer thus rises in humidity, reducing the difference in humidity between the skin and the air. This slows down skin evaporation and the exchange of heat to the air. Air movement shifts this boundary layer of warm, moist air, allowing the skin to come in contact with drier, cooler air that can cool more efficiently.

Summary
In Part 1, I've taken a look at the basic principles governing the movement of heat, and tried to give you a feel for the way these forces interact with the environment. We've looked at comfort, and found that the experience of thermal comfort is largely subjective to the individual.

In the next article, I will move from the general to the specific. I'll try to apply these principles of thermal design to the goal of creating a comfortable, passively cooled house in the Barton Creek valley of tropical Belize.

Access
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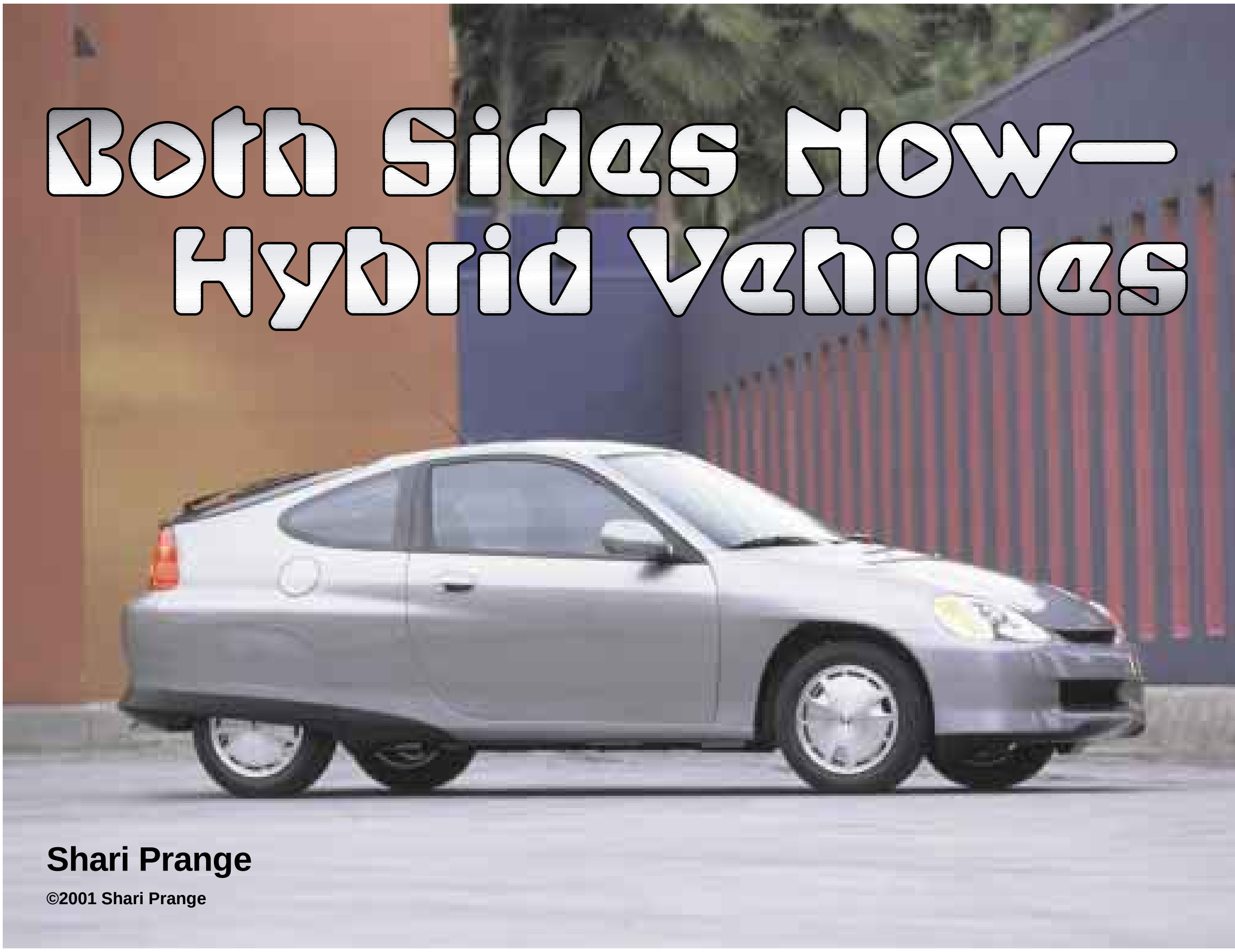
Resources for Further Study:
Building for the Caribbean Basin and Latin America; Energy-Efficient Building Strategies for Hot, Humid Climates, Kenneth Sheinkopf, 1989, Solar Energy Research and Education Foundation, 4733 Bethesda Ave. #608, Bethesda, MD 20814 • 301-951-3231 Fax: 301-654-7832 • plowenth@seia.org www.seia.org

Air Conditioning: Home and Commercial, Edwin P. Anderson and Roland E. Palmquist, Theodore Audel & Co., a division of Howard W. Sams & Co., Inc., Indianapolis, Indiana, 1978. Any library should have a comparable book on air conditioning that will treat this subject thoroughly.

Architecture For the Poor, 1973; and *Natural Energy and Vernacular Architecture, Principles and Examples with Reference to Hot Arid Climates,* 1986, Hassan Fathy, both published by The University of Chicago Press, Chicago. These books can be hard to find. I was able to locate them through my regional inter-library loan program and have them brought to my local library.

Both Sides Now— Hybrid Vehicles



Shari Prange

The hybrid Honda Insight looks like any other car on the outside—but it's very different on the inside.

What has four wheels, a lot of batteries, and isn't an electric car? Answer: a hybrid car.

A hybrid car is an attempt to have the best of both the internal combustion and the electric vehicle worlds. We are suddenly hearing more about them because the major auto manufacturers and the media are telling us that hybrids are the next hot thing.

For the manufacturers, hybrids mean they don't really have to give up the gasoline-powered engines that they so dearly love. For the most part, the major auto manufacturers never wanted to build pure electric cars anyway. When pushed into a corner, they produced a few hundred of them, made customers run an unprecedented gantlet of restrictions to get them, and then discontinued them and declared them failures while dealers still had long waiting lists of disappointed would-be electric car drivers. (Author's note: This reflects the somewhat cynical opinions of this writer, which are not necessarily those of *Home Power* staff and management.)

Having taken away the toy we really wanted, automakers are now trying to distract us with another toy that's "almost the same thing, only better." Despite my somewhat jaundiced view of this maneuver and what it means for pure electrics, I have to be fair and admit that a hybrid electric vehicle (HEV) is a valid concept, and has a useful place in the public fleet. There are different types of hybrids, with different strengths and weaknesses. Let's take a look at just what hybrids are, and what they mean to the average driver.

What Is It?

A conventional vehicle is powered by a traditional internal combustion engine (ICE) burning a fuel such as gasoline. Gasoline has a relatively high energy density, so a car can carry enough of it to drive two or three hundred miles. Then the car is refueled by pouring more gasoline into the tank, a simple task requiring only a few minutes.

An electric car uses batteries to power an electric motor to drive the wheels. This system is much more efficient in the use of energy (and much cleaner and quieter).

However, it is much less efficient at storing energy, so the car can only travel fifty to a hundred miles before needing a recharge. The recharging process takes several hours, unless an expensive and very high-powered charging system is used.

A modern commercial hybrid has both a gas-powered engine and a battery-powered electric motor working together to drive the car. It sacrifices some of the clean, quiet simplicity of a pure electric to gain the range and quick-fueling features of a gas car. This is a valid compromise. Although a pure electric car could handle the vast majority of the typical driving done in this country, there are situations that require something more. For some people, particularly those living off-grid in a remote area, a pure electric is just not a viable option. For those situations, a hybrid is certainly a better choice than a pure gas car in many ways.

Series, Parallel, or Both?

There are different types of hybrid configurations. In the series hybrid, the internal combustion and electric systems operate in a single drive system. The gas engine runs a generator, which charges the batteries, which power the electric motor, which drives the car.

The main problem with this type of system is that it takes a very large engine and generator package to put out enough power to keep the batteries topped off. It usually isn't possible to get such a system into a home conversion. With a smaller ICE system, driving drains the batteries faster than the generator can charge them. The gas engine extends the range a bit, but not a lot, and at some point you still have to stop and plug in for a few hours.

In the parallel hybrid system, the gas engine and electric motor work side-by-side, and both of them actually drive the wheels of the car. This system can be designed so that the car is a pure electric most of the time. A flip of a switch allows it to draw on the gas engine only when extra power is needed, or when the batteries are tired.

The problem with this type of system is that it is bulky, complex, and expensive. You must fit two entire drive systems into one chassis, and control and coordinate both of them.

A third type of hybrid combines these two systems—sort of a hybrid hybrid. This is the type of system used in the Toyota Prius and Honda Insight. Sometimes the gas engine drives the wheels of the car. Sometimes it charges the batteries. Sometimes it does a little of both at the same time.

Both ICE engines and electric motors have some modes of operation that are most efficient, and other modes that are less efficient. When either one is expected to cover a full range of driving conditions, its efficiency will vary. By using both systems' strengths to complement each other, each can operate more efficiently. It's possible to get away with a smaller engine, generator, battery pack, and motor combination than either a straight series or a straight parallel system would require—or a pure gas or pure electric car.

What's Available?

The hybrid concept does not lend itself well to home hobbyist conversions. The kinds of components needed to build an effective hybrid just are not readily available off the shelf, so hobbyists have to make do with components that weren't really designed for the job. Home-built hybrids tend to be crowded and noisy. In addition, they may put out many times more pollution than a standard gas car, and have not much more range than a pure electric conversion. But with the resources of a major manufacturer to design from scratch, a hybrid can be a very nice machine.

The major auto manufacturers are currently switching their efforts from pure electrics to hybrids. The most striking difference between the two is not technology, but marketing. A year ago, there were more than half a dozen pure electric vehicles on the market. However, most were only available to fleets. Of those available to

Under the hood of the series-parallel hybrid Insight, made by the Honda Motor Corporation.

mere mortals, most were only offered by lease, and you could count on your fingers the cities in which they could be found.

In addition to qualifying financially for the not-inexpensive leases, prospective customers had to meet unique requirements, such as owning their own homes, and living within a specified mileage of the leasing dealership. And if you went to the companies' Web sites in search of these cars, you often found their pages hidden away in obscure corners, full of puffery and short on facts.

By contrast, the two hybrids currently on the market are offered for sale or lease at dealerships across the country, just like "normal" cars. If you go to the manufacturers' Web sites, you will find them listed beside all the other standard models, with complete specs. Both of these cars come from Japanese manufacturers. This is no surprise. Once again, Tokyo leads the way, and Detroit reluctantly follows.

While the two cars are both hybrids, they are the products of different design philosophies. We'll take a look at the details of both of them, starting with the Honda Insight this issue, and the Toyota Prius next time.

Honda Insight

The Insight was the first hybrid electric vehicle introduced in the United States, making its American debut just before the Toyota Prius, in the summer of 2000. The Insight is a two-door, two-passenger coupe, so it is suitable for singles or couples, but would only work for a family as a second car. Its manufacturer's suggested retail price (MSRP) starts at US$18,880, which is a little less than the Prius. This is not a profitable retail price for Honda, nor will the company disclose what sales price would yield a normal profit margin. Instead, the Insight is regarded as a learning experience and an investment in the future.

The ICE system uses a small three-cylinder 73 hp engine. The engine was deliberately reduced in size to yield high fuel economy. The engine was also designed to use VTEC variable valve timing to burn fuel more completely, which increases its fuel economy and lowers emissions. Unlike a standard gas car, the engine in the Insight is turned off completely when the car is standing still at a stoplight, coasting downhill, or braking. It does not waste fuel or create emissions by idling unnecessarily.

The electric motor is a 10 KW brushless DC permanent magnet motor, which is very small for a passenger car motor. For comparison, the typical brushed series DC motors in conversions are 25 KW or more at the same rpm. The permanent magnet type of motor can be very efficient within its optimum rpm band. The motor also doubles as a generator. During deceleration, regenerative braking uses the car's momentum to generate electricity to recharge the batteries.

In a hybrid like the Insight, the overall system can be optimized so that the motor spends most of its time working in its most efficient mode. The motor draws its power from a pack of 120 nickel metal hydride (NiMH) cells of 1.2 volts each. The battery pack is rated at 6.5 amp-hours at the 20 hour rate, as compared to 230 amp-hours at the 20 hour rate for the typical lead-acid batteries in conversions.

The car is available with two choices of transmissions—either a 5-speed manual, or a continuously variable transmission (CVT). The CVT is a type of automatic transmission that constantly changes gearing to maintain optimum efficiency. To the driver, it feels like driving in one gear at all speeds.

The Insight's overall drive system is called "Integrated Motor Assist" (IMA), which reflects the design philosophy behind the car. Unlike the Prius, which operates in pure electric mode when appropriate, the primary driving force in the Insight is always the gas engine. It starts up immediately when you depress the throttle. In fact, the electric motor and battery pack system in the Insight is not capable of moving the car by itself. The car can, however, be driven with the electric motor disabled, although at a reduced level of performance.

The Insight is a gas car with an electric motor assist. The idea is that most gas cars have much more engine capacity than they need most of the time, but they have to have it available for those few times of peak power demand. (This is true for pure electrics, too.) The rest of the time, this excess capacity is simply excess baggage.

Honda chose to design a small efficient engine that is the proper size for most of the car's needs. Then it added a small electric motor to give a boost for those times when more power is needed. Since the motor never has to move the car by itself, it can be only as big as it needs to be to supply that added power for the engine. In fact, it's a tiny thing, less than 2.5 inches (6.4 cm) thick, placed between the gas engine and the transmission.

The Insight also features an all-aluminum frame, making the entire vehicle weigh in at a feathery 1,878 pounds (852 kg). The result is a car with very high gas mileage and low emissions. The EPA rating for the Insight is 61 mpg (26 km/l) in city driving and 68 mpg (29 km/l) on the highway. The Insight is rated as an ultra low emissions vehicle (ULEV) with a manual transmission, and a super ultra low emissions vehicle (SULEV) with the CVT option.

Driving the Insight
When you start the car, both the gas engine and the electric motor come to life. Normally, the electric drive motor also acts as the starter motor for the gas engine. However, if the battery pack is too low, an auxiliary conventional starter motor starts the engine using the auxiliary battery.

As you begin to accelerate, both the electric motor and the gas engine will be providing power to the wheels of the car. This is also true under other high load conditions, such as climbing a hill. In this situation, the motor is acting as a motor, not a generator.

Conversely, if you are decelerating, the motor acts as a generator to put electricity back into the battery pack. This process creates drag, which is used to assist in slowing the car down. The entire system—recharging the batteries and decelerating the car—is known as "regenerative braking," often shortened to "regen."

While this is happening, the gas engine is also "turned off," in the sense that it is not burning any gasoline. There is a pretty complex set of criteria for determining exactly when the gas engine is shut down, and whether it is a "fuel cut" shut down or an "idle stop" shut down. In general terms, the gas engine only shuts down when the car is coasting, braking, or stopped. There are some other criteria, however, which override those and will keep the engine running even in those conditions. For example, the engine may keep running if the battery pack state of charge is low, if the engine is not yet warmed up, if the air conditioner is operating, or in stop-and-go traffic when you leave it in gear.

When the car is cruising, only the gas engine is driving the wheels. The electric motor acts as a generator, recharging the battery pack as needed. The motor also supplies electricity to the car's accessories via a DC to DC converter to step down the voltage, and a conventional 12 V battery. Eliminating the conventional alternator reduces the load on the engine, leaving more energy free to drive the wheels.

Pros & Cons
So how does the Insight compare to a pure electric such as the Honda EV Plus, or a home conversion? The biggest difference, of course, is fueling. The Insight is fueled in a few minutes by using an ordinary gas pump. A home conversion can be charged from any ordinary outlet, while manufactured EVs like the EV Plus must use a special charging station. However, either of these pure electric vehicles will require several hours to fully recharge once the pack is depleted.

Some people feel gas refueling is "easier" simply because they are used to doing it. And gas stations are common no matter where you go, while access to EV chargers, or even ordinary outlets, is less available when you are away from your home base. On the other hand, pure EV drivers feel that recharging is easier because you can do it at home. You don't have to make a detour or extra stop in your travels, and you don't have to wrestle smelly gas nozzles. Simply plug it in when you get home at night, and unplug it in the morning. So convenience is in the eye of the beholder.

The Insight certainly has either type of pure EV beat for range before refueling or recharging. If you need to drive farther than a pure EV can go, this may be the option for you. It will also outshine conversions for performance and amenities, but the EV Plus can hold its own on both of those counts (if, of course, you are lucky enough to get a lease for one).

The Insight will perform better than a conversion in severe cold as well, since the NiMH batteries are less subject to reduced capacity due to low temperatures than lead-acid batteries. The battery pack costs about the same, although it is much smaller in capacity than the typical lead-acid pack in a conversion. However, since it uses NiMH batteries, and they are never deeply discharged, it is guaranteed for eight years, compared to a four-year cycle life for lead-acid batteries in a conversion. By contrast, the pack of NiMH batteries in the EV Plus costs dozens of times as much, but since it is included in the lease, replacing it is not an issue for the user.

In fact, the biggest drawback to the Insight is not based on economics, performance, or user friendliness. The biggest drawback is environmental. In the end, the Insight is still a gas-powered internal combustion car. The electric system is secondary to the ICE system, not an equal partner. The car is still firmly connected to the petroleum umbilical cord, with all its attendant issues of pollution and unstable supply. This is not creating a new automotive paradigm. It is simply reducing the negative aspects of the existing paradigm.

Whether the Insight is a good thing or a not-so-good thing depends on what you are comparing it to. If you are able to meet your driving needs equally well with either a pure electric car or the Insight, and the deciding factor for you is environmental, the pure electric is the preferred choice.

But as I said at the beginning, in some situations, a pure electric just can't cut the mustard. Perhaps you live off-grid, and can't swing an energy system big enough to power both your house and a car, or you live a long way from anywhere and halfway up a mountain, or your work requires a lot of driving. This is not pure EV country. If your reality dictates choosing between an Insight and a conventional gas car, the Insight is certainly the winner.

Another point is that most American households have more than one car, and one of them is often used only for local driving. If this is your situation, perhaps your local car could be a pure electric, while the Insight could handle your longer range needs.

I have only brushed the surface of the Insight's technology in the space available here. If you are interested in more details, there are a couple of very good Web sites listed below. Next time, we'll look at a slightly different hybrid option in the Toyota Prius.

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Honda America Insight Web site: www.honda2001.com/models/insight

Insight Central, an independent Web site: www.insightcentral.net

EV Tech Talk

Electric Vehicle Battery Layout and Interconnection

Mike Brown

What do you mean when you say, “connect the batteries in a series string,” and how do I do it?

In the last part of my three part series on battery racks and boxes, I briefly mentioned connecting the batteries in series. I also said that it would be nice if the most positive and most negative terminals of the string end up at the place where the cables need to come out of the box. This article will explain the process in detail.

Defining Terms

The place to start is defining the terms “series” and “parallel” as they apply to battery hookup. In a series hookup, the positive post of one battery is connected to the negative post of the next battery, and so on until all the batteries are hooked up. The positive and negative terminals that are at each end of the string are called the most positive and most negative terminals of the string.

The total voltage of a series string is equal to the voltage of an individual battery times the number of batteries in the string. A typical electric vehicle (EV) battery string uses sixteen 6 volt batteries, so the total string voltage is 96 V. The amp-hour capacity of the string is equal to the capacity of one of the batteries in the string.

In a parallel hookup, all the positive terminals in the string of batteries are hooked together and all the negative terminals are hooked together. The total voltage of a parallel string is equal to the voltage of one of the batteries in the string. The amp-hour capacity of the string is equal to the amperage capacity of the individual battery times the number of batteries in the string. In a normal electric car conversion, we need to use a series string of batteries to achieve high enough voltage for highway speeds.

Placement of Terminals

The batteries we use are composed of individual 2 volt (nominal) cells arranged in groups of three in a 6 volt battery, groups of four in an 8 volt battery, or groups of six in a 12 volt battery. The number of cells determines the placement of the battery’s terminals. The 6 volt battery has an odd number of cells (three), and has its terminals on the diagonal corners of the battery. The 8 volt battery and the 12 volt battery have even numbers of cells (four and six respectively), so they have their terminals on the opposite ends of the same side of the battery.

