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THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #92 December 2002 / January 2003

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Cover: "Good morning, tracker"—sunrise over Allan Sindelar's PV array near Madrid, New Mexico. Photo by Allan Sindelar of Positive Energy, Sante Fe, New Mexico.

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Scamming to Save the Planet

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"Frying Squad Foils Cooking Oil Car Scam" read the headline of a recent article published by *The Guardian,* and forwarded to us by several *Home Power* readers from the UK. The London-based newspaper reported that police in Wales were issuing fines, and threatening seven-year jail terms, to motorists apprehended while running their diesel rigs on vegetable oil, which is untaxed. The "crime" was tax evasion. The tip-off was the sweet smelling exhaust coming from their tail pipes.

Wales is a hotbed for vegetable powered transportation, and motorists opting to run their vehicles on something other than petrol are definitely drawing some heat. One veggie oil commuter recounted his experience of being pulled over by an unmarked police car. "The officer went to the fuel tank, dipped it, and found cooking oil. I put my hands up to the offence, but the car was towed away." He was fined £500 (US$780) for using an illegal, untaxed fuel, and stuck with a £150 (US$234) towing charge.

Home Power reader David Harten, from Avenel, New Jersey, read the article and had this to say, "Why arrest people for doing the right thing? Next thing you know, they'll be arresting people for riding bicycles and avoiding fuel taxes." Eventually, there will be emissions-based taxes, and the polluters will be the ones who pay.

Biofuels are part of the solution to our transportation woes. It's something we can do now. The use of biofuels creates a short, closed carbon loop. Each year, the crops that are grown to make the oil, fix the same amount of carbon dioxide present in the vehicle's emissions. It's a balanced ecological system.

On this side of the big pond, my own quest for a diesel Toyota truck recently ended in a show of generosity. A friend in Taos, New Mexico passed along her trusty, 1982 pickup for free, when she heard I was going to fuel it with used vegetable oil. Whether or not the "powers that be" get their war for oil, I'm cruising with a clear conscience. And I'll make sure to keep an eye out for those that "serve and protect" in my rearview mirror.

–Joe Schwartz for the greasy *Home Power* crew

People

Daniel Bisbee
Mike Brown
Sam Coleman
Marika Febus
Rick Germany
Eric Grisen
Kathleen Jarschke-Schultze
Stan Krute
Don Kulha
Don Laughlin
Don Loweburg
Chuck Marken
Tom Markman
Harry Martin
Carol Montheim
Ken Olson
Stephany Owen
Karen Perez
Richard Perez
Linda Pinkham
Shari Prange
Benjamin Root
Connie Said
Joe Schwartz
Philip Squire
Michael Welch
John Wiles
Dave Wilmeth
Ian Woofenden
Solar Guerrilla 0023

"Think about it…"

"Find out just what the people will submit to, and you have found out the exact amount of injustice and wrong which will be imposed upon them.

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The limits of tyrants are prescribed only by the endurance of those whom they oppress."

—Frederick Douglas

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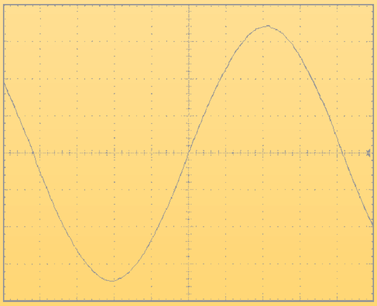

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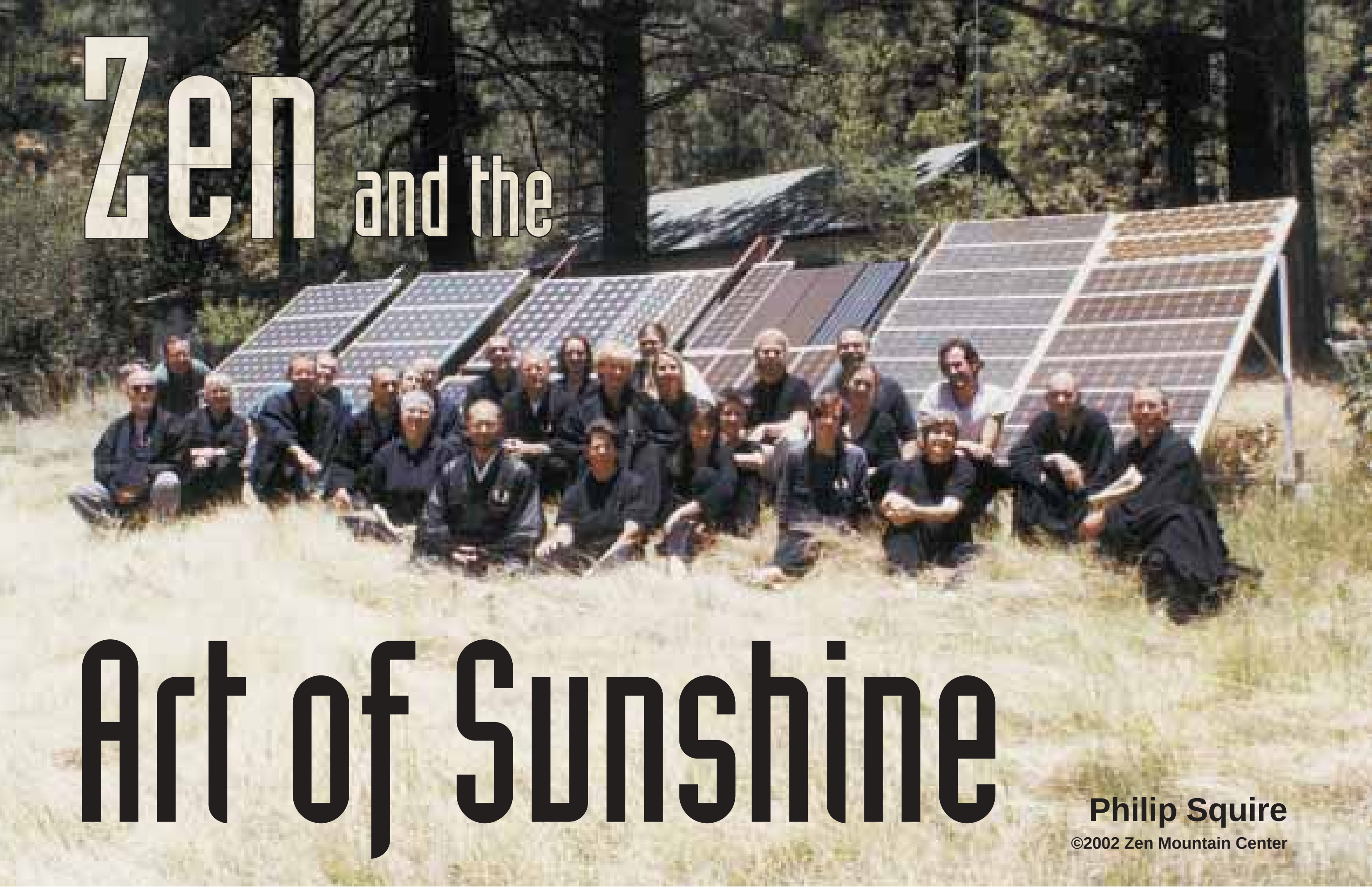
Zen and the Art of Sunshine

Philip Squire



Zen Mountain Center residents and members in front of the 1.2 KW array—a mixed assortment of Arco, Siemens, and BP solar-electric panels.

Zen Mountain Center is a Buddhist retreat and training center located in the San Jacinto Mountains of southern California. We are nestled in a steep-walled canyon with meadows, chaparral, and dense stands of pine, cedar, and oak. The canyon is 1.1 miles from the nearest utility hookup.

The property, covering 160 acres of pristine wilderness, was originally purchased in 1981 by the Zen Center of Los Angeles as a summer mountain retreat. It has now grown to include a year-round population of about 15 monks and lay residents, and up to 50 visitors and residents during retreats and workshops.

Early in the development of the property, we conducted an environmental impact study to establish eco-friendly limits on the number of people and buildings to be supported by the canyon. This was to ensure that the awe-inspiring beauty of this land and the health and well-being of its furry denizens would be preserved.

Electricity for the New Center

Few people, even back in 1981, were willing to live without electricity. With these limits in mind, we started to consider how to power all the functions of a modern community. Our options included:

- Bringing in utility electricity from the road end by either utility pole or buried cable;
- An engine generator, battery, and inverter combination; or
- PVs, batteries, inverter, and an engine generator.

Hydro and wind power were not deemed feasible, since both wind and water flows in the canyon are fairly intermittent.

The upfront cost for extending the utility grid up the road in 1982 was at least US$66,000, and is approximately double that today. PV was the second most expensive option, at US$15,000. The engine generator, battery, inverter option turned out to be the least expensive in the short term, but the prospect of noise and air pollution in the quiet of the canyon ruled this out as a long-term solution. However, engine generators were used in the very early days as an initial power source.

The outlying cabins rely on their own PV systems—
a couple of panels, a charge controller, and batteries.
The only electrical amenity is 12 volt lighting.

The PV system was eventually selected as the most viable option due to lower initial cost compared to bringing in the utility line. The use of PV would also require significant energy conservation, and ensure that we would not just be transplanting suburbia into a mountain environment.

Heating & Cooking

Following the decision to go with solar electricity, the obvious choice for heating, cooking, and refrigeration was propane. In the early days when winter residents were few, woodstoves were used for heating. But with few exceptions, gas heaters have been phased in over the years. The first reason for this is that we are in a very high fire danger area, with only one road out down the canyon. A second reason is smoke, and a third is the logistics of gathering, cutting, and distributing all that firewood.

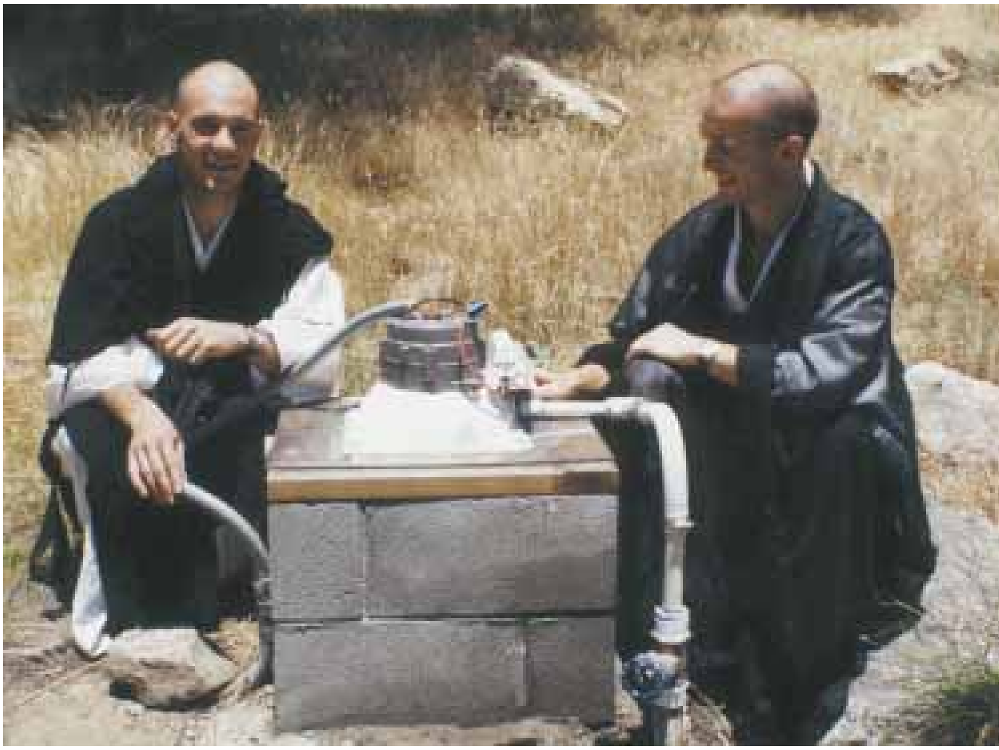
We use propane for water heating, to fire one commercial and two domestic stoves, and to run six assorted gas refrigerators and one freezer. We have two, 500 gallon (1,900 l) tanks that are filled on a regular basis by a supplier from our local town of Idyllwild (10 miles; 16 km away). These feed underground gas lines to serve accessible buildings, with bottled propane providing for outlying cabins and trailers.

Developments in Electricity Generation

At present, Zen Mountain Center has about twenty separate structures, including meditation halls, kitchen and dining facilities, guest accommodations, a workshop, meeting rooms, and a large bathhouse. All these structures were built by our Abbot, Charles Tenshin Fletcher, a building contractor by trade, and twenty years of hardworking Zen Center members. Most of these buildings are located on about an acre in the lower end of the property, and are powered by what we call the “main system.”

The remaining structures (two cabins and two trailers) are located in the upper part of the grounds. These are powered by their own individual PV arrays due to their distance (up to 1,500 feet; 460 m) from the main electrical system. These systems consist of two or three Arco M-75 panels, a Sun Selector M16V 3.0 charge controller, and two, 6 V Trojan T-105 batteries (220 AH at 12 volts).

Alex Capdeville and Philip Squire with the hydroelectric turbine. They have been responsible for the construction and maintenance of the current system.



The control room— Trace SW4024, two Trace C40s, RV Power Products SB50, E-Meter, disconnects, and overcurrent protection.

These smaller systems have given very little trouble since they were installed. The only maintenance that has been needed is replacement of one faulty charge controller, adding water to the batteries, and very occasional charging (by portable engine generator) during periods of low sun and heavy usage.

The main system has gone through a number of changes and expansions since 1981, but originally grew from a consolidation of several different PV systems dotted around the lower property. In 1993, when it was first put in place, it consisted of a combination of eighteen Arco M-75s and eight Arco16-2000s on a fixed mount in our lower meadow—located 100 feet (30 m) from the batteries and connected with four, #2 (33 mm^2) USE, direct burial cables. About half of these modules were used and had considerably reduced outputs from their rated values.

A 30 amp charge controller and voltage monitor (Speciality Concepts SC2), and a 3,000 watt Westec Systems W3000-24 120/240 inverter were the electronic brains of the system. The system also included eight, 6 volt Trojan L-16s (700 amp-hours at 24 volts), a 6.5 KW Honda ES6500 gasoline engine generator as our backup, a 24 volt battery charger, and a Todd Engineering power switch to change the output from inverter to generator (or vice versa) during charging. The output from this system was delivered as 240 VAC to all individual building breaker boxes, and powers 120 VAC loads inside the buildings.

This system provided learning experiences for PV novices, and delivered most of the electricity in the canyon. It was totally manual, and required monitoring to ensure that the batteries did not get too discharged during low sunshine days.

Over the first two years the batteries were in use, they lost most of their useful capacity. The main problems appeared to spring from a faulty battery charger coupled with not enough knowledge about how and when to recharge the bank. Consequently, the bank never received a full generator charge, and certainly never an equalizing charge. As usage increased, the PV array became increasingly undersized, which meant that there was never enough solar input to bring the batteries to a full state of charge. Ruining a battery bank in two years was quite an expensive lesson.

Sixteen Trojan L-16s store 1,400 AH at 24 V. The batteries are in a separate room, and are well insulated (a removable blanket of fiberglass insulation is added during the winter months).

The main bathhouse and community room, with propane heating and electric lighting—no hair dryers allowed!

The tallest thing around—the Air 303 perches atop a 100 foot (30 m) pine.

One other problem was that there was a short loss of power during the generator/inverter switchover, which meant keeping the computer people informed about the upcoming reboot. Also, if heavy power tools or the washing machines were being used, the lights would flicker and the computers would go down. (We found that the modified square wave output from our inverter was not compatible with separate, stand-alone, computer UPS systems.)

Upgrading the System

In the summer of 1995, we decided to bite the bullet and go high tech. We calculated that in the next five years, we could be using anywhere from 4 to 8 KWH a day, depending on the number of residents. The maximum power draw of around 3 KW would occur if several power tools and the kitchen's vent fan were running at once. So we needed an inverter that could provide that sort of output over a short period of time, and enough surge to get the motors started.

We also wanted an automatic starting option for the generator, and as pure a sine wave as we could get. The battery storage should be enough to get us through a couple of days of cloudy weather, which meant purchasing at least 20 KWH (approximately 800 AH at 24 V).

After researching several options and raising the necessary cash, we purchased and installed a Trace SW4024 inverter and a propane powered 7 KW Kohler 7CCKM generator with an hour timer. The batteries were hooked up to the inverter through an Ananda SF400-T disconnect. The output was then fed into our main breaker box located on the outside of the workshop, and from there to the rest of the property.

The old batteries were kept in place with the hope that an equalizing charging regime would bring them back to life. When that failed, we tried the EDTA treatment, but this also had little effect. It seemed that most of the generator and solar electricity that was pumped into them just disappeared. So digging into our pockets again, we bought as many new batteries as we could afford without seriously undersizing the system. Sixteen Trojan L-16s were purchased, which gave us a total storage of 1,400 amp-hours at 24 volts.

This amounted to a useful storage of around 700 AH (17 KWH) if we were to use the recommended 50 percent discharge depth. We also built a new generator shed with one room for the generator, inverter, and meters, and one room for the batteries. Four additional PV panels (Arco M-60s) from a system powering the kitchen and guest accommodations (which was subsequently hooked onto the main system) were added to the main PV array, giving us a maximum output of around 30 amps at 24 volts.

In October 1996, we purchased a Trace C40 charge controller with digital display and a Cruising Equipment E-meter. Together, these meters allowed monitoring of total amp-hours produced and consumed, and showed

A power shed in the pines with the Honda ES6500 engine generator outside. The Honda acts as a second backup.

Zen Mountain Center Loads

Workshop	Qty.	Run Watts	Hrs./Day	Days/Wk.	Avg.WH/Day
Circular saw	1	500	1.0	1.0	71.4
Band saw	1	1,000	0.5	1.0	71.4
Compressor	1	1,000	0.5	1.0	71.4
Drill	1	750	0.5	1.0	53.6
Lights	4	50	1.0	1.0	28.6
Generator Shed					
Inverter idle load	1	16	24.0	7.0	384.0
Wash House					
Washing machines	2	500	3.0	2.0	857.1
Office					
Computer	3	100	7.0	5.5	1,650.0
Printer / fax	2	100	1.0	5.5	157.1
Lights	2	20	4.0	5.0	114.3
Phones	2	2	24.0	7.0	96.0
Answering machine	1	2	24.0	7.0	48.0
Kitchen					
Lights	4	20	4.0	5.0	228.6
Vent fan	1	1,500	0.5	2.0	214.3
Blender	1	300	0.5	6.0	128.6
Mixer	1	200	0.5	5.0	71.4
Bathhouse					
Lights	8	20	2.0	7.0	320.0
Community Room					
Computer	1	100	3.0	5.0	214.3
Lights	4	20	4.0	3.0	137.1
TV/VCR	1	120	3.0	2.0	102.9
Dormitories					
Lights	12	30	4.0	2.0	411.4
Staff Housing					
Lights	15	30	2.0	7.0	900.0
Vacuum cleaner	1	700	1.0	6.0	600.0
Computers	4	100	2.0	4.0	457.1
Coffee maker	1	800	0.5	7.0	400.0
Answering machines	6	2	24.0	7.0	288.0
Television/VCRs	2	100	2.0	2.0	114.3
Stereos	7	15	1.0	5.0	75.0
Meditation Hall (large)					
Lights	16	40	4.0	2.0	731.4
Meditation Hall (small)					
Lights	4	20	1.0	6.0	68.6
			Total average WH per day		9,066.0

Based on resident population of 15; energy consumption can double during retreats and workshops.

that we were using a lot more than we'd estimated.

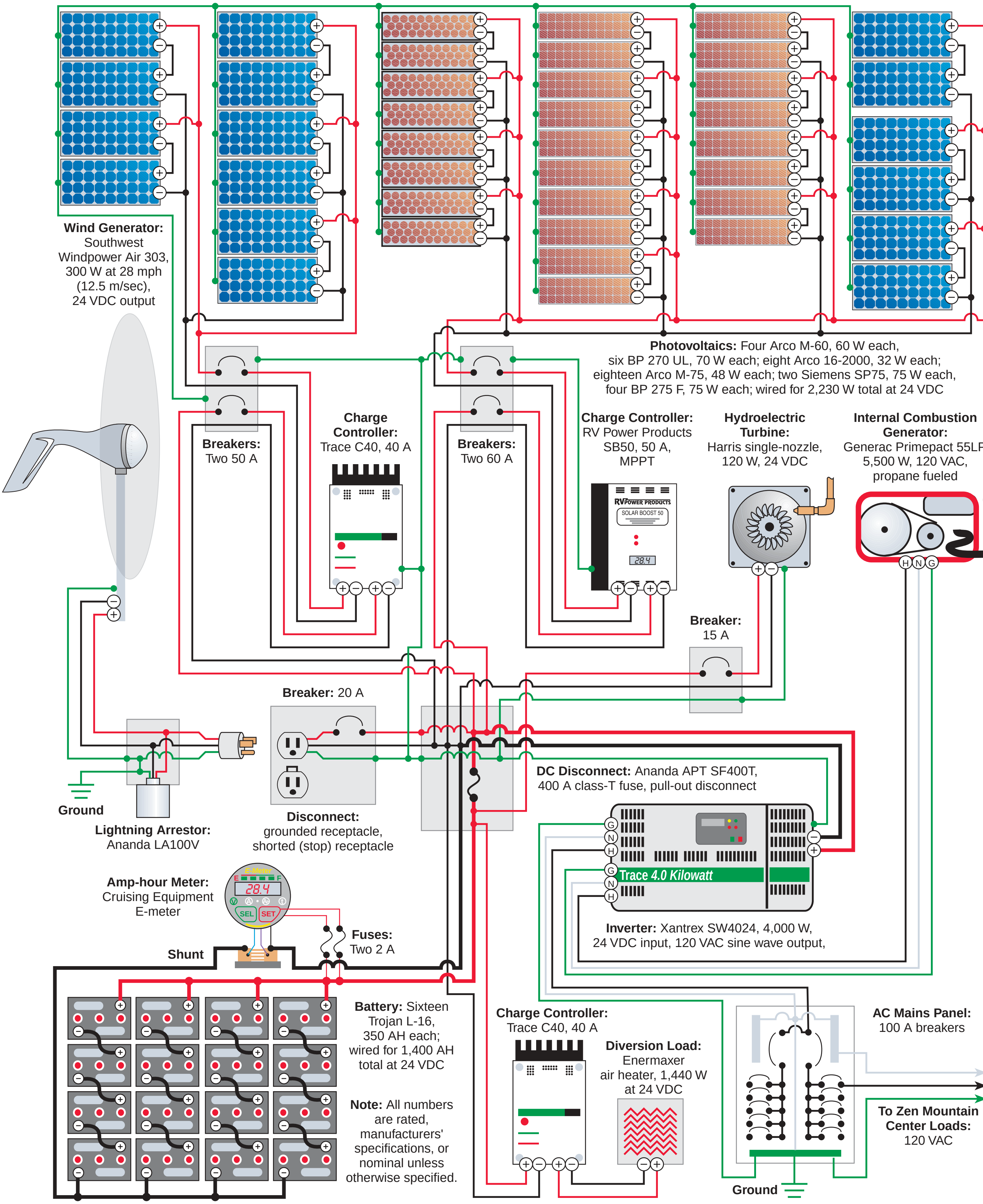
On the average day, instead of the 4 to 8 KWH we'd calculated, our total energy consumption was more like 8 to 9 KWH. Because we were producing only 4 to 5 KWH on a sunny day, the center was seriously underpowered. This explained why the generator was running every two to three days. With this energy deficit in mind, we have been purchasing panels as we can afford them, and installing compact fluorescents everywhere.

Over the past few years, we have added two Siemens SP75s, six BP Solar 270ULs, and four BP Solar 275Fs, giving us a maximum output of around 1.2 KW. With the higher current through the wires, we beefed up the connection between the array and the inverter to four, #3/0 (85 mm^2) cables. We also split the main array into two subarrays (300 W and 900 W), and purchased an RV Power Products Solar Boost 50 as the additional charge controller.

With the extra panels, we are now about 100 percent renewable during summer. We will still be slightly underpowered during winter and when we host large retreats. Our goal is to be 100 percent green powered on an average day during winter. We do, however, plan to keep covering the intermittent spikes in energy consumption during large guest retreats with an engine generator rather than another subarray of solar-electric panels.

Since we added the Solar Boost 50 charge controller, I notice that there can be as much as a 15 percent increase in output on cold days during the winter when the batteries are low. There isn't much gain during the summer when the batteries are full most of the time and the voltage is high. But overall, this unit is worth the cost.