As we discussed in the previous articles, the physical layout of the batteries is pretty much determined by the space available in the car or truck we are converting. Now we have to orient the batteries in the battery box so that their terminals are in the best position to be interconnected in series.

The first thing to determine is which side and which end of the battery box the most positive and most negative battery cables have to exit. The location of the holes in the box for these cables should be at a place that is closest to the next battery box or component that the cables are going to. It is important to avoid long cable runs, partly because of the internal resistance of the cable, but mostly due to the cost of the cable. Make sure that you have room between the battery box and the body of the car for the cables to exit without sharp bends.

Planning on Paper

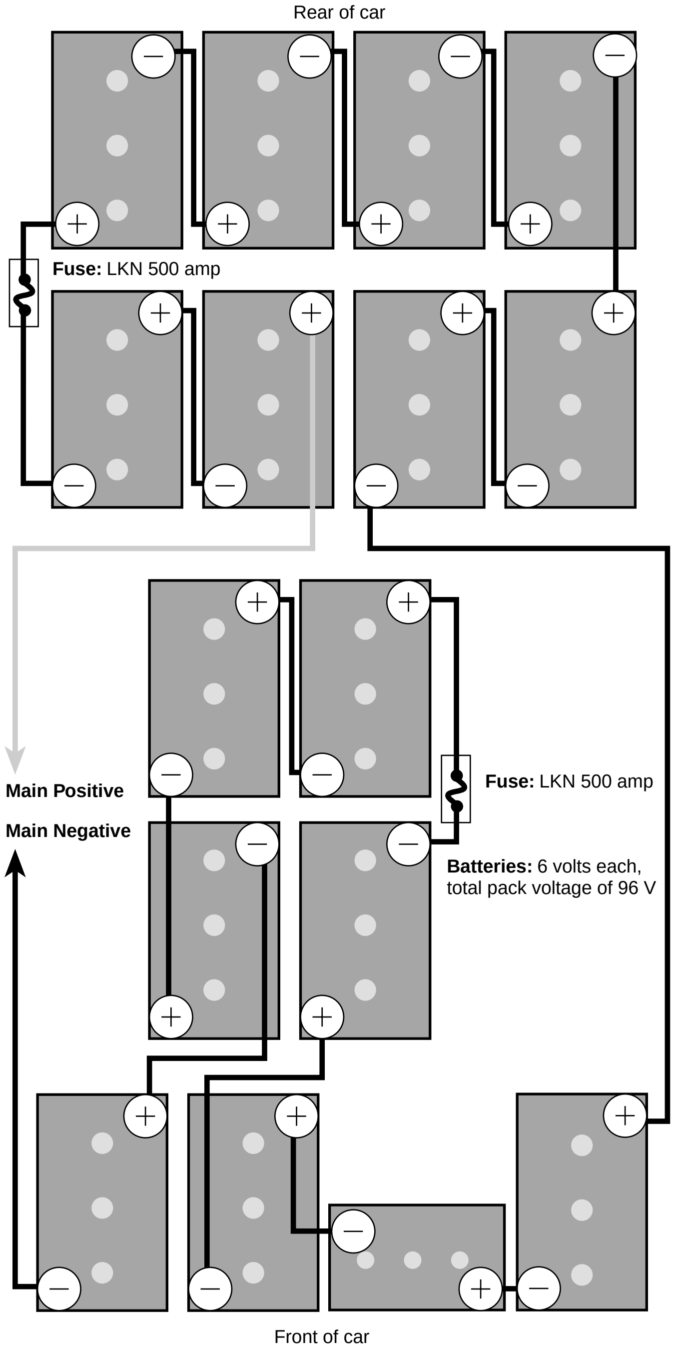
Once the locations of the cable holes have been determined, you can start to arrange the batteries in the series string for that box. Since this is often a trial and error process and batteries are heavy and hard to move, this task should be done on paper.

To make building this paper battery pack easier, I have scale drawings of the batteries we use. There are enough batteries on a sheet to lay out a 144 volt pack of that type of battery. All the terminals and filler holes are shown in their proper location and orientation. If you would like some of these sheets, write or email me. Be sure to tell me which battery you want—6, 8, or 12 volt.

Cut out the individual batteries. Get a piece of paper big enough to hold all the batteries you are going to use, and a stick of removable glue. Now you’re ready to start building your string.

Draw an outline that matches the size and shape of your battery box, so you can see how the paper batteries will fit. Starting with the rear battery box, place the first battery in position with the positive terminal against the side or end of the box that you have chosen for the cables to exit. This positive terminal is the most positive terminal of this battery pack. Use a little glue from the glue stick to hold the paper battery in position.

Voltsrabbit Battery Pack Layout



Install the next battery in the string in its place, with its positive terminal positioned to allow it to be connected to the first battery's negative terminal. It is important that the interconnect—the cable or strap that connects the two battery terminals—doesn't run over the tops of the battery filler caps, interfere with other terminals, or cross over other interconnects. Continue placing the paper batteries in this manner until you have filled the box. The negative terminal of the last battery is the most negative terminal of this battery pack.

Cable Entry and Exit Points
Just as the number of cells in a battery determines where the terminals are on the lid, the number of rows of batteries in a battery pack has an effect on where the most positive and most negative terminals are located in the pack. A single row of batteries hooked up in series will have these terminals at the ends of the row. A long cable running along the top of the batteries or outside the box will be necessary to bring the most negative end of the string out of the pack on the same side or end of the box as the positive end.

Two rows of batteries can be interconnected at the opposite end of the pack. Continue the series hookup so that the most negative terminal is located on the same side of the box as the most positive. The amount of space required for a three or four row box makes them rare, but hooking the rows in series can be done with a little thought and cable.

Work with your paper batteries until you get a layout that suits you. Repeat this process with the remaining boxes. This is the time to pay attention to the placement of the cable holes in the boxes for the most efficient cable run to the next box or component.

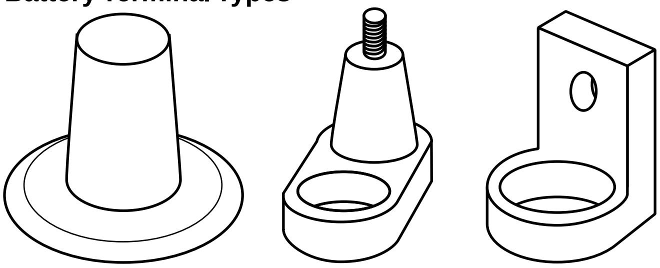
At this point, you have two or three separate battery packs hooked together in a series circuit, with a most positive and most negative terminal for the total combined pack. You will also find that one of these terminals is at the end of the rear pack and the other is at the end of the front pack. I prefer to have the most negative end of the series in the front of the car. This makes a short connection between it and the controller, which is located at that end to be close to the motor.

Which side of the front pack the most negative connection exits from will depend on the exact location of the controller. A little work with the paper batteries should bring these two connections as close to each other as possible. The most positive side of the circuit can then be brought to the front of the car (and to the area of the circuit breaker, main contactor, and controller) by means of a long cable from the rear.

We now have a battery pack laid out on paper. We were careful to position the batteries so that the interconnects between them didn't interfere with other parts of the batteries or each other. We positioned the most positive and most negative terminals of the separate battery packs to minimize the length of cable runs. We brought the most negative battery pack terminal close to the controller. Now it's time to connect these batteries to each other.

Terminal Types
The first step of the interconnection process must be taken before you order the batteries. This is deciding

Battery Terminal Types



which type of terminal you want on the battery. There are three types of terminals available for the golf cart batteries we use: the automotive terminal, the universal terminal, and the "L" terminal.

The automotive terminal is the one that most of us are familiar with—a round tapered post sticking out of the top of the battery. When used with the automotive-style cable end, its large contact surface combined with an almost 360 degree clamping action makes for a good reliable connection. The drawback of the automotive post is the cable end itself. The cable ends for #2/0 (67 mm^2) cable are large and bulky. This makes it very difficult to build an interconnect for two batteries that have their terminals close together. The other problem with automotive-style cable ends is the expense, which is US$4 to $5 each, times twice the number of batteries in your pack.

Another choice, the universal terminal, is an automotive terminal with a 5/16 inch (8 mm) threaded stud sticking vertically out the top of the post. The theory is that a cable can be attached to the battery with an automotive-style cable end (see above) or with a 5/16 inch cable lug over the stud. The cable lug-over-stud method works well in golf carts, where low amp draws permit lightweight #2 (33 mm^2) cable interconnects. This is why ninety percent of the golf cart batteries sold have universal terminals.

However, in the road-going EV where 400 to 500 amp momentary draws are common and heavy #2/0 (67 mm^2) welding cable is used for interconnects, problems arise. The terminal is subject to "cold creep." This is a process by which lead will flow at room temperature while under pressure. This process is accelerated by the heavy cable interconnect, small contact patch (less than one half square inch (3 cm^2)), heat from the high amp draws, and the split-type lock washer used to try to keep the assembly tight.

All of this can result in a loose connection. The lead of the terminal deforms, and the stud creeps upward, relieving the tension on it. If you tighten the nut, the stud pulls out of the terminal a little more, and things get loose again. When a battery connection is left loose, resistance develops, and this causes heat. Under a high amp draw, a lot of heat is generated. The battery post melts, the series string is broken, and the car stops, hopefully without catching fire.

In addition to the loose connection problems, the stud adds 1/4 inch (6 mm) to the overall height of the battery, which could become critical in a tight battery layout.

The third (and best) terminal choice is the L terminal. On this terminal, the 1-1/8 inch (2.9 cm) square base is soldered to the battery post that comes up from the inside of the battery. The vertical arm of the "L" is the same width as the base, and is 1/4 inch (6 mm) thick. It also has a 5/16 inch (8 mm) hole through its center.

This is the type of battery post that I recommend. Its large flat surface allows the entire flat end of the cable lug to make contact with the battery terminal, which leads to less resistance. The horizontal 5/16 inch hole, when used with the nuts and bolts provided with the batteries and some special low-tension washers, makes for battery connections that don't loosen up on their own and cause problems.

Copper Strap

Now we move to a point further along in the conversion. You have bought the batteries, with L terminals, and installed them according to your paper layout. Now you have to build and install the interconnects.

Normally, #2/0 (67 mm^2) welding cable is used for the high current, high voltage traction battery interconnects. With copper lugs properly crimped to the cable, this is very safe and reliable. The drawbacks of the welding cable are bulk (with its insulation, it is 5/8 to 3/4 inches (16–19 mm) in diameter), lack of flexibility in short lengths, and the expense of the cable and lugs necessary to hook up a large number of batteries.

I normally use copper strap to interconnect the batteries in my electric cars. This strap is 1 inch wide by 1/16 inch thick (25 x 1.5 mm). I have a local sheetmetal shop shear copper sheet into the amount of 1 inch strap I need. We have used this on 500 amp, 144 volt EVs under racing conditions, as well as on cars that are driven daily in hilly terrain, with no problems.

Attach the copper to an L terminal in the following manner. Place a 5/16 inch flat washer under the head of the battery bolt. Insert the bolt through the terminal, the copper strap, a low-pressure lock washer called a Belleville washer, and into the battery nut. The result will be a connection with a one square inch (6.4 cm^2) contact area that will not loosen up on its own.

I like the copper strap because the narrow cross-section of the straps greatly reduces their interference with battery holddowns fastened to the bottom of the battery box lids. The only place I don't use the strap as an interconnect is where the batteries to be connected are at different levels, as in the Voltsrabbit's front pack.

Building the Interconnects

Working with the copper is relatively easy because of its softness. It is easily cut and drilled, and it can be bent by hand in a bench vise. To make the interconnects, you first need to make a model out of thin cardboard cut in 1 inch (25 mm) strips. Bend the cardboard into the shape needed, and use the unfolded model to size and mark the bend points on the copper strap.

Cut the copper strap to length, mark the bend points, and drill the 5/16 inch (8 mm) holes in the ends for the battery bolts. At the same time, cut a piece of 3/4 inch (19 mm) diameter shrink tubing long enough to cover the entire copper strap, not including the ends, where it makes contact with the battery terminals. I have found it easier to slip the shrink tubing over the copper strap before making the final bend. Use a heat gun to shrink the shrink tubing after the interconnect is bent to its finished shape.

You will find that the interconnects come in four or five shapes, and that you will use several of the same one or two shapes in each battery pack. Find out how many of each interconnect you need for the whole car, and make them all in one production run.

While you are making interconnects, be sure to make one fused interconnect for each separate battery pack. To do this, I take an interconnect and cut out a section from the middle that's the same length as the fusible link. I mount the link—a 500 amp time delay fuse—in between the ends with nuts and bolts, and include a 1/4 inch (6 mm) Bakelite block behind the link to give it some extra support. Be sure that the copper strap and the fusible link ends are in direct contact, and that the Bakelite block is behind them both, not between them. This little addition to the system can save you from disaster in case of a short.

Cable Connections

The #2/0 (67 mm^2) cables that connect the separate battery boxes to each other, and connect the battery pack to the drive components, need some special attention. These cables should be secured to each other and the chassis at regular intervals. They should not, however, be pulled tightly over a sharp edge or be allowed to move slightly against a flat piece of the body. Over time, the insulation would wear through, causing a problem.

The two cables that run from the rear battery pack of the car to the front pack should be held tightly together so that their electrical fields cancel each other out. This eliminates a source of electrical noise that might cause problems with other parts of the car. We tape the two cables together into one bundle, along with several small gauge wires that also need to get from the back of the car to the front.

Then, because the bundle has to run under the car, we run it through a piece of 1-1/2 inch (38 mm) diameter spa tube long enough to cover the wire bundle where it is exposed to the road. This is flexible PVC tubing available at sprinkler supply houses, used to plumb spas. The tube assembly is held to the chassis by brackets and hose clamps. The spa tube is not necessary if the cables and wires can be run through a protected space in the chassis of the car. Bundling them together is still a good idea for ease of handling and neatness.

This is my fourth and last article explaining the steps needed to install and hook up the batteries, when converting a gas or diesel car or truck to electric power. I hope I have given a clear picture of how it is done. If you have further questions, or would like more explanation of some of the points, feel free to contact me.

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Wŏrd Pow´ẽr

Renewable Energy Terms

Circuit—Electrical Path

Ian Woofenden

Derivation: From Latin circumire, *to go around.*

The derivation of this electrical term says it all. To be a circuit, it has to "go around." Moving electrons do the work in what we call "electricity." But they aren't moving from point A (battery or utility power station) to point B (your loads) and stopping or being "used up." They are moving in a circle through the source, to the load, and back to where they started again. (Yes, techies, I'm glossing over the distinction between DC and AC. Stay tuned.)

To have an operable circuit, there needs to be not only a path from the energy source to the load, but a path from the load back to the source. Think of a circuit as a conveyor belt or a bicycle chain, moving the electrons that are part of the copper or aluminum conductor around and around in a big circle. Push the chain forward at any point, and the whole thing will start moving.

An even better analogy for a circuit is blood flow in the body. The heart is like a battery or generator, and blood is like electrons being pumped around a complete circuit, doing the work of keeping the body cleaned and oxygenated on the way.

One simple circuit uses a flashlight battery, two wires, and a flashlight bulb. Connect a wire from the positive end of the battery to the positive terminal on the bulb. Then run another wire from the negative terminal (usually the outer case) of the bulb to the negative end of the battery. You now have a complete circuit, and if there is energy stored in the battery, the bulb will light up. The electrochemical energy in the battery pushes electrons in the wires around the loop.

If you disconnect one of the wires anywhere in this circuit, you'll have what we call an "open circuit." The electrons can't flow, and the light bulb will go out. This is exactly what you do whenever you turn off a light switch in your house. You are opening the circuit, which makes it impossible for electrons to flow.

Now imagine another scenario with our battery setup. Take the bulb out of the circuit, and connect the two wires that you removed from the bulb to each other. You now have a direct loop from the battery's positive end to its negative end. This is called a "short circuit" (or "short").

I like to think of a load (the bulb in this case) as a valve that regulates the flow of electrons. Each load allows electrons to pass at a certain rate (we call it amperage). But if there is no load in the circuit, the only limitation on electron flow is the resistance of the wire and the voltage of the source. So all the energy in the battery tries to flow through the wires in a hurry. This often results in melted wires (or a fire burning your house down) and then an open circuit, or a fuse or breaker opening the circuit.

Some basic principles govern circuits. Key among them are Kirchoff's Laws. They state two key things: The voltage drops in a circuit are equal to the supply voltage, and for every electron that enters a part of the circuit, one electron leaves that part of the circuit. The electrons flowing around the circuit do not build up anywhere. It's like water in a hose—you cannot compress the water.

Voltage is similar to pressure. In your garden hose, some pressure is lost to the friction in the hose and to running the oscillating device in your sprinkler. Wires have some resistance too, and this reduces the voltage. Loads also present resistance to the source voltage. All the resistances in the electrical circuit make voltage drops, and these voltage drops will add up to the input voltage.

Unlike your garden hose, an electrical circuit is a closed system. And electrons are not exactly like water. You won't be spilling electrons out on the floor if you cut open your lamp cord and hold it up to drain. As Kirchoff's Laws state—electron in; electron out.

It's important to understand that the generator and battery are not *making* electrons. The electrons (charged particles) are already in the material of the wire. The generator and battery are just pumping the electrons through the circuit. Also, the load is not "using up" the electrons. They are doing work as they pass through the load, but just as many come out as go in.

There are different types of circuits, and I'll be talking about them in upcoming columns. But they all have to allow electrons to flow in a complete loop. From simple flashlight circuits to complex industrial wiring plans, it all boils down to electrons "going around."

Access

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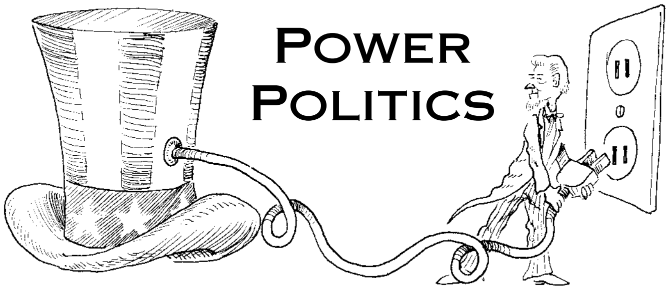

New Department of Energy

Michael Welch

The elections are over, and from the renewable energy (RE) and environmental perspectives, the worse of two evils has definitely become president. I reflect on the part that the Green Party, Ralph Nader, I, and many others may have played in this result.

Did Ralph Nader's votes cause Al Gore to lose the election? The Nader campaign says it was Gore's own fault. While the Democrats were placing blame for their upset outside their own ranks, the Nader campaign was pointing at their poorly run campaign. Nader said that Gore entered the election with "every advantage against a marginal, ill-equipped, and corporate-dominated Texas governor." He continued, "Yet, the Vice President mismanaged his campaign into a deadlock with Bush, and now he has only himself to blame for the Democratic fiasco."

Lack of enthusiasm in the Democratic base hurt the Gore campaign. The abandonment of progressive issues and the failure to address issues important to the public, like renewable energy, corporate crime, WTO-NAFTA, election finance reform, the drug war, and universal health insurance, contributed to the feeling that voting for Gore meant nothing to them.

According to Nader, "In the end, Al Gore made his appeal on one major campaign pitch—that he was not George W. Bush." "That simply was not enough to bring millions of stay-at-home voters to the polls."

Nader supporters wanted to vote for someone they believed in. Also, if Gore lost, or won by only a narrow margin, it might provide a much-needed wake-up call for the Democrats to get back to their progressive roots. And if Bush won, they hoped that a four-year term of blatant corporate and right-wing support would create a backlash that would propel the environment, and social and economic justice, into the forefront of U.S. politics.

Time will tell, but already there have been demonstrations in the streets and a small resurgence of volunteers, memberships, and donations for environmental non-profit organizations.

Bush DOE Appointee

We are now stuck with a very unpalatable political situation, including the changes that could happen in the U.S. Department of Energy. Spencer Abraham is our new U.S. Secretary of Energy. Between him and his boss, George Bush, things aren't looking up for our energy future.

"What qualifications does Abraham have for this position?" has been a question asked over and over in recent weeks. His visible qualifications include being recently defeated in a race for Michigan Senator, co-chair of the National Republican Campaign Committee, deputy chief of staff to VP Dan Quayle, and one term in the Senate, where he acquired a radically right-wing voting record. In other words, he is not qualified based on any energy background.

His power in his party is huge, and his support among Bush corporate sponsors is solid. After losing the Senate race, he set his sights on an administration position. The Bush transition team had to give him something, and after doling out the other positions, the only thing left in the upper level cabinet was energy secretary. It looks like we are stuck with him, and there was very little fight over his nomination. Folks had no smoking gun that could block his appointment, and most of the media attention was focused on other appointments, especially attorney general nominee John Ashcroft.

It is odd that nobody sees the need to have an energy secretary with experience in the energy field. Pundits are saying it is enough to have someone with the management skills to handle a large department. Not even environmentalists or RE supporters are saying he can't do the job.

Anti-Environment

Abraham's environmental record is horrible. Though he hasn't had a lot of chances to deal with energy issues, he has been against funding for RE, against better mileage standards for vehicles, and in favor of gutting standards for the storage of nuclear waste. His lifetime League of Conservation Voters (LCV) record is a dismal 6 percent, and more recently, 0 percent. He made the LCV's "dirty dozen" list of candidates with the worst of environmental records, whose races should be strongly opposed.

Abraham is a founding member of the radical right Federalist Society, which is dedicated to rolling back federal laws protecting environment, natural resources, public health, civil rights, occupational health and safety, and labor rights. He was also a sponsor of a bill that would have entirely eliminated the agency he now heads. But now the Bush administration states that the energy issues facing our country are important, and that Abraham no longer wants to kill the DOE.

Pro-Corporate

Abraham's love for the auto industry is very troubling, and they really like him too. In a *Washington Post* article, Debbie Dingell, president of the General Motors Foundation, said, "He understands the energy issues more than people think." "When you come from Michigan, you pay attention to these things," Dingell said.

Of course, understanding energy issues from the corporate auto industry viewpoint is a lot different than from the common citizen's viewpoint. It was exactly that difference that caused him to lose his U.S. Senate race in Michigan. A last minute campaign to publicly expose the truth about his environmental record is what did him in. That loss freed him up to become available for the secretary of energy position.

The Edison Electric Institute, an association of utility companies, is also happy with his appointment. With Abraham's record of corporate support, no big companies or their lobbyists seem displeased. I guess there are a few blessings to be counted. It is a good thing he wasn't appointed to the transportation secretary position. Imagine the damage he could do on behalf of the auto industry in that department.

Arctic National Wildlife Refuge

Many are afraid of the energy policy that Abraham will want to implement. Bush, his boss, has made it very clear that he wants to open up the Arctic National Wildlife Refuge (ANWR) to oil and gas exploration. This is the one of the biggest issues that mainstream environmental groups are focusing on.

Abraham has voted against the refuge's sanctity in the past. And this is what he had to say in early January about opening the refuge, "We have vast resources within the United States, and these are crucial to our country's security." He believes we can open the ANWR to oil and gas exploration, "while meeting our responsibilities as good stewards of the land, the air, and the water." Yeah, right.

But it may be difficult for the Bush administration to open up ANWR. In the final days of the Clinton administration, environmental groups put a lot of pressure on Clinton to further protect ANWR by executive order. But Clinton would not do it, saying that the protections already enacted by Congress were more powerful than what he could do by executive order. According to the Clinton administration, it would take a further act of Congress to allow drilling, and the Congressional balance of power may not allow such a bill to pass.

California's Crisis

The other issue that is knocking at the door of the new DOE is the reliability of our country's electricity supply—particularly in California. Bush has made it clear that he does not want to intervene any further, and that it is actually California's problem to solve. On the other hand, Abraham and Bush agreed to extend emergency orders for an additional two weeks until February 7. They agreed on the extension based on Governor Gray Davis' promise that that would be all that was necessary. (For more info on the California energy crisis, see *Ozonal Notes, From Us to You,* and *IPP* in this issue.)

Bush and Abraham did recognize that California's local problem is affecting the whole nation, and that it may not be localized for long. California is not the only state to be lagging in power plant construction, and not the only one slated for utility restructuring. The Bush administration wants more power plants, and has hinted that it may be willing to relax environmental standards so that plants can be licensed and built more easily and quickly. One thing is for sure—it would take a miracle for the Bush administration to push for RE as the best answer for developing new power plants.

In the meantime, activists in the RE world and environmental movement are gearing up, forming coalitions, and getting ready to incorporate the public backlash that many are predicting. Between the California energy "crisis" and ultra-conservatives taking over the White House in a barely legal coup, the environment, energy conservation and efficiency, and renewable energy may get a solid boost after all.

Access

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Don Loweburg

End of the Independent Installer?

Alas, it has been reported that the end of the independent renewable energy (RE) installer is near. At least this is what I've been told by some of my PV industry colleagues. They delivered this message with conviction and earnestness, and I don't consider it an attack. Of course, they are wrong.

In order to understand their point of view, I must put myself in their shoes. Generally, they are looking at photovoltaics (PV) and our goal for a renewable future from an institutional and programmatic perspective. They think in terms of megawatts. They think in terms of PV rooftops on entire tracts of housing. They think in terms of skyscrapers and building-integrated PV (BIPV). I truly support this vision. But this is not the only game in town.

Just as there are companies that build skyscrapers and large subdivisions, there are also custom builders who are building fine homes and doing remodels. I don't think the market for custom homes will disappear because of a boom in the mass housing market. In fact, the desire for choice and individuality in the face of mass uniformity is often a driver for custom products. Mass PV programs often offer little choice—one or two choices in module technology and appearance, for instance. Standardized rooftop mounting is often the only choice with the mass-market approach.

System capacity is often limited. "Sir, will it be the 2 KW system or the 5 KW system?" The independent PV system designer-installer offers choices. Of course, presenting choices takes more skill than doing cookie-cutter systems. Economies of scale can suffer a bit. But this is generally understood when a customer chooses a custom product. So I really don't think that the independent installer is finished.

Keeping the Edge

Most professional installer-dealers I know did not "go get a job" in PV. They created their own job from scratch, based on their own vision and energy. This is the main reason why PV professionals don't need to worry about being put out of a job by mass programs. We recreate our jobs every day.

All of us have grown with the technology. Often, from our own experience living with and using PV in our daily lives, we have a depth of understanding, not just of the technology, but also of energy efficiency and good design. We routinely do load audits and help our customers understand where their electricity is going. None of this occurs for customers who participate in the mass-market PV programs. On the contrary, these programs speak of the "number of roofs" installed per week and reward managers for reducing labor costs, or as I have heard, "squeezing the turnip."

California Utilities Crash & Burn

There is no doubt that real turmoil exists in California. In the first week of January, the California Public Utilities Commission raised rates 9 percent, though the utilities wanted 30 percent (and may get it). California's Governor Gray Davis met in Washington D.C. with President Clinton and Federal Reserve chairman Greenspan. On the heels of Governor Davis' return, Greenspan made an unexpected 1/2 percent interest rate reduction, which will reduce the cost of borrowing money. This generally helps a slowing economy, but this rate reduction is a special gift to California's investor owned utilities (IOUs), which are borrowing heavily.

A few days later, Southern California Edison announced a layoff of 1,400 workers, and the possibility of bankruptcy. On talk radio, it's the "who to blame" game. Is it the IOUs, the politicians who voted for deregulation, or the greedy independent generators? We know who the losers are—ratepayer-taxpayers (the public). We know who the fixers are—the commanders of the respective national, state, and financial dominions.

Who are the winners? They are the unregulated utility holding companies who have made record profits this last year. Bold headlines in the January 16th *San Francisco Chronicle* proclaim, "Stealthy Deal Protects Profits of PG&E's Parent." Like a masterful shell game con, enormous wealth has been transferred from the regulated IOUs and ratepayers to the utility holding companies—and few have noticed!

Regulated IOUs, the bastard spawn of capitalism and socialism, the invention of early 20th century robber barons designed to thwart the early public power movement, are no longer needed! Many would propose that we somehow stumbled into deregulation through a series of "mistakes." I would counter that we are going exactly in the direction charted by the unregulated energy holding companies. Never has there been a better case for independent power!

Grabbing for Crumbs

The recent passage of SB1194 in California (discussed in *IPP, HP81)* has provided additional publicly funded support for renewables. The California Energy Commission (CEC) was designated the program administrator, and charged with designing the details of the program and its funding distribution. As part of that process, the CEC invited stakeholders to provide input last November. IPP, CALSEIA, and several other groups provided written and verbal comments to the Commission requesting desired program features.

Included in those proposals were increased buydown support, low interest financing, increased consumer education about the PV option, programs to install PV on public buildings, elimination of sales tax, and other tax benefits. I hope that by next issue we will have some positive results to report.

The product of that process, the *Draft Investment Plan for Emerging Renewables,* was recently circulated by the California Energy Commission. The fact that few of our recommendations were adopted is a matter of deep concern. On top of that, within the draft plan were two unrequested and extremely alarming proposals by the commission. They are IOU (regulated utilities) participation and eligibility for PV buydown dollars, and the classification of natural gas (non-renewable) fuel cells as renewable and therefore eligible for support.

The commission proposed that because biogas (renewable) fuel cells are eligible for support, and since natural gas fuel cells have no greater emissions of selected pollutants (NO_x and SO_x) than biogas fuel cells, they should be classified as renewable. This analysis completely ignores the fact that the CO_2 emitted from the fossil fuel powered fuel cell is a net plus while the CO_2 load from a renewable source is neutral. Natural gas is not a renewable fuel! The poor (non-existent) logic of their convoluted rationale indicates that the commission intends to completely disregard the wishes of the legislature and the public.

Concerning the matter of IOU eligibility for PV buydown support, the commission made no explanation whatsoever. These two proposed changes are either a bold attempt to abrogate the intentions of the legislature, or symptoms of intellectual dysfunction. IPP plans to oppose these changes and expects to be joined by CALSEIA and other parties.

Are They Listening?

The sale of Trace Engineering to Xantrex was discussed in *HP80,* and some questions were posed about the future of Trace. One positive sign was a public statement by Xantrex that they were committed to a value added, knowledge-based system of distributing their products.

As a continuation and re-enforcement of that early goal, a recent Xantrex press release stated that they will be conducting "focus groups." The purpose of these groups will be to generate input from people with field experience installing Trace inverters. The first group met in Sacramento, California in early February 2001. Xantrex plans similar group meetings in various parts of the country during the next year. This should be a valuable opportunity for both wrenches and Xantrex. Product improvements on the wrenches' wish list include a standard five-year warranty and non-volatile programming memory.

There has been some angst regarding the future direction of Xantrex. These gestures (coupled with action) help dispel that. Though fuel cells may well be a significant future application for Xantrex technology, it's good to know that Xantrex is making a significant commitment to renewable energy applications today. PV is a reality, while small-sized fuel cells exist as prototypes only.

Anyone for ICE-T?

Over the years, we have documented the struggle to get PV and renewables connected to the grid. Subjects such as net metering and interconnection standards for inverters have been discussed many times and will continue to appear here. There is certainly much still to be accomplished. Though the PV industry is proud of its accomplishments—net metering laws in over thirty states and a recognized interconnection standard for small inverters (IEEE929)—these successes are limited.

For example, in many states, net metering is allowed only for systems under 10,000 watts. Language in many net metering laws limits total PV capacity. In California, it cannot exceed one-tenth of one percent of total utility capacity. Inverters are required to be installed with redundant physical disconnect switches, though this requirement is unnecessary with modern inverters.

Compromises such as these were necessary. PV proponents constantly had to play small and compromise in order to achieve initial success. Each achievement could be used as a platform for the next round. So, for instance, in California, we have had a succession of net metering laws, the latest of which allows for time-of-use valuation. In California, we are poised at a major step toward getting more PV on the grid.

In past issues, we have discussed the ongoing California Public Utilities Commission "Order Instituting Rulemaking and Distributed Generation." As part of these proceedings, the PV industry has made a proposal called the Independent Clean Energy Tariff (ICE-T). The proposal would eliminate all standby charges, exit fees, or any other extra charges for systems of up to 1 megawatt. Though not net metering, ICE-T would allow a power sales contract with an energy service provider.

In order to engage in power sales, fair rate schedules for distribution wheeling (transporting power between two points) must be established. This is another element in the ICE-T proposal. ICE-T has broad support by consumer advocates, environmental organizations, and the PV industry. I am the contact person for ICE-T, acting on behalf of IPP. The opposition? The three regulated utilities—PG&E, SCE, and SDG&E. If ICE-T is adopted in California, the economic possibilities for grid-connected PV will be greatly improved.

Corporate Shuffle

On January 16, 2001, Schott Corporation announced its purchase of Applied Power Corporation. Applied Power, previously owned by Idaho Power, is the parent company for three companies purchased last year—Alternative Energy Engineering (AEE), Solar Electric Specialties (SES), and Ascension Technology. Schott Corporation is the North American headquarters for the Schott Group in Germany. Schott Corporation manufactures specialty glass and related products. Sam Vanderhoof (previously of Trace Engineering) has been named president of Schott Applied Power Corporation.

The fusion of Schott's glass technology with Applied Power's marketing and renewable energy engineering capability suggests the creation of an integrated module manufacturer, systems distribution, and renewable energy service company. It is not much of a leap to wonder if Schott's glass expertise will be applied to PV module manufacturing. Companies like Schott, Kyocera, and Siemens represent an independent breed of vertically integrated international PV company. They may provide a competitive counterbalance to the traditional energy companies like oil and utilities that have also acquired PV manufacturing and distribution capabilities in recent years.

Last fall (announced October 16), Real Goods merged with Gaiam, a Lifestyle of Health and Sustainability (LOHAS) company. Gaiam markets to what they call "cultural creatives." Quoting the press release, "Gaiam intends to consolidate a majority of Real Goods' operations into its established infrastructure and leverage Gaiam's operational efficiencies and proprietary products, while maintaining the Real Goods brand name and mission."

Interestingly, Gaiam also owns Jade Mountain. This is a significant consolidation of two one-time competitors in the internet/catalog sales arena. I suspect both companies will shift emphasis away from energy systems towards the consciousness-widget type product.

The MUNIs and PV

In *IPP, HP80,* I made some comments about the Sacramento Municipal Utility District (SMUD) PV program. It was noted that SMUD is going into the PV business and marketing their systems outside their district boundaries. Because they offer the lowest-priced PV systems in the country, many dealers and some manufacturers are concerned. Put simply, the contention is that SMUD may be engaging in unfair, anti-competitive practices.

Vince Schwent of SMUD recently made a presentation on their PV program to the California PV Alliance. He firmly asserted that SMUD would not use "public goods" funding to subsidize out-of-district sales. Vince also assured the audience that SMUD would build profit into the pricing of its systems. A stated goal of the program was to make "PV sales a self-sustaining business for SMUD."

Many in the audience left the meeting without much change in their level of concern. The fundamental question is, should a public agency be engaged in the for-profit market? A public power agency is formed for a specific purpose. In this case, it is to deliver power to the citizens of the district. Going into business selling PV outside the district is another thing. If PV, why not other products? I suggest that we have a misuse of public authority.

There are two reasons that this might not go anywhere. First, the SMUD product may not make it in the greater marketplace. In fact, one reason SMUD may be pushing its product outside the district is that they are not making the required sales volume internally. SMUD is using a relatively inefficient thin-film module that has about twice the weight per square foot of high-efficiency crystalline products. On the roof, this translates to twice the area and four times the roof load per unit of power delivered. Maybe low cost is not the only issue here?

Second, the voters of SMUD may have questions and reservations about this activity. Does it really serve their interests? On a practical level, this will only become a hot issue when SMUD starts doing volume sales outside the district. We are not there yet. If it comes to that, I'm sure better legal minds than mine will be scrutinizing this issue.

Los Angeles Water and Power (LAWP), also a public power agency, has a PV program that began about a year ago. Though not fully up to speed, this program will take off next year when a US$5 per watt rebate becomes available. LAWP's program avoids the problems of SMUD by using a simple rebate program similar to California's Emerging Renewables Buydown. Currently the rebate is US$3 per watt. The higher rebate is offered for modules manufactured in Los Angeles. Siemens is currently building a plant there.

LAWP apparently does have one problem. They are not complying with the net metering law. I've received information from a reputable source that LAWP has an insurance requirement that is different from the legal requirement. The law states that a customer shall not be required to obtain additional homeowner's insurance. LAWP is requiring a certain level of insurance, and that the customer name LAWP as an additional insured. Both these requirements go beyond what the law requires.

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Real Goods-Gaiam merger
www.gaiam.com/gaiam/0,1267,Press:learn:item:10,00.html

Schott Glass-Applied Power purchase, www.schottglass.com, search for "Applied Power"

Rolling blackouts; Lots of coverage and good analysis in the *San Francisco Chronicle* • www.sfgate.com, search for "energy" or "rolling blackout"

California Energy Commission, Draft "Investing in Renewable Electricity Generation in California," Marwan Masri, Manager, Renewable Energy Program, California Energy Commission, 1516 Ninth St., MS-45, Sacramento, CA 95814 • 916-654-4531
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Buying Safe Cables

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

Photovoltaic (PV) modules will supply energy for thirty years or more when illuminated by the sun. Cables and conductors used in PV systems need to be able to carry that PV-supplied energy safely for thirty years or more without deterioration.

Numerous types of conductors, wire, and cables are widely available from a number of sources with a bewildering array of labels and prices. How do we determine that a particular cable is safe for use in a particular application, and that it will remain safe over the many years that our renewable energy systems will be producing energy?

In previous *Code Corner* columns, we have covered the conductor type markings (USE-2, NM, RHW-2, THW, etc.) required on cables to be used in various locations in a PV system. We have discussed the environmental conditions that require type markings for conditions such as exposure to sunlight, temperatures, and moisture.

Unfortunately, there are many sources of electrical cables that do not have these markings. These include auto parts stores, hardware stores, building supply stores, and welding supply shops, among others. Many of these cables do not have any marks or labeling that ensure that they have been tested and evaluated for safety in any application.

To ensure the greatest probability of buying and using safe, durable conductors that meet the requirements of the *National Electrical Code (NEC),* you should look for cables that have at least the following markings or labels. First, the type marking (USE-2, RHW-2, THWN-2, etc.) should be on the cable, and that type marking should be appropriate for the particular application, such as module interconnections or battery-to-inverter cables.

The second mark should be the mark of a nationally recognized testing laboratory such as UL (Underwriters Laboratories). This indicates that the cable has undergone extensive testing for the application, and has been "listed" for compliance with the appropriate UL standard for that type of cable. The *NEC* requires that all equipment used in electrical systems be listed. UL is the only laboratory that is recognized and accepted throughout the United States for testing and marking cables. Note that cables bearing the CSA (Canadian) or CE (European) marks must also have the UL mark to comply with U.S. requirements.

UL Standards for Cables

Underwriters Laboratory has two major functions in the electrical energy industry in the United States. The first function is to write, coordinate, and publish safety standards. The second function is to test and evaluate materials and equipment against those standards. A safety standard is a document that details all of the tests and the results of those tests that a particular type of cable must meet before it can be listed as complying with the standard.

For example, UL Standard 44 for "rubber-insulated wires and cables" was first published in 1917, and has had fifteen major revisions since then. The latest edition was published in 1999 and is now titled "Thermoset-Insulated Wires and Cables." This standard covers conductor types such as RHW, THW, XHHW-2, and similar cables that are acceptable for use as battery cables in a PV system. Numerous companies and other agencies that design, manufacture, sell, install, and inspect cables are involved in keeping the standard current.

This standard is more than seventy pages long and is updated periodically. It is completely revised every few years as the technologies for making, using, and testing cables change. In addition to requirements on what types of rubber and synthetic rubber are required to make the cables, numerous tests are included in the standard. These tests are used to verify the quality, durability, and safety of the cables.

Each UL standard references other UL standards that must also be met. For cables, there are additional standards that establish requirements for the insulation material and the copper used in cables. Here are some of the basic tests, each of which is spelled out in specific detail in the standard:

- Dielectric voltage—withstand test in water
- Insulation resistance in water at rated temperature
- Insulation tests in air at rated temperature
- Alternative spark testing
- Mechanical water absorption test

- Capacitance and specific inductive capacity tests
- Tests for stability factor
- Cold-bend test
- Deformation test
- Crushing tests
- Dielectric breakdown after glancing impact
- Dielectric breakdown after scoring
- Horizontal-specimen flame test
- Vertical wire flame test
- Sunlight-resistance test (tray cables)
- Oil resistance
- Gasoline resistance

The standard details each test, how it will be conducted, and what results are required for passing.