Zen Mountain Center Renewable Energy System



Zen Mountain Center Main System Costs

Item	*Cost (US$)*
18 Arco M-75 modules	$5,400
Trace SW4024 inverter	3,500
Generac Primepact 55LP propane generator	2,800
8 Arco 16-2000 modules	2,400
16 Trojan L-16, lead-acid batteries	2,400
6 BP Solar 270UL modules	2,100
Boxes, breakers, fuses, conduit, cables, etc.	1,500
4 BP Solar 275F modules	1,400
4 Arco M-60 modules	1,200
Harris microhydro turbine	800
2 Siemens SP75 modules	700
SWWP Air 303 wind generator	500
2 Trace C40 charge controllers	370
RV Power Products Solar Boost 50 controller	350
Ananda APT SF400T disconnect	300
E-Meter amp-hour meter	190
Enermaxer diversion controller, 1,440 W	150
Ananda LA100V lightning protector	60
Total	$26,120

Energy Distribution

We are using three, #2 (33 mm^2) cables from the inverter to a main service panel. From there, using the same cable size, electricity is fed underground to subpanels at individual buildings and complexes around the property. The main panel is fused with 100 amp breakers.

The old Westec inverter used to give us 240 VAC, which we delivered using the three, #2 (33 mm^2) cables with two hot legs, and one neutral. With the new 120 VAC Trace inverter, and all the cable direct burial, we decided to jumper the original hot legs together at the main breaker box and at individual breaker boxes. This gives us two, hot #2 cables and one #2 neutral. Each subpanel is grounded individually.

Quirks, Glitches, & Pleasant Surprises

A few other interesting changes occurred in our operating system after the upgrade that are worth mentioning. Just before the upgrade, we installed an extractor fan and swamp cooler in our kitchen to live up to the requirements of the Department of Environmental Health in Riverside County. These two fans together draw about 2,000 W. This is a tremendous amount of energy for a small system like ours, so we use it as sparingly as possible. With the experience we've gained over the years, we'd have purchased different fans, but we rarely use them, except when things get really smoky.

With the old Westec inverter, it was impossible to start the two fans at the same time. This may have been because the high surge, undersized wiring, or the modified square wave was not to the liking of the fans. This caused some inconvenience, since the motors were started by the same switch in the kitchen, and it meant climbing onto the roof and disconnecting one while the other started up. Also, if the fans were restarted after a short break in operation, there were loud groans of protest from the motors. We blew up one capacitor this way. However, with the advent of the new Trace inverter, all these problems miraculously disappeared.

The sine wave output has now allowed installation of UPS systems for the computers. UPS systems wouldn't work properly with the old inverter—something to do with heat buildup and sensitivity to the quality of incoming power. These UPS systems are an absolute necessity, because we constantly experience flickers in the power whenever a washing machine or power tool starts up. This could be caused by a slight undersizing of the underground cable to the various buildings, resulting in a voltage drop as the motorized culprit kicks in.

This does not occur when the generator is running, which puzzled us at first, since the inverter has a higher surge capacity than the generator (10 KW compared to less than 7 KW). But we came to find out that when charging batteries from an engine generator, Trace SW series inverters will back off on the charge rate and actually draw energy from the batteries to assist the generator in powering large loads if need be.

The inverter has overload protection, and shuts off if it experiences a load of more than 10 KW (in other words, if there is a short in the system). This is fine except that if there *is* a short somewhere on the property, the inverter will shut the whole system down before an individual magnetic breaker in one of the buildings can do its job. This means that it's harder to find the source of the short. And once you know where the short is, it can be a long walk to restart the system, and it's an inconvenience to everyone else at the center.

Even the waveform of the Trace SW4024 sine wave inverter may not remove the nasty hum from a stereo amplifier. From experiences of people around here, it appears that the hum depends on the brand and model of stereo that you buy. I bought a Sony boombox, only to hear a loud hum that would not go away, even when securely grounded. I exchanged it for a similar product from Aiwa, which is as quiet as a mouse using CD and radio, but still emits a slight noise running the cassette deck. It seems worthwhile to experiment, especially if you're going to spend a bit of money.

Engine Generator Lemon
Our Kohler engine generator spent a fair amount of time in the repair shop immediately after its purchase. We had to get a completely new one when one of the cylinders developed a crack and sent oil and smoke pouring out of the generator shed. The replacement model developed some problems too. One spark plug was continually being plugged with black carbon deposits every 30 hours of operation. This occasionally resulted in misfiring, and required regular replacement. Oil was also appearing around the breather tubes, suggesting that perhaps the rings were not properly seated.

After an almost complete rebuild (under warranty), it appeared that the problem had been mostly taken care of. However, after perhaps a year of trouble-free operation, the Kohler really gave up the ghost, due to arcing (we think) in the main coils. So we purchased a Generac Primepact 55LP with a three-year warranty.

But sadly, this too has been giving us headaches, with bad thermal breakers, oil leaks, and other unidentifiable problems. So we're hunting around again for something that really works—any suggestions? All the more reason to keep on working towards 100 percent renewable energy.

Wind in Our Future?
Zen Mountain Center is committed to reducing our reliance on the engine generator, so we are increasing the size of our PV array as the money becomes available. Recently we've decided to look again at feasibility of wind and water as energy sources. As mentioned earlier, we didn't think we had enough of either resource for useful energy generation. However, we started to experiment with wind, using an Air 303, just to be sure. In the cooler months, there are some terrific gales (Santa Anas), which come from the high desert and sweep over our mountains and down into the canyon.

In January of 1999, we installed an Air 303 in the top of one of the tallest pine trees near the electrical shed. Since the Air is priced about the same as a single solar-electric panel, and has the potential for putting out 400 watts during very strong winds, it appeared worth the initial investment.

The downside to this wind generator is that it is not at all quiet. It has a distinctive moan when wind speeds get above 20 mph (9 m/s), which has been a little irritating to those used to the whisper and rush of wind in the pines.

The Air 303 is hooked up via 100 feet (30 m) of #8 (8 mm^2) UV Romex running down the tree (stapled as required by code) through a removable, three-point plug and socket (for quick disconnect from the electrical shed in case of pending lightning) and a 20 amp fuse to the battery bank. We also installed an Ananda LA100V lightning arrestor in-line, in case we forget to disconnect the wiring during storms.

We recorded the output of the Air 303 using an E-Meter for the first year. We received about 1,500 amp-hours (at 24 volts), or 36 KWH for a twelve-month period. In the same time period, our PV array gave us 1,632 KWH. Investing the same amount of money that we spent for the Air 303 in another solar module would yield perhaps three times the annual energy output. Considering this, plus the higher maintenance requirements for the wind generator and the intermittent nature of our wind resource, we decided that solar electricity is a much better bet than wind for our site.

Microhydro
Water power is something we're now looking into. The wells from which we gravity feed potable water for the center (horizontally drilled into the granite at the back of the canyon) are at an elevation about 180 feet (55 m) higher than the electrical shed. And we already have a 2 inch pipe for water supply and fire protection running around the property.

We gave Don Harris of Harris Hydroelectric a call and discussed the feasibility of installing one of his microturbines. Don came down and talked us through the installation, and we have now connected one of these amazing little pieces of equipment to the water system and the electricity system.

Don gave us several different nozzle configurations for our system, based on our available head and flow rates. We are still in the testing stages, but will probably be running a flow rate of 6 to 9 gpm for an output of 100 to 150 watts. This could provide a major portion of the electricity we need in one fell swoop!

The microhydro turbine is directly wired to the battery bank via 100 feet (30 m) of #2 (33 mm^2) cable through a 15 amp breaker. Since the microhydro must be connected to a load at all times to control the turbine's rpm, we also installed a second Trace C40 (in diversion mode) and an Enermaxer 1,440 W air heater and fan diversion load. Any excess electricity produced by the turbine is dumped to this load once the batteries are full.

The bulk and equalize set points on the diversion Trace C40 are set a couple of points above the set points on the solar charge controllers and Trace inverter. This ensures that the output from the solar array or generator does not start discharging into the heater/fan diversion load when battery voltage approaches bulk or equalize voltage. When we run an equalizing charge with the propane generator (we don't have enough capacity to do this with renewables) we make sure to hit the equalize button on the diversion Trace C40.

The success of this project, however, depends on whether we have enough water in our aquifer. Our wells are our only water supply, and this is southern California. We are not sure what kind of effects moving this amount of water from one end of the property to the other will have on the riparian ecosystem around the wells, and on the viability of our water supply.

We're planning to only operate the hydro system during the winter, once the rains and snows arrive. We'll keep a close eye on biological health, well flow rates, and surface water levels in the stream bordering the well site. It may be that we won't feel comfortable with running the turbine even during the winter for any length of time, but at the very least it will be a backup supply for when the wind isn't blowing, the sun isn't shining, and the generator has decided to quit.

Renewable Community

Living in a community with renewable energy is an ongoing education in how to balance a large and diverse group of needs with the realities of a finite amount of energy. Informing visitors and residents regularly about the need for conservation, and the necessity for using energy efficient lighting and appliances is part of a process that keeps us aware that electricity comes at a cost.

At Zen Mountain Center, we are directly aware of that cost, since we produce the stuff. Everyone who visits here experiences living with renewable energy. And if we do nothing else than alert people to the fact that every time we flick a switch, we are having an effect on the environment, it will be well worth it.

Access

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Alternative Solar Products, 27412 Enterprise Circle W, Ste. 101, Temecula, CA 92590 • 800-229-SOLAR or 909-308-2366 • Fax: 909-694-1458
mark@alternativesolar.com • www.alternativesolar.com
System components

Harris Hydroelectric, 632 Swanton Rd., Davenport, CA 95017 • 831-425-7652 • Hydroelectric turbine and consultation

Off the Grid: Starting Small

Daniel Bisbee

A small solar-electric system meets the Bisbee family's needs. They've lived with the system for three years, and made a number of changes to improve the system's performance and safety.

Our off-grid adventure began in January 2000 in Vermont's Northeast Kingdom. After spending a month and a half with no electricity at all, we began to build our system. We have started small, putting things together gradually—living with the system, studying how it works, upgrading the weak points, and learning. It has not always been easy, but it has been fun, and we learn something new almost every day.

In the fall of 1999, my wife, two daughters, and I had purchased our dream house on 92 acres in northern New England for a very reasonable price. The property is on a town road with regular telephone service, but no grid electricity. Other potential buyers backed away when the electric company quoted US$7 a foot to bring in the utility line from about a mile away (about US$37,000).

The previous owners had taken their homebrew, tractor-mounted generator when they left, and we briefly considered an engine generator for our main electricity producer. We balked at the expense of a good engine generator and its associated costs, and instead decided to go ahead with our dream of a solar powered home.

First I should confess that we do not desperately need electricity here. Our stove, refrigerator, and water heater are all propane. Water is gravity fed from a spring. An airtight woodstove provides heat. Large windows and good orientation of the house mean we need no interior lighting during the day. We use electricity for lights, music, television, and a laptop computer. Various other appliances and tools are used as the battery storage allows.

Purchasing & Installing the System

Part of our reason for moving here was to reduce our debt, so our solar-electric system had to be cheap and therefore small. The Internet provides an incredible amount of information about off-grid living. Most suppliers of independent power equipment have Web sites. After visiting the Web sites of several *Home Power* advertisers, we purchased a kit from SolarOnSale.com.

The kit consisted of three, 60 watt solar-electric panels, a charge controller, an inverter, and a pile of #12 (3 mm^2) wire. We purchased two, 6 volt golf cart batteries from the local auto parts store, and a set of heavy-duty jumper cables from Wal-Mart.

With this pile of stuff in the basement and a little trepidation, we began. The first job was to set up the panels. Reading *The Solar Electric Independent Home Book* from New England Solar Electric, we learned that a fixed array at an angle of 60 degrees would work well for our location, about 45 degrees north latitude.

To make a module rack, we constructed two equilateral triangles out of 2 by 4s, 4 feet (1.2 m) on each side. These two triangles were then connected using another 8 foot (2.4 m) 2 by 4 and a couple of 1 by 3 lath strips. We ended up with a long, low easel, with a place for the three panels to rest on a 2 by 4 ledge at the bottom. With no electricity, all the construction was done outside with hand tools. This was mid-January, with the temperature around 20°F (-7°C), so construction was rough. However, the frame has survived two winters and is in fairly good shape.

We shoveled the snow away from an area near the basement door and dragged the easel into position. Next, we set the panels on it and wired them to the charge controller and batteries. The jumper cables were cut in half and connected between the batteries and the inverter, using the original alligator clamps in makeshift fashion at the battery bank. A 50 foot (15 m) extension cord was strung across the basement and up the stairs.

We plugged in a table lamp with a 15 watt compact fluorescent bulb. Woohoo! We were producing electricity from the sun! After nearly a month and a half with only flashlights and a single Aladdin lamp, we were thrilled.

The next step was to integrate the system into the house wiring. We ran wire from the inverter to the circuit breaker panel. After this, circuit breakers were turned on for the kitchen and living room. This gave us a grand total of four compact fluorescent bulbs—60 watts total.

How (Not) to Set Up Solar-Electric Panels

One of the first and most important things we learned was how not to set up our PVs. Our easel worked well until the first windy night. At around 4 AM, we found ourselves plucking one of the panels out of the snow where it had blown off the rack. We used some wire left over from another project to tie the panels onto the frame.

Another lesson came on a bright, clear morning when the panels just refused to produce. A light dusting of snow had completely covered the panels. A quick brush with a broom fixed that. This was followed by a big sigh of relief that we had not mounted the panels on the roof.

Our next lesson came during a thaw. Our house has a metal roof. On warm days, the snow on the roof will warm up and slide off all at once. Unfortunately, the PVs were right where the roof dumped the snow. The good news is that all the panels stayed securely tied to the frame. After digging out the panels, we moved the whole assembly a bit farther from the house.

Late in the spring, we observed the sun rising behind the panels. We had mistakenly assumed that the house was oriented due north-south. A check with a compass revealed that the house really sits on a northeast-southwest line. Reorienting the panels solved this little problem.

Yet another lesson came in June. The panels were not charging the batteries at the rate we anticipated. One of our panel connections made in the cold of January with numb fingers had loosened. We redid all the

Dan Bisbee's daughter Cally sweeps off the panels.

Bisbee System Loads

Item	Qty.	Avg. Hrs./Day	Avg. WH/Day
TV / VCR, 70 W	1	2.000	140.0
CF lights, 20 W	1	6.000	120.0
	2	3.000	120.0
	2	2.000	80.0
	5	0.250	25.0
Fluorescent ring bulb lights, 30 W	1	4.000	120.0
	1	1.000	30.0
	2	0.250	15.0
Laptop computer, 60 W	1	1.000	60.0
Stereo, 25 W	1	2.000	50.0
Vacuum, 1,100 W	1	0.033	36.7
Blender, 720 W	1	0.008	6.0
Shop vacuum, 900 W	1	0.006	5.0
Circular saw, 1,200 W	1	0.003	3.3
Drill, 360 W	1	0.008	3.0
Scroll saw, 150 W	1	0.017	2.5
Jig saw, 360 W	1	0.006	2.0
Total Average WH per Day			818.5

connections with spade connectors and corrosion-inhibiting lithium grease.

Charge Controller

Our original kit came with a Lyncom SR12C charge controller that appeared to be working well. However, the supplied literature stated that the maximum PV input was 7 amps. We calculated the full output of our panels at about 10.5 amps. We were afraid that this high current would damage the controller, so we decided to upgrade.

After perusing *Home Power* and surfing the Web, we purchased an RV Power Products Solar Boost 50 from GotSolar.com. The controller's pulse width modulated (PWM) regulation increases battery longevity. More important, its maximum power point tracking (MPPT) technology actually increases the PV current to the batteries.

The cold climate we have here in northern Vermont results in high PV array voltages, and allows us to gain maximum benefit from the controller's MPPT capabilities. We have seen up to a 25 percent boost to the batteries over what we used to get from the PV array.

We chose the 50 amp model over the 20 amp model, so we will be able expand our system without having to upgrade the controller. The charge controller works well with only one minor flaw. In a 12 VDC nominal system, at very low inputs (less than 1.5 amps), there is actually slightly less output current than input current due to the power requirements of the charge controller itself.

Batteries

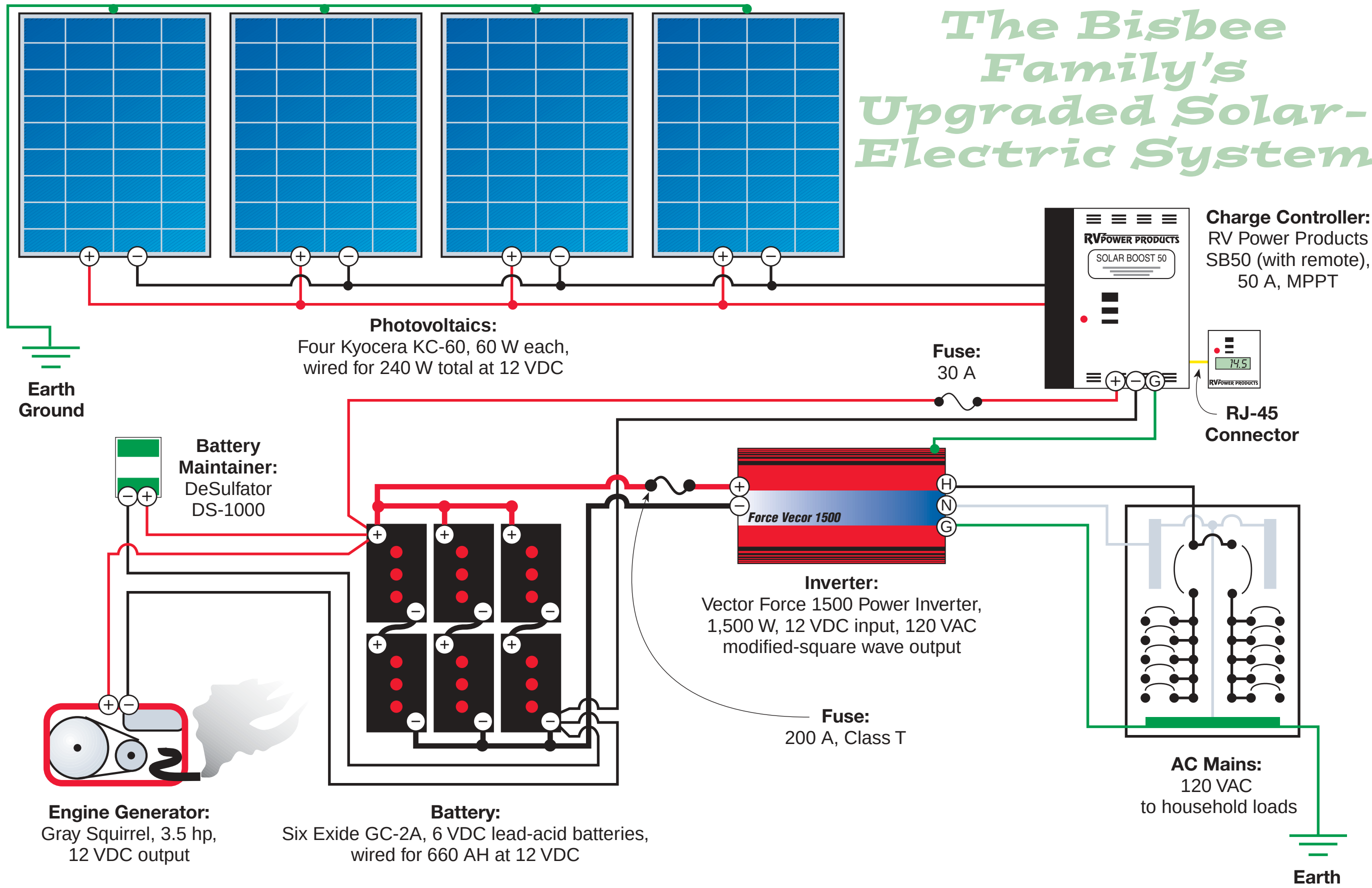
Since we were building our system on a budget, we chose lead-acid golf cart batteries for energy storage. We purchased two, Exide GC-2A, 220 amp-hour, 6 volt batteries from our local auto parts store. These cost around US$65 each plus a US$8 core charge for each battery.

We thought two batteries would be enough for the small amount of electricity we would require at the start. However, the batteries were fully charged early on sunny days and yet there was not enough to get us through more than one or two cloudy days without draining the batteries. A month after we bought the first two batteries, we ordered four more Exide GC-2A batteries to more closely match the battery bank to the solar-electric panels. We also cut the alligator clamps off and installed proper battery lugs instead.

Due to the cold winters here, it is necessary to keep the batteries inside, in our basement. We received conflicting information on battery boxes. One side said

Homemade rack details and proper PV placement have been part of the Bisbees' learning process.

The Kyocera KC-60 panels enjoy an open solar window.



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

that we should have a vented battery box because the batteries would be in the living quarters. The other side said that because hydrogen is so light, it would simply dissipate unless the room was small and airtight.

When lead-acid batteries charge, they give off explosive hydrogen gas. With just two batteries, we were not overly concerned with hydrogen gas buildup. But with six batteries, we decided that a vented battery box would be a worthwhile addition. We put a 1$^1/_4$ inch PVC pipe to the outside through the wall of the battery box.

The battery box actually has three purposes. First, it lowers the possibility of explosion due to hydrogen gas buildup. A second purpose is to keep the area looking nice. The pine box is much nicer to look at than a big group of batteries and wires.

The third purpose is that it protects the batteries from us. With two kids, a dog, and a cat wandering around, it makes sense to have the batteries protected. This point was driven home when I was checking the tightness of the battery cables recently. The wrench slipped out of my hand and I dropped it on the batteries. It clattered harmlessly on the floor, but could have caused a serious problem had it landed across the exposed terminals.

Inverter

Since the house is on a town road, the previous owners assumed that the utility grid would arrive someday, so the house was wired for conventional 120 VAC electricity. This includes a standard circuit breaker panel, AC outlets, and conventional light fixtures. Adapting our solar-electric arrangement to the existing wiring required an inverter to convert the 12 volts DC from the batteries to 120 volts AC.

The inverter supplied with our kit was a Vector Force 1500 Power Inverter. This inexpensive, modified square wave inverter is still working well after three years. After two years, it is working well. It is rated for 1,500 watts continuous output with a surge of 3,000 watts. So far, the biggest load has been a 10 amp (1,200 watt) circular saw. From what we've learned since installing the system, we plan to add a sine wave inverter in the 600 to 1,100 watt range to the system.

Reducing Our Usage

They say that one dollar spent on efficiency results in a three to five dollar savings in solar-electric generation gear. With only 180 watts (rated) of PVs, we had to drastically reduce our energy consumption. First, all the lightbulbs were replaced with compact fluorescent bulbs. With these, a 15 watt bulb provides illumination similar to a 60 watt incandescent bulb.

Next, the 120 watt, 27 inch color TV and 70 watt VCR went out and were replaced by a 70 watt, 13 inch TV/VCR combination. This is plugged into a switched

Bisbee System Costs

Solatron Technologies	*Cost (US$)*
First 3 panels, inverter, 1st charge controller	$1,359
4th Panel	309
Local Auto Parts Store	
2 Golf cart batteries, 6 V, 220 AH	146
4 More golf cart batteries, 6 V, 220 AH	292
GotSolar.com	
2nd Charge controller with remote display	389
Wilderness Energy	
Generator, 12 VDC, 50 A	285
Independent Power	
Battery desulfator	135
New England Solar Electric	
Disconnect, class T fuse, book	125
Total	$3,040

power strip, so we are not powering the remote control circuitry all the time.

After that, the 90 watt computer and 150 watt monitor were replaced with a 60 watt laptop computer. The microwave oven and coffee maker were happily given away. The 200 watt stereo still sits in a box in the basement. The 1,200 watt table saw sits idle in the barn. On evenings after cloudy days, we all head for the bookshelf instead of the television—an added benefit.

Monitoring the System

The only system monitor we have right now is the meter supplied with the Solar Boost 50 charge controller. With it, we can monitor charging voltage during the day and battery voltage during the night. Additionally, we can measure incoming PV amperage and "boosted" amperage.

Using battery voltage to determine state of charge (SOC) is not very accurate because battery voltage varies as the system is charged or discharged. Our use of voltage as a system monitor is limited to a "more is better" concept. This system is rather crude, but it does give us an idea of the state of charge of the batteries. We plan to install a proper amp-hour meter as our next upgrade.

Giving In

In spite of our drastic reductions in electricity usage, we still run short on those long winter nights or after a string of cloudy days. We have given in just a bit with our renewable energy lifestyle and purchased an engine generator. It's not one of those big ones that can run a full sized "normal" energy inefficient house, but a small 12 VDC engine generator that we can use to charge the batteries after a few cloudy days. This means that we don't have to listen intently to every forecast to decide if we can use more than one light for the evening after yet another cloudy November day.