In *HP80,* a report was presented on testing welding cable for acid resistance. Since all rubber and plastic insulated conductors are considered to be inherently acid-resistant in electrical applications, no test is specified for acid resistance in the UL standard. The inadvertent inclusion of the term "acid-resistant" in Section 690-74 in the 1996 *NEC* was corrected in the 1999 *NEC,* and this term no longer appears.

Testing to the Standard
The standard is used by nationally recognized testing laboratories to test the cables. UL at the present time is the only laboratory testing, listing, and labeling cables used in electrical power systems complying with the *NEC.* This is the second function that UL has with respect to cable markings.

A nationally recognized testing laboratory is one that has gone through a lengthy evaluation process conducted by special certification agencies that ensure that the lab has sufficient personnel with the appropriate educational backgrounds and experience, and sufficient test and evaluation equipment to properly perform the required tests. Test equipment must be calibrated against calibration standards directly traceable to the National Institute of Standards and Technology (previously, the National Bureau of Standards).

A cable is submitted to UL for testing against the standard. UL tests the cable, and, if it passes all of the tests in the standard, UL allows the manufacturer to use the UL mark (the letters "UL" in a circle) on the cable indicating that it is a listed product. UL also visits the manufacturer's facility and determines that the equipment and processes used to make the cable are of sufficient quality and consistency to ensure that each production run of the cable has uniform properties (meets the standard).

However, the testing does not end there. Any time there is a change in the materials used in the cable, or in the way in which the cable is made, the manufacturer must notify UL and resubmit the modified cable for evaluation and possible retesting.

Every three months, UL visits the cable manufacturer as part of their followup service. They verify that the materials and production processes are still producing the same cable that was originally tested. UL may pull random samples of cable from the production line or the warehouse and retest them at any point.

To further establish the continuing quality of any listed cable in this highly competitive industry, other cable manufacturers test samples of their competitors' cables, and protest to UL if the listed cables do not meet the standard in any way.

Make an Informed Decision
Yes, you can purchase unmarked or improperly marked wires and cables at electronic stores, hardware stores, the welding shop, and auto supply stores. They may work quite well in a PV system. But then again, they may not.

How are you to know that a piece of unmarked (no type mark, no listing mark) cable x that you bought yesterday will perform the same as a similar piece of unmarked cable that you bought at the same store a year ago? Is cable x bought in Arizona the same as cable x bought in California? Will either of these cables withstand the test of time? Did the manufacturer cut costs by making the insulation a little thinner? Did the manufacturer change insulation materials to a type that might save a few pennies, but might crack or catch on fire more easily? Were costs reduced by accepting copper with more impurities that might become brittle or have a higher resistance?

The use of a properly type-marked, UL-listed cable ensures that most of these uncertainties are eliminated. With reliable PV modules producing electricity for thirty or more years, it seems prudent to buy cables that have been thoroughly examined and tested by trained, experienced personnel. The system installer and owner will then not have to worry about the uncertainties of using unmarked cables.

Questions or Comments?
If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC,* feel free to call, fax, email, or write me. 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-FC04-00AL66794. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

Access

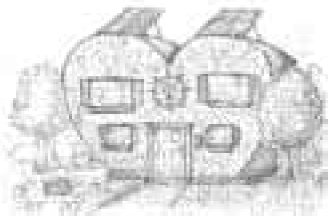
John C. Wiles, Southwest Technology Development Institute, New Mexico State University, Box 30,001/ MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 Fax: 505-646-3841 • jwiles@nmsu.edu www.nmsu.edu/~tdi

Sponsor: Sandia National Laboratories, Ward Bower, Department 6218, MS 0753, Albuquerque, NM 87185 505-844-5206 • Fax: 505-844-6541 wibower@sandia.gov • www.sandia.gov/pv

National Electrical Code® and *NEC*® are registered trademarks of the National Fire Protection Association. The 1999 *NEC* and the *NEC Handbook* are available from the NFPA, 11 Tracy Dr., Avon, MA 02322 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org

Underwriters Laboratories, 333 Pfingsten Rd., Northbrook, IL 60062 • 847-272-8800 Fax: 847-272-8129 • northbrook@us.ul.com www.ul.com

Home & Heart



Kathleen Jarschke-Schultze

A couple of years ago, Bob-O and I bought the house and land next door at a tax auction. In our usual style, a series of coincidences happened that led to the knowledge of the auction only a week and a half before the sale.

The last tenants had moved on before the sale. We gave them over a year to come and get their stuff from the house. They eventually came back, got a few things, and split. They left us a lot of trash and two dead vehicles. Cleanup has been slow. I cleaned out the kitchen and started making soap in there. After my first attempt at soapmaking in our kitchen, when I accidentally spilled musk essential oil on the counter and could not remove the smell, Bob-O vetoed any further soapmaking activities there.

Since there is no power or water system at the other house yet, cleaning opportunities are inhibited somewhat. I need water more than I need electricity. But I also can't haul my vacuum cleaner over there to clean up the accumulated dust, dirt, and crud.

I Found It!

While in town the other day, I was cruising the local secondhand stores, exercising my lively sense of thrift. I came across a small cordless vacuum cleaner. It was a Eureka brand vacuum—The Boss Lite—a black cordless broom with no attachments. It stood 48 inches (122 cm) tall and sported a motor-driven brush roll on the business end. A small sticker on it proclaimed, "$6. Works." This seemed to me to be ideal for my purposes. I envisioned charging it at home and using it at the other house.

The unit came with a plastic holder that attaches to the wall to hold the vacuum when not in use. When you place the vacuum in the holder, it automatically plugs the unit into a battery charger. The only way to not engage the charger is to unplug the wall cube transformer at the outlet.

When I got home, I tried out the vacuum. Its performance was anemic. I put it on the charger and left it for 24 hours. I tried it again. Same lack of suction. I figured I was out six bucks and had learned not to trust little tags that say, "Works."

Bob-O came home from a trip that had kept him away for several days. "What's that?" he queried, seeing the vacuum cleaner leaning against the wall. I told him about my deal that wasn't such a good deal. He looked it over and found a small sticker with a recycling symbol that said, "Contains nickel-cadmium batteries. Must be recycled or disposed of properly and in an environmentally safe manner. May not be disposed of in a municipal waste. For information, call 1-800-282-2886."

Bad Memory

"That's your problem," he said, "It's got NiCds. They have what is called 'memory effect.' If they are not discharged completely before recharging, the battery thinks it can only charge so much." The drawback of this model is that after taking it off the wall hanger/charger and using it for a short time, it would be replaced on the hanger/charger and the batteries would be recharged, remembering only shallow use. Voila! Built-in obsolescence—call it Dustbuster syndrome.

The owner's manual may have warned against this, but no manual was with the unit when I bought it. And from the condition of the batteries, it was apparent that the previous owner had ignored any instructions about charging.

Bob-O suggested that I take the vacuum apart and give him the battery pack. I really get high enjoyment from taking things apart and assembling them. Whenever we buy anything that needs assembly, I do it. Barrister bookcases, gas barbecue, chipper/shredder, bathroom cabinets, trimmer/mower—I have assembled them all.

Zen in a Vacuum

There is something so gratifying about sitting down with instructions and tools and completing a project. I find it very relaxing and Zen. Taking things apart is almost as good. The difference is that there are no instructions, and you must remember the dismantling order and where all the bolts and screws go. Not quite as relaxing and Zen, but more adventurous.

I got regular and phillips-head screwdrivers and a cup for the screws, and began. The vacuum cleaner was like a puzzle. I wanted to dismantle the unit as little as possible, since there would be a lapse of time between taking it apart and re-assembling it. However, every removed screw led me to another, until the whole unit had to be split—from the motor-driven brush roll to the handle—just to get to the battery pack. Through

Kathleen with her secondhand, but revitalized, Boss Lite cordless vacuum. Its NiCd battery was brought back to life through several charge/discharge cycles.

diligence, I was successful. I gave Bob-O the battery pack, after marking the connections on top so I would know what color wire went where.

Bob-O took the battery pack and put it on his Maha battery charger. It can charge nearly any size and configuration of rechargeable battery larger than AAs. We also use a different Maha charger designed specifically for AA and AAA rechargeables for our small flashlights and radios. Both chargers have a feature that runs batteries through a cycle of total charge and then total discharge. Bob-O charged and discharged the vacuum cleaner's NiCd battery pack several times.

Lightweight Sucker

Two days later, he returned the battery pack to me. I reassembled the vacuum cleaner. At the end of assembly, I had two screws left over. Oh well—I did my best. The test run was flawless. The vacuum cleaner really worked! Oh, not as well as my big one, but I didn't expect that.

Our patterned rug in the living room is mostly dark shades of blue. There is a navy blue runner in front of the wood stove. These areas really show wood chips or shoe and dog detritus. The little vacuum picks up the hair and dirt clods and wood bits very well. It's amazing how much better that room looks if those areas are vacuumed. The Boss Lite only weighs four pounds (1.8 kg). It's so easy to just grab it and spot clean the rugs. It has a plastic dirt reservoir that easily unsnaps and empties, with no replacement bags.

When the vacuum cleaner loses suction power after several uses (about 20 minutes total), I turn it on and put it in the bedroom, where I don't have to hear it, and let it run completely down. I then put it on the holder/charger. The wall cube on the charger says it draws a maximum of 6 watts, but we measured the charger unit, and it uses only 2.2 watts. I let it charge overnight, remove it from the charger, and use it when needed, keeping it off the charger until it's completely discharged. I haven't taken it to the other house yet. I like it too much to leave it over there for now.

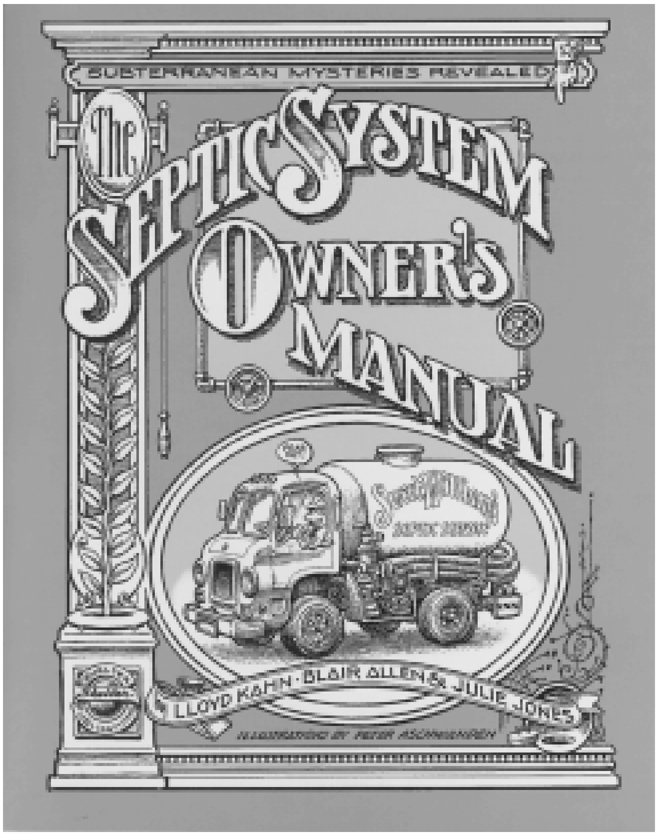
Recycle, Reuse, Repair

If you are going to spend real money on a new cordless appliance, you should be looking for units with nickel metal hydride (NiMH) batteries. These batteries do not have the memory effect of NiCd batteries, and they are far more benign to the environment when they finally do wear out. If you choose not to buy a cordless appliance because it does not have nickel metal hydride batteries, be sure to let the manufacturer know why they didn't get your money. Consumer demand is a real change motivator—use it.

Before you discard that cordless "whatever" that uses NiCds, try the charge/discharge cycling trick. You may get your "whatever" back. Remember—recycle, reuse, repair. It feels good.

Access

Kathleen Jarschke-Schultze is learning Tarot at her home in Northernmost California, c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520
kathleen.jarschke-schultze@homepower.com



By Lloyd Kahn, Blair Allen, & Julie Jones
Reviewed by Michael Welch

About one-fourth of the more than 110 million housing units in the United States have septic or cesspool systems for dealing with household wastewater. Of these, 10 percent are malfunctioning or inoperable.

That's a lot of funky wastewater systems. I have long wondered about septic systems. I recall my dad bemoaning that he had to have one, and the pumper truck that came every year or two to empty the tank. Our system had problems, especially during the holidays, when ugly smelling liquid would bubble up through the drain of the shower stall when the toilet was flushed. And later, my folks were upset at the cost of hiring a backhoe to dig new leach lines in our back yard.

When this book arrived, I dove right in to find out exactly what these systems were and how they worked. I started with two questions in my mind—both were answered and more. The first was how to find my septic tank. The previous owner of my home told me, "It's over there somewhere," while waving his finger to the east of the house. So I had a rough idea, but the book told me how to poke the ground with a piece of rebar and follow the house waste pipe or the drainfield pipes back to the tank.

My second question was whether my system will be better off if I conserve on water use as much as possible. The answer is yes, generally speaking. The less water you use, the longer the retention time in the tank for better separation of solids, and the better the anaerobic digestion in the tank. Aerobic digestion in the soil of the drainfield benefits from this retention time too. But more important than using less water is minimizing the solids that go into the tank.

A common concern among septic system owners is whether or not to use chemicals in the system. Don't worry too much about household cleaners going down the drain. Even though bacteria don't like such things, they have little effect on the health of the system. But don't use this as an excuse to use other than earth-friendly household cleaners. The stuff still ends up in the environment when sludge is removed, or if it is dissolved and goes to the drainfield with the effluent.

This book is easy and even fun to read. It is illustrated by Peter Aschwanden, who also did the illustrations for the classic John Muir book, *How to Keep Your Volkswagen Alive.* It does a pretty good job of avoiding the potty jokes and puns that you might expect in such a non-scholarly book.

It explains how and what the tank and drainfield do, and goes deeply into system maintenance and failure. It also contains chapters on greywater, composting toilet systems, the history of waste disposal, and small-town system upgrades. It has excellent access info, a glossary, and a comprehensive bibliography.

This is a great book. Read it, and you will understand that septic system maintenance is something that should be a periodic chore. Even if your septic system appears to be operating properly (as in, "Hey, it works great, I never have to pump it!"), it could very well be on the verge of filling with solids and possibly sending sludge into the drainfield. And a clogged drainfield can be very difficult and expensive to fix. Buy this book as cheap insurance.

Access

The Septic System Owner's Manual, by Lloyd Kahn, Blair Allen, & Julie Jones. ISBN 0-936070-20-X. 163 pages. US$14.95 plus $3.95 shipping charges from Shelter Publications, PO Box 279, Bolinas, CA 94924
800-307-0131 or 415-868-0280 • Fax: 415-868-9053
shelter@shelterpub.com • www.shelterpub.com

Reviewer: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884
michael.welch@homepower.com
www.igc.org/redwood

HAPPENINGS

INTERNATIONAL
Free instructions, photos, drawings, & specs to build solar cookers & water systems with local materials purchased with local currency. Sunstove www.sungravity.com

Green Empowerment finances microhydro power projects & other renewable energy projects in the third world. We are continuing the work of Ben Linder in Nicaragua & working with indigenous groups in the Philippines & Borneo. Volunteers needed to work on projects in developing countries. www.greenempowerment.org

Solar On-Line Internet-based courses. Revolving basis, year-round. PV Technology & Opportunities; PV Systems Design Basics; PV Systems Design: Professional; Solar Homes: Healthy Buildings; Solar Energy for Global Development. SóL, PO Box 217, Carbondale, CO 81623
Fax: 559-751-2001 • SoL@SoLenergy.org
www.SoLenergy.org

CANADA
April 2–7, '01; Solar, Wind, & Water Power For Off-Grid Living; Lasqueti Island, BC. Site analysis, system sizing, equipment, appliances, lab exercises, & tours. See "COLORADO" for Solar Energy International (SEI) access • Local housing & logistics: Melinda Auerbach, Morewater Road, Lasqueti Island, BC V0R 2J0 Canada • 250-333-8898 • Fax: 250-333-8670 • melinda@lasqueti.net

Alberta Sustainable House; open house 3rd & 4th Saturdays, 1–4 PM. Cold-climate features & products for health, environment, conservation, RE, recycling, low energy, self-sufficiency, appropriate technology, autonomous & sustainable housing. Free. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 Canada • 403-239-1882 • Fax: 403-547-2671
jdo@ucalgary.ca • www.ucalgary.ca/~jdo

The Institute for Bioregional Studies demonstrates & teaches ecologically oriented, scientific, social, & technological achievements. IBS, 393 University Ave., Charlottetown, PEI C1A 4N4 Canada
902-892-9578

Vancouver Electric Vehicle Association. Call for meeting info. PO Box 3456, 349 West Georgia, Vancouver, BC V6B 3Y4 Canada • 604-878-9500
info@veva.bc.ca • www.veva.bc.ca

INDONESIA
November 7–10, '01; Renewable Energy Indonesia, Jakarta. RE showcase, part of Electric Indonesia trade show. Overseas Exhibition Services, 11 Manchester Sq., London, U.K. W1M 5AB • +44 (0)20 78622090/2000
Fax: +44 (0)20 78622098/2001
indonesia@montnet.com • www.montnet.com

JAPAN
November 11–16, '01; Enviro Shiga 2001. Nagahama Dome, Shiga, Japan. International environmental business exhibition, incl. RE, water conservation, waste reuse & recycling, environmental monitoring, & environmentally sound products. Shiga Env. Business Exhibition Assoc., Shiga Pref. Gove Bldg. 4-1-1, Kyomachi, Otsu City, Shiga, 520-8577, Japan • +81-77-528-3793 • Fax: +81-77-528-4876 • www.pref.shiga.jp/event/messe

NETHERLANDS
May 8–10, '01; Sustain 2001: World Sustainable Energy Exhibition & Conference, Amsterdam
sustain2001@rai.nl

NICARAGUA
July 31–Aug 10, '01 (repeated Jan. '02). Course on solar energy in Nicaragua. Intro to PV for developing countries, course offers lectures, field experience, & eco-tourism. Taught in English by Dr. Richard Komp & Professor Susan Kinne. US$850. Contact Barbara Atkinson • 215-942-0184
lightstream@igc.org

RUSSIA
May 28–30, '01; Russian Technologies For Industrial Applications—Renewable Energy; St. Petersburg; One of series: "Results of Fundamental Research for Investments" workshops for implementing non-traditional RE technologies. By The Russian Foundation for Basic Research & St. Petersburg United Research Center. Info: Prof. S. G. Konnikov, 194021, St. Petersburg, Polytekhnicheskaya 26 • 812 247 99 68
Fax: 812 247 58 94 • IWRFRI@pop.ioffe.rssi.ru
www.ioffe.rssi.ru/IWRFRI

SWITZERLAND
May 28–30, '01; Montreux Energy Roundtable, Montreux, Switzerland. Montreux Energy Limited, 100 New Kings Rd., London SW6 4LX, UK
(44-20) 7348 6083 • Fax: (44-20) 7348-6080
www.MontreuxEnergy.com

NATIONAL U.S.
May 19–26, '01; American Tour de Sol, solar race: Waterbury, CT to Pittsfield, MA to Albany, NY for festivals. Then east to Greenfield & to festivals at Worcester & Boston, MA. NESEA, 50 Miles St., Greenfield, MA 01031 • 413-774-6051
Fax: 413-774-6053 • nhazard@nesea.org
www.nesea.org

May 15–17, '01; Solar Express 2001; Topeka, KS to Jefferson City, MO. Solar bikes with & w/o pedals & bodies. Info: 800-606-8881 • www.solarbike.org
hq@solarbike.org

July 15–25, '01; American Solar Challenge, solar race on historic Rt 66: Chicago, IL to Los Angeles, CA. 3 starts: Chicago, IL; Rolla, MO; & Barstow, CA. Info: 800-606-8881 • hq@formulasun.org
www.formulasun.org

Pollution Prevention Video Series. Appalachia Science in the Public Interest offers 42 videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar-Powered Automobile, Quilted Insulated Window Shades, & more. US$25 + S&H, broadcast-quality tapes available. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • Fax: 606-256-2779 • aspi@kih.net • www.kih.net/aspi

American Wind Energy Association. Info about U.S. wind industry, membership, small turbine use, & more • www.awea.org

State financial & regulatory incentives for RE: reports. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480
Fax: 919-515-5778 • www.ncsc.ncsu.edu/dsire.htm

Energy Efficiency & Renewable Energy Clearinghouse (EREC): Insulation Basics (FS142), New Earth-Sheltered Houses (FS120), PV: Basic Design Principles & Components (FS231), Cooling Your Home Naturally (FS186), Automatic & Programmable Thermostats (FS215), & Small Wind Energy Systems for the Homeowner (FS135). EREC, PO Box 3048, Merrifield, VA 22116
800-363-3732 • TTY: 800-273-2957
energyinfo@delphi.com • www.eren.doe.gov

Energy Efficiency & Renewable Energy Network (EREN): links to gov. & private internet sites & "Ask an Energy Expert" online questions to specialists. 800-363-3732 • www.eren.doe.gov

Green Power Web site: deregulation, green electricity, technology, marketing, standards, environmental claims, & national & state policies. Global Environmental Options & CREST
www.green-power.com

National Wind Technology Center. Assisting wind turbine designers & manufacturers with development & fine tuning. Golden, CO
303-384-6900 • Fax: 303-384-6901

Tesla Engine Builders Association: info & networking. Send SASE to TEBA, 5464 N. Port Washington Rd. #293, Milwaukee, WI 53217
teba@execpc.com • www.execpc.com/~teba

Sandia's Stand-Alone Photovoltaic Systems Web site: recommended design practices, PV safety, balance-of-system technical briefs, battery & inverter testing • www.sandia.gov/pv

Solar Energy & Systems. Fundamentals of Small RE: Internet college course. Weekly assignments reviewing texts, videos, WWW pages, & email Q&A. Mojave Community College • 800-678-3992
lizcaw@et.mohave.cc.az.us
www.solarnmc.mohave.cc.az.us

Federal Trade Commission (free pamphlets): Buying An Energy-Smart Appliance, Energy Guide to Major Home Appliances, & Energy Guide to Home Heating & Cooling. Energy Guide, FTC, Rm 130, 6th St. & Pennsylvania Ave. NW, Washington, DC 20580 • 202-326-2222 • TTY: 202-326-2502
www.ftc.gov

Solar Curriculum for schools. 6 week science curriculum or individual sessions—free! Over 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center • 321-638-1017 • www.fsec.ucf.edu

ALABAMA
Centre, AL. The Self-Reliance Institute of NE Alabama seeks people interested in RE, earth-sheltered construction, & other self-reliant topics. SINA, 6585 Co Rd. 22, Centre, AL 35960

ARIZONA
August 8–10, '01. Flagstaff, Arizona. Third annual Southwest Renewable Energy Fair. At the NAU campus in conjunction with a national RE conference. Greater Flagstaff Economic Council, 1300 South Milton Rd., Suite 125, Flagstaff, AZ 86001 • 800-595-7658 or 520-779-7658
Fax: 520-556-0940 • swref@gfec.org
www.gfec.org

Glendale & Scottsdale, AZ. Living with the Sun: Lecture series by AZ Solar Energy Assoc. History & current overview of concepts, design, applications, & technologies on solar heating/cooling, architecture, landscaping, PV, & cooking. 7–9 PM, first Wed. of every month at Glendale Foothills Branch Library, & third Tuesday of every month at Scottsdale Redevelopment & Urban Design Studio. Jim Miller • 480-592-5416

Tax credits for solar in AZ. A technician certified by the AZ Department of Commerce must be on the job site. ARI SEIA 602-258-3422

ARKANSAS
Sun Life Constr. by Design: Seminars 3rd Sunday

of each month on our passive solar earth-sheltered project. Hands-on seminars incl. ferro-cement, building dwellings for minimal materials expense. Loren Impson, 71 Holistic Hollow, Mt. Ida, AR 71957 • 870-867-4777 • loren@ipa.net www.Sun4Life.com

CALIFORNIA

May 12–14, '01; Take Your Bedroom Off the Grid; Arcata, CA. Hands-on workshop: How to install PV as your budget allows. By Johnny Weiss. Redwood Alliance, PO Box 293, Arcata, CA 95518 707-822-7884 • redwood.alliance@homepower.com www.igc.org/redwood

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State University. Ongoing workshops & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551 ccat@axe.humboldt.edu • www.humboldt.edu/~ccat

Energy Efficiency Building Standards for CA. CA Energy Commission • 800-772-3300 www.energy.ca.gov/title24

COLORADO

Carbondale, CO. SEI: hands-on workshops. 1 & 2 week sessions. PV Design & Installation, Advanced PV, Wind Power, Microhydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Solar Energy International (SEI), PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 sei@solarenergy.org • www.solarenergy.org

FLORIDA

April 28, '01; 2nd Annual Electric Car Rally, Fort Pierce, FL. Sponsored by Grassroots Electric Vehicle Club. Steve Clunn, 1918 S. 34th St., Fort Pierce, FL 34947 • 561-465-1982 1sclunn@email.msn.com • www.grassrootsev.com

ILLINOIS

April 20, '01; S. IL Univ. Earth Day, Carbondale, IL. Info: Aur Beck • 618-893-4087 power@midwest.net

April 22, '01; Southern Sustainable Fair, Turley Park, Carbondale, IL. Info: Aur Beck 618-893-4087 • power@midwest.net

April 26–27, '01; PV Utility Intertie Class, Davis Caves, Armington, IL. Info: Jeff Green 815-469-5334 • Jeff_Green@msn.com

April 28, '01; Davis Caves Earth Fest. Info: Ruthanne Davis • 309-392-2574 earthfest@daviscaves.com • www.daviscaves.com

April 29, '01; Stelle Earth Day Tours, Stelle, IL. Tours from 11 to 4. Contact: Kelly Greenlee, SunWize Technologies, #1 Sun St., Stelle, Il 60919 815-256-2224 • kgpv@stelle.net

IOWA

July 1–Sept. 31, '01; Iowa Electrathon season. Registration US$44 incl. fees for all events, insurance, rule book, manual, & newsletter subscription. Iowa Electrathon, Nora Johnson, CEEE, Univ. of Northern Iowa, Cedar Falls, IA 50614 • 319-273-7575 • electrathon@uni.edu

Prariewoods & Cedar Rapids, IA. Iowa Renewable Energy Association meets 2nd Sat. every month at 9 AM. All welcome. Call for schedule changes. IRENEW, PO Box 355, Muscatine, IA 52761 319-288-2552 • irenew@irenew.org www.irenew.org

KANSAS

May 9–11, '01; Formula Sun Grand Prix; Topeka Heartland Park Racetrack. Solar vehicles try to get the most total miles. Technical checks May 7 & 8. Qualify for Solar Challenge. Info: 800-606-8881 hq@formulasun.org • www.formulasun.org

May 11–13, '01; Solar BikeRayce; Topeka Heartland Park Racetrack. Solar bikes with & w/o pedals & bodies. Qualifier for Solar Express (see "NATIONAL U.S."). Info: 800-606-8881 • www.solarbike.org hq@solarbike.org

KENTUCKY

Livingston, KY. Appalachia—Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, more. ASPI, Rt 5 Box 423, Livingston, KY 40445 • Phone/Fax: 606-453-2105 aspi@kih.net • www.kih.net/aspi

MASSACHUSETTS

Greenfield Energy Park needs help preserving the historic past, using today's energy & ideas, creating a sustainable future. Greenfield Energy Park, NESEA, 50 Miles St., Greenfield, MA 01301 413-774-6051 • Fax: 413-774-6053 nhazard@nesea.org • www.nesea.org

MICHIGAN

Tillers International, classes in draft animal power, small farming, blacksmithing, & woodworking. 5239 S 24th St., Kalamazoo, MI 49002 • 616-344-3233 Fax: 616-344-3238 • TillersOx@aol.com www.wmich.edu/tillers

MISSOURI

June 3–5, '01; Energy 2001: Kansas City. Energy Efficiency Workshop & Exhibition • 410-997-0763 Fax: 410-997-0764 • energy@epponline.com www.energy2001.ee.doe.gov

MONTANA

August 20–25, '01; Biodiesel Workshop, Max Farm, Superior, MT. Incl. biodiesel & straight vegetable oil. See "COLORADO" for SEI access • SEI Biodiesel Coordinator: David Max • zenfuel@yahoo.com

Whitehall, MT. Sage Mountain Center: seminars & workshops, one day, inexpensive sustainable home building, straw bale const., log furniture, cordwood const., PV, more. SMC, 79 Sage Mountain Trail, Whitehall, MT 59759 • Phone/Fax: 406-494-9875 cborton@sagemountain.org

NEW HAMPSHIRE

Spinning a Web of Solar Spirits; workshops on living with the sun. 1st Wed. of every month. Sunweaver, 1049 1st, NH Turnpike, NH 03261 • 603-942-5863 Fax: 603-942-7730 • fonature@tiac.net

NEW MEXICO

Moriarty, NM. Workshops on RE, energy conservation, sustainable living, & energy independence. "Proffit" From The Sun 505-281-1300 days • 505-832-1575 eves & weekends • proffit@flash.net www.proffitfromthesun.com

July 18–20, '01; PV Systems Symposium; Albuquerque; reduce system costs, increase reliability, improve performance, remove barriers, & grow sustainable markets. Info: Connie Brooks, 505-844-4383 • cjbrook@sandia.gov

NORTH CAROLINA

Saxapahaw, NC. How to Get Your Solar-Powered Home: Seminars 1st Sat. of each month. Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 336-376-9530 • Fax: 336-376-1809 solarvil@netpath.net

NEW YORK

April 16–21, '01; PV Design & Installation, Ashokan Field Campus, Woodstock NY. Site analysis, system sizing, equipment, appliances, demonstrations, lab exercises, & hands-on installation. See "COLORADO" for SEI access

April 21, '01; North Country Sustainable Energy Fair, Canton Middle School, Canton, NY. Tours of solar homes April 22. Keynote by Ed Smelloff. Workshops and exhibits on RE production & conservation. Info: Scott Shipley • 315-386-4928 shipleyscott@hotmail.com • www.ncenergy.org

July 24–25, '01; Increasing Productivity through Energy Efficiency; Tarrytown. ACEEE 2001 Summer Study on Energy Efficiency in Industry. rlunetta@erols.com • www.aceee.org

OHIO

Perrysville, OH. RE classes: 2nd Sat. each month. Straw bale class 3rd Saturday, April–September. Solar Creations, 2189 SR 511 S., Perrysville, OH 44864 • 419-368-4252 • www.bright.net/~solarcre

OREGON

Sept. 15, '01; Roseburg, OR. Aternative Energy Fair, Umpqua Community College. dallasit@internetcds.com

April 21, '01; Columbia Gorge Earth Day, Renewable Energy Fair, Earth Day Run; downtown, Hood River; electric cars, electric bikes, hybrid cars, & other enviro info; Columbia Gorge Earth Network, PO Box 276, Hood River, OR 97031 earthnetwork@gorge.net www.gorge-earth-network.org

May 19, '01; John Day, OR. Annual tour of RE homes, EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • info@solwest.org www.solwest.org

EORenew Workshops, '01; John Day, OR. June 1–3: Simple Solar Water Heating, a hands-on installation workshop. July 25–27: Pre-SolWest workshop; Upgrade our office to solar! A hands-on class will do an energy efficiency and solar upgrade to make an office cost-effective. July 30: John Day, OR. Post-SolWest workshop. How to instrument your system for continuous data logging. See above for EORenew access.

July 28–29, '01; John Day, OR. SolWest Renewable Energy Fair. Over 80 exhibits, demonstrations, workshops, & "Tour de John Day" electrathon race. See above for EORenew access.

September 8, '01; Seneca, OR. Oregon Tree Farmers of the Year. Sustainable forestry and sustainable living tour at Lance and Jennifer Barker's Morning Hill Forest Farm. See above for EORenew access.

Cottage Grove, OR. Advanced Studies in Appropriate Technology, 8 weeks, 4 students per quarter internship. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 541-942-0302 • dstill@epud.org www.efn.org/~apro

June 4–August 13, '01; Cottage Grove, OR. 10 week course researching & developing improved A.T. devices for NGOs in third world. Work on real problems, creating original contributions. See above for Aprovecho access

April–July; Energy Education Training. Locations in OR & WA. Classes: Addressing Residential Customer High Bill Complaints, Energy Auditor Training, Non-Intrusive HVAC Testing, Sizing Residential HVAC Equipment & Duct, Residential Water Conservation, Commercial Building Data Logging, Energy Management Certificate, Building Operator Certification, EZ Sim-Billing Analysis Software, Electricity from the Sun. Info: Northwest Energy Efficiency Alliance, Lane Community College, 4000 E. 30th Ave., Eugene, OR 97405 800-769-9687 or 541-988-4729 • Fax: 541-988-4723 • neei@lanecc.edu • www.nweei.org

August 10–20, ‘01. Williams, OR. Advanced Permaculture Design Certificate Course—Keyline Water Management: A Whole Systems Approach. For those who want to become more competent designers. Cost: US$1,100 incl. 3 homegrown meals a day, camping, course materials, & field trips. Seven Seeds Farm, 3220 East Fork Rd., Williams, OR 97544 • 541-846-9233 sevenseeds7@hotmail.com

RHODE ISLAND
An energy co-op is being organized to provide renewable electricity, energy efficiency & conservation services, & group purchases of “Energy Star” appliances and related products. Info: Erich Stephens • 401-487-3320 erich@sventures.com

TENNESSEE
April 23–28, ‘01; PV for Ecovillages workshop for the off-grid home. Lectures, labs, & hands-on instruction. Eco Village Training Center at The Farm in Summertown. See “COLORADO” for SEI access

Summertown, TN. Kids to the Country: a nature study program for at-risk urban Tennessee children. Sponsorships & volunteers welcome. The Farm, Summertown, TN 38483 • 931-964-4391
Fax: 931-964-4394 • ktcfarm@usit.net

TEXAS
Sept. 28–30, ‘01; Texas RE Roundup, Fredericksburg. Exhibits, demonstrations, workshops, tours. Texas RE Industries Assoc. & Texas Solar Energy Society, PO Box 9507, Austin, TX 78766 • 512-345-5446 • Fax: 512-345-6831
R1346@aol.com
www.renewableenergyroundup.com

El Paso Solar Energy Association bilingual Web site. Info in Spanish on energy & energy saving www.epsea.org

El Paso Solar Energy Association: meetings normally held 1st Thurs. of each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 epsea@txses.org • www.epsea.org

Houston Renewable Energy Group: meets last Sun. of odd-numbered months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 • jferrill@ev1.net
www.txses.org/hreg/HREGhome.htm

VERMONT
June 1–22, ‘01; Sustainable Design, Building, & Land Use; Plainfield, VT. Explores the history of agriculture, social ecology & design, organic agriculture, appropriate technology, alternative building, permaculture, ecological restoration, & more. Institute for Social Ecology • 802-454-8493 www.social-ecology.org

July 11–14, ‘01; PV System Installation: A hands-on, how-to installation to supplement distance learning with practical hands-on skills. SóL, PO Box 217, Carbondale, CO 81623 • Fax: 559-751-2001 SoL@SoLenergy.org • www.SoLenergy.org

July 14–15, ‘01; SolarFest: Energy Fair & Solar-Powered Music Festival; solar energy workshops, sustainable living exhibits, music, child’s activities, more. Middletown Springs, Vermont. Info: 802-235-2050 • wwwsolarfest.com

WASHINGTON, DC
April 19–21, ‘01; Renewable Energy for the Developing World, by Solar Energy International. Info: ASES, 2400 Central Avenue, Suite G-1, Boulder, CO 80301 • Fax 303-443-3212 www.solarenergyforum.org

April 22–23, ‘01; Small Fuel Cells & Battery Technologies for Portable Power Applications symposium, Renaissance Hotel. The Knowledge Foundation, 18 Webster St., Brookline, MA 02446 717-232-7400 • Fax: 617-232-9171 custserv@knowledgefoundation.com www.knowledgefoundation.com

June 3–7, ‘01; Windpower 2001: Annual meeting of the American Wind Energy Association. Grand Hyatt. AWEA, 122 C St. NW Suite 380, Washington, DC 20001 • 202-383-2500
laura_keelan@awea.org • www.awea.org

WASHINGTON STATE
Energy Education Training, locations in WA & OR. See OR entry for info.

October 11–14, ‘01, Guemes Island, WA; Microhydro workshop. Class & labs followed by tours, incl. Canyon Industries, turbine manufacturer. US$400. See “COLORADO” for SEI access • Local coordinator: Ian Woofenden, PO Box 1001, Anacortes, WA 98821 • 360-293-7448 • Fax: 360-293-7034 • ian.woofenden@homepower.com

October 15–20, ‘01; Guemes Island, WA: PV Design & Installation workshop. Site analysis, system sizing, equipment, appliances, demonstrations, lab exercises, & a complete hands-on installation. US$550. See “COLORADO” for SEI access. See above for local coordinator.

October 22–27, ‘01; Guemes Island, WA: Build Your Own Wind Generator workshop, with Hugh Piggott; of Scoraig Wind Electric, Scotland. US$550. See “COLORADO” for SEI access. See above for local coordinator.

WISCONSIN
Amherst, WI. Midwest Renewable Energy Association (MREA) workshops. April 6–7, Wind Power for Rural Areas. May 5, Basic PV. May 6, Intermediate PV. May 26, Solar Hot Water Installation. June 10, Solar Water & Space Heating. June 11–15, Utility Intertie Wind Installation. June 16–20, Advanced PV installation. Call for cost, locations, instructors, & further workshop descriptions. Significant others half price. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 Fax: 715-592-6596 • mreainfo@wi-net.com

June 22–24, ‘01; Renewable Energy & Sustainable Living Fair (MREF), Amherst, WI. Exhibits, workshops, & demonstrations. The best fair. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 Fax: 715-592-6596 • mreainfo@wi-net.com

June 23, ‘01, Amherst, WI. Xantrex Technology Inc. would like to invite dealers of Trace products to an open house discussion forum at MREF after show hours on Saturday. Due to space, attendance will be limited. Please stop by the Xantrex booth with your business card to receive your invitation.

the Wizard speaks...

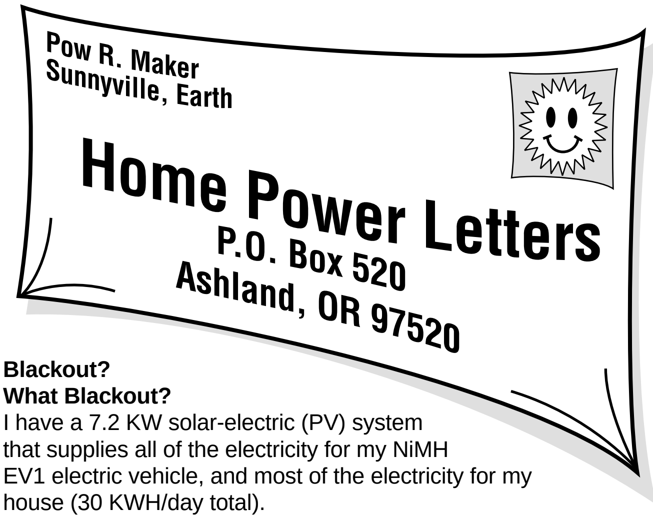
Energy Resources

With the recent shortages of electricity in California, it has become clear that the production of energy cannot remain solely in the hands of private industry. These shortages, along with rising natural gas prices, have shown that both state and federal governments need to play a part in the production and delivery of energy resources.

Instead of tax cuts, government budget surpluses should be used for solar and wind energy installations. These could be backed up by fuel cells using stored hydrogen. The hydrogen would be created by these same solar and wind installations. This process could be instituted quickly with modular installments of complete systems.

The energy produced could then be sold to local utilities at fair market rates. This would allow the government to stabilize energy prices, and still partially recoup its initial investment. When economies of scale begin to have their effect, it may be possible to attain complete payback in thirty years or less.

Such government investment in energy resources would have more than just an economic benefit. It would also have environmental and social value. A clean, continuous, and fairly priced energy source is necessary for social and economic progress. Energy is far too vital a commodity to be subject to a profit-only oriented market.



Blackout?
What Blackout?

I have a 7.2 KW solar-electric (PV) system that supplies all of the electricity for my NiMH EV1 electric vehicle, and most of the electricity for my house (30 KWH/day total).