We chose a Gray Squirrel engine generator from Wilderness Energy, which is no longer in business. It is essentially a 3.5 horsepower lawnmower engine connected to a car alternator. This gives an output of 50 amps at 12 volts (600 watts). After a cloudy winter day with little or no charging from the PVs, running the engine generator for an hour keeps us going.

The generator didn't come equipped with any charge regulation. I'm looking for a high current, variable resistor to put in the line as soon as possible. Also, the alternator's built-in regulator limits voltage to around 13.5 volts maximum, so we can't bring the batteries up to a full state of charge using the engine generator. So this unit is not yet set up to be as useful as possible, but it staves off battery damage and electricity deprivation during cloudy weather.

Dan Bisbee checking his system—solar has him smiling.

The battery box is safely vented and enclosed below the power center.

Slowly Upgrading

As we have lived with the system, we have slowly been adding to it. Fusing was not included in our original kit. We now have a fused disconnect between the charge controller and the batteries, and a class T fuse between the batteries and the inverter. We purchased a DeSulfator DS-1000 battery conditioner at Vermont's SolarFest to extend the life of our batteries. Finally, in preparation for our third winter, we added a fourth KC-60 solar-electric module, giving us a total of 240 watts (rated) of PV capacity.

We plan to continue expanding the system as knowledge and money allow. First, we would like a better way of measuring the charge in our batteries. An amp-hour meter would give us a better indication of battery state of charge (SOC) than our present battery voltage readings.

An array disconnect and a combiner box are in the plans too. We presently throw a heavy wool blanket over the panels or wait until after dark to work on the panels or charge controller.

The next item will be a sine wave inverter. Even though our present modified square wave inverter seems to be working fine, we think a sine wave inverter would be better for our appliances. It may take that annoying little hum out of some of our compact fluorescent lights and AM radio. After that, we may enlarge our solar-electric array and increase the size of our battery bank.

We Did It Ourselves

We purchased the majority of our system through discount Internet firms with relatively few hassles. A defective inverter was replaced after one phone call, and missing PVs were drop shipped from the manufacturer overnight.

Did we save money by purchasing everything via the Internet? Yes and no. We have a system that works, but after upgrading everything to where we want it, we will be in the same price range as kits offered by the full service dealers.

Building our system one piece at a time has allowed us to learn about solar electricity without being completely overwhelmed or breaking our budget. The system lacks some of the integration of a system provided by a full service dealer. But there is something nice about knowing where each component is, how it is wired, and exactly what it does. We did it ourselves, and the education we have gotten from our system is nothing short of astounding. And that is priceless.

Access

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Air Land 403
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Southwest Wind Power, Wind Generator
Honda Silent 2.0 KW, $895
Kubota 6.5 KW, $3,550
$790 Danby Propane Refrigerator
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The Bergey XL.1 24 VDC battery charging wind system is the most technically advanced small wind turbine on the market today. It provides superior energy production performance with the "Tornado Tuff" ruggedness that has made Bergey turbines best sellers since 1980. And, best of all, the XL.1 is value priced to give you the most bang for your buck.

The XL.1 now features an upgraded PowerCenter controller that idles the rotor once the batteries are full (Warning: Be prepared to spend hours flipping lights on and off to cause the rotor to speed up or slow down. Highly addictive to techies.) and provides a convenient push button brake function. In addition, we doubled the dump load capacity (to 60A) and gave it proportional (PWM) control to more accurately maintain battery voltage, added a "wattmeter function," made customizing set-points a snap, and added a polarity checker for the wind and PV inputs.

Compare features, performance, price, reputation, and warranties. We think you will find that the Bergey XL.1 is the clear choice for your home power system. Get product information and find a dealer near you by visiting our web site: www.bergey.com.

PowerCenter Controller

- 60A Wind Regulator
- 30A Solar Regulator
- 60A Dump Load Control Circuit
- Voltage Booster for Low Winds
- Battery and System Status LEDs
- "Wattmeter" LED Function
- Timed Equalization Function
- Push Button Rotor Brake
- Slow Mode Rotor Idling
- Easy Set-Point Adjustment
- Polarity Checker

Typical Performance: 5.2 kWh DC per day

4 Times More Energy Than the Air 403[1] **1.8 Times More Energy Than the Whisper H40[2]**

1–Air is a registered trademark of Southwest Windpower, Inc.
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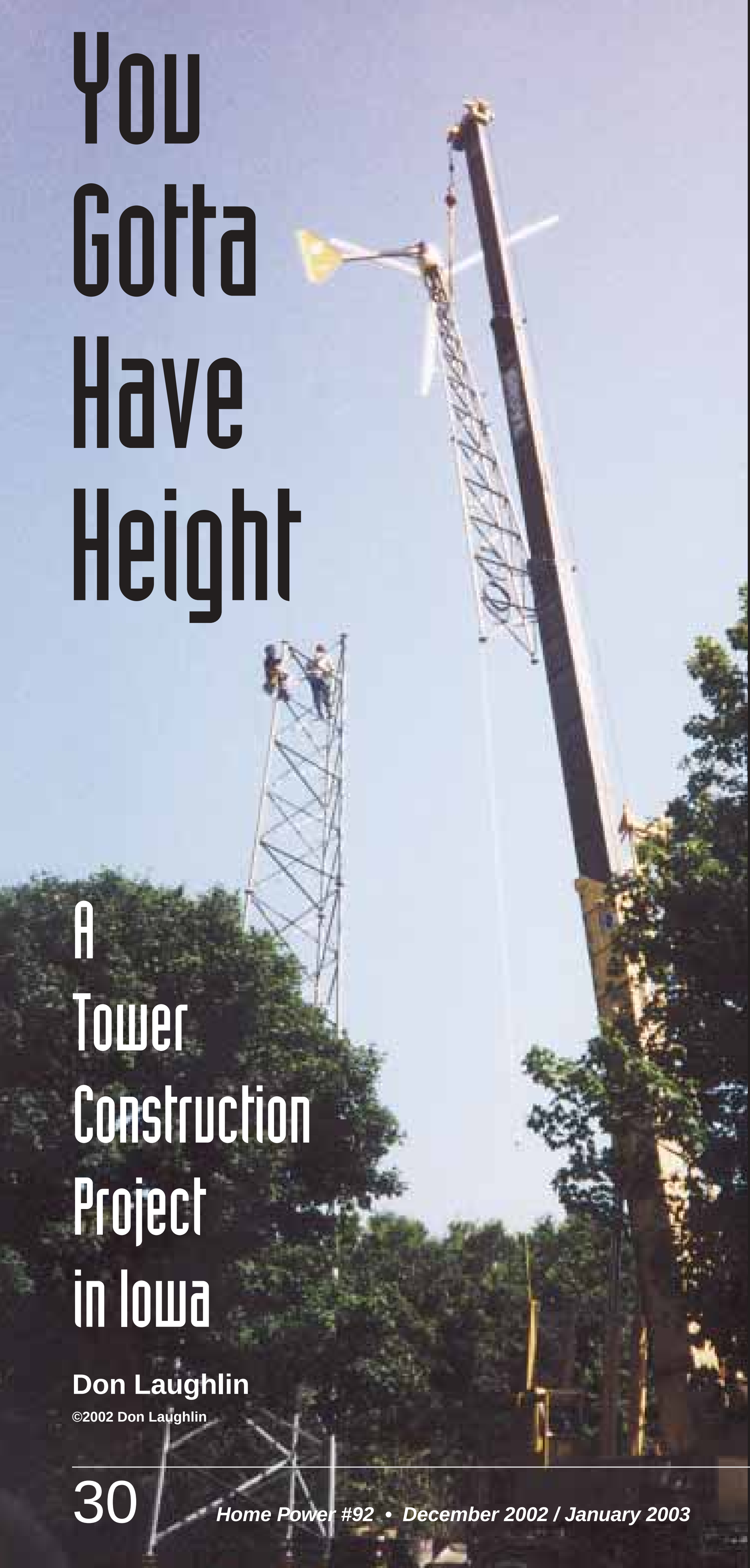
Don Laughlin



Wind generated electricity has become relatively common in Iowa. Major wind farms are now in operation generating megawatt-hours of energy that is being bought by Iowa utilities. Small producers are furnishing their own electricity. At least one is selling excess to the utility. Over the past five years, I have become increasingly jealous of those who were actually doing it. I was only talking about it.

I finally succumbed to the urge and bought a Whisper 3000 (a discontinued turbine) still in the original packaging. While I made plans to put it up, my calculations kept showing me that I really would like to have more energy. Then one night while browsing around on eBay, I discovered a "10,000 watt wind generator, still on the skids." It turned out to be a Bergey Excel, and I couldn't resist the temptation.

For several years, I have been an avid member of the Iowa Renewable Energy Association (I-RENEW), an educational organization that uses demonstrations and workshops to get the RE message out. In planning my wind generator installation, it was a given to use the installation as a teaching tool. What follows is not about my wind-electric system, but the adventures of getting my new wind generator up in the air.

Siting Process
Two facts govern siting a wind generator.

1. The energy in the wind is proportional to the cube of the wind velocity ($P \sim V^3$).
2. Over most terrain, the higher you go, the higher the velocity.

From these two facts, you can say that height is of the essence. Increasing tower height is the easiest way to increase output of a wind-electric system. The most common error in wind-electric installations is using too short a tower.

Our home is on about four acres. The general topography in all directions is gently rolling farm fields. Elevation changes are usually no more than 70 feet (21 m) in any quarter mile. Prevailing winds are from the northwest. The west half of our place is fairly well covered with walnut trees that are now about 30 feet (9 m) high. The east half is windbreak, pasture, and lawn, with large shade trees and buildings.

The highest spot on the acreage is near the southwest corner among the walnut trees. This would be my first choice site. But this site is the farthest distance from the house and would require a long wire run of more than 1,000 feet (300 m). The next highest site is only 125 feet (38 m) north of the house, right next to the wind break. We decided that this was the best place for our tower considering the topography and wire run.

I first thought of a tilt-up tower because I liked the idea of working on the generator on the ground. But a tilt-up needs a large open area because the guy wires must be in the clear as the tower tilts up. For a 90 foot (27 m) tower, the guys would need 45 feet (14 m) on all sides. A fixed, guyed tower would present the same need for clear space. Either one of these choices would mean cutting out too many trees. Our final decision was to use a freestanding tower.

Locating a wind generator close to or among trees needs careful thought. Wind blowing against a grove of trees rises to form a turbulent zone that can be many feet thick. Above that, however, is a zone of smooth accelerated air. A generator should never be located in a turbulent area, and it is best to get it into the faster zone. The standard guideline is to be 30 feet (9 m) above anything within 500 feet (150 m).

A 100 foot (30 m) tower would put my generator above the turbulent zone and into the acceleration zone far into the future. I have a 300 foot (91 m) long windbreak and a grove of walnut trees directly west of the tower site. The land with walnut trees slopes downhill away from the tower. I don't expect either the walnuts or windbreak trees to get more than 60 feet (18 m) tall.

Tower Found—Too Short
Once the site was determined, my search for a freestanding tower began. I located a used, 80 foot (24 m) Rohn SSV not 5 miles away in a shed, mostly disassembled. This would not put me high enough above the walnut grove to the west and the maple trees to the south. I needed to add 20 feet (6 m) to the tower. The top of the Rohn tower tapered to the plate to which I would bolt the generator. There was no way to go higher on that end. So I had to add 20 feet to the bottom.

The Rohn company was helpful, and agreed to build a bottom 20 foot (6 m) section. If I would send all the markings stamped into the steel plates of the tower I had, they would find those markings on their plans and build to fit. Unfortunately, the tower had been discontinued, and they could not find matching drawings.

The Only Choice—Build It
A friend and structural engineer, Larry Marsh, encouraged me to build the bottom 20 foot (6 m) section myself. He offered to do the design work. He needed the taper of the existing tower and the thrust on the propeller at whatever wind velocity was to be our design

Don's homemade, 20 foot bottom section (black, background) is attached to the original Rohn, 20 foot bottom section (silver, foreground).

The homebuilt base section's geometry was extrapolated downwards from the Rohn's original bottom section. The structural design was the same.

limit. Bergey Windpower Company said that the thrust on the Excel was 2,000 pounds (900 kg) in winds up to 125 mph (56 m/s).

To get the taper of the tower, Larry took measurements from the top 20 feet (6 m), the only section fully assembled at that point. By projecting 80 feet (24 m) down, he estimated the dimensions of the base. From these, he calculated stresses and steel sizes needed for that size base, tower height, and thrust.

The plan was simple, and as it turned out, adequate. I would build a section with features matching the existing Rohn. The section would have three legs with braces between them, with 1 inch (25 mm) thick, flat steel flanges welded on both ends of the leg. These flanges would bolt to the Rohn flanges at the top, and to the foundation piers at the bottom. This meant steel pipe for the three corners, with angle iron braces. I planned to follow the same pattern of bracing as the original tower, so that the transition from Rohn to homebuilt would not be obvious.

This was my first experience at building a major steel structure. I was keenly aware that in a couple of months, a crane would be lowering a 40 foot (12 m) section of tower down onto what I was about to build. With friends and acquaintances and a US$150 per hour crane crew watching, where would I hide if the bolt holes didn't match? Not only did the holes between the sections have to match, but my section had to hold the 80 foot (24 m) Rohn absolutely vertical—that is, the center line vertical, not the tapered sides of the tower. Each side had to have exactly the same slope. There is no place to put a level on a three-sided, tapered tower, whether on its side or standing.

Designing the Homebuilt Section

Our design called for three, 5 inch, schedule 40 steel tubes for legs. Off-the-shelf steel comes in 21 foot (6.4 m) lengths, so that determined the height. Each tube was to have an 8 by 8 by 1 inch (20 x 20 x 2.5 cm) steel flange welded onto each end. The $^7/_8$ inch (22 mm) holes for $^3/_4$ inch (19 mm) bolts near the corners of these flanges would mate with the Rohn tower at the top, and the homebuilt foundation legs at the bottom. Each flange had a large hole in the center to fit the outside diameter of the 5 inch tubing. By slipping the end of the tube three-fourths of the thickness into the flange, two continuous beads could be welded around the circumference of the tube.

Larry had calculated that the flanges could be welded onto the ends of the tubes with a single bead—without cutting the 5 inch (13 cm) hole in the plates—and still give adequate strength. But the galvanizing requires no

The 40 foot sections were assembled horizontally. Tripods, a winch, and block and tackle were used to position the 300 pound legs for welding.

closed cavities, so the large holes were needed to leave the inside of the tubes accessible.

Preparing the Steel

With so many holes to drill, it was important to make jigs so that we would not have to mark each hole with a center punch. This was easily done by clamping steel guides on the drill press table. For drilling two holes in the brace-plates, the guides were clamped on so that the piece could be flipped over after one hole, and the second could then be drilled.

For the three pairs of end flanges that were to mate, I clamped each pair together and drilled through 2 inches (5 cm) of steel for each hole. These mated pairs were coded with a center punch mark on the edge to keep them paired. Braces could not be jigged, so each hole had to be marked, center punched, and drilled.

My drill press is a small one, so many pilot holes were used to work up to a large one. In the case of the largest holes, it took four smaller bits before the $^{7}/_{8}$ inch (22 mm) bit could be safely used. Drilling in steel should always be done with care. Bits should be kept sharp, work should be clamped securely to the table, and cutting oil should be used.

Constructing the Homebuilt Section

To allow the braces to be bolted to the corner tubes, we welded, on edge, 7 by 2 $^{1}/_{2}$ inch (18 x 6 cm) plates onto the tubes. Five pairs of plates, spaced 4 feet, 11 inches (150 cm) apart, were spaced 60 degrees around the circumference of each tube. Each plate had two holes to receive the ends of two braces, and was aligned so that it could receive braces from an opposite tube.

Welding these plates onto the 5 inch, schedule 40 tubes caused them to warp. The center of each tube was displaced from a straight line by about $^{1}/_{2}$ inch (13 mm). The only consequence was that the braces were all unique to a place on the tower, and had to be measured, cut, drilled, and marked for that place.

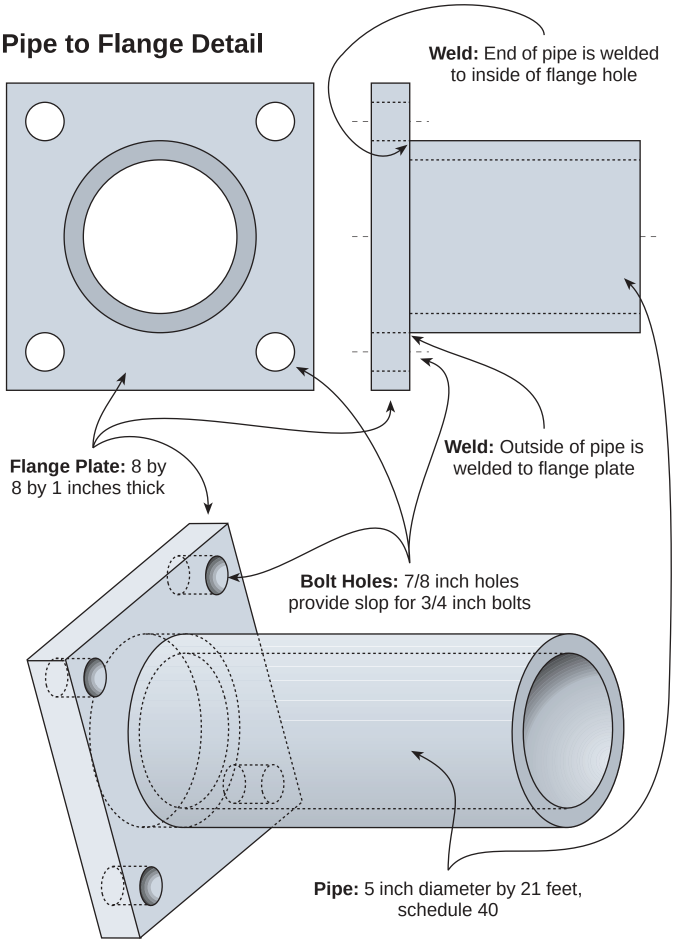
Braces between tubes were bolted flat—a low plate on one tube to a higher plate on the other tube. This made a zig-zag pattern of braces up the tower. The bases of the tower legs were about 11 feet (3.4 m) apart, and braces varied in length from about 12 feet to 8.5 feet (3.6–2.6 m).

All bolts used in the tower were ASTM grade A325. This is a hardened, structural steel bolt with a heavy head designed for oversized holes. The ones I used were hot-dipped galvanized.

Finding Perfect Alignment

My plan was to assemble the bottom 20 foot (6 m) Rohn section out in the driveway with the big end toward the

Pipe to Flange Detail



garage. When all the bolts were in place and tightened down, including the ones where the braces cross, I assumed that this would be a rigid structure. It should be the same size and shape, whether on its side or standing. Knowing the flexibility of steel, this was a scary assumption, but the best I could do.

A solidly welded bead makes things as near "cast in stone" as you can get. It was essential that the tower sections be assembled and aligned before welding began. Three flanges were bolted onto the bottom of the Rohn section. Two legs were lying on the ground, so it was easy to slide two, 5 inch, schedule 40 tubes into them. They were slid in to a depth of $^{3}/_{4}$ inch (19 mm) and rotated so the lower brace-plates were horizontal. They were carefully aligned with the Rohn corners. Then braces were measured, cut, drilled, and bolted into place. Care was taken that the tubes neither fell out of the end flanges nor slid farther in. It was important to maintain the ledge for welding the tube to the flange.

Getting that third tube in place was a challenge! Each tube weighed 300 pounds (136 kg). All three had to be held exactly in place before welding. In addition, the upper tube had to be solid enough, before its braces were in place, to support a ladder, so we could climb up

Alignment is crucial for the tower pieces to fit together and to be structurally sound. But a three-legged, tapered tower has no plumb component, so string lines were used to create a center line for reference.

to bolt the braces on. To do this, I built two temporary tripods with a winch on one and a block and tackle on the other.

Then came the final challenge to my homebuilt construction. The tower sits on three angle iron legs (4 x 4 x $^3/_8$ inches x 8 feet long; 100 x 100 x 10 mm x 2.4 m long) cast into the concrete foundation to form piers. Each of these legs has an 8 inch (20 cm) square by 1 inch (25 mm) thick flange welded flat to each end. Leveling bolts are located between the bottom tower flanges and the leg flanges.

These foundation legs do not taper with the tower, but are vertical and parallel to each other. This forms a slight angle with the tower. For the tower to stand plumb, this angle must be exactly the same for all three sides. This was accomplished by bolting the three foundation legs onto the unwelded tower flanges, and aligning accurately before welding.

The Rohn and homebuilt sections and foundation legs were laid out in position. For alignment purposes, a cross-sectional center point was located at four levels. These were: bottom of the foundation legs, bottom of the homebuilt section, and bottom and top of the Rohn section. The point was located by finding the center between each set of two legs, and stretching a string from that point to the center of the opposite leg.

By doing this for each leg, the three lines should cross at a center point. These four center points were needed to form a straight line down the center of the tower. With blocks, shims, and a jack, the tower was jockeyed around until the four center points lined up. This turned out to be easier than I had expected. Now the brace bolts for the homebuilt section could be tightened down, and the tube ends could be tack welded to their flanges.

The tack welds consisted of three short beads, spaced as evenly as possible around the circumference. Once this was done, the three tubes and all braces were carefully disassembled and removed from the Rohn, so as not to strain the tack welds. Final welding was done with the tubes laid out on sawhorses and rolled, so that the work was always on top. A trip to a galvanizing plant produced a shiny, new, 21 foot (6.4 m) tower section ready for assembly.

Preparing Tower Sections to Mate

Towers are designed with oversized holes for the express purpose of making connections easier. A $^3/_4$ inch (19 mm) bolt requires a $^7/_8$ inch (22 mm) hole. But even with sloppy holes, there is not much room for error between legs cast in concrete and the rigid tower. Also, no one wants to fight with misaligned holes while strapped to the side of a tower many feet above the ground.

For good alignment between the legs in the concrete and the bottom of the homebuilt section, a solid, rigid template was of utmost importance. I made one of scrap angle iron and flat plate, with four, $^7/_8$ inch (22 mm) holes in the three corners. I didn't skimp on holes for bolting to the tower and legs. Twelve, $^7/_8$ inch holes provided a reliable connection. To get its dimensions, the template was sandwiched between the top of the foundation legs and the bottom tower flanges while alignment was being done. Then, to pour the piers, the template was used to get the exact placement of the legs.

Building the Foundation

The tower rests on a concrete foundation. The bottom of the foundation, 7 feet (2.1 m) below ground level, is a square concrete slab, 15 feet (4.6 m) on a side and 2 feet (0.6 m) thick. Integral with the slab, via lots of heavy rebar, are three steel and concrete piers. The walls of the excavation served as forms for the slab, but the piers were formed with Sonotubes. These are round, waxed cardboard tubes. They are removed by cutting them apart once the concrete has set.

It has been said that a good backhoe operator can "pick your teeth" with his machine. The skill of our operator was used to form the excavation so that no forms were needed for the slab. The sides were kept plumb, and 15 feet (4.6 m) apart. With a laser level, the bottom was kept flat and at a depth of about 7 feet (2.1 m). We hit water and dumped in a yard of gravel to make walking possible. With a laser level, an orange line was sprayed on the clay sides to mark the top of the concrete pour.

Two layers of rebar were laid on a 12 inch (30 cm) grid. One was spaced 20 inches (51 cm) above the other with short pieces of vertical rebar. These extended down to the gravel and stood on bricks to take the weight. All rebar crossings were wired together.

The three piers, with the steel foundation legs embedded, were an integral part of the whole foundation. These angle iron legs were stood on end and set down into the rebar grid. They were braced with stakes in the bank. For each pier, six pre-bent, #7 rebars ($^7/_8$ inch; 22 mm diameter reinforcing rods) were maneuvered into place. These permanently tied the piers securely to the slab. Circular rebar loops, spaced 12 inches (30 cm) apart up the piers, were wired securely to the six vertical bars. The template was bolted to the top of the legs so they would be in exactly the right place to mate with the tower.

Three concrete and rebar piers, poured around 8 foot angle iron legs, are embedded in the foundation.

The tower foundation is a 15 foot square slab, 2 feet thick, buried 7 feet deep.

The 18.75 cubic yards of concrete was poured in two stages. The 15 foot (4.6 m) square by 2 foot (0.6 m) thick base was poured first. Then the template was removed to allow placement of the 18 inch (46 cm) diameter cardboard forms (Sonotubes) around the legs. The template was replaced, and the second pouring filled the Sonotubes. The template was kept in place until the backfilling was done to be sure nothing moved.