We were totally unaware of the rotating block outage that hit our house and neighborhood, so I called PG&E two days later to check. I was at work when the blackout hit. I couldn't do any work and was stuck in the dark. I called my spouse from my cell phone and she said the lights were on at home and she didn't notice anything unusual. Well, as I later learned from PG&E, there was no power on in the whole neighborhood except at my house, where we didn't even notice!

The EV1 is a true zero emissions vehicle (TZEV) since I recharge from zero emissions electricity I generate myself. EVs (and compressed natural gas vehicles) can use the HOV lanes single occupancy because they are much cleaner than conventional cars. Even gasoline/electric hybrids aren't allowed in the HOV lanes with a single occupant, because of the pollution.

Of course, I'm still very concerned about California's electricity and natural gas supply and cost problems. No man is an island. I'll have power at home, but the blackouts will still heavily impact me and others with blacked out residences, traffic lights, businesses, schools, etc.

One of the wonderful things about a solar-electric system and a utility intertie system is that in a local way, it helps to prevent blackouts. The PV system's electricity generation corresponds closely to the super-peak summertime load, putting power onto the grid at the time when it's most desperately needed to avoid blackouts. The grid is effectively a 100 percent efficient battery for the PV system. If the PV system were not intertied with the grid, energy for non-daylight hours would be stored in batteries. Putting the energy into the batteries and taking it out results in 20 to 30 percent loss of energy. So a grid intertie system is a wonderful symbiotic relationship. The PV supports the grid when the grid is at its weakest. And during nighttime hours, the residence takes power from the grid with no battery losses, at a time when the grid (normally) has excess capacity and wants to find users for this excess.

There are clean non-polluting alternatives to the centralized power plants that take so long to build. Our PV system contract was signed on December 28, 1999. Our system was spinning the meter backwards, feeding energy onto the grid on March 1, 2000. About two months total, and we weren't even trying to do it quickly. Try getting a utility-scale power plant designed, approved, permitted, built, and online in two months time! Conventional power plants take several years from project start to operation *if* things go smoothly.

With the current trends in utility rates, PV systems will have paybacks in less than seven years! A much wiser investment than a Lincoln Navigator! Governor Davis announced executive orders today providing US$50 million for rebates for construction of small renewable energy facilities and a 50 percent tax credit for homeowners and businesses that install renewable energy systems. See www0.mercurycenter.com/premium/front/docs/davis09.htm. Mike Thompson • mikt@slip.net

8th Grader Gets Wise

In school I am involved in a project called ROGATE. In this program you must do in-depth research on a topic you have chosen. I chose to research solar energy, and how its benefits compare to conventional electricity. As a requirement, I must get my work published in at least two magazines. While searching on the Internet, I came across your Web site.

Many people don't realize that there are other energy sources in the world besides conventional electricity. I spent about five months researching, and found lots of interesting data. My hypothesis was that solar energy will be a benefit in the future due to its reasonable costs and minimal environmental impact. I contacted many scientists who work in the field, received packets of information, and found details on the Internet. I also found sites of people who disagreed with my hypothesis.

I found many benefits when researching. They pertain to solar energy being renewable and more convenient:

1. As long as the sun exists, there will be solar energy.
2. Solar energy does not produce pollution and is cleaner.
3. There are plenty of places to put the solar panels, such as rooftops and highways.
4. The number of electricity outages would be reduced.
5. Solar energy can also be used to heat water.
6. Fossil fuel prices are rising, so as solar energy is used more, prices drop.
7. The U.S. spends US$38 billion for oil/petroleum, but solar energy costs US$120 million a year.
8. Licensed electricians help you install solar panels easily.
9. Panels are thin, lightweight, and easy to handle. They can also be tilted or laid flat.
10. Solar panels continuously generate electricity during daylight hours.
11. The cost of solar energy will definitely become lower over the next few years.
12. Solar energy has no harmful odors, and has easy-to-fix problems.
13. It can also continuously generate without close attention for a long period of time.
14. Solar energy can be combined with other power sources.
15. The panels can withstand most severe weather conditions.
16. More photovoltaic panels can be installed as you demand more.

This summary proves that my hypotheses is inconclusive because there is still much debate on the topic, and my hypotheses states "in the future," meaning the results cannot be determined at the present time. Sincerely, Resha Soni, Grade 8, 161 South Hill Dr., Westampton, NJ 08060

Hello Resha. Good work on your research. I have included your address in case others want to send you more information. Maybe by "in the future," you mean as a major source of energy. I hope so, because really, solar energy is a source for here and *now. Many thousands of people get all their electricity from the sun, and many thousands more use it to heat water—right now! Good luck with your project, and enjoy seeing it in print. Michael Welch*

Hi Resha, Solar-electric panels have supplied my family with over half of its electricity for almost twenty years (wind generators provide most of the rest). Michael's right that thousands of people are using this technology now, and have been for years and even decades. It takes pioneers to show the rest of society what is possible. Many of us started when it didn't make economic sense, but we knew it was the right thing to do. One T-shirt I've seen says, "We have the technology." That's true. We just need to decide to use it. Thanks for your letter. See the next letter for some compelling reasons to use solar-electric systems.
Ian Woofenden

Nails the California Energy Problem
Dear California Assembly Member Christopher Wahgsaporn, It is good to hear that the assembly is seriously considering offering long-term incentives for photovoltaic systems as part of the total solution to the power crisis.

I hope you and Assemblyman Strickland will be able to incorporate photovoltaic systems into a total *long-term* solution for keeping the lights on in California. Photovoltaic power is not a panacea by any means, but linking privately owned residential photovoltaic arrays into the overall power distribution system makes a lot of sense.

Insistence upon using only large-scale power generation and saying that small-scale electrical power generation has no place in California's energy infrastructure is shortsighted. It's a bit like saying we should only use semi trucks and buses on California roads, and that cars, vans, pickup trucks, flatbed trucks, RVs, utility trailers, and motorcycles have no place in California's transportation infrastructure. Analogies are always suspect, but this analogy hits very close to the mark.

In a complex network infrastructure, there is no "one size fits all" solution. This is true whether the network in question is computers, routers, the Internet, aircraft and airports, water aqueducts and water distribution systems, railroads, natural gas distribution, gasoline distribution, or electrical distribution. There are always tradeoffs to be considered in such complex networks, and hybrid systems of one type or another almost always give "the best bang for the buck."

Photovoltaic (PV) grid intertie electricity cogeneration has the following advantages:

1. It is produced where the power is needed. There are no power transmission losses caused by shipping the power from outside California.

2. The PV array peak power is usually produced when you need it most. For example, peak power comes on hot summer days. The summer of 2001 should be interesting, as we scramble to find enough power to keep California's lights and air conditioners on.

3. Sunlight that is falling on a PV array during the summer is not adding to the heat load of the building. Instead, it is decreasing the amount of insolation on that building, thus reducing the amount of electricity needed to air condition that building. It is also increasing the amount of power in the power grid, thus increasing the electrical power available to people to use to air condition their houses.

4. PV is decentralized. You don't have to shut down a PV array because the power plant is shut down for scheduled or unscheduled maintenance. You can usually isolate part of a PV array and work on it while the rest of the array is still producing power.

5. It is highly reliable. This is one of the reasons why the U.S. Coast Guard uses PV arrays to power thousands of navigation devices in the nation's waterways. This is one reason why CalTrans uses PV arrays to power thousands of emergency call boxes on California freeways. This is one reason why the International Space Station and almost all orbital satellites use PV arrays.

6. PV has high availability. There are no power transmission bottlenecks with PV arrays. The power is produced where you need it, and any excess power generated is distributed locally. This reduces the need to transmit power from where it is produced in Utah or Oregon to where it is needed in California. It also reduces the effects of power distribution system bottlenecks, such as the two-line bottleneck in central California.

7. PV is green, non-polluting power. You don't have to relax pollution control standards to put PV arrays online. It reduces the need for power generated by polluting sources.

8. PV is cost effective, even if you totally discount the items cited above. System payback takes about twelve years in California today. Current and proposed electricity rate hikes will shorten the payback period. PV power costs on the order of US$400/megawatt-hour, and the cost trend line is going down. Peak power on the electricity spot market currently sometimes costs US$500/megawatt-hour or more, and the cost trend line over time is going up.

9. PV is highly resistant to terrorist attacks on the power generation infrastructure. Question: How do terrorists go about destroying millions of PV arrays, short of detonating a nuclear weapon in a populated area? Answer: They don't.

10. PV arrays at home quite literally give the power to the people instead of to big government or big business. We provide incentives to help people own their own homes by making them affordable to buy. The technology now allows us to do the same thing with regard to home power generation. This concept is in line with Thomas Jefferson's concept of the semi-autonomous yeoman farmer.

California spent roughly US$1.2 billion a few days ago to buy electricity on the spot market in order to prevent rolling blackouts for a few days. There is no assurance that the state will ever be reimbursed. Had that amount of money been spent over the past few years as an investment in the state power infrastructure by putting residential PV systems in place in California, we might well have avoided or delayed the onset of the current electrical power crisis. The severity of any power shortage certainly would have been minimized.

A rough analysis follows:
- Cost of a 2,000 W home PV system, including installation (per Siemens Solar of Camarillo, CA): US$16,000 for the system, US$1,000 for installation, US$17,000 total.

- Average AC power produced per day: 11 KWH (one kilowatt-hour equals one thousand watt-hours).

- Number of systems in place if US$1.2 billion had been used as 50 percent subsidy for home PV systems: 141,176

- Total average power produced per day (more in summer, less in winter): 15.53 GWH (one gigawatt-hour equals one billion watt-hours).
- Lifetime power output, assuming a 25-year panel life (per Siemens Solar PV panel warranty): 141,705 GWH

Question: Would California be in the current electrical power crisis, had we invested US$1.2 billion over a period of years in a home PV infrastructure producing an average of 15 GWH per day? Answer: It seems unlikely.

Interestingly enough, the numbers say that a PV-equipped home with a 2,000 W system would produce about one gigawatt-hour of electricity over the expected lifetime of the PV array. Do the math.

The argument that helping citizens install home PV systems subsidizes the rich at the expense of the poor is bogus. Putting PV online helps everyone avoid power blackouts. Power blackouts hurt the poor, the ill, and the infirm much more than they hurt the rich and the middle class.

Bottom line: Subsidizing solar-electric systems in private homes makes sense and saves the taxpayer money in the long run. It reduces pollution. It helps to stabilize the power grid. It increases the reliability and availability of the electrical system, thus making it safer for people with medical conditions that require electrically powered medical devices.

The purchase of grid intertied PV arrays with optional battery backup by homeowners should be subsidized in the same manner as we currently subsidize home mortgages, and for much the same set of reasons. I hope this information will be of some slight assistance to you. Wishing you and yours the very best. Rodger Morris
MorrisRL@phdnswc.navy.mil

Computer Power Answers
Dear *Home Power,* I'd like to respond to the letter in *HP81* about computer power draw. Laptop power consumption has increased for several reasons. The bigger screens draw more, and backlit screens draw a lot more. These improvements are probably worth the extra power they consume. Hard disks are bigger, but actually consume less power in many cases since they have smaller, lighter platters with higher storage density.

The biggest increase is faster processors, specifically Intel. The old P133 and P166 consumed only 11–12 watts, and the new PII/PIII 400-600 MHz units draw as much as 20 watts just for the CPU! Intel has never really addressed this issue (creating a huge market opportunity for Transmeta as a side effect).

Newer laptops do indeed use 16-20 volts, which makes battery and power supply design simpler for them. There's a new standard for mobiles called EmPower, which is simplifying things a bit. A programmable DC/DC converter feeds a specific cord for your laptop/palm/cell phone/etc., and that cord tells the converter what voltage to output. The converters are about 90 percent efficient, which is a bit better than the series losses of an inverter and the AC adapter combined. The downside is that they cost about US$100. The upside is a new cable/adapter is under US$20 in many cases, and the system works in airplanes (if you can afford the first class seat where most airlines have installed them at this point). I'm trying to find out how to rig up an adapter for 24 V sources, but haven't gotten very far yet.

Try www.xtendmicro.com and www.targus.com for EmPower-compatible stuff. Kurt Albershardt • info@es-ee.com

More Computer Power Answers
As a note for all those people who look at using laptops, I have been looking for DC-DC computer supplies for a while. A fresh search turned up some models. See http://citadeltechnology.com.

I'm not happy with their connection method, but I am sure it can be changed: www.amtrade.com. These guys make some server class DC-DC computer supplies along with a model or two of ATX supplies. The minimum efficiency on these supplies are higher than the maximum efficiency most offline supplies have. Coupled with ACPI computers, or special power-saving software (CPU Idle or Rain/Waterfall), you can make a serious improvement in a PC's power consumption in a solar-electric system. Carl Morris msftrncs@htcnet.com

Michigan RE?
Hello *Home Power,* I am fairly new to your Web site. I find it extremely helpful. I have read almost everything I can get my hands on. I would like to build a self sufficient, single residence home. I am interested in PV for electricity, wood and solar for heat, RE sources for water purification, and generator and gas for backups. I am at the point where I would like to see some working systems. I know there is a database for manufacturers and consultants. However, I am not ready to buy products or hire a consultant yet. I was hoping to take the approach of talking to RE homeowners first, seeing their systems, and asking for their recommendations for consultants and products.

I saw one couple from Michigan with a small DC system featured in *HP80.* Good for them! If possible, I would like to see complete home systems like the Lords' home (but not quite that big). Can you give me any homeowner contacts closest to Saginaw, Michigan? Thank you. If you cannot, still thanks. I will take any other recommendations. Sonia Beauregard
ssbeauregard@earthlink.net

Hello Sonia, We do not give out names from the HP *subscriber database, but we're happy to print your letter and encourage folks with RE systems in your area to get in touch with you. I would also encourage you to make your way to energy fairs in your area (see ads in* HP). *The fairs are a great place to meet people, see products, and get an idea of how RE systems work. The Midwest RE Fair in Amherst, Wisconsin in June is the grand-daddy (mommy?) of them all, and it would be worth your while to make the trip there. The fairs often include tours of RE homes in the area. Your approach is excellent. Do see as many homes and systems as possible before you start to design and build your own. Ian Woofenden*

State of Denial
Living off-grid since 1972, I have watched choices of "Energy is cheap, so let's waste it…" turn into "What happened that energy costs so much—what are we going to do?" I watched President Carter try to develop an energy policy, and President Reagan scrap it. I watched Bush and Clinton go through their cycles. Now I get to see what comes next. And all this time, I just go on getting free deliveries of energy daily from the sun. People still ask, "When will renewable energy become practical?" It's as though they are denying that thousands of us have been living this way for the last thirty years.

I'm glad to see that by means of *Home Power,* SolWest, the Midwest Renewable Energy Association, Texas Renewable Roundup, Solar Energy International, Southwest Renewable Energy Fair, and all the other informational and educational venues, the word is getting out.

But I am still appalled at the state of denial that pervades our politicians, news media, and self-styled energy experts. Problem-solving seems to be a lost art. Keep up your good work. Jerry Igo, Mosier, Oregon

Hi Jerry, I'm also frustrated that so many people have been and are waiting for RE to become "practical," "economical," and "cost-effective." I think what they are really waiting for is for it to become easy. *We live in a culture with drive-up this and instant that, and folks are much too used to having others do their thinking for them.*

At this stage of the game, RE systems take thought, planning, and (perhaps the biggest stumbling block) personal change. It's surprising how many people I talk with sound excited about renewables at first, but when I start talking about appliance efficiency and getting a handle on their loads, they're gone. I conclude that they want an instant, simple, and cheap solution that they don't have to do much about.

What's the culprit in this scheme? Well, it's not just one thing, but I point my finger at the unreal pricing that on-grid folks have become used to. Subsidizing anything makes people take it for granted, and it makes it very hard for them to make intelligent decisions based on real information. The time, money, and trouble that folks like you have gone through to live with renewables for decades would look much less daunting if the real cost for grid energy showed up on utility bills.

Don't despair. All this pioneering is *doing lots of good, and folks like you are going to be more and more of a resource for people who do finally see the light. Ian Woofenden*

Decoding the Code

Hi, Thanks for a great magazine, which I have enjoyed for many years. I live in Scotland, where U.K. electrical regulations apply, but I always home in on articles in *Home Power* that relate to your *National Electrical Code (NEC).* It's important to understand how to install a safe system that will continue to be safe in the future, and satisfy inspection by safety professionals. Such codes largely transcend national divides, and so they only differ in details. (For example, our regulations here require that the voltage drop between the supply terminals and the load should not usually exceed 4 percent.)

The worst thing about codes and regulations is usually the way they are written—in terms that make them dull and inaccessible to the average reader. They need interpreters. I would like to see clear statements of what the code requires, and *why.* I want the code de-mystified and made user friendly, as a safety tool.

Writing about the code unfortunately has a bad effect on people. It brings out something akin to religious dogma, with an arrogant dash of one-upmanship. *HP's Code Corner* is very code driven, without question. For example, we have to use the ludicrous 1.56 safety factor for module current, and then apply it to the short circuit current, and then factor in high temperature correction. Under these bizarre conditions, I would not mind if my breakers tripped (good idea too). Then again, we have to calculate voltage drop to several places of decimals (even though the cable-resistance table in *(HP80)* applies to 75˚C, and the cable is oversized and running cold). What is this supposed to teach us? Give up and leave it to the mathematics professors?

I have come to rely on the "wrenches" to lighten things up, and bring in a dose of reality. For example, welding cables are good for inverter installations, so why not use them? But *Wrench Realities, HP81,* page 52, came as a real wrench. Instead of a breath of reality, we got another load of code, with chapter and verse, and no jokes. No explanations either—just repetition. What's so important about conduit on low voltage cables? It's not required over here. Are we being dangerous? No explanation. What sort of fuse should have been used, where, and why? That would have been educative to the readers. How do you guard against acid spillage and physical damage to cables? This information would have been more valuable and interesting than the license number of the author.

Keep up the flow of information about how to install safe, efficient systems. Please encourage your authors to tell us why and how, as well as what not to do. Thanks. Hugh Piggott hugh.piggott@enterprise.net

Hugh, Who would have ever thought that Bob-O would stand accused of "over-Coding" I-Yi-Yi! I agree with you—it did come off as pretentious and somewhat scary. It was *scary, but apparently the dogma ran over my karma. We should have provided more explanation. That* Wrench Realities *article wasn't originally meant to be an article at all. The unfortunate homeowner was totally frustrated at the situation. He hired me as an independent expert to assess the installation in preparation to a possible lawsuit. It happens. I showed my write-up to Richard to validate what many of us have been saying all along—be careful about who you hire to design and install your system. He thought the safety issues involved were so important that we should share it.*

I also agree with you that the NEC is written in stiff and often byzantine language. It is also wrong sometimes. Anyone who can remember the requirement for grounding conductors as large as 4/0, less than ten years ago, will acknowledge that. Your case of the goofy 1.56% of short circuit current for fusing of PVs is another great example. Unfortunately, the code is written and interpreted by folks who are largely well educated, but under-experienced in the field that they seek to regulate. That is especially true as the code applies to RE and other emerging technologies. It's just the way it is. Wrenches wrench. They are usually too busy to write. The folks writing the NEC, for their part, do not go far out of their way to invite or encourage differing opinions. It's a cush job—don't rock the boat.

That being said, I agree with and follow about 95 percent of the NEC. The trick is to understand both the spirit and the letter of the code, and to know which to follow in a given situation. That comes from study, and especially, field experience. Folks who make their living writing and interpreting generally don't wrench. Some used to, no doubt, but their experiences rarely apply to current technologies.

UK and NEC codes are close to parallel in most instances. Our maximum safe voltage drop is 5% to your 4%, for example. Close enough. We *differ* hugely *in the areas of grounding and conduit. I know UK-trained wrenches who think we're completely mad to ground a current carrying conductor or put perfectly good wires in a conduit where they may heat up. They do, however, clamp the wires down well so they don't fly around if shorted. Frankly, I can see values in both theories.*

I also agree with a master electrician from Minnesota who took me to task for the article. His conclusions were mostly based on the interpretations that the NEC *wasn't meant to address wiring below 50 V, and according to* NEC *90-2(b)(5), we are essentially a power providing utility to whom the code does not apply! Now we're talking!*

In the end, it all comes down to providing a safe installation that the local inspector (the AHJ, in the pedantic terms of the code) *can live with. It helps as well if I can sleep at night knowing I've done my best for my clients. Bob-O*

Hi Hugh, Yes, the Code Corner *columns are heavy on the code, as they are intended to be. I try to present as many options as possible, but space and legal restrictions preclude listing all of the possible brands and catalog numbers of fuses, circuit breakers, conductors, etc. I do try to explain the markings and type designations that RE people should ask for or look for when they buy equipment. If purchases are made of the properly marked equipment, the installer has the best chance of getting a safe, reliable, and durable system.*

We in the RE world need to remember that we have power generation devices (particularly PV modules) that will be producing rated power for at least the next thirty years, and possibly much longer. The current life design standard for wiring (for example) is only thirty years, so it pays to take into account all of those safety factors that you have listed. These high currents and voltages can and do happen. And when they do, we are using the cables in a manner that may bring into question whether they will last as long as our power sources. Any code has to address the worst-case environmental conditions in the geographic area that it covers. It is a fact that the output from PV modules is significantly affected by these environmental conditions. Here in the U.S., the environmental conditions range from very hot to very cold. Fortunately, there are allowances in the U.S. code for installations in these extreme areas.

Equipment available in European countries (and other areas) is made to different standards and marked differently than equipment here in the U.S. I understand that this makes it difficult for non-U.S. Home Power *readers to find similar equipment. To some extent, the Americas are getting their act together as the* Canadian Electrical Code *and the* Mexican Electrical Code *are similar, but not identical to the U.S.* National Electrical Code. *Standards developing organizations like UL (Underwriters Laboratories), CSA (Canadian Standards Association), CE (European Community), DIN (Germany), and others are working toward harmonizing the equipment standards so someday we may have a common set of markings. These same agencies are also working on international electrical codes. In some cases, the European electrical codes are more restrictive than the U.S.* NEC.

Unlike Europe, where there are standards for double insulated cables (that provide added physical protection for conductors), the U.S. has no specific standard for such cables. Our multiple-conductor, non-metallic sheathed cables type NM (ROMEX) are the nearest equivalent. The European standards and codes (in some countries) allow the use of these well-protected double-insulated single conductors in exposed environments. Our single-conductor cables (without the benefit of double insulation) are required to be in conduit to provide the necessary degree of physical protection. Additionally, the cables in conduit are forced to be physically close together, minimizing the electromagnetic forces that can move cables around—possibly causing damage. I have seen single-conductor exposed cables between a battery bank and an inverter jump over 6 inches when passing the starting surge currents from a deep well pump. Furthermore, if metallic conduit is used, radio-frequency interference from the inverter may be reduced. John Wiles

Calling All Rhode Islanders
Dear *Home Power,* I would like to inform all of your Rhode Island readers that some very exciting developments are happening in our state with regard to renewable energy, energy conservation, and efficiency! A group of us have been working to form an energy co-operative that will provide electricity generated from renewable sources, efficiency and conservation services, and perhaps even group purchase discounts of products such as "Energy Star" rated appliances, residential solar-electric systems, and biodiesel for the oil burners that are so common in our region.

We've already received some funding from foundations to start the ball rolling, and by the time this letter is published, we will most likely be incorporated and have elected our first board of directors. But it's not too late to get involved on the ground floor of this exciting development, and we need all sorts of people to make this happen. Regardless of talents, knowledge, or interests, we probably have an important job that you could help us with. Our meetings are attended by utility engineers, RISD students, community organizers, and business people, among others. Anyone interested in joining our effort should contact me. Thanks for helping us get the word out! Erich Stephens • 401-487-3320 erich@sventures.com

CIS Contacts
Here are some contacts for CIS solar cells at the University of Florida, as requested by Keith Elliott from British Columbia in *HP81.* An article at www.eng.ufl.edu/home/pubs/Solar1.htm, written on July 21, 1999, lists: Writer: Aaron Hoover ahoover@ufl.edu; Sources: Sheng Li, 352-392-4937 shengli@eng.ufl.edu; Tim Anderson, 352-392-0882 tim@nersp.nerdc.ufl.edu; Other sources: Oscar Crisalle, ASO Professor of Chemical Engineering • crisalle@ufl.edu; Paul Holloway, DIS Professor, Materials Science Engineering pholl@mse.ufl.edu. I hope this helps. Brian Bartholomew bb@world.std.com

Comments on *HP81*
Dear *Home Power,* Some comments on *HP81.* Pedal Power TV article: The author mentioned trouble with powering the surge required by the degaussing coil in his TV. This coil activates just momentarily when the TV is first turned on to demagnetize the screen and preserve the correct color display. That coil uses a surge of power to operate just at the same time the rest of the TV requires a surge to start, and together it is a big load on pedal generated power for the TV. It can also be a problem starting up a TV with a small inverter. The author recommended one solution was disconnecting it and never moving the TV again to avoid picking up magnetism on the screen that would require degaussing. I would suggest a better answer is not to just disconnect the degaussing coil, but to connect a toggle switch in one of the coil's power wires. This way you can leave it turned off when starting up the TV, avoiding the two simultaneous surges. But you can always hit the switch later to activate it if your picture starts to get color smudges. This trick lets a larger TV set start on a smaller inverter of limited surge power too.

Code Corner: There is a much easier way to find the correct wire size to avoid voltage drop, without all the resistance calculations. Many solar books and catalogs (Backwoods Solar catalog page 43, or the *Solar Electric Independent Home* book from New England Solar) have charts for finding the wire size needed for a given current in a given length of wire. It is very simple to use by finding the row with the watts or amps of your appliance or solar array, going across that row to wire distance one way from end to end, and the column you are in shows the wire size to use for 5 percent or whatever voltage loss. The only time you really need to calculate the actual ohms resistance of the wire is where the wire size varies throughout a run of wire, as in #10 for 20 feet and #6 for the next 100 feet. Then you would have to calculate each section separately and add the resistances together to get the total. Otherwise, the readily available charts will make correct sizing sure and quick. Most of these charts apply to copper wire only, not aluminum, unless it specifies that it is for aluminum.

In the same *Code Corner,* John Wiles says "Want to use aluminum conductors to save money over copper? No problem." I disagree that there is "no problem." In real life, there are very frequent problems using aluminum conductors in DC circuits, at least in buried cables, such as to solar modules or water pumps. Aluminum can be carefully installed in conduit and with the proper anti-corrosion contacts at the ends, but problems *do* happen often enough with DC on buried aluminum conductors that most installers won't risk it. Aluminum corrodes and electro-plates very easily when exposed to DC and a wet environment. A pinhole puncture or fracture in the insulation of the buried positive aluminum cable will turn even heavy gauge aluminum wire to a section of insulation full of only white powder within a year, and the buried cable is useless. If aluminum wire is installed in conduit, the chances of such failure are lessened, but my advice is to spend the money for the copper wire (which is usually a gauge smaller than the aluminum wire required for the same job). Steve Willey, Backwoods Solar Electric Systems steve@backwoodssolar.com • www.backwoodssolar.com

Steve raises a point that is useful to many HP *readers. Anyone using a smallish inverter may want to consider performing the modification he suggests on the TV. Doing so will greatly diminish the starting current and allow the function of the degaussing coil to be preserved. Again,* please, *to anyone working on a TV,* be careful. *The voltages inside are lethal. Sincerely, Aaron Dahlen*

Another option for wire sizing is to use a voltage drop spreadsheet. There's one for Mac and one for PC on HP's *download page #2 at www.homepower.com/download2.htm, under "Wire." Just plug in the numbers and the spreadsheet does the work. Ian Woofenden*

Hi Steve, I agree fully with you about using aluminum conductors. I try to discourage people wherever possible from using them due to the problems you have stated. Unfortunately, I still get calls from people who want to use them, and they know that most of the conductors used by utility companies (what do they know?) are aluminum. Also, these aluminum cables are widely available. The electrolysis problems associated with DC circuits and aluminum conductors have not been widely publicized or documented. If you have some good information, please share it. We may need to put some sort of advisory (not a requirement) in the code if we can satisfy any objections raised by the cable manufacturers. John Wiles

Drumming & Dancing in Light

As a *Home Power* subscriber, I thought you may be interested in an email I just received from Somaliland. I have recently sold a number of PV items including two Unisolar lighting kits, two Steca inverters, twenty DC lights, two Morningstar controllers, eight BP 75 watt modules, cables, fuses, etc. to Kirsten, who works as an aid worker running a number of orphanages in Somaliland. Her mail really brought home to me the value of an electric light—something most of us take for granted—and the real value of solar power in areas without electricity:

Hi Allan, How is everything in Dubai? I have received the lights bulbs from David, and the orphanage in Buroma received their two panels yesterday. You should have seen the children when the light was turned on. They grabbed a drum and danced. The orphanage is housing 120 children. The smaller children and the girls are accommodated in a small building; the boys sleep in some worn-out tents. The kitchen is placed in the yard, without any shelter (they also got some plates so that they do not need to eat in turns). The women running the orphanage got a laptop and a printer for their office—also run by solar. It was a good day! Indeed it is a good idea to give them solar-electric systems, since there are no running costs (although I will have to purchase some spare bulbs, but that can wait). Hope to hear from you again concerning the items ordered. I hope it is not too troublesome to facilitate this transaction. Best regards. Kirsten, Hargeisa, Somaliland

The lady needs support. I sent a copy of the email to Steca and got a donation of 25 of their DC CF lights. As she also bought eight BP275s, I am trying to get a donation from BP.

Kirsten has been in my showroom for several hours on two occasions. She seems to me to be a dedicated aid worker and now a PV enthusiast. When she arrived in Somaliland from the Danish branch of Save The Children, there was a non-operational donated PV system (which seemed to me due to bad battery maintenance and locally purchased car batteries).

She now has a local electrician she met in Dubai, who seems to understand PV and batteries and who has now installed two DC systems with Morningstar controllers and AC/DC systems of both 12 V and 24 V using Steca 400 watt (12 V) and 900 watt (24 V) inverters with built-in PV controllers. She claims all are working great. We supplied AC-Delco maintenance-free Mariner M27MF 105 AH batteries, which are now manufactured locally, so they are low cost and are usually "fresh"—probably the best value locally for small-scale PV applications.

Imported maintenance-free and gel batteries may spend months in hot containers and warehouses. And I have had to return several imported "new" VRLA gel cell batteries that were reading below 10 volts to local suppliers (who do not understand my complaint). Local battery acid seems always diluted with well water and is chlorine contaminated, so dry cells are also a problem.

Actually, that email from her made me feel great. At first she "drove me around the twist" with hours of questions and negotiations, but her mail made it all worthwhile. Also, *if* I can overcome my fear of flying on ancient Russian jets, which is the only way to get to Somaliland (I had a bad episode before on these in Azerbaijan), I have been invited there to check on the systems. I may go in early March after my 50th birthday. If so, I will send photos, etc. Alan Dickson, Dubai solstice@emirates.net.ae

Sine vs. Modified Sine

I have some novice questions, please. What household electrical devices are OK to run on a modified sine wave inverter without damage? I have read in *Home Power* that it is recommended to not run any delicate items with a motor on modified sine, but can I run my compact fluorescent lights, TV, radio, etc? How about devices that are on very infrequently with a motor, like a household mixer? Relative to the type of device or power consumption, what is the importance of overheating these motor-driven items?

I have devised a long-range plan for electrical independence, and will be starting out small. I will take one room or area type—lighting for instance—and move it off-grid. I would like to buy a cheaper modified sine wave inverter in the beginning, and don't want to fry anything. Basically, I have to understand the theory of a situation first before acting. I appreciate in advance your clearing this fuzzy area up for me.

Thank you for being there for people who want to move toward being environmentally and socially independent. I was starting to feel all alone in Oklahoma on this issue until I searched the Web one day. I love my subscription to your magazine! Frankie Evans frankie.evans@af-group.com

Hello Frankie, I would suggest buying a sine wave inverter. About the only household loads that operate well *on modified sine wave power are resistive loads such as incandescent light bulbs and electric heaters. All other appliances suffer performance, efficiency, and longevity problems when powered by modified sine wave power.*

All the loads you describe above are reactive loads. The compact fluorescents will have an audio buzz, get hotter, and be less efficient and shorter lived. The TV will most probably show noise lines on the picture and the audio may have an annoying buzz on it. The household mixer will run slowly and appear underpowered. All motors will run more slowly, run hotter, be less efficient, and be shorter lived.

Some appliances will fry and die immediately when operated on modified sine wave power. This list includes laser printers and many computer peripherals such as CD-ROM burners, most motors with speed control circuits, and some types of cordless tool rechargers. Save your money for a sine wave inverter, even if you have to start small. Richard Perez

Solar Incentives in Colorado
I hope you can help me. After browsing your site (awesome information, by the way), I found myself very, very upset. I work for a small internet company in Nederland, Colorado. We recently bought our first PV panel with visions of offering 100 percent solar-powered Web development. I surfed the Web in hopes of finding state or federal incentives for switching to solar (we need about sixteen panels and the rest of the shebang—about US$12,000 worth of stuff). I was completely appalled by the lack of help our state gives! Is the information about state incentives on your site up to date, and if it isn't, where can I get the current info?

I am ready to fight for the right for solar incentives. After all, we are a state with sooooo much sun! Do you have any recommendations or advice to help me out, Web sites, or grant/incentive information? I would be so excited to get this project rolling. I feel oppressed by our state at the moment. We are practically the only state without incentives! I can't believe it. I am so disheartened!

In any case, I love what you all are doing at *HP*. If you need any Web assistance, we would be glad to help you out as well. If you come up with any information to help me out, I would greatly appreciate it. Thanks so much and keep up the good work. Tanya Bokat, tbokat@planetmind.net

Hi Tanya. What is really needed is for the folks interested in fighting this fight to get organized. You all won't do that much individually, but as a group you could make great strides. What say, Coloradans, can you work with Tanya?

Thanks for the offer on the Web assistance. I do the Web work for Home Power, *and from time to time run into problems. I will keep your address handy. We are in the midst of changing our Web host to SolarHost.com—do you know of them? They offer completely solar-powered hosting. Michael Welch*

Pick a PEX
Richard, We are in the process of building a new home and will be installing radiant floor heating. The plan is to use solar collectors to heat water in a storage tank prior to distribution to the floor system via a heat exchange unit.

The location is the central coast of California—Pismo Beach area—which is normally 50 to 75 degrees. Air conditioning is with open windows, since we are at the beach with a mild climate. The house has two stories. The second floor is the only living space, and the first will be on grade used as a garage, workshop, and storage area.

My question for you is about the installation of the pex tubing to transport the water supply as the heat source. Which method of installation will radiate the heat best? Or, after all is said and done, does it really make a difference? Should we install tubing over the wood subfloor and then pour 1-1/2 inches of concrete to create a thermal mass? Or should we install the tubing between the floor joists below the wood subfloor with the proper insulation to drive the heat up?

Considerations are cost, and weight of concrete in the event of an earthquake (and possible structural damage to the home from movement of concrete as a shifting mass). Should the system leak, location and repair is certainly easier with the between-joist method. And if we install between the joists, there will be a certain amount of heat gain for the garage area. I plan to install radiant heat in the slab of the garage to help maintain a stable environment throughout the house.

We will also be installing a backup source to boost the temperature when extra heat is needed. What's your opinion on a 96 percent efficient boiler versus a heat pump? We will be generating our own electricity through rooftop photovoltaics. I realize that with all solar installations, there is the cost versus benefit. In this situation, I'm not really sure how to balance the scales. Your wisdom in this area will be appreciated. Jim Thomas jimthomasins@hotmail.com

Hello Jim. A concrete slab will greatly increase thermal mass and even out the floor's temperature. You will be able to store more heat, which will lessen the amount of hot water you have to store, and reduce the use of your backup heat source.

If the underpinnings (the framing on the first story) are stout enough to support the concrete slab, the slab will actually increase the home's strength. The concrete slab should have "road wire" embedded in it. This wire holds the PEX tubing in place, and makes the concrete very rigid.

Finish the concrete floor with tile if possible. This adds more thermal mass and is compatible with a heated floor's expansion and contraction. Tile also works well if you have designed windows into the south side of the building.

The under-a-wood-floor method commonly goes down with sheet metal strips, which seal the PEX to the floor's underside and help transfer the heat to the wood. The big problem here is that wood is a lousy thermal conductor, and on top of that, it doesn't like the drying effect of being heated, and the expansion/contraction it produces. Wood has low specific heat—it doesn't store heat well. This leads to much wilder temperature swings on the floor.

I'd go with the slab on the second floor if possible. My hands-on experience with this is limited to our new 2,200 square foot building here. It has a thermal slab on the ground floor. We have four inches of foam insulation underneath six inches of concrete, with embedded PEX tubing. It is finished with inexpensive tiles.

We have yet to fire it off with solar collectors, but the slab already stores direct solar gain from the south facing windows. It never *gets cold even when outside temperatures drop to well below freezing. We are adding about 300 square feet of solar collectors this summer. The backup heat source is a wood-burning heater. Our house is R-29 in the walls and R-40 to R-58 in the roof, with a lot of south facing glazing.*

Go with a propane or natural gas-fired boiler for backup, unless you are ready to spend some big bucks on PVs and batteries. When the sun is shining, your solar heating system should produce all you need. If the sun isn't shining, the energy to run that heat pump will have to come from batteries, recharged by PVs, which is a big expense.

If the home is well insulated (this is super important), the solar heating collectors properly sized, and sufficient thermal storage on hand, you shouldn't have to resort to the backup heater very often. Richard Perez

One Million 1 MW Wind Turbines
Greetings. In *The Wizard Speaks* in *HP80,* you point out that ten thousand square miles of solar panels (at 10 percent efficiency) would be enough to power the United States.

The CIA World Factbook shows that the United States consumes 3.666 trillion KWH per year. This number divides conveniently by 365, to yield a daily consumption of 10 billion KWH on average. Dividing this number by 10 to get daily peaks suggests that we need to have 1 billion KW of generating capacity online during a "normal day."

1 billion kilowatts is simply another way of saying 1 million megawatts. Since commercial-scale wind turbines run from 750 KW to 2 MW, it is convenient to use a 1 MW wind turbine as a reference. Spacing 1 MW wind turbines at 1/10th of a mile (528 feet), it is possible to cover one square mile with 100 turbines. A square 100 miles by 100 miles is ten thousand square miles, times 100 turbines, is one million turbines.

A typical county is 40 miles wide, or 20 miles from the border to the county seat. Any four or five counties in any one of the windier states in the country (North Dakota, Texas, Wyoming, etc.) would be large enough to run the whole country. Needless to say, the actual physical turbines would be distributed over a much wider area.

At US$1 per watt, this is a US$1 trillion investment. Over the next thirty years, as fossil and nuclear plants reach the end of their useful life, an investment of US$30 billion per year would steadily make wind power replacements for less desirable alternatives. PV panels, at a cost of US$4 to $5 per watt, would be difficult to justify as matters stand right now.

There is another way of looking at the 10,000 square miles, if the discussion remains focused on PV. Our census shows a population of 281 million people as of April 1, 2000. Multiplying 10,000 square miles by 5,280 x 5,280 yields an area of 279 billion square feet. Dividing this by 281 million yields roughly 1,000 square feet per person. Take the area of all the parking lots, all the "big box" retail stores, all the schools, public buildings, and private residences, and it doesn't take much to figure out that we already cover more than 1,000 square feet per person with buildings, asphalt, or concrete. Shading much of this real estate would cut cooling costs and/or damage to paint, roofs, etc., so it may be possible to recover the substantial additional cost of solar power through complimentary economies.

The bugaboo in all this is the "unreliability" of renewable energy sources. Over time, of course, these things are 100 percent reliable. Since water power is highly reliable and controllable, and since water is essential to civilization anyway, the reliability issue can be solved by attacking another problem simultaneously. This is to create enough water impoundments and stair-step lakes so that excess energy generated during off-peak hours is used to pump water uphill. This can be run through water turbines during peak hours.

Any particular geographic region will run short of water from time to time. This suggests that this system does not work unless it is possible to transport large amounts of water around the country on demand. Typically one area of the U.S. is dry during periods when another part is flooding. The impoundments should be designed so that water can move laterally from one reservoir to another. There are some issues associated with mixing the contents of various ecosystems by doing this. It may be necessary to purify any water transported this way.

Our consumer society will eventually bring all these things to pass, because we tend to demand these things whether they are rational or not. Water consumption is likely to rise considerably as we continually build bigger houses on bigger lots. Conservation is nice, but conservation only occurs when costs are high. When costs are high, technology is applied to bring costs down. This technology is what will eventually (actually, fairly soon) make the renewable alternative fully competitive. Meredith Poor, San Antonio, Texas • mnpoor@txdirect.net

Ozonal Notes

Richard Perez

The California Energy Crisis

The recent California energy crisis has given us a glimpse into the future. It's caused this nation to take a hard look at energy. What caused this crisis? Will it happen elsewhere? What can we do to prevent these blackouts in the future?