Tower Costs

A good tower, with a solid foundation, is not a low-cost item. Checking a wind generator manufacturer's Web site and looking at the costs of equipment does not tell the whole story. The wind generator itself generally represents less than 50 percent of the cost of the complete system, and sometimes much less.

Different tower sites will have a variety of different costs. For instance, I had to build a driveway with three loads of gravel to get the crane in and out. Excavation and foundation expenses (whether for freestanding or tilt-up towers), crane rental, electrical wiring down the tower and into the power room, instrumentation (anemometer and amp-hour meter, if you want them), and labor costs will vary.

Laying the foundation is not a trivial operation. Setting up the rebar grid, leveling the feet, and pouring the concrete require skilled labor. You might save a lot of headaches and even money by hiring a competent contractor. The hourly wage will be high, but he or she will work quickly and efficiently. And then you can be sure that your investment will not lean in the first 100 mile per hour wind that comes your way.

Erecting the Tower

One of the requirements for a successful hands-on workshop to erect a freestanding, 100 foot (30 m) tower with a 10 KW Bergey wind generator is a windless day.

Friday, June 29, 2001 dawned clear and calm. After introductions among the thirteen people gathered to study wind technology, siting, politics, problems, and opportunities, Dennis Pottratz introduced the three-day schedule. By then, the small crane had arrived to set up the 21 foot (6.4 m) homebuilt section. The foundation, with three piers protruding from the ground, had been poured a month before.

The tower had been previously assembled on the ground in three partially completed horizontal sections. The workshop crew got the experience of finishing the assembly, and making sure the alignment was perfect for the sections to be mated. They mounted the Excel, with the blades and tail, and the anemometer to the top 40 foot (12 m) section of tower. All bolts were tightened and double nutted. Tail fin bolts were torqued to 20 foot-pounds, and the blade nuts to 150 foot-pounds. The three, #2 (33 mm^2) copper wires to come down the tower were coiled and tied to the bottom of the top section.

This is no time for misaligned bolt holes!

This section, the middle 40 feet (12 m), and the 21 foot (6.4 m) homebuilt section, were positioned for the cranes to hook on above their center of gravity and lift into place. When the homebuilt section was put together, it became apparent that some of the twelve bolt holes didn’t fit the template exactly. This is the triangular steel pattern used to transfer the exact position of the holes from the lower tower flanges to the legs in the piers before they were cast in concrete.

After loosening brace bolts on one side, a come-along encouraged the holes to line up. Super tightening of the brace bolts seemed to make a reliable match. During the workshop, I watched anxiously as the crane lowered my homebuilt section onto the foundation legs—all twelve leveling bolts dropped into place!

By Saturday morning, when the tall crane came for the final lift, there was still little air movement. By noon, as we were in the final stages of bolting down the top 40 feet, a slight breeze had come up. Three men, working at the 60 foot (18 m) level, where the wind velocity was much greater, struggled more than two hours to get the last four of the twelve bolts in place.

While tower work was going on, others were cleaning out the trench for the underground lines from the tower to the house, and laying the three, #2 (33 mm^2) copper wires. Still others were working in the battery room mounting switches, the voltage control system, inverter, and connecting the entire system. In perfect accord with our needs, the final day of the workshop arrived with a brisk breeze. We could observe the production of electricity, and watch the batteries charge at about 35 amps at 120 VDC nominal.

The workshop crew in front of the 10 KW Bergey Excel on the completed 100 foot Rohn/homebuilt tower.

Laughlin Tower Costs

Manufactured Tower & Crane	*Cost (US$)*
Rohn tower, 80 foot, used	$2,000
Crane	1,260
Used Tower Total	$3,260
Homebuilt Tower Section, 21 feet	
Sandblasting, galvanizing, trucking	$1,036
Bolts, nuts, washers	707
Welding	680
3 tubes, 5 inch, 21 feet, Sched. 40	414
Angle iron for braces, 2 1/2 x 2 1/2 x 3/16 in.	340
9 flange plates, 1 inch steel, 8 x 8 inches	98
19 steps, Rohn	70
Miscellaneous	57
New Section Total	$3,402
Excavating, Base, Landscaping, Driveway	
Labor	$1,250
Concrete, 19 yards	1,209
Rebar	865
Gravel, 3 loads	666
Backhoe work	229
Sonotubes	170
Black dirt, 1 load	100
Skip loader rental	60
Excavating & Misc. Prep Total	$4,549
Grand Total	$11,211

The workshop program included a handout with topics on wind characteristics with relation to trees, buildings, and open land. We discussed the advantages, disadvantages, and costs of different towers available. Dennis presented data and costs for different wind generators on the market. We discussed safety and lightning protection, and the crew installed the best known grounding system for the tower. The workshop concluded to the satisfaction of all that a very professional wind-electric system had been installed.

I'm often asked, "What is the payback on this huge expense?" I answer the question by reciting the costs of SUVs and vans, all in the US$20 to $30 thousand range. Then my question is, "Did you ever hear of a normal person calculating the payback on their SUV?" Of course not.

Payback is the wrong question to ask. People spend money for what they perceive to be important. I perceive increasing the use of renewable energy to be of supreme importance. The task facing the renewable energy community is to educate society to shift its spending priorities from energy-consuming items to perhaps equally expensive items that are sustainable. Power boats can be replaced with sailboats, SUVs with compact hybrid cars, and on and on. A just and secure society will not be low cost. I want to furnish a model of what can be done.

Access

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irenew@irenew.org • www.irenew.org

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Foundation contractor

Fastenal Company, PO Box 978, Winona, MN 55987
507-454-5374 • Fax: 507-453-8049
fasteners@fastenal.com • www.fastenal.com
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800-377-2692 or 843-383-7000 • Fax: 843-383-7008
gaye.lloyd@sonoco.com • www.sonoco.com
Sonotubes

Rohn Industries, Inc., PO Box 2000, Peoria, IL 61656
309-697-4400 • Fax: 309-697-5612
mail@rohnnet.com • www.rohnnet.com • Original tower

Bergey Windpower Company, 2001 Priestley Ave., Norman, OK 73069 • 405-364-4212
Fax: 405-364-2078 • sales@bergey.com
www.bergey.com • Excel wind generator

McNeilus Steel, Inc., Box 249, Dodge Center, MN 55927 • 800-733-6336 or 507-374-6336
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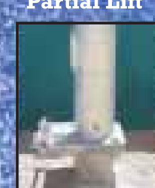
*Patent Pending

Down Position

Partial Lift



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WORK FOR PEACE

Neptune's Phantom Unveiled

Tom Markman

Even when this washing machine is "off," it still draws 10 watts.
Tom Markman installed a timer switch (shown next to outlet) to eliminate the phantom load.

If you read the marketing literature for the Maytag Neptune washing machine, you might feel that your purchase of this washing machine, over all others, is doing the environment a big favor. This may be true in some respects—lower water consumption, more spinning action to remove water from the clothes before drying them, and an annual energy consumption rating that's about average in the industry.

The electrical energy requirement (not including water heating and well pump) is a very respectable 90 to 145 watt-hours per load. This makes the Neptune a welcome addition to a renewably powered home. But after just three days of owning this seemingly clean and green friend, an unsuspecting secret emerged from our laundry room. Neptune has a nearly 10 watt phantom load—a load big enough to keep our inverter idling, even though nothing else in the house is on.

Watching Watt-Hours

Like many people living off the grid and relying on a limited energy source for their electricity needs, we carefully watch every watt-hour consumed in our house. As part of this monitoring, every night we verify that our inverter has quietly slipped into the "search" mode after the last light is out.

Our Trace 2624SB inverter draws 10 watts at idle, and only about 0.5 watts when it's in search mode. More than once, we have discovered something accidentally left on or something still plugged in that prevented our inverter from sleeping. Why our Neptune washing machine was sometimes a phantom and sometimes not was still a mystery that needed to be solved before the Neptune would be invited to stay on a long-term basis.

What was the secret of the Neptune phantom? After some research and several loads of laundry, our theory started taking shape. It turned out to be simple, if not very sensible. After the washer's cycle, the Neptune's circuitry draws 10 watts until the washer door is opened and closed.

The short-term solution to eliminating this phantom was simple. Opening and closing the washing machine door after a load is finished makes the phantom disappear. (If we leave the door open, and no other loads have pulled the inverter out of search mode, the washer light will cycle the inverter on and off. This is irritating, and it works the inverter unnecessarily. It also can be hard on some AC loads.)

One option to solve this problem was to announce a new house rule: "Whenever you hear the washing machine stop washing, open and close the door." That had some obvious disadvantages. Who will do that when no one is home? Accepting this solution would have completely overlooked the fact that our children's selective hearing would have just become a little more selective. "I didn't hear it stop," (because the Freeplay radio was too loud) would quickly make the list of the top ten reasons for not doing this simple task. Clearly, I needed to find a way to eliminate this phantom.

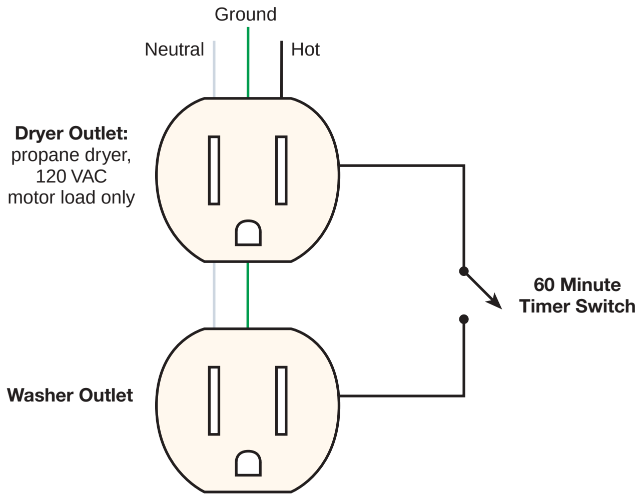
Maytag to the Rescue?
I figured that Maytag should be able to help. After all, they designed this machine, so certainly they could offer some suggestions on how to correct the problem. Their marketing literature implies their commitment to the environment and conservation. I hoped that they would be concerned about the thousands of machines out there wasting so much energy. Perhaps our machine was just defective—maybe there was a bad component, a stuck valve, or a relay not working correctly.

After a week of explaining my problem to various Maytag customer support people and waiting for returned calls that never came, I finally found my way to a design engineer who was willing to listen. Progress at last! I explained carefully what I had discovered with our Neptune, and that I was looking for someone to help me find a way to solve this issue.

His understanding of the issue was immediate, "That is not a malfunction. It is the way it was designed, and if you do anything to change the design, it will void your warranty." He went on to ask how had I determined this was happening, and why would anyone ever care. I explained our off-grid status, and that the number of hours of sunshine in Minnesota don't allow us to be so wasteful with our energy. He was obviously unimpressed, and offered to transfer me back to customer service if I wanted to discuss returning the machine.

What a Waste!
So what does this energy wasting design flaw amount to? It's "only" 10 watts, right? I did a little back-of-envelope calculation. Maytag considers sales numbers for the Neptune proprietary, but they say that they've sold "hundreds of thousands." I'll be conservative and use 300,000. I made a number of phone calls, and basically made a fool of myself asking people how long

Timer Switch Wiring Diagram



Note: Receptacles come standard with two outlets paralleled together. Separate the outlets' hot connection by breaking the thin metal jumper between the screws on the hot side of the outlets.

their clean laundry sits in the washer until it is moved to the clothesline or dryer. Based on my family and friends, clean laundry spends an average of 15 hours a week in the washer, or 780 hours per year.

So, 300,000 machines, times 780 hours per year, times 10 watts, equals 2,340,000 kilowatt-hours per year. That's a big number! It's the amount of energy used by 250 average homes in the U.S. in a year. And at an average cost per KWH of US$0.08, it amounts to about US$187,000 per year wasted by the consumer, all because of this design flaw. And Maytag says that it isn't a problem.

I shudder to think about this wasted energy and money. It seems like Maytag's engineering department could learn a lesson from their marketing department: conservation and efficiency sell products!

The Solution
Living off-grid for eight years has made me creative when it comes to solving problems like this. We have found ways around similar phantom loads in numerous other appliances in the house—the microwave, the stereo, the TV and VCR, all the rechargeable devices—the list seems almost endless. I could figure this one out too.

The solution I found to correct this problem is fairly simple. If you can't stop the appliance from consuming energy, don't give it any energy to consume. From a local hardware store, I purchased a 120 VAC Intermatic FD60M, 60 minute mechanical timer switch, a junction box, and 1 foot of three-conductor, #14 (2 mm^2) wire. The timer is rated at 120 to 277 volts, and up to 12 amps at 125 volts AC or 10 amps at 270 volts AC. The whole setup cost me less than US$25.

I installed the junction box in the wall right above the washing machine, so it is convenient to start the timer before every load of laundry. I then rewired the outlet so that the clothes dryer was always powered and the washing machine was only powered while the timer was on. To do this, I wired the timer between the dryer outlet and the washer outlet.

Sixty minutes is typically sufficient for a load of laundry. This timer solution has solved the phantom load problem for the times when we cannot drop everything to open the washing machine when it stops. This solution also avoided modifying any part of the washing machine, so there are no warranty issues.

Cleaning Up

Even though turning dirty laundry into clean laundry in our house accounts for more than 25 percent of our energy use, we were not willing to compromise much on the convenience of a standard washer and dryer. The Neptune was not a perfect solution, but it does support our off-grid lifestyle by making better use of resources than many other solutions.

With the addition of the Intermatic outlet timer, the Neptune works well as part of our off-grid system. And more important, it does not require us to take our clothes down to the lake for washing, or rely on our children's selective hearing.

Access

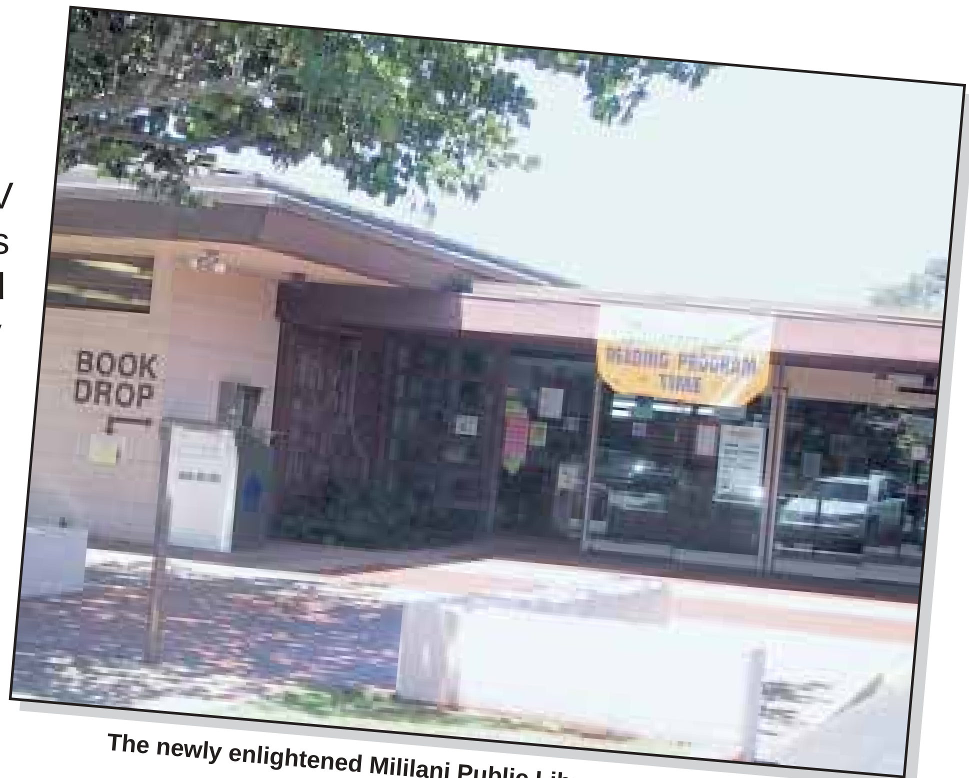
Tom Markman, PO Box 40, Avon MN 56310
dekkt@msn.com

Maytag Customer Service, 240 Edwards St., Cleveland, TN 37311 • 800-688-9900 (U.S.) or 800-688-2002 (Canada) or 773-272-3000 • Fax: 641-787-8676 www.maytag.com • Maytag Neptune washing machine

Intermatic, Intermatic Plaza, Spring Grove, IL 60081 815-675-2321 • Fax: 815-675-7055 webmaster@intermatic.com • www.intermatic.com Timer switch

Think Globally, Act ~~Locally~~ Globally

Carol Montheim



The newly enlightened Mililani Public Library, Mililani, Hawaii.

Friends look at our PV panels and say, "It's great that you did that!" I try not to roll my eyes as I ask, "So, you're a fan of the Dick Cheney school of thought?" This provokes a puzzled look from friends who are not big Cheney fans.

I try again: "You think we put those panels up out of 'personal virtue?' That we're paying piles of money to save the planet?" They admit they thought it was something like that.

I explain that four types of people install solar-electric systems: environmentalists, survivalists, hobbyists, and capitalists, and that I fall mostly into the "capitalist" category. Few buy this argument.

Guerrilla Efficiency Profile 0002

Date:	**November 2002**
Action:	**Lightbulb Replacement**
Efficiency Guerrilla:	**Carol Montheim**
Location:	**Mililani Public Library, Mililani, Hawaii**
Estimated Energy Saved per Year:	**3,374 KWH**
Estimated Money Saved per Year:	**US$439**
Estimated CO_2 Abated per Year:	**5,061 lbs**

I point out that my PV system will pay for itself in twenty years. They aren't impressed—though some of their 401(k) plans will take much longer than that to mature. Some say I'm just rationalizing a project I would have undertaken at any cost to help the environment. How can you argue with someone who claims you have an ulterior motive?

A Lightbulb Goes On over My Head

While waiting one day to check out a book at the Mililani Public Library in Hawaii, I felt something gently warming the top of my head. I looked up to see a 75 watt incandescent bulb. The room had a bunch of them. I felt as if a leaking faucet was dripping on my head.

A quick calculation showed that the library could replace its incandescents with compact fluorescents and get payback in under a year. That seemed pretty good compared to the twenty years for our PV system. Hmm, someone remind me why we got that PV system, when we could have just given some bulbs to the library? Oh, right—we're capitalists.

Public Library Lighting Retrofit Costs

Item	*Cost (US$)*
24 SpringLamp CF bulbs, 23 W	$262.80
Shipping	6.01
State tax deduction (8.25%)	-22.18
Federal tax deduction (27%)	-66.59
Total	$180.04

Greed Is Good

At least now I could show that we had no ulterior environmental motive, that we were in it for the money. The argument was simple: The PV system's financial return was good, but the environmental return wasn't outstanding. If our goal was to help the environment, we could have filled a car with compact fluorescents and gone around handing them out to strangers.

Why does nobody recognize the profit motive? Why do anti-enviros succeed in portraying enviros as extremists, painting them as willing to sacrifice their hard-earned money for little or no benefit?

Vice President Dick Cheney's infamous quote that conservation is a "sign of personal virtue" is part of how they do it. While he sounded like he was complimenting people who worry about their electric bill, he was actually dismissing them as impractical idealists. It's a classic "divide and conquer" tactic.

Modern fixtures deserve modern bulb technology.

Here's some personal virtue for Mr. Cheney to consider: Next year, our annual electric bill will be US$750 less than it was in the late 1980s—and our house is twice the size of the condo we lived in then.

Personal Virtue after All

I convinced a few friends that I really am greedy. If I wasn't greedy, I'd be saving money for the library instead of for us. Perhaps I used that argument too often, or perhaps that 75 watt bulb softened my brain each time I stood under it while waiting to check out books. One day I asked the library if they'd like some lightbulbs.

Library patrons don't notice, but the accountant sure does.

Head librarian Wendi Woodstrup graciously accepted my offer. I gave them a "sampler" pack of four different bulbs, roughly equal to their current incandescents in light output (lumens), to try. We agreed that the new bulbs shouldn't compromise lighting quantity or quality in any way.

We chose twenty-four, 180 series, 23 watt SpringLamp bulbs from TCP, Inc. These bulbs cost a little more than others, but are rated for 15,000 hours and have a light output equivalent to a 90 watt incandescent. At 40 hours per week, they should last until the end of the decade, and they provide more light than the bulbs we replaced.

The library has had the bulbs for just a short time, but they seem happy with them. Patrons don't seem to have

Public Library Lighting Retrofit Savings

Efficiency Item	*Savings (Watts)*	*Savings per Wk. (KWH)*	*Savings per Yr. (KWH)*	*Savings per Yr. (US$)*	*Abated CO_2 per Yr. (lbs.)*
Lighting load reduction from 75 W to 23 W for 24 CF bulbs replaced	1,248	50	2,596	$337	3,894
Air conditioning load reduction for 24 CF bulbs replaced, estimated	374	15	778	101	1,167
Totals	1,622	65	3,374	$439	5,061

Assumptions:
- 40 hours per week average light usage
- US$0.13 per KWH electricity cost
- 1.5 lbs. CO_2 per KWH electricity

noticed a difference, which is good. Wendi says they expect reduced costs both on their electricity bill and in their lightbulb budget, since they don't have to keep buying new ones.

Rates of Return

We haven't finished expanding our PV system, but we can estimate the eventual cost and how much energy the completed system will produce. We currently have 880 rated watts of Siemens SP70 and SP75 panels, with a Trace SW4048 inverter. We use a One Meter from Brand Electronics to measure both DC produced from the panels and net AC produced after loss to the batteries (which get used only during utility outages) and the inverter.

The PV modules produce about 3.6 KWH DC per day. When we add another 600 watts of panels in 2003, we'll expect to get about 6.0 KWH DC per day. The conversion losses seem to be a fixed 0.7 KWH per day, no matter how much sun the system gets, so we estimate the final system will net about 5.3 KWH AC per day.

PVs are great, but can't touch a CF for payback.

Based on these estimates, we can fill in the comparison table, Producing Energy vs. Saving Energy, which shows the dollar cost and energy return for our PV system and for the library project. We could have gotten both projects done more cheaply if we had been careful about comparison shopping. But small variations don't matter when you look at the big picture: the PV system will produce electricity for about 24 cents per KWH, while the library project will save energy at a cost of under a penny per KWH.

That's about a thirty-five-fold difference in efficiency. Hmm, someone tell me again why we got that PV system?

Acting Globally

Most people make sure their lighting and appliances are as efficient as possible before they shell out the big bucks for a PV system. If you really want environmental bang for the buck, should you invest in efficiency for others before you invest in PV? As Geoff Pritchard pointed out in a recent letter (*HP89,* page 144), giving away CF bulbs does a lot more for the environment than putting up a PV system.

It does more for the wallet, too. Our US$180 "investment" will save the library about US$4,300 over the remainder of the decade, assuming electricity prices grow at a modest 4 percent per year. That's not counting hundreds of dollars saved by not having to replace short-lived incandescent bulbs.

Producing Energy vs. Saving Energy

PV System Project Itemization

Estimated cost after tax credits	$14,000
Estimated energy produced annually	1,950 KWH
Projected system lifetime	30 years
Projected lifetime energy production	58.5 MWH

Library Project Itemization

Cost after taxes	$180
Energy saved annually	3,374 KWH
Projected lifetime (15,000 hrs.)	7.5 years
Projected lifetime energy savings	25.3 MWH

Comparison of the Two Projects

PV energy production cost	23.9¢ / KWH
Library energy savings cost	0.7¢ / KWH

In Perspective

Perhaps the most important thing is to realistically measure costs and benefits. Some Hollywood enviros have declared themselves “green” because they drive hybrid cars, but the added US$7,000 cost of those cars yields less environmental benefit than a solar hot water system, which costs less. It yields less than many PV systems. It yields far less than US$7,000 worth of efficient lightbulbs.

That’s not to say we should forgo making a profit and always fund someone else’s efficiency first. If you’re off the grid, making your own electricity is essential. Even if you’re on the grid, investing in PV helps promote research and the industry, speeding the transition to a renewable energy economy.

Should you put your own house in order first, or act more globally? Is it better to reduce your own fossil fuel usage, or reduce someone else’s if that’s more cost effective? Would your neighbors think you were crazy if you offered to give them a solar hot water system? Would you be?

Access

Carol Montheim (a pseudonym, since the lightbulb donation was anonymous) is a software engineer living in Hawaii • carolmontheim@earthlink.net

TCP, Inc., 300 Lena Dr., Aurora, OH 44202
800-324-1496 or 330-995-6111 • Fax: 330-995-6188
sales@springlamp.com • www.tcpi.com • SpringLamp CF lightbulbs

Brand Electronics, 421 Hilton Rd., Whitefield, ME 04353
888-433-6600 or 207-549-3401
info@brandelectronics.com
www.brandelectronics.com • Digital power meters

EFI, 40 Washington St., Ste. 3000, Westborough, MA 01581 • 800-876-0660 or 508-870-2277
Fax: 888-655-6767 or 508-870-9933 • info@efi.org
www.efi.org • Efficient lightbulbs

Guerrilla Efficiency Defined

Energy efficiency is the most effective action for moving the planet toward a sane energy future. Education is the first step in increasing public awareness of energy efficiency. Installing compact fluorescent lightbulbs and implementing other efficiency measures in your community is fun, and it helps increase the use of energy efficient technologies. Practice random acts of efficiency and sensible acts of conservation!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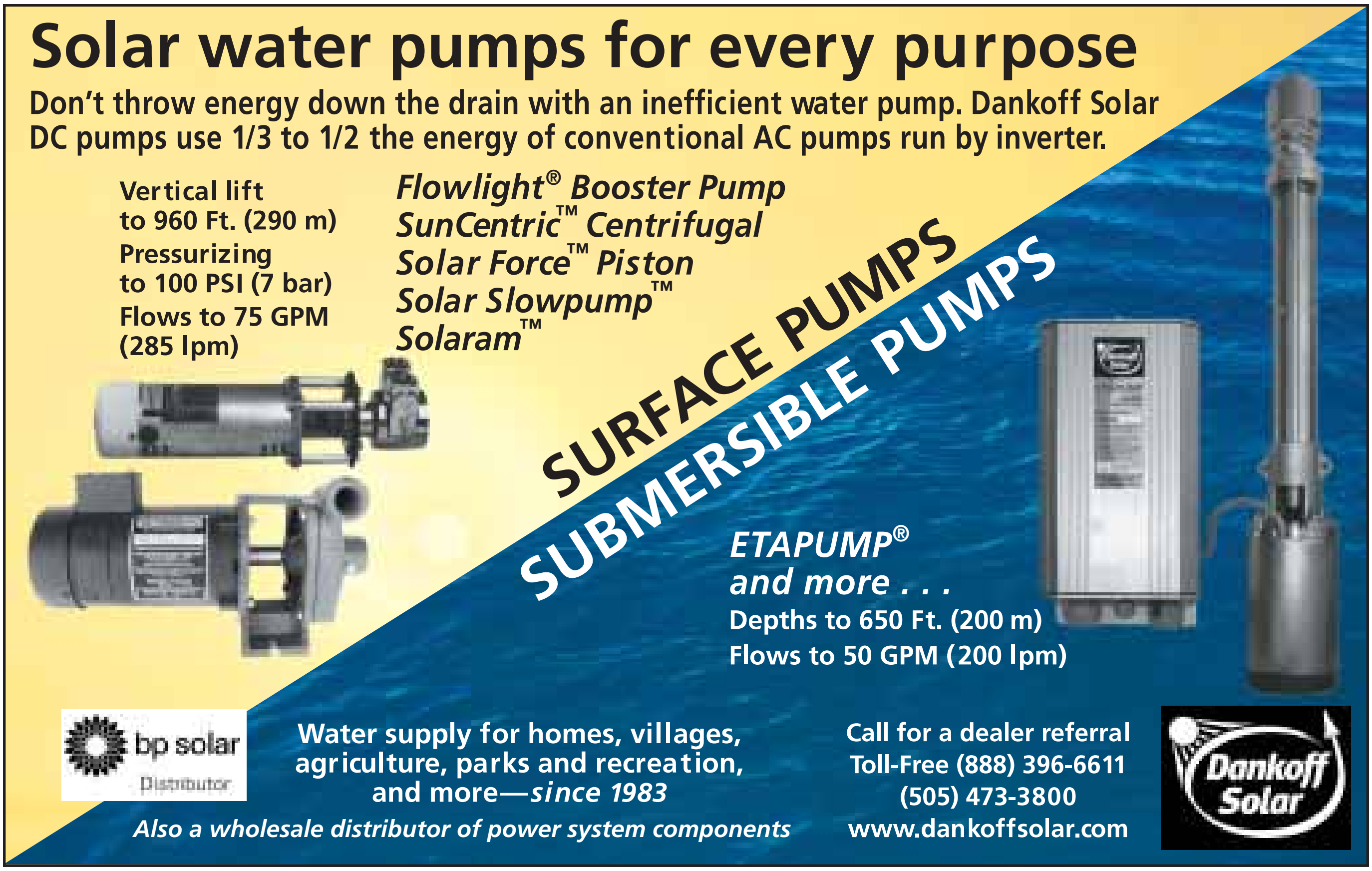
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Energy Fair Scrapbook ’02

Richard Perez

People’s energy fairs really began in the summer of 1990 with two fairs—the Solar Energy Expo & Rally (SEER) in Willits, California, and the Midwest Renewable Energy Fair (MREF) in Amherst, Wisconsin. This year, just twelve years later, dozens of renewable energy fairs were happening nationwide.

There were so many energy fairs that *Home Power* was hard put to send a crew to even a small fraction of them. The simple concept of energy fairs for regular people, instead of just industry insiders, has really caught on. Folks everywhere are attending with a hunger for knowledge, networking, and equipment. If you’re organizing an RE fair for 2003, please send complete information to happs@homepower.com so we can publicize your event in our Happenings section and on our Web site.

Here’s our scrapbook of some of this year’s fairs. If you didn’t attend at least one energy fair this summer, you missed out on something very special. These events are well worth planning your summer around. Please see the end of this article for a list of energy fairs, their features, dates, and access information.

Our energy future—nuclear or solar?
The IREA fair is changing the world, one mind at a time.

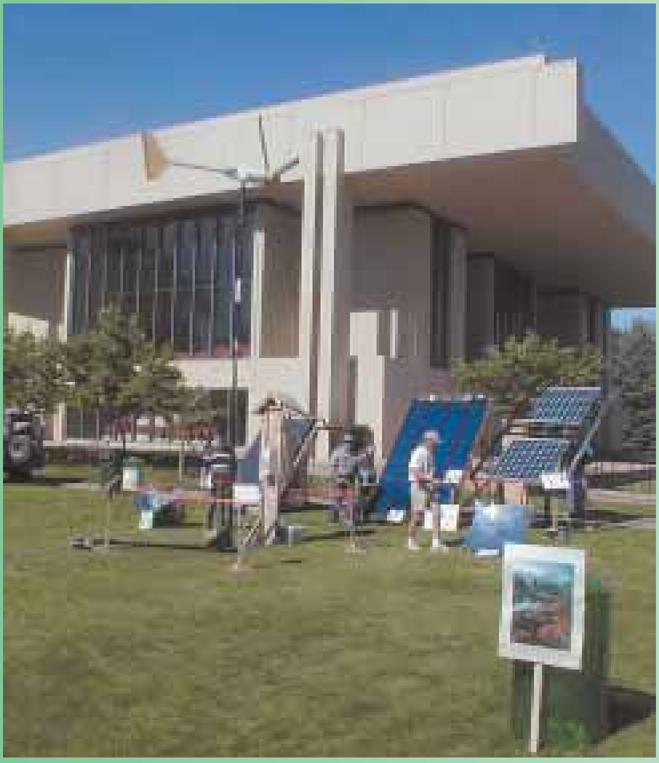
Kids playing in front of the ComEd PV trailer.
There are lots of activities for kids at the Illinois fair.

Iowa State University's Solar Challenger drew a lot of curious onlookers at this year's fair.

MAKING RENEWABLE ENERGY A REALITY
I-Renew

Knowledge is power! The I-RENEW fair offered 66 free workshops—like this one on home energy efficiency.

The Brooks Solar display at the NW RE Festival on the campus of Whitman College in Walla Walla, Washington.

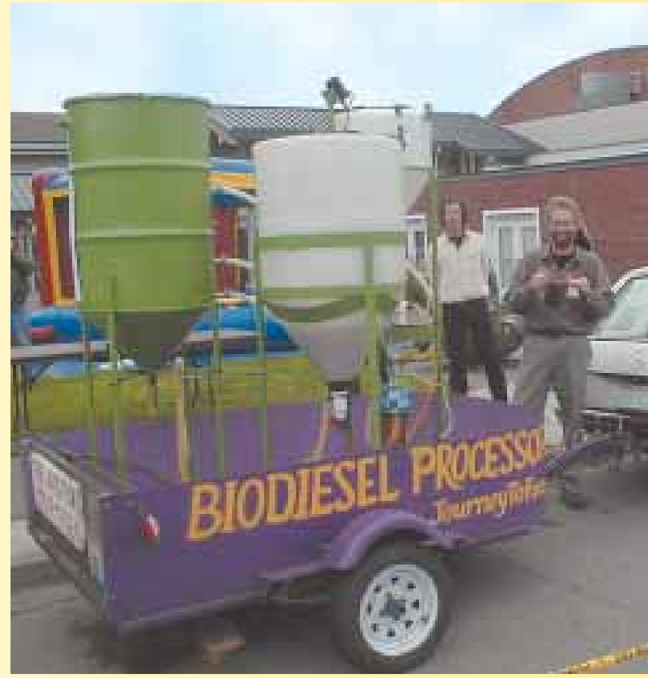


NORTHWEST
Renewable Energy
FESTIVAL

Thirty exhibitors shared information and featured renewable energy equipment at the fair. Shown here are four of Outback Power's FX inverters, their AC and DC boxes, and two MX-60 charge controllers.

OLYMPIC 2002 ENERGY EXPO

**Saving energy saves everything—
like money, resources, and our environment.**



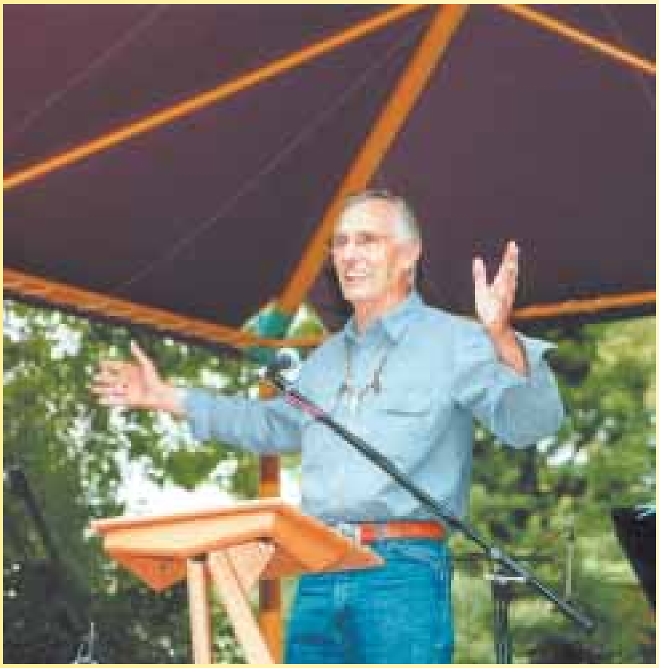
Teaching another way—Scott Durkee and Mike Pelley with Mike's mobile biodiesel processor. Their biodiesel workshop in Washington state focused on how to make this veggie fuel from waste oil.

Renewable Energy and Sustainable Living Fair

The Power to Change the World

Left: Nature exhibited its awesome force at this year's fair in Custer, Wisconsin. Workshops continued under the tents despite the rain, thunder, and lightning. The MREA's rain gauge crested over the 12 inch mark. Then the sun returned for a glowing Saturday and Sunday.

Below: A bird's eye view from the top of the MREA's wind generator tower. This year's fair hosted 100 workshops and 150 exhibitors, live music, and activities for the kids.



ROCKY MOUNTAIN
sustainable living fair

Top: Guest speaker Dennis Weaver addresses the crowd at the 3rd annual Rocky Mountain Sustainable Living Fair.

Right: Carol Weis (left) from Solar Energy International explains to fairgoers how photovoltaic modules work.

Solar Fiesta!

Above: Smitty from AAA Solar putts through the crowd at this year's New Mexico Solar Fiesta fair.

Right: Daniel Love from Advanced Communications schooled the crowd on using cell phones in the outback.

SOLARFEST

Leading by example—New England's SolarFest fair is an off-grid event.

While the solar powered stages rocked, Ed Witkin's kinetic sculpture pedaled to the beat.

Author Paul Hawken inspires a lively, northern California crowd at SolFest 2002.

SolFest

The Kidlandia solar stage featured kid's workshops and entertainment.

Kids at SolWest in John Day, Oregon had the opportunity to build their own pizza box solar cooker.

SOL WEST
Renewable Energy Fair

The Grass Car—promoting a more sustainable future by spreading the greasy word about biodiesel.

Scott Carlson—selling solar in southern California.

Rick Cullen of RV Power Products scopes out an EV.

Southern California
Renewable Energy Expo

POWER UP
Alternative Resources Today to Ensure Tomorrow

The Southwest Renewable Energy Fair

Solar Energy International—turning on Arizona people to renewable energy through hands-on education.

Chris Worcester of Solar Wind Works nerds out on wind generators and PVs with fairgoers.

TEXAS RENEWABLE ENERGY

ROUNDUP

GREEN LIVING & SUSTAINABILITY FAIR

Electric vehicles, big and small, were really popular at the Texas RE RoundUp.

Over 90 exhibitors, including Meridian Solar, were at the fair.

2003 Renewable Energy Fair Info*

Fair	Area Served	Dates '03	Fair Site	Fair Features	Cost / Day (US$)
Illinois Renewable Energy Fair	Illinois	Aug. 9–10	Ogle County Fairgrounds, Oregon, IL	80 workshops, 100 exhibitors, keynote speakers, music, electric vehicles	$5 Ages13–16, $3 Under 12, free
Iowa Renewable Energy Expo	Iowa	Sep. 6–7	Prairiewoods Franciscan Ctr., Hiawatha, IA	66 workshops, 60 exhibitors, Electrathon, tours, camping, keynote speakers	Free Donations welcome
Northwest Renewable Energy Festival	Northwest	Sep. 19–21	Whitman College, Walla Walla, WA	25 workshops, 30 exhibitors, tours, keynote speakers, student activities, kids' zone	Can of food (for local food bank)
Olympic Energy Expo	Northwest WA	Oct. 12–13 (tentative)	Vern Burton Comm. Center, Port Angeles, WA	21 workshops, 35 exhibitors, speakers, kids' activities, EVs, building technologies	$3 Under 15, free
Renewable Energy & Sustainable Living Fair	International	Jun. 20–22	MREA grounds, Custer, WI	100 workshops,150 exhibitors, keynote speaker, headliner & local music, kids' activities	$8, $20 all days, Jr. & Sr., $5 Children, free
Rocky Mountains Sustainable Living Fair	Colorado	Sep. 13–14	Lincoln Center, Fort Collins, CO	25 workshops, 100 exhibitors, live music, kids' stuff, beer garden	$8, $12 weekend Students & Sr., $5 Under 7, free
Solar Fiesta	New Mexico	Sep. 27–28 (tentative)	Indian Pueblo Cultural Center, Albuquerque, NM	31 workshops, 41 exhibitors, kids activities, solar cooking, entertainment, alternative vehicles	$20, $35 weekend Exhibits only, $2
SolarFest	New England	Jul. dates TBA	New site, TBA	25 workshops, 75 exhibitors, music (solar powered stage)	$40 both days, $30 in advance
SolFest	Northwest California	Aug. 23–24	Hopland, CA	55 workshops, 115 exhibitors, tours, keynote speakers, music, kids' activities	$20, $15 adv. Sr. prices TBA Under 12 free (tentative)
SolWest Renewable Energy Fair	Pacific Northwest & Inland West	Jul. 25–27	Grant County Fairgrounds, John Day, OR	40 workshops, 50 exhibitors, minstrels, Electrathon, camping, Brookside Lunartics	$5, $10 all days, Jr/Sr $2, $4 all days Under 12 free
Southern California RE Expo	Southern California	Aug. 16–17 (2nd day tentative)	LA County Fairgrounds, Pomona, CA	25 workshops, 100 exhibitors, solar powered music, EVs	$6 Under 14, free
Southwest Renewable Energy Fair	Southwest	Aug. 8–10 (tentative)	Northern Arizona University,	36 workshops, 60 exhibitors, keynote speaker, kids' energy fair, SW RE Conf.	Free Parking fees only
Texas Renewable Energy Roundup	Texas	Sep. 26–28	Market Plaza, Fredericksburg, TX	80 workshops, 90 exhibitors, intensive workshops, tours, music	$5 Under 12 free (tentative)

*Covers fairs mentioned in this article only.

Access

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richard.perez@homepower.com
www.homepower.com

Illinois Renewable Energy Fair, Bob Vogl, 1230 E. Honey Creek Rd., Oregon, IL 61061 • 815-732-7332
sonia@essex1.com • www.illinoisrenew.org

Iowa Renewable Energy Expo, IRENEW, PO Box 355, Muscatine, IA 52761 • 563-875-8772
irenew@irenew.org • www.irenew.org

Northwest Renewable Energy Festival, PO Box 1501, Walla Walla, WA 99362 • 509-525-8479
Fax: 509-525-4163 • info@nwrefest.org
www.nwrefest.org

Olympic Energy Expo, Alternative Technologies Seminars, 1327 Caroline, Port Angeles, WA 98362
360-457-4047 • Fax: 360-417-2880
vangies@olypen.com • www.olympicenergyexpo.com

Renewable Energy & Sustainable Living Fair, Midwest Renewable Energy Assoc., 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • info@the-mrea.org
www.the-mrea.org

Rocky Mountains Sustainable Living Fair & Assoc., 349 N. Shields, Fort Collins, CO 80521 • 970-310-9079
info@sustainablelivingfair.org
www.sustainablelivingfair.org

Solar Fiesta, NMSEA, 1009 Bradbury SE, #28, Albuquerque, NM • 87106 • 888-886-6765 or 505-246-0400 • Fax: 505-246-2251 • info@nmsea.org
www.nmsea.org/Solar_Fiesta

SolarFest, PO Box 1052 Middletown Springs, VT 05757
802-235-2866 • info@solarfest.org
www.SolarFest.org

SolFest, Solar Living Institute, PO Box 836, Hopland, CA 95449 • 707-744-2017 • sli@solarliving.org
www.solarliving.org

SolWest Renewable Energy Fair, EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633
info@solwest.org • www.solwest.org

Southern California RE Expo, Ray Boggs, 888-647-6527 • Fax: 909-877-8982
info@socalenergyexpo.com • www.socalenergyexpo.com

Southwest Renewable Energy Fair, Greater Flagstaff Economic Council, 1300 South Milton Road #125, Flagstaff, AZ 86001 • 800-595-7658 • 520-779-7658
Fax: 520-556-0940 • swref@gfec.org
www.gfec.org/swref/

Texas Renewable Energy Roundup, Texas Solar Energy Society, PO Box 16469 Austin, TX 78761
512-345-5446 • Fax: 512-345-6831 • R1346@aol.com
www.renewableenergyroundup.com

Matrix
Solar Technologies
PHOTOWATT

Heat Exchangers for Solar Water Heating

Chuck Marken

Don Keefe of AAA Solar brazes a double-wall, shell and tube, heat exchanger.

If you are planning to heat your water with the sun, your solar hot water system will probably include a heat exchanger. You don't need a heat exchanger if you are circulating domestic water directly through the solar collectors, such as in a batch water heater, direct pump, or recirculation-type solar water heater. But if you need a closed loop or drainback-type water heating system, read on. This article will help you choose the right heat exchanger for your solar hot water system.

Heat exchangers have been in increasing use since around the time of Ben Franklin. He understood the increased efficiency of adding an iron front to a fireplace and exchanging the heat from the fire through the iron into the air in the home. Just as the convection heat exchange of the Franklin Stove dramatically improved home heating more than two hundred years ago, the performance of most solar water heaters is dependent on an efficient exchange of heat.

Heat exchangers come in three general flavors—air to air, air to liquid, and liquid to liquid. Examples of air-to-air exchangers are woodstoves and forced air furnaces. Car radiators are a good example of air-to-liquid exchangers. These two types of exchangers are also used in many other applications. But virtually all solar water heaters use liquid-to-liquid heat exchangers.

As discussed in previous solar hot water articles in *Home Power,* solar heating collectors depend on large black surfaces (absorber plates) to collect the sun's energy. The plates are bonded to relatively small tubes to transport the energy to a tank of water. In climates with subfreezing temperatures, a separate, *nonfreezing* fluid, like glycol (or water in drainback systems), is circulated in the solar collectors to protect the copper tubes from freezing and bursting in the winter. A liquid-to-liquid heat exchanger is a necessity where one fluid collects heat and another distributes it.

Efficiency & Material Design Features

Heat transfer between any two substances is determined by the overall conductivity, surface area, and temperature differential between them. The prime factors contributing to an efficient heat exchanger design are:

- High surface-to-volume ratio
- High conductivity
- High temperature differential (delta-T) between fluids
- Sufficient flow rate
- Specific heat (heat content) of the fluids

Beyond efficiency and safety, you are interested in a heat exchanger that will resist all potentially harmful factors of the operating environment, including temperature, corrosion, and chemical properties. You should consider all of these factors in the design and selection of heat exchangers for solar hot water.

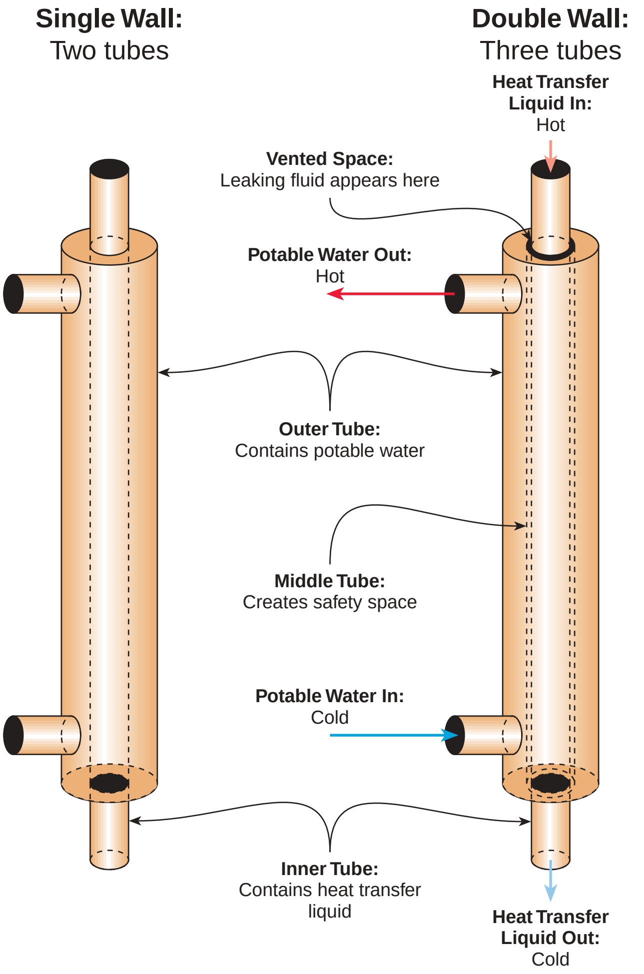
Liquid-to-liquid heat exchangers for residential applications are almost always made of copper or stainless steel. Commercial and industrial heating systems sometimes use steel exchangers, but these large installations usually have personnel carefully monitoring the fluids and regularly adding chemicals that inhibit the corrosive effects of water.

High temperature plastics have been used, but the thermal transfer characteristics of synthetic plastics cannot match that of metals. They are much less efficient, and the overall performance of the system can suffer significantly.

Tubular, Single-Wall Exchangers

A single-wall heat exchanger has only one wall or pipe surface separating the two fluid streams in the system. The simplest and least expensive single-wall heat exchanger is a coil of copper tubing, in line with the domestic hot water supply and immersed in an unpressurized tank of water. The water in the tank is circulated through the collectors, and the collectors and piping are angled downwards to allow the water to drain back into the reservoir tank when the sun isn't shining.

For drainback systems using water as the heat transfer fluid in the collector loop, this is the most common choice for efficiency and cost. This drainback system



heat exchanger was extensively covered in *HP86* and *HP88*.

Another single-wall heat exchanger configuration is called a tube-in-tube exchanger (also called shell-and-tube). A good example of a tube-in-tube exchanger is a $^{1}/_{2}$ inch (13 mm) copper tube soldered or brazed inside a 1 inch (25 mm) copper tube.

Appropriate fittings are readily available at plumbing supply houses and home centers, so single-wall, tube-in-tube exchangers are a relatively easy do-it-yourself project. One fluid (typically the collector loop fluid) is pumped through the smaller inner tube, and the second fluid is pumped through the larger tube, collecting the heat from the outer surface of the warmer inner tube.