Deregulation

Electric power deregulation is often compared to the deregulation of the telephone communications industry. The essence of deregulation is that the governments stop determining how an industry operates and the prices it may charge. Instead, the operation of the industry is left to the marketplace. While this worked with the phone companies, it has been far less successful with the utility power industry.

In the case of the phone companies, the service they sold was in ample supply. But that is not the case with electricity. During the decade of the 1990s, power consumption rose in the U.S. by over 25 percent, while new generation was increased by only 7 percent. This is a recipe for disaster.

Electric power dereg in California left it up to the marketplace to determine the amount of power available, and what it would cost on a wholesale level. When wholesale power got scarce, the prices went through the roof. Wholesale power prices were deregulated, but retail prices remained controlled. This left one of the largest utilities in the world (PG&E) without enough power to service its customers, and a financial deficit of over 100 million dollars a day.

PG&E's financial bonds went from highly rated, to a ranking with the lowest and riskiest junk bonds. This in turn put the hurt on major banks (such as Bank of America), which were heavily invested in PG&E bonds. The net effect of California's deregulation was to bankrupt one of the largest utilities in the world, create a financial/political crisis, and shut off the power to many homes and businesses with rolling blackouts. The ramifications of this energy crisis will continue for months and years to come.

Deregulation allowed PG&E to divest itself of the less profitable generation portions of its business—they no longer make most of the power. Instead, they simply transmit and sell it. Their power suppliers saw a golden opportunity and jacked up the prices to the point where even mega PG&E could not afford to buy the power. This lead to the first intentional blackouts in California since the Second World War. And the blackouts continued for many days….

The current darling of the utilities is the natural gas turbine. These power plants are quick to fire up and about as clean as carbon burning gets. Since no one wants either a nuke or a coal plant located near them, natural gas turbines are just about all that utilities have been building for the last ten years. During the initial hit of the California energy crisis, these natural gas turbines were working overtime. The net result was that natural gas prices skyrocketed and there were shortages of natural gas. The situation in California cannot be solved by building more power plants if there is no fuel to run them.

It is time to reexamine deregulation of electric power utilities. Their product has become so essential to us that we cannot afford to leave its availability and wholesale price up to free market forces. We need some form of regulation to keep utility power constantly available and affordable. While political regulation scares me just as much as letting the marketplace run wild, we need to insure the reliability and affordability of electricity. The recent energy crisis in California clearly demonstrates this. Other states have better dereg programs that appear to be working for now (like Pennsylvania, which has deregulated both wholesale and retail power).

Energy Conservation

During the depth of California's energy crisis, I was deluged with phone calls and emails from folks with huge power bills who were suffering from blackouts. Most had never heard of a compact fluorescent light, much less a solar water heater. Many had all-electric homes. I gradually realized that the power consumers in California were as much to blame for the blackouts as the utilities. Some of these households were slurping up hundreds of kilowatt-hours every day! They had never made any efforts to reduce their electrical power consumption. They seemed to think that power was limitless, and that they had a God-given right to it at a cheap price.

In fairness, some of the freaked-out Californians were running fairly energy efficient households, but they were being blacked out just like everyone else. They were concerned and angry. They were paying for their neighbors' energy excesses, and they weren't pleased about it. Many were ready to go solar, and ready to spend the money necessary to get an independent power supply.

The California energy crisis could have easily been avoided if each household would have reduced its power consumption by just a few percent. Just by setting the water heater five degrees cooler, or by turning off a few lights, or unplugging phantom loads, there would have been enough power to go around without blacking out anyone. This didn't happen. Power consumption continued unabated until the utility was forced to black out areas of the state. The only consumption decreases during rolling blackout periods were in the areas that were actually blacked out. Everyone else continued to slurp as usual. This really surprised the utilities.

Renewable Energy
The combination of flawed deregulation, poor utility planning, and unbridled consumption left California, the world's sixth largest economy, without enough electricity to go around. If it can happen there, it can happen anywhere. The solution? Well, it comes up every morning.

Of all the proposed solutions, only renewable energy, increased conservation, and increased energy efficiency really really make sense. California has already rejected nuclear power. Conventional power plants foul the air, and Californians have already objected to that. The only real and sustainable solution involves renewable energy. Fortunately, California is blessed with abundant sunshine, wind, and falling water.

What California needs, and what this whole nation needs, is distributed renewable energy generation. If homes were equipped with rooftop PV arrays and utility intertied inverters, there would be no energy crises. Each home could produce its own power and contribute its surplus solar electricity to the nation's energy supply.

This nation's rooftops contain more area than is required to supply electricity to the entire country. I calculate that we have about 4.6 times more roof area just on the homes in the U.S. to power *everything* nationwide (businesses and manufacturing included). And I generously discounted for north-facing roofs, and allowed for utterly miserable solar insolation.

Distributed generation would also ease the burden on the overtaxed long distance power distribution network. We wouldn't need to build new long distance power lines, thus saving the expense and land use they require.

In my *Ozonal Notes* column in *HP81,* I discussed the United States' transition to a solar-hydrogen economy. We have the technology to eventually eliminate fossil fuel burning and nukes. All it takes is using solar energy. All it takes is having the good manners to accept what nature is freely offering us in the form that she offers it.

In the past, the prime objection to solar energy has been its cost. A quick look at the over 2 billion dollar cost of just one month of the energy crisis in California should cause us to reexamine our financial objections to solar energy. We're going to pay either way. For my money, I'd rather have a clean and sustainable energy solution.

A Solution to California's Energy Crisis
This solution relies on the people of California. You can do it—you can make this problem go away and never return. Begin with conservation and efficiency—examine your electrical power usage and eliminate waste. Buy and use compact fluorescent lighting. Buy and use a solar hot water heater. Improve the insulation in your home. Replace your out-of-date energy-guzzling appliances.

I'm not talking doing without here—I'm talking getting the maximum usefulness out of every kilowatt-hour of energy we use. Fortunately, off-gridders have already blazed this trail—they know how to squeeze the maximum benefit out of every KWH.

Next, install a solar-electric system on your roof, with a utility intertied inverter. This will cost you less than buying a new car. It will make your home not only energy independent, but also allow you to share solar energy with your neighbors. California already has a net metering law in place that requires utilities such as PG&E to buy your surplus solar energy at retail rates.

California also has some of the most attractive solar incentives in the nation, including a generous buydown program (see Eric Hansen's article on page 48 for more details). With the California government incentives, your new solar-electric system could cost far less than a new car. Consider that you are buying a minimum of twenty-five years of electricity in advance. Once it's paid for and installed, you're done spending money on electricity. Consider that the electricity will create no pollution.

You pay your money and you make your choice.

Paper Chase
Home Power is currently on the great paper chase—again! The mill that was supplying our 30 percent postconsumer paper shut down unexpectedly. Due to economics, the economy, fluctuating pulp prices, etc., the highest postconsumer content that we can find is only 10 percent. But it costs 50 percent more than the paper we used for this issue.

Most of the available paper with high-postconsumer content is uncoated single sheet, in other words, office paper. The big coated web rolls that we need, with any appreciable postconsumer content, are not readily available and very expensive.

We'll definitely keep looking, and if any of you have any suggestions or sources, please let us know.

Nerd Notes
On February 3, Xantrex held a focus group in Sacramento, California. Xantrex, the company that recently purchased Trace, Statpower, Heart Interface, and Cruising Equipment, wanted input for their new products. This meeting, the brainchild of Xantrex's Ezra Auerbach, Tony Boatwright, and Pagan MacKay, is the first time that any manufacturer in the small-scale RE industry has formally asked its customers what they want in new products. I can only hope that this idea catches on, and that other manufacturers will solicit feedback from their customers regarding new products. Good work, Ezra, Tony, Pagan, and Xantrex!

Access
Richard Perez, *Home Power,* PO Box 520, Ashland, OR 97520 • 530-475-3179 • Fax: 530-475-0836
richard.perez@homepower.com • www.homepower.com

Q&A

To Track or Not to Track…
Dear *HP,* I am a subscriber and have two questions that I would appreciate your expertise on. I am told that here in northern Vermont it is not cost-effective to purchase trackers for PV arrays—that more energy will be gained by spending the cost of the tracker on extra modules.

I will be purchasing a backup generator. What are the relative merits of gasoline, diesel, and propane with regard to fuel efficiencies, maintenance, longevity, etc.? Thanks, Michael Clark, Greensboro, Vermont

Hello Michael. The viability of a tracker doesn't depend on latitude, but on solar exposure. A tracker is worth the extra money if the site receives dawn to dusk sun. There is also a minimum number of modules worth tracking. With the current cost of modules and trackers, it is not cost effective to track any fewer than eight modules. If you have a tracker site and at least eight modules to track, using a tracker is more cost effective than purchasing more modules. Expect a 25 to 40 percent energy increase from the modules that are tracked.

When it comes to engine generators, propane is the best fuel. It has none of the transportation and storage problems inherent in diesel and gasoline. Propane also burns cleaner, reducing engine maintenance. And during your cold Vermont winters, the propane generator will be easier to start. Richard Perez

Hi Michael, Another thing to consider is what times of year you have a serious need for energy. On many renewable energy sites in northern climes, non-tracked systems already have a surplus in the summer when we have a big solar window and less need for lighting and electronics. But there may be very little sun in the winter (because of latitude and weather) when we really need energy. So in some cases, tracking can be a questionable investment unless there's a big non-winter load. Ian Woofenden

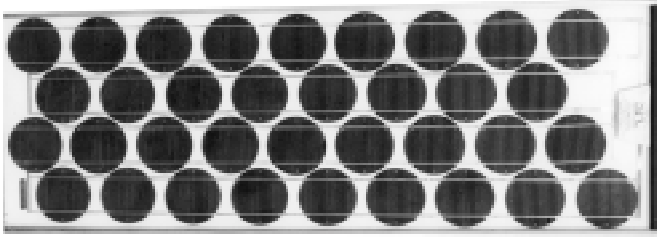
Power versus Energy
I live on a farm in northern Alberta, Canada, and due to the increase in prices of electricity, we are looking into alternative energy sources. I have found your site to be one of the best sources of information on this subject. I do have one question that I can't find the answer to anywhere. When a PV panel's wattage is mentioned, does it mean per hour or per day? For example, if I have a 75 watt panel, would it produce 75 watts an hour or by the day? If you could help, it would be great. Sincerely, Daniel Prudholme, blackfox@telusplanet.net

Hello Daniel. Watts (power) are instantaneous. Watt-hours (energy) are watts multiplied by time. A 75 watt PV will (theoretically) make 75 watt-hours during one hour of full sun at 25 degrees module temperature. (Real world module output is generally about 85 percent of rated output.)

In a five-hour solar day, that same 75 watt PV will make about 375 (more like 325 in reality) watt-hours during that five-hour solar day (75 watts times 5 hours equals 375 watt-hours of energy). Richard Perez

Mystery Module?
Dear *Home Power,* At the 2000 MREF, I purchased a used solar panel. It was manufactured by Solar Power Corporation in Massachusetts. It is Model No. LG120-12, with Serial No. 51,144. First, I have done some basic tests on it and noticed that in full sun the open circuit voltage never goes above 15 volts. Any idea why? Short circuit current is 1 amp. A close inspection of the panel shows no signs of cell fractures or any other signs of deterioration.

Second, would *Home Power* or any of your readers have any spec sheets on this panel or any further information about its history or technical specifications? Anthony Skelton, Warwick, England skeltonanthony@hotmail.com



Help! Does anyone have a spec sheet on this PV?

Sorry Anthony, I don't know anything about that module. But some very healthy modules are designed with 15 VOC. How about it, HP *readers, can anyone help Anthony with the specs for this module? Richard Perez*

DC Wiring
Our first home is under construction, and we are doing it ourselves. Since our home is to be small and just for the two of us, I'd like to run primarily on 12 volts—compact fluorescents, ceiling fan, radio, etc. I figured on using a small inverter for TV and other things that I will have to use. I bought a 300 watt inverter at a discount store for US$50. I plan to use propane for the water heater, dryer, range, fridge, etc. to reduce the electrical load.

Do you know any books on 12 volt house wiring? I bought the booklet *Wiring 12 Volts for Ample Power,* but I'm looking for something directed more at a home wired with tried and true methods.

I believe I can run #10-2 Romex for my circuitry of approximately 5 amps. My home runs will be around 50 feet or less, and have two to three outlets per circuit. Can I use standard 120/240 VAC breakers and box, or do they have to be 12 volt?

I'd like to use Interstate T-105 batteries, since I can buy them for US$45 each. Do they hold up as well as Trojan? I plan to start out with twenty T-105s, and recharge with a propane 12 V engine/alternator. We'll add modules and a wind generator (Air 403) as we can afford them. We will probably be paying a lot for propane and 12 V items initially, but at least we will be grid-free.

I also need a 12 volt smoke detector with 9 volt battery backup (ordinarily 110 VAC with 9 V backup in case of power failure is required by electrical code). Do they make 12 volt GFI outlets for wet areas?

I realize running primarily on 12 V is more difficult, but we're financially limited, and buying the big inverter and hardware is cost prohibitive. If it fails, we're shut down. If my 300 watt inverter goes down, I can simply break out a spare.

My building inspector thinks I am nuts, but is willing to go along with us. I haven't talked with the electrical inspector yet, but as long as we're legal with the *NEC,* we shouldn't have any problems, should we? Tim and Joannie King, Pegram, Tennessee

Hello Kings. Sounds like a great project; here are a few observations. My initial thought is that by the time you spend all that *money on DC wiring and the more expensive DC appliances, you could have bought a moderate-sized inverter and installed simplified AC wiring. When I wired my house, I wired it for both AC and DC, knowing that I could not afford another inverter—similar to your situation. Fortunately, my inverter has had zero problems in its six years, and I have not had to fall back on DC lighting, etc. But since I do have the DC wiring, my always-on loads like my answering machine do not keep my less efficient inverter up and running.*

If you do go the DC route, consider spending the minimal extra $$ to wire the house for AC at the same time. Almost every 12 volt household I have heard of has eventually wanted to add a good-sized inverter. To do the new AC wiring after the walls are closed up will be much more expensive.

Doing your DC wiring to code will not be easy, but if you work things out with the electrical inspector before installation, both you and the inspector can be satisfied with the results. You must use DC breakers in your system, but they will fit inside a standard breaker box. I would bump the wire size up to #8 so that the voltage drop in your circuits does not affect your appliances.

Twenty T-105 batteries? Wow, that's a lot of batteries for such a small system. You may find that you will be running your generator a lot more than you think to keep the batteries topped off. Seems like you could get by with a much smaller battery bank than that, but I have not seen your load calculations. Personally, I like the Interstate batteries just fine. I don't really have any preferences, but they look like a good deal.

I do not know of 12 V GFI outlets. In fact, there is no such thing as a DC outlet. In my house, I use the 20 amp AC outlets for the DC circuits. They have receptacle slots that are different than the standard AC outlets. One is vertical and the other is horizontal. That way I can't accidentally plug an AC appliance into a DC outlet, and vice versa. If the inspector requires GFI outlets for your house, you may be out of luck. You can just avoid putting outlets in the bathroom and kitchen, but many inspectors would not find that acceptable.

I did find 12 and 24 volt smoke detectors, but they were very expensive. They are special models for multiple-detector systems that go into motels, etc. There was no battery backup on them, but there may be some out there that have that. I would try to reason with the inspector to allow strictly 9 volt battery detectors. That may be your only alternative; only further research will tell. Michael Welch

DC/DC Converters

Sir, You were referred to me by my solar elmer, John Holmes KA6KAA, for a possible answer to my current challenge. I am just starting to become grid-independent here in San Diego, and have built a 24 VDC solar and wind system. However, I run an extensive radio shack with lots of radios, TNCs, and antenna controllers on 12 VDC.

At first I thought I could pick off 12 VDC from the 24 VDC battery bank, but was met with unbalanced loads, erratic charge controller indications, and current loops (via the RF cables). Now I have a separate 12 VDC battery bank that I would like to charge from the 24 VDC system.

Searching for a DC/DC source battery charger, I did find one via the Majorpower.com site, model number BCD300-32-12, but it costs US$383. Living on a shoestring down here with the rising cost of electricity due to deregulation, I am looking for alternatives. Could you direct me toward a less expensive answer to this design problem? Thank you in advance, John Feist, AA6QN aa6qn@pacbell.net

Hello John. As you discovered, center tapping that 24 VDC battery bank to get 12 VDC is not *the thing to do. This causes all the problems you mentioned, and also leads to premature battery failure.*

Any commercially made 24 VDC to 12 VDC switching power supply in the 20 plus ampere range is going to cost around US$300. Vanner, in Columbus, Ohio, makes a product called the Voltmaster, which is designed to do this job in motorhomes and home power systems. Their 20 amp model costs around US$300 also. We've used this unit, and it's fairly RF quiet, efficient, and reliable. See HP33, *page 84, for a review of the Voltmaster.*

Here is a company that makes a 20 amp, 24 VDC to 12 VDC converter for around US$100. A reader sent me this data, so it's secondhand. Innovative Circuit Technology Ltd., 9775 188th St. #402, Surrey, BC V3T 4W2 Canada • 604-888-6304

You can also homebrew a circuit called the "charge shuffler." It's perfect for the job, if you can live with round-the-clock maximum 3 amp input to the 12 VDC battery. See HP39, *page 68. You can also homebrew a DC/DC power supply that is also limited to about 3 amps. See* HP37, *page 82. Richard Perez, N7BCR*

Thank you for your response. Please publish my letter, since it may help others. I did receive a response from another amateur, and he mentioned www.mpja.com, product number 8600-PS, which is an 8 amp, 24 to 12 VDC converter for US$29.95. John Feist, AA6QN aa6qn@pacbell.net

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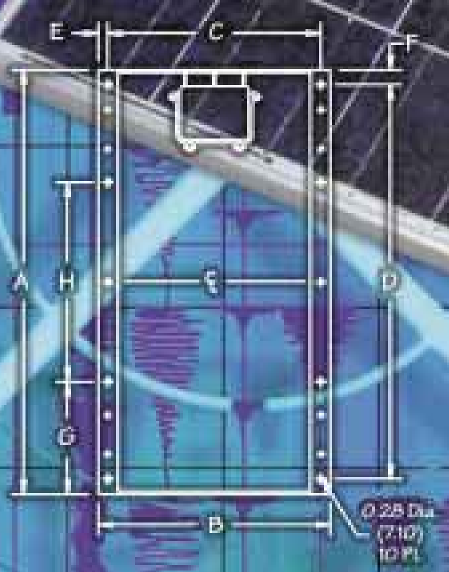

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The following information about your renewable energy usage helps us produce a magazine to better serve your interests. This information will be held confidential. We do not sell our mailing list. Completion of the rest of this form is not necessary to receive a subscription, but we would greatly appreciate your input.

NOW: I use renewable energy for (check ones that best describe your situation)

- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
- ☐ Recreational electricity (RVs, boats, camping)
- ☐ Vacation or second home electricity
- ☐ Transportation power (electric vehicles)
- ☐ Water heating
- ☐ Space heating
- ☐ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
- ☐ Recreational electricity (RVs, boats, camping)
- ☐ Vacation or second home electricity
- ☐ Transportation power (electric vehicles)
- ☐ Water heating
- ☐ Space heating
- ☐ Business electricity

RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ☐ Solar power
- ☐ Wind power
- ☐ Hydro power
- ☐ Biomass
- ☐ Geothermal power
- ☐ Tidal power
- ☐ Other renewable energy resource (explain)

The GRID: (check all that apply)

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❏	❏	Photovoltaic modules	❏	❏	Methane digester
❏	❏	Wind generator	❏	❏	Thermoelectric generator
❏	❏	Hydroelectric generator	❏	❏	Solar oven or cooker
❏	❏	Battery charger	❏	❏	Solar water heater
❏	❏	Instrumentation	❏	❏	Wood-fired water heater
❏	❏	Batteries	❏	❏	Solar space heating system
❏	❏	Inverter	❏	❏	Hydrogen cells (electrolyzers)
❏	❏	Controls	❏	❏	Fuel cells
❏	❏	PV tracker	❏	❏	RE-powered water pump
❏	❏	Engine/generator	❏	❏	Electric vehicle

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