Tube-in-tube exchangers can be constructed with any diameter tubing, but the efficiency of the heat exchange is reduced with larger sizes. The ratio of the surface area of the tube to the volume of liquid contained within (surface-to-volume ratio) is an important consideration in heat exchanger design. The larger the tubing, the smaller the surface-to-volume ratio, and the decreased efficiency of the heat transfer.

Higher heat exchange requirements use the shell-and-tube design—many small tubes contained in a single larger tube (the shell). Hot water boilers, instantaneous water heaters, and many shell-and-tube exchangers are designed with relatively small passages for the water, which increases the efficiency of the heat exchange by increasing the surface-to-volume ratio.

Single-Wall, Plate-Type Heat Exchangers
Plate-type heat exchangers are very compact, very efficient, single-wall heat exchangers. Many plates are sandwiched together with very small passages between each plate. One fluid is pumped through one side of each plate, and the second fluid through the other side.

Good, plate-type heat exchangers are always constructed of stainless steel. Stainless steel is used due to its strength, and because of the extremely small fluid passages that are easily clogged. Dissolved particulates in water do not tend to stick to stainless steel, and stainless steel exchangers can withstand all but the most corrosive fluids.

An Alfa Laval single-wall, plate-type exchanger.

Although stainless steel is inferior to copper in heat transfer properties, the high efficiency of plate heat exchangers is derived from the very high surface-to-volume ratio resulting from the very small waterways. Plate exchangers are used in many solar assisted, radiant floor home heating systems; hot tubs; and other applications that don't require a double-wall heat exchanger.

Single vs. Double; Safety & Code
The Uniform Solar Energy Code is quite picky about safety when using fluids other than water in a solar collector loop—with good reason. The issue of single-wall versus double-wall heat exchangers is of fundamental concern.

A single-wall heat exchanger has a single wall of separation between the two fluids exchanging heat. A point of corrosion or break in the single wall would permit a nonpotable fluid on one side to contaminate the domestic water on the other side. The direction of flow from one side to the other is determined by the relative pressure between the two sides of the heat exchanger.

When solar water heaters started gaining popularity in the mid-1970s, many systems used toxic ethylene glycol solutions (car antifreeze) as the heat transfer fluid in the collector loops. The first national solar code was written in 1982, and called for a heat exchanger with double-wall construction. The double-wall construction makes it impossible for the solar collector loop fluid to mix with the potable domestic hot water in the home's plumbing system.

A double-wall heat exchanger has two walls of separation between the two fluids. The space between the two walls may also be vented to the atmosphere, so a leak in either side of the heat exchanger would cause the fluid to flow out of the system, instead of the two fluids mixing together. Of course, the double wall and vented space offers less thermal conductivity between the two fluids. So double-wall heat exchangers are inherently less efficient than single-wall heat exchangers. But a well-made double wall affects the overall system efficiency by less than 5 percent, and many fill the vented space with conductive paste.

The Uniform Solar Energy Code (USEC) requires double-wall heat exchangers for use in solar hot water systems when a fluid other than potable water is used for the collector loop fluid. Safety is always more important than efficiency. Although almost all systems today use nontoxic propylene glycol mixtures as the heat transfer fluid, anyone could mistakenly add car antifreeze to the system, so the code remains in effect today.

Double-wall heat exchangers in wide use today are incorporated into five different designs:

- Immersed, double-wall, double-coil heat exchangers for unpressurized storage tanks
- Immersed, instantaneous or on-demand heat exchangers
- Immersed, bonded, double-wall heat exchangers incorporated into pressurized storage tanks
- Exterior, vented, double-wall heat exchangers
- Wraparound, double-wall heat exchangers

Immersed, Double-Wall Heat Exchangers
A double-coil, immersed exchanger is very similar to the single-wall drainback heat exchanger mentioned above. Two separate coils of copper tubing are immersed in a

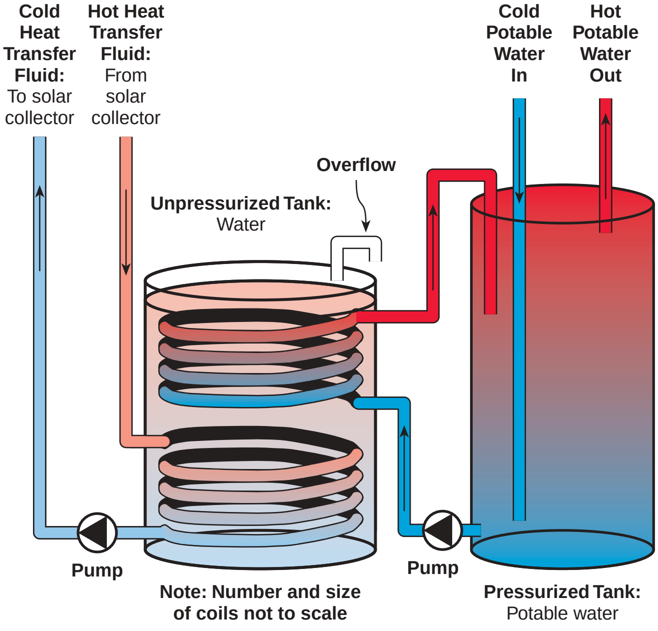
A 900 gallon tank with coils for glycol, DHW, space heat, and swimming pool.

tank that is usually unpressurized. The collector loop fluid is pumped through one coil, and the domestic hot water (DHW) is pumped through the other. If the wall of the tubing in either coil should leak for any reason, the other tube will still be intact. Even with the astronomical odds of the two tubes being breached at once, the DHW is going to have a higher pressure, and it will overflow the tank and alert the owner that something is wrong.

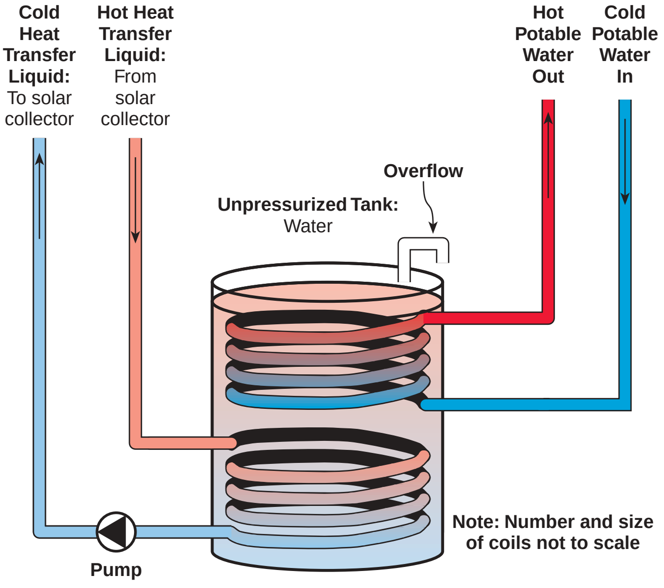
The DHW pump typically pumps the water through the DHW coil many times, and stores it in a separate pressurized tank for use when needed. Double-coil, double-pumped, immersed heat exchangers of this type are usually used in systems with large storage requirements. A rather inexpensive option is to add a third coil to the tank and use the pumped fluid in that coil for home heating.

An immersed, instantaneous or on-demand heat exchanger is similar to the previous one, but requires only one pump in the system for the collector loop. The pressure of the upstream cold water from a well, municipal water system, or cold water storage tank passes the water through the DHW coil a single time.

Immersed, Double-Wall, Double-Coil Heat Exchanger (Multiple Pass)



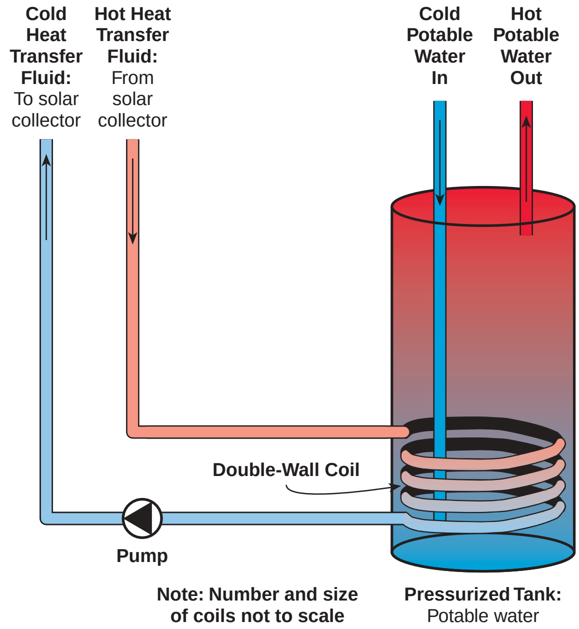
Immersed, Double-Wall, Double-Coil Heat Exchanger (Instantaneous)



This type of heat exchanger has the required double-wall construction, but has some definite limitations. The amount of heat that is transferred to the DHW is very dependent on the rate of flow through the coil, the size and length of the tubing, the temperature of the incoming water, and the length of time that the water is in contact with the coil. If the demand for hot water is low or intermittent (many small demands to allow the heat exchange coil to refill and heat up), this design works well. Without very long lengths of small diameter tubing, the demand of two or three hot water taps at once will give less than satisfactory hot water for most families.

Immersed, bonded, double-wall heat exchanger tanks manufactured today are typically the most expensive of all the different heat exchanger designs available. Double-wall heat exchangers of this type require special tooling to bond two tubes together, but still leave a path where fluid can escape if either of the two tubes are breached. This type of heat exchanger is also known as a vented, double-wall exchanger—the vent being the path through which a leaking fluid will escape.

Immersed, Bonded, Double-Wall, Heat Exchanger



A shell-and-tube, double-wall exchanger on a tank with all necessary components.

Exterior, Vented, Double-Wall Heat Exchangers

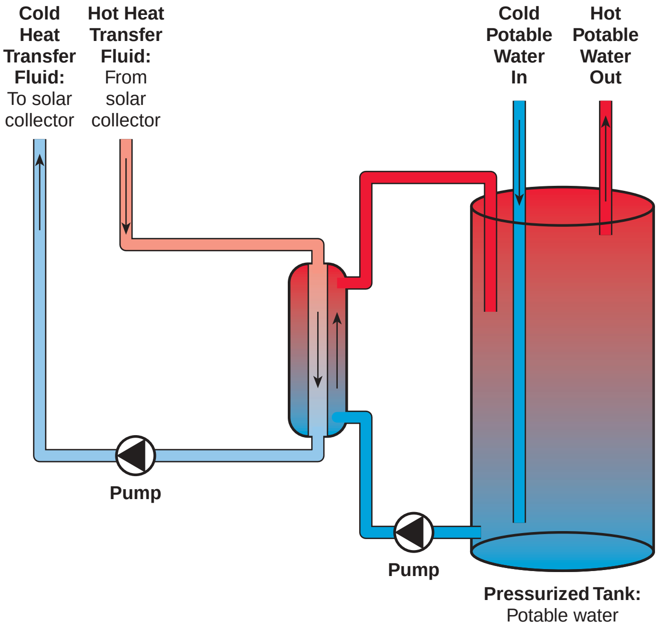
Exterior, double-wall heat exchangers are generically either a tube-in-tube or shell-and-tube exchanger. From a distance, they can appear to be identical to the single-wall exchangers. The big difference is a third tube that is mechanically bonded to the inner tube of the exchanger. Some designs include a thermally conductive paste between the two, mechanically bonded, inner tubes to increase the efficiency of the heat exchange. See the illustration on page 69.

The collector fluid is pumped through the inner tube, and the DHW through the outer tube. The second inner tube provides the double wall, and the mechanically bonded space between the inner tubes provides the vent for a leaking fluid to escape. An exterior exchanger has less efficiency than an immersed exchanger, but offers greater flexibility in design, and typically a lower cost. The two liquids in these exchangers are counterflowed, allowing a more even heat transfer in the exchanger, as shown in the drawing on the next page.

Cutaways of a shell-and-tube, double-wall heat exchanger.

The heat exchanger can be used with any size of pressurized storage tank, including a normal electric water heater with a simple field modification. This design also normally requires a second pump, much like the single-wall, double-coil design. The component aspects of an exterior exchanger make the system more installation intensive, but this is somewhat mitigated if replacement parts are needed.

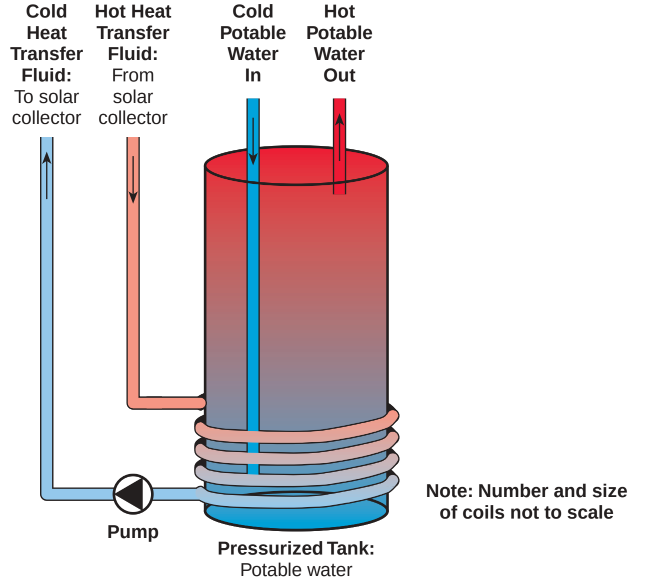
Exterior, Vented, Double-Wall, Heat Exchanger



Wraparound, Double-Wall Heat Exchangers

A wraparound, double-wall heat exchanger approaches the efficiency of an immersed heat exchanger, but tends not to have premature failures associated with immersed copper coils in a pressure tank. The design once again incorporates a coil of copper tubing, but it is wrapped around and bonded to the outer steel surface of the tank. Since the coil is under the tank insulation and outer steel jacket, it isn't noticeable. The only way you know you have this type of exchanger/tank design is the extra inlet and outlet on the side of the tank near the bottom.

Wraparound, Double-Wall, Heat Exchanger



The design only requires the collector loop pump because the exchange of heat is between the copper tube and the steel tank surface. This meets the double wall requirement of the code, and any leaking fluid will appear at the bottom of the tank. The only real drawback to this design is that only one company manufactures the exchanger/tank, and it only comes in one size, 80 gallons (300 l). The 80 gallon exchanger/tank has a suggested retail price of about US$1,200.

Design Advantages & Limitations

All of the DHW system designs, with the exception of the instantaneous exchanger, pick up heat all day and store it in a pressurized tank. Demand flows are not critical with these systems. You will run out of hot water when it has been used up and replaced with cold water. There is no major difference with three or four taps running at once—the hot water will be there for your demand. The designs don't increase the heat much on each pass, about 4 to 7°F (2–4°C) depending on the flow rates of the collector and DHW loop, and the size of the exchanger.

All of these residential-class systems have a limitation—120 gallons (450 l) is the largest tank available without moving into commercial-class tanks. The price of really large pressurized tanks can be very high, and you may have to wait six weeks or more for a factory to build one.

A two collector system in Anywhere, U.S.A., with a 66 gallon (250 l) pressurized storage tank, is typically enough for a family of three or four. The DHW pump in a

A shell-and-tube, double-wall exchanger in an insulated box on the floor.

counterflow exchange design system picks up 5°F (3°C) with each pass through the exchanger. Using a 3 gpm, 1/100 horsepower pump, the flow "turns the tank over" about three times an hour, a 15°F (9°C) rise per hour. With a starting temperature of ground water at 50°F (10°C), the tank will be about 130°F (54°C) after six hours of operation.

Sizing a Heat Exchanger
Sizing wraparound and immersed, double-wall designs is easy—they only come one way from the factories, so the sizing is predetermined. Heat exchangers for water heater designs that are 120 gallons (450 l) and smaller can normally be sized with the guidelines below. Larger systems require some real engineering.

All the immersed designs that use copper coils in an unpressurized tank (with the exception of the instantaneous exchanger) will usually have heat exchanger lengths that conform to the 60 and 100 foot (18 and 30 m) coil lengths available in plumbing supply houses and some home centers. The smallest is 30 feet (9 m) of 1/2 inch (13 mm) tubing, used in many small 10 to 20 gallon (35–75 l) drainback tanks. Tanks up to 120 gallons (450 l) use 50 and 60 foot (15 and 18 m) lengths.

The guideline for counterflow, double-wall exchangers is 1 lineal foot (0.3 m) of 1/2 inch (13 mm) inner copper tube for every 5 square feet (0.46 m^2) of collector surface area. This is for heat exchangers with a smooth, in-line, copper tube. Some manufacturers incorporate finned tubes as the inner tube, and others have grooves formed into the inner tube that can increase this ratio up to approximately 1 lineal foot per 10 square feet (0.9 m^2) of collector.

There is only one rule for immersed instantaneous exchangers—more length of smaller tubing is better.

Shell-and-tube, double-wall exchanger in a module with pump and expansion tank.

Adjusting and filling a system that provides DHW and radiant floor assist heating.

Some very small systems, sized for only one very energy conscious individual have been satisfactory with a 60 foot (18 m) coil of 1/2 inch (13 mm) tubing. As demand goes up, the tubing needs to be longer. Some have used many coils, piped in parallel, to achieve satisfactory performance. Variation in ground water temperature can weigh heavily on the length of the exchanger. Lower incoming water temperatures dictate appropriately longer coils of tubing.

Plate-type heat exchangers have no standard design rules since they are typically used for non-DHW applications that are many and varied. Because of this, plate-type heat exchanger manufacturers should always be able to provide a good matrix of performance, much like pump performance curves. These give the exchange of heat in BTUs, depending on a single flow rate and temperature difference. The supplier of this type of heat exchanger should be able to help you determine what size is appropriate once you specify the square feet of collector area.

Maintenance & Service
Heat exchanger maintenance is dependent on a single factor—how do the fluids flowing through the exchanger affect it in the long term? Virtually all heat exchangers suitable for solar heating applications are made from copper or stainless steel to minimize maintenance. As explained above, maintenance is not much of a problem with stainless steel exchangers.

Copper exchangers may need a more watchful eye, since copper is much more prone to corrosion. A glycol solution that has turned acidic from abuse or constant overheating can cause pitting and premature failure. In

Pros & Cons of Heat Exchanger Types

Type of Heat Exchanger	*Ideal Applications*	*Beneficial Features*	*Limitations & Drawbacks*	*Single or Double Wall*
Instantaneous, double-coil exchangers in an unpressurized tank	Low demand, domestic hot water systems Systems with unpressurized storage tanks	Inexpensive	High DHW demand usually gives poor performance Size and length of tubing is critical	Double
Immersed, double-wall, double-coil (or more) exchangers	Larger systems with large unpressurized storage tanks with options for home heating	Failsafe freeze protection when used in glycol-type systems	Typically larger and more complex systems Storage tank material must be rated for hot water	Double
Counterflow, external, shell-&-tube, double-wall exchangers	Domestic hot water systems in any climate	Solid freeze protection Good efficiency Good flexibility for sizing	More complex system More expensive than coil-type exchangers	Double
Immersed, mechanically bonded, double-wall exchangers incorporated in pressurized tanks	Domestic hot water systems in any climate	Easy to install Solid freeze protection in glycol systems Usually best efficiency of double-wall types	Normally the most expensive Limited number of sizes manufactured	Double
Wraparound, double-wall exchangers bonded on pressurized tanks	Domestic hot water systems in any climate	Easy to install Solid freeze protection in glycol systems Very good efficiency	Limited number of sizes manufactured affect flexibility Tank is expensive	Double
Plate-type external exchangers	Radiant floor integrated solar heating systems	Very efficient Very compact Reasonably priced	Most are single wall & not for use with potable water	Single
Drainback systems with an immersed exchanger coil	Domestic hot water systems in mild climates using water as collector loop fluid	Good solution for domestic hot water in milder climates	Questionable failsafe freeze protection in harsher climates	Single
Single-wall, external, shell-&-tube exchangers	Domestic hot water systems in drainback systems Heating systems using glycol	Can be used with a small water heater as a drainback tank, for small radiant floor systems, & for glycol systems Inexpensive	Questionable failsafe freeze protection in drainback systems Less efficient than plate exchangers in glycol heating systems	Single

most solar water heaters, acidic glycol solutions primarily affect the longevity of the collectors, since they are usually built with thinner wall tubing.

The DHW side of the heat exchanger is of much more concern due to the dissolved particulates (hard water) in water in many parts of the country. These particulates, typically calcium, precipitate out of the water when heat is applied. Over the years, this can cause so much of the material to dissolve out and stick to the walls of the tube that efficiency is impaired. With very hard water, the DHW side of the exchanger can clog completely over time. This doesn't happen often in most locations, but it is a known cause of the failure of many systems, mostly in selected areas of the western U.S.

A good example of this sort of problem is automatic coffee makers. In hard water areas, you need to clean them out by running vinegar (a light acid) though them every few years. The same type of maintenance may be necessary for both immersed coil and counterflow heat exchangers too.

If the problem is not noticed by the diminishing performance of the system until fully clogged, a heavier acid solution is needed. This heavier duty cleaning is probably best left to professional solar hot water people who are familiar with the somewhat vigorous chemical reactions that occur when mixing acids with hard water deposits. Light solutions of muriatic acid and water, and a product called Entech 52 have been successfully used for this heavier duty cleaning.

Pros & Cons of Heat Exchanger Types

The variations of heat exchanger types can look imposing when you are considering one for your solar hot water system design. The choices are mostly budget dependent. See the comparison table.

Single-wall exchangers are a good answer for solar assisted, radiant floor heating and drainback systems that use water in the collector loop. A plate-type for radiant floors and an immersed coil for drainback systems will normally give the best value in these systems. Double-wall exchangers are needed for antifreeze (glycol) systems.

Heat exchangers in unpressurized storage tanks are better for multiple uses like space heating and DHW. Pressurized tanks with immersed or wraparound exchangers typically cost more, but are easier to install. Exterior heat exchangers have more flexibility for system sizing, component location, and maintenance, and usually cost less, but are more installation intensive.

What design is best for you? Use a double-wall design if you are heating domestic hot water with an antifreeze solution in the collector loop. Use a less expensive, single-wall heat exchanger for drainback systems. Initial costs, design flexibility, hot water demand, and space to put the equipment are all considerations that deserve your careful attention when deciding what type of design best fits your needs.

Access

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How to Install a Solar Water Heater; Closed Loop Antifreeze System, by James E. Cook, Save On Solar, 1988. ISBN 0-9619932-0-0 • Available used

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"The man who on his trade relies, Must either bust or advertise."

Sir Thomas Lipton — 1870

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TOP SECRET

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

PROFILE: 0023

DATE: September 2002
LOCATION: Northern Hemisphere
INSTALLER NAME: Classified
OWNER NAME: Sunny Kilowatt
INTERTIED UTILITY: Classified
SYSTEM SIZE: 112 Watts
PERCENT OF ANNUAL LOAD: 1%
TIME IN SERVICE: 8 months

I have always been interested in energy efficiency, and hopeful for renewable energy's success. As a renter, I wasn't sure how to do my part.

After reading about the MicroSine 100 inverter and grid-tied systems in Home Power 85 and 86, I knew that a small system was easy to build, relatively inexpensive, and feasible for a renter.

While searching for a MicroSine, I came across the Evergreen Solar ES-112 system that includes two, 66 watt PV modules and a MicroSine already prewired. I purchased the system and mounting hardware from a very helpful local RE dealer.

Setting up this system was unbelievably easy. All I needed was a few tools and a #14 outdoor extension cord. This is true plug-and-play solar electricity. I cut off the female end of the extension cord, and wired it into the junction box on the back of the system.

I pointed the array toward the sun, and plugged the inverter into a weatherproof outlet. It was a beautiful, sunny March day. I walked to my utility meter, and immediately noticed that it was creeping backwards. What a thrill! After proving that it works, I mounted the array in its current, semipermanent place.

Given how easily this solar project came together, I intend to expand the system's capacity, looking for more components that are modular, provide quick setup, and guarantee safe deployment.

My system is safe and will not harm anyone (including utility workers). Nor will it damage the air, water, or land. It is efficient, capturing a readily available resource (sunlight) and generating electricity at the point of use. The same cannot be said about fossil fuel and nuclear plants.

So why guerrilla? Simple--why pay the utilities and governments to allow me to use solar energy when they have been obstructing its use for years? I believe in fair and open markets. Fossil fuel and nuclear plants enjoy many subsidies (direct and indirect), while not bearing the true cost of their impact on the environment. Once solar electricity is on a level playing field, I'll play by the rules. Until then, I'll think of it as my personal, sun powered Boston Tea Party.

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.


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Things *That* Work!

Tested by Home Power

Solar Dynamics True-Sine Harvester

Joe Schwartz

In recent years, there's been a proliferation of the use of portable, electronic devices in the U.S.—cell phones, laptops, PDAs, digital cameras, video cameras, MP3 players, and CD players. The list goes on and on. All of these devices rely on electricity, either directly or via batteries. Solar Dynamics manufactures the Harvester product line—portable PV power plants that will power up your portables and charge their batteries with sunshine.

Product Overview

The Harvester is a complete PV system that's built up on a frame resembling a hand truck. It's designed for portability. The unit's power center includes a Concorde 12 volt, 104 amp-hour (24 hour rate) sealed, absorbed glass mat (AGM) battery. We tested the True-Sine Harvester, which includes a 600 watt Exeltech XP600 inverter. The AC power quality of this inverter is excellent, and is well suited for powering consumer electronics. (Check out the Things that Work! review of the XP600's big brother, the XP1100, in *HP75*.) A 12 amp, pulse width modulated (PWM) Steca Jota charge controller with LCD display and integrated temperature sensor regulates battery charging. All these components are housed in a weather resistant enclosure.

The Steca charge controller's LCD display shows PV current, DC load current, battery voltage, and battery state of charge (SOC) based on voltage. Two LED battery status indicators also provide system SOC information. The charge controller's display is on top of the power center unit, and easy to see. It also has a low voltage disconnect feature, just in case you lose track of the SOC.

The power center rests in a powder-coated tubular steel frame. A 50 W rated, ASE crystalline PV provides charge current. Some additional tubing, and a handle attached to the PV, make up the rest of the unit's frame. A pair of 12 inch (30 cm) wheels with knobby tires makes moving the Harvester easy, even over rough ground.

The portability of the unit allows for manual tracking of the sun's daily path. The tilt angle of the module is adjustable as well. The retail cost of the True-Sine Harvester we tested is US$1,985. The unit carries a one-year warranty.

Documentation & Setup
The Harvester's documentation includes a 28 page manual, a laminated, quick setup sheet, and individual manuals for both the inverter and charge controller that are incorporated into the unit. In a world filled with marginal manuals, I'd rate the Harvester manual as superb (even with the typos). It contains step-by-step setup graphics, text, an appliance run time table, and more.

First time setup of the unit took a leisurely half hour. By the time my morning cup of coffee was gone, the Harvester was collecting sunshine. The unit is designed for the consumer market, and the simplicity of assembly reflects this.

Connectivity
The back of the power center has two DC input receptacles. A weather resistant, polarized receptacle and cable assures correct polarity between the positive and negative PV leads and the charge controller. An automotive cigarette lighter style receptacle accepts DC input from the optional 10 amp, AC-to-DC charger available from Solar Dynamics, or directly from a running automobile or other DC power source.

The power center has four, DC output receptacles—two cigarette lighter style and two polarized RV style. These receptacles are handy for running DC appliances and recharging cell phones, laptops, rechargeable batteries, and the like. The addition of an adjustable DC-to-DC converter will allow you to power DC loads directly at 3, 6, or 9 VDC.

The Exeltech XP600 has two grounded receptacles for AC output. You have to remember to shut off the inverter if you're not powering AC loads at the time. A nice addition to the AC output of the inverter would be a search mode. This would allow the inverter to power down when no AC loads are present, and would help conserve the limited energy stored in the Harvester's battery.

Goin' Mobile
The Harvester will fit into the trunk or back seat of most vehicles. The dimensions of the Harvester power center are 21 by 10 by 20 inches (53 x 25 x 51 cm). Fully deployed, the Harvester PV module, frame, wheels, and power center measure 49 by 26 by 23 inches (124 x 66 x 58 cm).

The power center simply unplugs from the PV module and framework, allowing it to be moved or loaded separately. The power center is heavy, at 75 pounds (34 kg). The rest of the unit's PV and frame assembly weighs 42 pounds (19 kg). Your ability to lift the unit should be considered if you'll be loading it into a vehicle on a regular basis.

Because the battery used in the unit is sealed, the Harvester is classified as nonhazardous. It can be loaded on an airplane and set up at the base camp of your next adventure.

Flat Tire Trip
After hauling the Harvester around for a couple of months, both the tires began deflating. I scratched my head a bit, since the pressure loss was equal in both tires. I checked for punctures and didn't find any.

It turned out that the tires used on the Harvesters weren't holding their pressure for the long term. The manufacturer has resolved the issue by going to a urethane "flat-free" tire.

You Have Options
Several additional Harvester models are available. It can be purchased with a modified square wave inverter. Export versions with 230 volt, 50 Hz, AC output are also

All the Harvester's parts can be assembled in a leisurely half-hour.

A 600 watt Exeltech inverter provides high quality power. The AGM battery is housed below in an insulated space.

available. Other options include a three-module unit for increased PV charging, a portable field office option that adds a work table to the unit's frame, and lighting and message display versions.

Depending on your application and typical usage of the Harvester, Solar Dynamics can set you up with AC and DC battery chargers to supplement PV charging. One option is a 10 amp, DC, bulk battery charger. The charger plugs into a 120 VAC receptacle. Another optional accessory is an automotive charging cable. The cable is 12 feet (3.6 m) long, fused, and equipped with two, male cigarette lighter style adapters. This setup allows you to charge the power center off your rig's alternator while you drive. Once either end is plugged into a power source, the other end becomes "hot," so pay attention if you use this cable.

Run Times

So what will the Harvester run? I've been using the Harvester up on a piece of undeveloped, off-grid property outside of Ashland, Oregon. I've had the Harvester power both AC and DC compact fluorescent lighting, a CD boom box, a battery charger for various portables, a notebook computer, and even a Starband satellite Internet modem.

I've been running the majority of my loads off the DC side of the unit, in an effort to eliminate the inverter inefficiencies from the energy equation. The use of all these devices is intermittent, and the loads can be easily switched to other PV charging systems when the Harvester's battery reaches a 50 percent state of charge (SOC).

Harvester run times will vary depending on the power requirements of specific appliances, ambient temperature, sunlight, and whether the loads are running on AC or DC. In general, make sure to use efficient appliances, and when possible, power appliances directly off of DC. The Harvester manual contains a table that lists sample run times for various appliances.

Sweet Product

The True-Sine Harvester is the nicest, all-in-one PV charging station I've had my hands on. It uses great components, is well built, easy to move, and simple for nontechnical folks to operate. If you're interested in a small, portable PV system, and don't want to build it yourself, check it out.

Access

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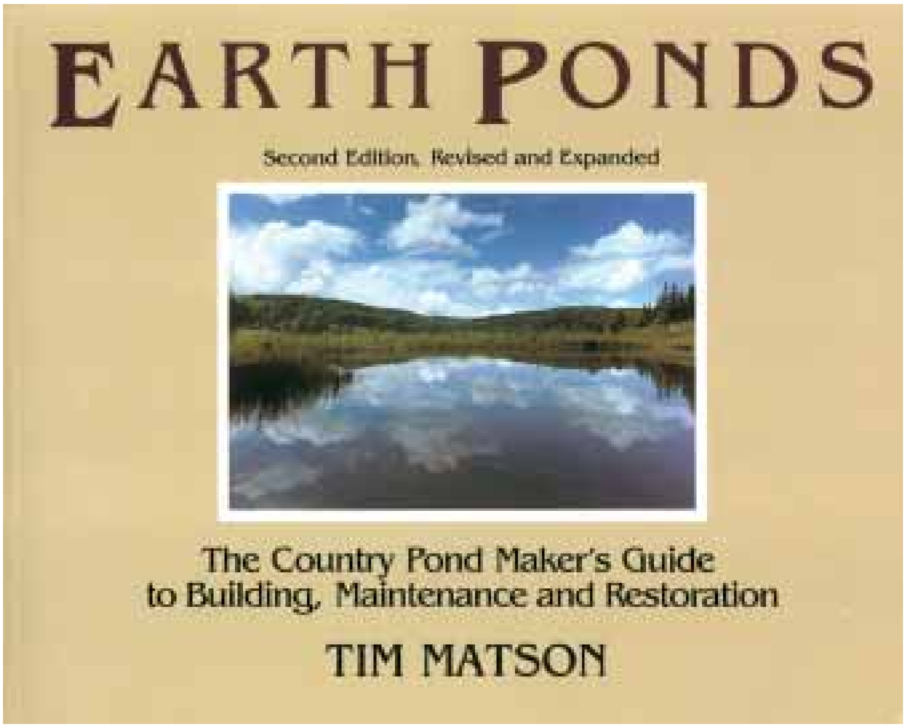
Things that Work! Criteria
The products reviewed in Things that Work! must meet three criteria:

1. The product must meet its manufacturer's specifications.
2. The product must be durable and last in actual service.
3. The product must offer good value for the money spent on it.

The reviewed equipment is not necessarily the best product for all applications.



Reviewed by Joe Schwartz

Every once in a while, I read something that changes the way I look at the world. Sometimes it's a profound, heavy piece—*A People's History of the United States*, by Howard Zinn comes to mind. But more often than not, it's something simple and subtle. I've seen Tim Matson's book, *Earth Ponds*, for years, but until recently, I had never cracked the cover.

Earth Ponds was first published in 1982, and then revised and expanded in 1991. The current edition is in its ninth printing. On the surface, the book's focus is the design, construction, and maintenance of small, homestead ponds. But the book has much deeper underpinnings. Matson's text conveys a historical reverence for these small bodies of water that is contagious.

Part I of the book, The Cabin Pond, chronicles Matson's experience building a pond on his homestead in Strafford, Vermont. I guess I was subconsciously expecting another, somewhat dry, how-to book. But Matson's opening section is literature of the finest kind. It takes the reader physically to the edge of Matson's pond site, and philosophically into the author's head. Together we experience the pleasure of watching a Vermont pond builder carve his way into the undeveloped pond site on a chugging, diesel D-6 cat. We watch the pond slowly fill, the threat of a winter flood, and the release of fingerling trout from the pond's shore.

The first part of the book left me captivated with the idea of building a pond, and the second and third parts of the book offer practical how-to pond information, including siting, excavation, spillways, repairs, and aquaculture. I savored each and every pond building detail that Matson presented.

For backwoods folks living on renewable energy, ponds make a tremendous addition to a piece of land. They offer surface water storage for irrigation and fire control. They provide an environment for raising fish and creating wildlife habitat. They create a place to swim in the summer, skate in the winter, and sit beside and contemplate the meaning of things.

More than once, while I was reading *Earth Ponds,* I couldn't resist setting the book down, pulling on my muck boots, and heading down to the draw in my meadow. The earth was still wet during the height of the summer, the banks rose gently above the intermittent creek bed, and the soil was sticky with clay. I lay in the middle of the obvious site for my dream pond, the grass turned to water, and I knew I'd found the perfect spot for my next project.

Access

Earth Ponds, by Tim Matson, ISBN 0-88150-155-7, 150 pages, US$19.95 from The Countryman Press, PO Box 748, Woodstock, VT 05091 • 800-245-4151 or 802-457-4826 • Fax: 802-457-1678 countrymanpress@wwnorton.com www.countrymanpress.com

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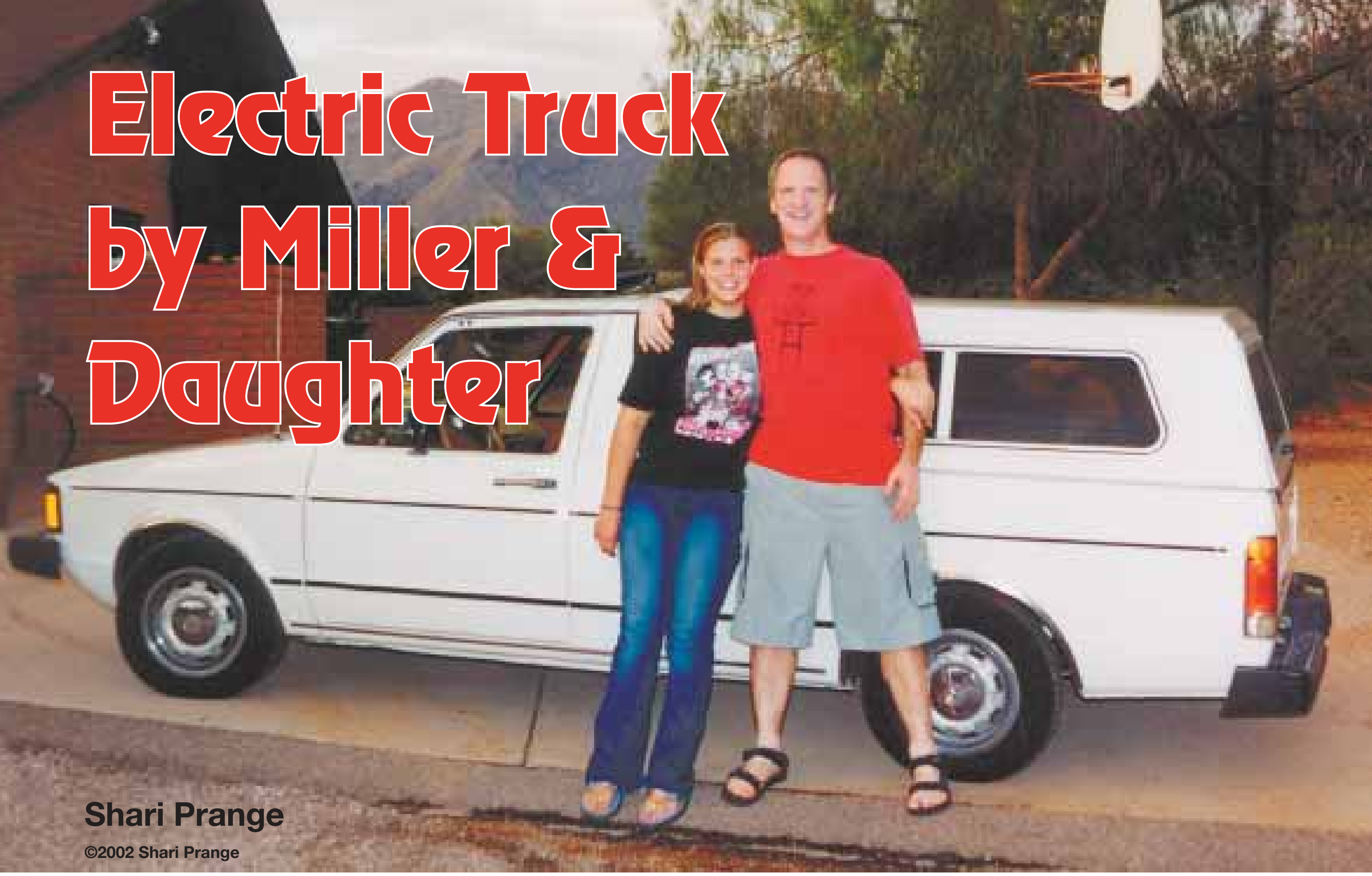
Electric Truck by Miller & Daughter

Shari Prange



Joe and Emily Miller posing proudly in front of their home-converted electric vehicle—a 1981 VW pickup.

For some people, a car is just a way to get from here to there. For others, it may be a fashion accessory, a political statement, or an ego prosthetic. A car can be a lot of different things to different people. It can be something extra special when a father and daughter build it together.

The Idea

The whole project started because Joe Miller wanted to do something positive for the environment. He had heard that 30 percent of the air pollution in the United States comes from cars. An electric car sounded like the solution.

Tucson, where Joe lives, is a very environmentally conscious city. It was one of the test sites for the GM EV1. The car intrigued Joe, but he didn't want to spend that kind of money. Then GM began to pull back, and the EV1s started to disappear from the streets, along with their once plentiful charging stations.

If Joe wanted an electric car, he'd have to build one himself. But he wasn't sure whether he was up to the task. Then, on a visit to Stanford University, he saw a home-built converted pickup truck. It was rough, but it gave Joe the confidence that he could do a conversion too.

What really got Joe moving, however, was his wife, Sarah. She felt that his work as an eye surgeon completely consumed his thoughts, and it was making him a narrow person. She told him that he needed to find a project that had nothing to do with eye surgery or sitting at a computer.

A Plan

In the first phase, Joe did a lot of reading about electric vehicles (EVs). He determined that Tucson, with its warm climate, was a good location, since he wouldn't need to worry about a heater/defroster or insulated battery boxes. His normal driving patterns on mostly flat city streets were also very suitable for an EV. He kept a daily mileage log for three months, and discovered that the most miles he drove in a single day was 65 (105 km), so he set a goal of an 80 mile (129 km) range, "just in case." Again, this was consistent with the performance of an electric conversion, so he was on the right track.

Then he started to get more specific. He felt that a front wheel drive vehicle would work better for weight distribution and handling. He also wanted a pickup truck to give him more room for batteries. Doing some of the design and fabrication was part of the attraction of the project for Joe. However, without access to a machine shop, he felt that his capabilities were limited.

He found a solution that looked like it would fit all his needs—a VW pickup truck. Based on the Rabbit chassis, they are front wheel drive, and accept most of a Voltsrabbit bolt-in conversion kit, at least the under-hood portion. And the portion in the truck bed would give Joe the opportunity for his own design and construction.

He located and bought a used 1981 Rabbit pickup for conversion. “I probably paid too much for it,” Joe said, “but it was very clean, and had a cap for the bed.” The truck had started its life in Hawaii, which Joe felt was a good omen.

Putting Tools to Metal

He drove the truck for several months, waiting for something bad to happen to the engine to justify the conversion. Unfortunately, when something bad finally did happen, it wasn’t to the engine. Instead, one of the axles pulled out and took part of the shift linkage and transaxle with it. Since he had to tear it all apart anyway, he decided that this was the time to do the conversion.

Then, as he began work on it, he discovered that everything he touched really needed to be replaced. Before he was finished, he had replaced all of the brake systems and wheel bearings, which added considerably to the time involved in the conversion.

Once he started taking the car apart, another interesting thing happened. His 15-year-old daughter Emily (or “Em”) started to hang around the garage, watching and asking questions. Finally, he asked her if she wanted to help. “I think he got tired of me staring at him,” she said.

Sarah encouraged the collaboration. She told Joe, “Spend some time with Emily. Before you know it, she’ll be gone to college, and you won’t even know who she is.”

“I really didn’t know anything mechanical before that,” Em said. “But now I feel like I know a lot about the car. I spent a lot of time sitting in it while my dad was working, and he explained how different parts worked. My dad and I really got to know each other too.”

At the same time, Em was learning theatrical set construction in school, so she and Joe decided to learn to weld together for both that and the truck project. Joe bought a stick welder, and gave Em her own welding apron, gloves, and goggles. “I have my own side of the garage to store my things on,” Em said. “I keep it real organized and neat.”

Baby Steps

The system Joe and Em installed was typical for a home EV conversion. It used a series wound DC motor manufactured by Advanced D.C. Motors. This is probably the most common motor in home EV conversions. Joe used the 8 inch (20 cm) diameter model. For his 120 volt system, this motor is rated for 21.7 hp continuous duty, and 83 hp momentary peak. It is mounted to the car’s original transmission by means of a precision machined aluminum and steel adaptor. The adaptor was included in the conversion kit, and was one of the main reasons Joe decided to buy a kit rather than separate parts.

After the motor was installed, Joe and Em were getting really anxious to see the car run, so Joe decided to do a little test. He jury-rigged a connection to the motor from a single, 12 volt, car battery, using a contactor that was rated for very high current. (As volts go down, amps go up, and vice versa. Running on only 12 volts instead of the intended 120 volts, the car would draw much higher than normal current.)

And the car moved! Slowly, silently, Joe and Em crept down the street. But their moment of “All right!”

They installed a Voltsrabbit conversion kit under the hood.

In the pickup's bed, Joe and Emily designed a custom space to safely carry the batteries and components that wouldn't fit under the hood.

transformed into "Uh-oh!" when the contactor welded itself shut, due to the unusually high current draw. "The truck just kept going and going," Em said, "like the Energizer bunny." Sarah watched in puzzlement as they drove up and down, up and down. Why didn't they stop?

Finally, Em jumped out of the slow moving truck and ran to the garage. Snatching a handful of tools, she ran back and jumped into the still circling truck, just like an action movie hero—except that the car chase was happening in slow motion. With Em's assistance, Joe bent under the dash to break the connection and stop the car.

Getting Serious

With that excitement over, it was back to the real work of conversion. In its finished form, the car's ignition key operates a contactor as an on/off switch. The throttle pedal operates a 0 to 5 k-ohm potentiometer, or potbox. The potbox, in turn, controls a solid state speed controller manufactured by Curtis Instruments. Based on the signal from the potbox, the speed controller meters out energy from the battery pack to the motor.

The biggest design issue in a conversion is battery placement. Joe used the 6 volt, flooded, lead-acid golf cart batteries that are the most common type used in home conversions. His were made by U.S. Battery, one of the two manufacturers that are overwhelmingly chosen for this type of battery (the other is Trojan Batteries). A 120 volt system requires twenty batteries, which weigh 67 pounds (30 kg) each. They must fit into the vehicle, be connected in a single series circuit, be accessible for service, and be adequately secured and contained for safety.

The kit Joe and Em used provided steel racks and holddowns for eight batteries under the hood in a split-level "L" arrangement over the motor. In a Rabbit sedan, there would be another steel rack and box for eight more batteries in the hatchback area, but that wouldn't work in the pickup. Joe and Em's job was to design and build something in the truck bed to hold twelve more batteries.

They welded a steel tray from 1/8 inch thick by 2 inch (3 x 51 mm) angle iron, and hand painted it with Rustoleum paint. Inside that, they built a plywood box with a hinged lid. On the inside of the lid, they installed pieces of PVC pipe that would press down on the tops of the batteries when the box was closed, keeping the batteries from bouncing inside the box.

Joe and Em also had to design and build a mount for the battery charger. It made sense for this to live in the rear of the vehicle, because the original gasoline fill opening makes a natural charging port. Joe decided to move the auxiliary battery and DC-to-DC converter from their place under the hood, and mount them with the charger. He installed them all on a board that runs the length of the battery box, with a welded, extruded wire cover over them.

The auxiliary battery is a normal 12 volt car battery that powers the lights, horn, wipers, and some of the control circuits for the drive system. The DC-to-DC converter taps high voltage at low current from the battery pack and drops it down to a regulated 13.5 volts at up to 25 amps to keep the auxiliary battery charged.

The truck also has a circuit breaker that will trip automatically, or can be tripped manually, in case of an electrical problem. Joe chose to remove the heater core and air conditioning system, and install the breaker in the dash where the climate controls used to be.

The Human Factor

The project became something of a family and community affair. Joe's brother-in-law supplied helpful welding advice over the phone from his home in Ohio. The neighbors listened to the banging and grinding, and waited for the inaugural voyage. Local boys dropped by with suggestions, mainly involving the ultimate sound system. "It's a real guy magnet," Em enthused.

Joe agreed, though from a slightly different perspective. "The geek factor has been a real blast. Jordan, the gearhead down the street, thinks it's cool, and that's the ultimate test."

The biggest frustration came when the truck was almost finished, and Joe severed a brake line. "It was a US$125 brake line from the front to the back of the truck," he said. "I could see that I'd have to replace it, and then refill and bleed the whole hydraulic system. At that point, I was getting really impatient to get the truck done. I was so mad, I just walked out and didn't touch it for two months."

It was Sarah, again, who gently but persistently pushed him back out into the garage to finish, after he had cooled down. Now the pressure to get it running had drained away, and it was simply a project, something that he and Em could work on and enjoy. It would get finished in its own good time.

Done at Last!

And it did. But not before a few more challenges were overcome. The weight of the batteries caused the rear end to sag. Joe added a set of "helper" leaf springs, which improved the situation, although the truck is still about an inch low. Eventually, Joe may look into custom springs for the rear. They put a new paint job on it, and the truck was officially signed off by the Arizona Department of Transportation on Earth Day 2002. It has a special alternative fuel license plate that exempts it from further smog inspections.

Since then, the truck has traveled about 2,000 miles (3,200 km). The only major problem it had was a hairline crack in a battery post, which started to melt. The battery was replaced under warranty. The hill leading up to Joe's house at the end of the day has been a minor problem. It's about 2/3 of a mile (1 km) long, and climbs a few hundred feet. On a hot day, the controller will hit its high temperature cut-out and reduce power to prevent damage. Joe is thinking about adding some fins to the heat sink under the controller, and/or ducting more air to it. He could also upgrade to a higher rated unit.

Joe has had the truck up to 65 mph (105 kph), and believes it could go faster. He's driven it as much as 60 miles (97 km) in a single day. A typical day for him is to spend the morning making stops at three different hospitals, and the afternoon at his office, where the truck can get four hours of charging. Joe has not detected any increase in his electric bills.

"I tend to be cautious," Joe said, "because I'm a doctor, and when I'm supposed to be somewhere at a certain time, I have to be there. But I've come to the point where I don't worry about it any more. I just get in the truck and go where I need to go."

Joe has learned some EV driving techniques, too. The car has an ammeter that gives real-time feedback on energy consumption. Joe has discovered that sometimes it isn't necessary to put the throttle to the floor. By watching the ammeter, he can back off to the point where he maintains his speed with the lowest current draw. As an avid bicyclist, he has also learned to drive the EV like a bicycle—get up to speed and then coast.

The truck's dash houses an ammeter for real-time feedback, a circuit breaker just in case of an electrical emergency, and a stereo so Joe and Emily can rock out, together.

He was pleasantly surprised by the truck's performance in a couple of unusual situations. At one point, the truck was the only functioning vehicle in the family, due to a sudden spate of collisions, and it met the challenge admirably. In another instance, Joe drove to the airport, parked it partially discharged (which is not recommended) while he flew out of town for three days. When he returned, the truck was able to complete the 40 mile (64 km) round-trip home with no problem.

He enjoys the reaction from other drivers, too, as they honk and give him the thumbs up. "The biggest satisfaction right now is that I'm not burning Saudi oil," Joe said. "I have a lot of friends who wish they could say the same."

More Than a Truck, It's a Relationship

Sarah thinks the project was a good thing, even if she didn't participate directly. "It was good for Joe and Em. Some parts weren't so fun, but other times they were as thick as thieves. And I enjoyed having him out in the garage. When he's on the computer, I don't like to interrupt, but in the garage, I felt I could step out and talk to him." She also thought it was good for Joe, who spends all his time working on a microscopic scale, to do something on a more human scale.

Em (who just turned 17) really enjoyed getting to work with her hands on the car, and learning how to weld. She got a sense of accomplishment out of it, the knowledge that she had done something no one else at school had done, and acquired some skills along the way.

She doesn't drive the truck. "If I drove it, I would crash it," she said. "I love it too much for that. And I couldn't afford the blow to my relationship with my dad."

But she does like to ride around in it with him. "We found out that we both like driving around with the Grateful Dead cranked up. We talked a lot, and I realized that my Dad wasn't just this ogre who wanted to make my life difficult, but somebody I could do things with. I heard about what he was like as a kid, and it made me feel better about myself. We discovered that we have a lot in common. It was great!"

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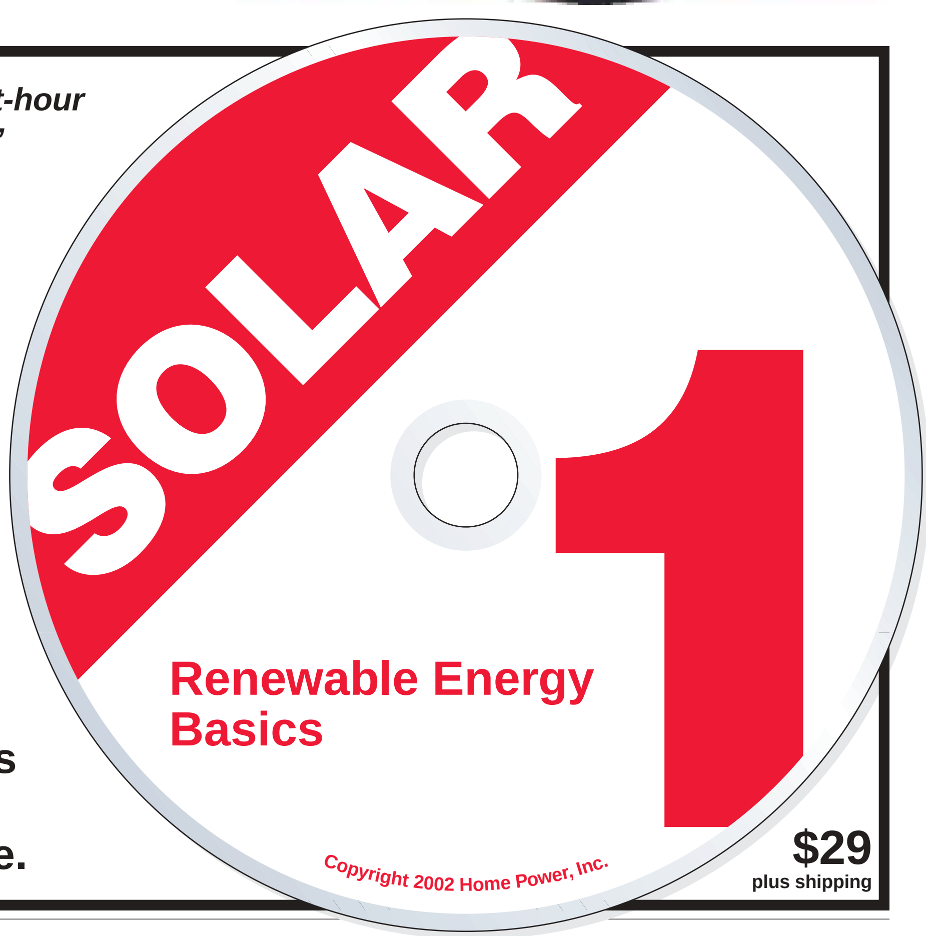


Charging Problems

Mike Brown

"I drove my EV home last night and plugged it in as usual. The charger turned on and ran for a couple of seconds, and then the GFI tripped and the charger shut off. What's going on?"

This is one of the most common charging problems that I hear about. Let's look at the cause, the cure, and how to keep it from happening again.

The Cause

GFI stands for ground fault interrupter. It is a device that detects an electrical leakage flowing to ground, and automatically turns off the power to the device it is connected to (in our case, the battery charger).

The GFI is a feature of most of the small, lightweight, onboard battery chargers found on most modern conversions. The chargers are small and lightweight because they don't have a heavy transformer in the AC input side of the charger to isolate the rest of the charger and the EV from the AC line current.

A GFI is an important safety feature that protects people from receiving a shock when they touch a vehicle while the charger is operating. If the GFI on a transformerless onboard charger detects a leakage to ground of four to six milliamps, it automatically turns off the power to the charger to eliminate the possibility of a shock.

Since the battery pack and the rest of the electric drive system is isolated from the car's chassis, it should take a major failure in the system's cables, wiring, or components to cause a loss of isolation that trips the GFI, right?

Wrong. Most of the time, when the GFI trips, it is a nuisance trip, often caused by a ground fault you can't even see—a conductive path between a battery terminal or fill cap and the chassis. This path is usually made up of dirt from road dust, and the small amount of battery acid that escapes from the vents in the fill caps during the final equalizing portion of the charge cycle.

Finding the Path

Because these paths are almost invisible, finding them can sometimes be a challenge. Start with a visual inspection of the battery pack for any obvious corrosion on any metal battery hold-downs or racks. Batteries in plastic or fiberglass battery boxes should not cause a ground fault unless they are leaking accumulated acid onto the racks that support them. Check the underside of the box or rack assembly for any signs of corrosion. If nothing obvious shows up visually, it's time to do an electrical check.

The electrical method of finding a ground fault requires an "auto-ranging" digital multimeter that, as an EV owner, you should already have. If you don't have one, Radio Shack has one for under US$50 that will do everything you need to do on an EV.

Before starting the test, turn off the ignition key and open the circuit breaker to isolate the battery pack as much as possible. If your circuit breaker is in the middle of the battery pack, and protects against shorts by breaking the series circuit of the pack, isolating the pack is done differently.

1. Open the breaker to remove battery pack voltage from the rest of the system.
2. Disconnect the cable that runs from the most positive terminal of the battery pack to the main contactor, at the battery terminal.
3. Close the circuit breaker to restore the series circuit.

Now you are ready to start the search for your ground fault. Set your digital multimeter to its DC volts setting and measure your total battery pack voltage to establish a baseline.

Place one of your multimeter's test leads on a good chassis ground. Place the other test lead on any battery terminal of the battery pack. If you didn't have a ground fault, the meter would read 0 volts because there would be no connection between the battery pack and the vehicle's chassis. However, since you have a ground fault, you will get a meter reading somewhere between 0 volts and the total pack voltage.

You can view the ground fault as a "connection" between the battery pack and the chassis at the point of the fault. As an easy example, if your EV has a 96 volt battery pack and the ground fault is exactly in the middle of the pack, your meter would read +48 volts with the battery pack probe at the most positive terminal and –48 volts with it at the most negative terminal.

Instead of the middle-of-the-pack voltage in the easy example above, what you will more likely see will be plus or minus voltages that are less than pack voltage. For example, let's say the meter reads a steady 36 volts. Now move the test lead to the next battery in the string. The meter reading will go up or down as more or fewer batteries are between the test lead and the ground fault.

Move the test lead down the battery string in the direction that lowers the voltage reading on the meter. Keep moving the test lead until the meter reads 0 volts. If you have a steady 0 volts, the fault is between the terminal your test lead is on and the chassis. If the meter shows a low voltage, for example 1.5 volts, the fault could be tracking between a filler cap and along the top of the battery to the chassis.

You have now found your strongest ground fault. There may be other lesser faults, but they will probably be eliminated when you perform the cure.

The Cure

Eliminating the type of ground fault described above requires a good cleaning of the battery tops and any metal parts of the chassis that are in contact with them.

In the interests of safety, before you attack the battery tops with cleaner and paper towels, put on your safety goggles and rubber gloves. You might also consider whether the shirt and pants you are wearing are expendable if they develop acid holes after their next wash. If not, change into clothes that you care less about.

Moving to the EV, completely remove at least two of the battery-to-battery interconnects. This breaks up the series string of the battery pack, which helps prevent shocks, burns, and exploding batteries. You also may have to remove the cables that interconnect separate groups of batteries so that you can remove perimeter-type battery hold-downs (we'll talk about these in a minute). Remove the battery hold-downs and set them aside. They will be cleaned and inspected later in the cleaning process.

For the cleaning, you will need at least one roll of paper towels (they are cheap and expendable) and some kind of liquid cleaner. Some people use a solution of baking soda and water. It foams up to show you where the acid is and neutralizes it, but you will also need to do a separate rinse with plain water before drying the battery tops. In addition, you have to mix your own solution (another step in the job) and rinse out the sprayer with water when you are done if you want to use it again.

I have used both Windex window cleaner and Simple Green, a general use cleaner. They neutralize the acid and clean the dirt off the battery tops in an easy spray on and wipe off action. Both cleaners come premixed in a spray bottle, and are relatively cheap. No, I don't own stock in the companies that make them—I just like them because they work.

Clean one battery at a time—spray just enough cleaner on the battery top to moisten it, and immediately wipe it dry with the paper towel. Spraying an excessive amount of cleaner on several batteries at a time is wasteful, messy, and could cause a future ground fault by washing dirt down between the sides of the batteries where you can't wipe it off. The dirt deposited there is a potential ground fault that could only be cleared by removing the battery and cleaning all four sides and the bottom.

When all the battery tops are clean, it's time to turn your attention to the battery hold-downs. Battery hold-downs usually are one of two types—"top strap" or "perimeter."

The top-strap hold-down is just what it sounds like—one or more flat metal straps, depending on how many batteries there are, placed across the top of the batteries. These straps are attached to the battery rack with lengths of threaded metal rod, commonly known as all-thread.

The perimeter hold-down is made of metal angle iron, welded into a shape that fits around the top outside edges of the batteries it is holding down. It is also usually attached to the battery rack using all-thread.

Both types of hold-downs are almost always made of metal, and hold the batteries to metal racks with pieces of metal all-thread. The battery racks are then bolted or welded to the vehicle's chassis. Add a conductive track of acid and dust between a battery terminal and the hold-down, and you get a ground fault.

When you are cleaning a hold-down of either type, examine it closely for corrosion. Hold-downs that are painted with ordinary paint will be most easily attacked by acid. You may want to use a stiff wire brush on these instead of paper towels. Any place that the corrosion has eaten through the paint should be washed with the cleaner, sanded down to bare metal, treated with the cleaner again, and then repainted.

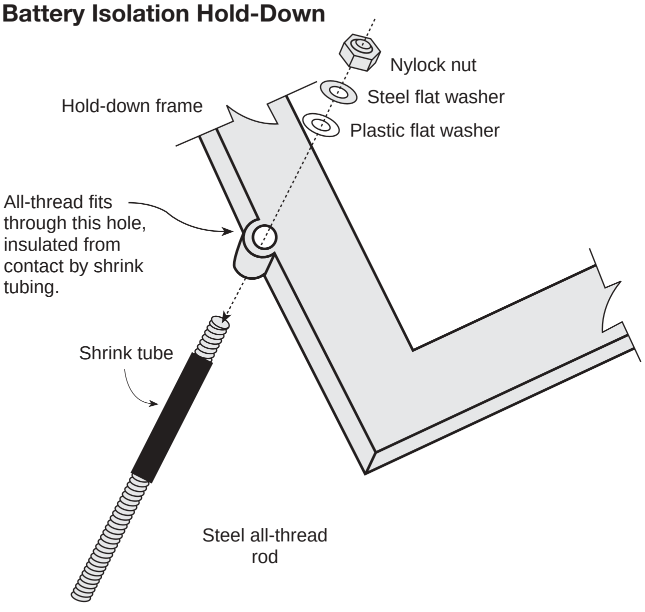
Some strap hold-downs are covered with plastic shrink tube. Check these for tears in the shrink tube and poor sealing at the ends, which will expose the metal strap to the acid. Also check for corrosion around the holes in both the metal and shrink tube that the all-thread goes through at each end of the strap.

If you find any acid damage, cut the old shrink tube off, clean and sand the metal as described above, and re-cover with new shrink tube. The ends of the shrink tube can be sealed with silicone sealer. Try to make the smallest hole you can in the shrink tube where the all-thread passes through the hold-down.

An Ounce of Prevention

The cleaning and repair process described above will clear your ground fault for now, but there is a good chance it will happen again. Don't despair! After going

Battery Isolation Hold-Down



through a couple of the GFI trip, clean, and repair cycles with my Voltsrabbit, I found my ounce of prevention.

It all started when the guy who was doing my powder coating decided on his own that polyester powder would work as well as the acid resistant epoxy powder that I specified. The acid ate right through a thin spot in the coating, and the GFI started tripping, usually at the worst possible time. I didn't want to replace the hold-downs until I had another batch of them to run through my new powder coater, but I needed the car.

The reason a ground fault exists is because continuity develops between the battery pack and the chassis of the car. Usually, the only places this is possible are the hold-downs, the racks themselves, or possibly the cables linking the battery pack to the rest of the car. The hold-downs are the most common culprits. Since there was going to be continuity between the battery tops and the damaged hold-down no matter what, I had to break the circuit between the hold-down and the chassis.

First, I marked the all-thread where it went through the tube welded to the side of the hold-down for it. Next, I installed pieces of shrink tubing onto the all-thread between the marks I had made, with about $^{1}/_{16}$ inch (1.5 mm) of shrink tubing above the top of the hold-down frame tube and about $^{1}/_{4}$ inch (6 mm) below the bottom of the tube.

Just to be sure that the all-thread and shrink tubing combination fit easily through the hold-down tube, I drilled the hole out with the next size drill bit larger than its inside diameter. Then I reinstalled the hold-downs over the all-thread, being very careful not to tear the shrink tubing. Finally, I installed a plastic washer over the all-thread, then the original steel flat washer, and fastened the whole assembly together with a Nylock nut.

The shrink tubing on the all-thread and the plastic washer between the top of the hold-down tube and the steel washer and nut isolated the hold-down from the chassis. No more ground faults. This modification worked so well that we started to include it in new Voltsrabbit kits, and made up a retrofit kit for existing cars.

This has been my take on causes and fixes for nuisance GFI trips in electric vehicles. I hope it helps someone out there. Note: The part of this article describing the process of finding the location of the ground fault was based on a post on the Internet Electric Vehicle Discussion List by Jeremy Phillips, which was later reprinted in the Sacramento EVA Newsletter.

Access

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EV Discussion List
www2.ald.net/~roden/ev/pages/evdl.htm

Renewable Energy Terms

Charge—Fundamental Property of Matter

Ian Woofenden

Derivation: From French charger, *and Latin* carricare, *to load a wagon, from Latin* carrus, *a car or wagon.*

Electrical charge is a fundamental property of matter, and understanding it is fundamental to grasping electrical concepts accurately.

In my column in *HP90,* I said that a flow of electrons is an electrical current. This is a useful way to think about current, but the description breaks down a bit in places. It is true that *in wires,* electron flow relative to the protons contained within atoms is an electrical current. But in a few cases, such as in batteries, it's not electron flow, but the flow of ions—atoms that carry a charge because they have lost or gained electrons.

In both cases, it is "charge," or charged particles, that flow. Charge is a difficult thing to define. It's rather like defining time or space. Charge is a component or property of atoms, but it is also, in a sense, a "thing." Everyone has felt a "charge" at one time or another, but you can't really hold one in your hand. It's like the wetness in water—we can talk about it separately, but I've never been able to separate the two myself.

Matter can be broken down into atoms, and atoms into charged particles, or "particles of charge" if you will. Electrons are negatively charged, while protons are positively charged. In most matter, these charges are equal in number, and balance each other out. So even though matter is full of charge, it generally has an overall electric charge of zero. The positive and negative charges are attracted to each other, which is what holds matter together.

Through a variety of means (heat, light, motion, magnetism, etc.), charges can become unbalanced in matter. This causes the charges to flow. In a PV module, photons of light bump charges along in a circuit. Light doesn't create the charges that it moves. The charges are already there—they are part of the material. But there's an energy input (via light in the case of a PV) at one end of the circuit, and an energy output at the other end where the load does work.

The origin of the word "charge" actually might confuse people about how electrical circuits function. In fact, there's a schoolroom analogy that says electrons are like train cars in the wire, where each carries a little bit of charge and dumps it one car at a time to be used by your appliances. This is misleading. The electrons have the same charge throughout the circuit, and flow in a circle. Energy makes a one-way trip, and actually flows in a field around the wire. Charges flow very slowly, while energy—the stuff that does the work—flows almost instantaneously.

When we say that we "charge" a battery, you might think that we're building up electrical charges in the battery. But in fact, we're storing energy via a chemical process, while the charges continue their slow trip through the whole circuit.

So charges flow through batteries, lightbulbs, and other loads. It is their movement that allows energy to flow from one place to another, but the charges are not "used up." In DC, the charges move in one direction. In AC, the charges wiggle back and forth. In both cases, the energy in the circuit is transferred in a one-way trip from source to load.

When we say "electrical current," we are talking about the rate of charge flow. Current isn't stuff that flows. Current is the rate of flow of the charges. A current is not energy, and a charge flow is not an energy flow.

In technical terminology, the charge flow rate is called amperes or amps—coulombs of charge per second. We measure the total charge that has passed a single point in amp-hours or coulombs—these are quantities of charge. When we multiply amp-hours by the voltage (system "pressure"), we get watt-hours, which is the energy generated or used.

Energy and charge are not at all the same thing. Energy is like sound, while charge is like air. Sound travels through air, but fortunately you don't feel a wind blowing in your face every time someone talks to you. The air is the vehicle that allows sound to travel, just as charges in a circuit are the vehicle that allows energy to travel.

So while you can put a charge in your musket, we actually put charge *through* our batteries and loads, and we don't get a charge out of them—we get energy.

Access

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I'm indebted to many people for inspiration and education in writing my columns—I'm not smart enough to do it without them. My thanks go to my many consultants and reviewers, and especially Bill Beaty, who has an enormous and fascinating Web site at www.amasci.com.

US Energy Policy: *Corporate Control & Another War for Oil*

Michael Welch

For the first time, our government's intent to make war on Iraq makes complete sense to me. Thanks go to a great article by Michael T. Klare in the October 7, 2002 issue of *The Nation* (see Access). Please read that article. If you can't get it via the Web address, ask me and I will e-mail or fax it to you.

Just like our invasion of Afghanistan (see Power Politics, *HP 87*), it appears that the oil supply and its control by U.S. corporations is the underlying reason for the upcoming attack of Iraq. Some points brought out in the Klare article:

- Imported oil will jump from one-half of U.S. usage in 2000, to two-thirds in 2020.
- Iraq has proven oil reserves of 112 billion barrels (second in the world to Saudi Arabia) and there are probably a lot more unproven oil fields, as well.
- Our relationship with Saudi Arabia, an oil ally, may deteriorate, so our government wants a backup oil supply. In fact, our government may welcome such a deterioration, so the U.S. could then ignore Saudi demands for action on behalf of Palestinians, and it would weaken OPEC control over oil prices.
- As it stands now, the Iraqi government has awarded oil field contracts to non-U.S. firms. But the government that would likely replace the Hussein administration in Iraq promises to invalidate those contracts, and most are expected to be re-awarded to U.S. firms that have links to the current administration.

Until seeing this article, I had thought that our government's need for war with Iraq had three totally different reasons: a smoke screen for our faltering economy, a smoke screen for not having achieved the stated goal of getting rid of Osama bin Laden, and the pure lust for power via world domination. Now I believe those are merely secondary reasons, yet still adding to the inevitability of war.

Domestic Energy Policy

A joint U.S. Senate and House of Representatives conference committee has been meeting to hammer out the differences between their two versions of the energy bill, which sets forth the official energy policies of the U.S. (See *Power Politics* in *HP85, HP88,* and *HP89*.) So far, things have been going as expected—not that well. The bill seems to be designed to increase oil consumption, maintain fossil fuel subsidies, give the nuclear industry more breaks, and give giant energy corporations the freedom to gouge us at will.

In Fall 2001, the Republican-controlled House passed its version, which was pretty much a rubber stamp of Bush's proposed energy policy. Then in April 2002, the Democratic Senate passed their version of the bill. The Senate bill had some differences; most notably, it did not include fossil fuel exploration in the Arctic National Wildlife Refuge (ANWR). Since most of the big environmental groups were so vehemently opposed to drilling in ANWR, that was one of a very few pro-environment concessions in the Senate version. Many environmental advocates believe that most of our concerns were ignored in the Senate version because so much attention was being focused on ANWR.

Politics is funny that way. Much of it is a big game by our elected representatives to see how much they can get away with. And with the biggest environmental groups focusing on one issue, we stood to lose a lot in other areas. Don't get me wrong. ANWR is an important issue to win, but I can't help but think that way too much attention was focused on it. Activists more in tune with legislative politics than I am, believe that ANWR was intentionally placed in the House bill, and therefore on the chopping block, to draw attention away from other issues. I think it worked, and it was a stroke of genius on the part of the current administration to push so hard for this.

Deja Vu

And now, things are poised for it to happen all over again. Since one house included ANWR drilling and the other didn't, the conference committee must decide if it ultimately is in or out. Conventional thought is that drilling in ANWR is such a contentious issue, it will be left out of the final bill. But several committee members are still pushing for drilling. This issue could again take away from environmental activists being able to influence the conference committee in other areas.

I've reported in the past about the contents of the Bush energy policy and what came out of Congress. Here are the latest (at press time) developments of the energy bill conference committee. There is quite a bit of work still being done by this committee, but their goal has been to be finished and have it on Bush's desk for a signature by the end of this Congressional session, before you read this.

Nuclear Bail-Outs

One action taken by conferees was to renew the Price-Anderson Act, which limits the financial liability of any nuclear power plant in the event of an accident. This act is arguably the single largest public "subsidy" for nuclear energy. While no money is directly handed over to nuclear plant owners under this law, it relieves them of the burden of carrying massive insurance policies. Without this subsidy, nuclear power plants would never be built. Insurance companies recognize the potential costs involved with a serious accident, and that eventually a huge U.S. accident is bound to happen, so insurance would be prohibitively expensive.

Nobody expected Price-Anderson not to be renewed, but I think by doing so, our legislators missed out on a perfect opportunity to level the playing field. Most folks understand that if subsidies like this were eliminated, renewable energy would have the opportunity to blossom in the face of declining nuclear and fossil fuel industries.

Nuclear Insecurity

Another opportunity was missed when conferees failed to do anything about security from terrorist threats at nuclear power plants. The Price-Anderson Act conference would have been a good time to add this in. According to the CIA, Al Qaeda forces have plans to attack U.S. nuclear power plants. And in spite of denial by our government and the corporate-owned media, many people think that the hijacked plane that crashed in Pennsylvania on September 11, 2001, was headed for the Three Mile Island nuclear power plant, and not Washington, D.C.

In a related note, the antiterrorist Homeland Security Act also does not deal with this issue, in spite of the efforts of a handful of legislators intent on trying to do the right thing. There is a Senate bill being considered to deal with this called the Nuclear Security Act. Unfortunately, the nuclear industry is keeping it from reaching the Senate floor for a vote. It is apparent that anything that would cast a negative eye on the nuclear industry is out of bounds, even if it means making them attractive targets for terrorists.

Fuel Mileage Standards

Other actions taken by conferees had to do with requirements for minimum mileage standards for auto makers in the United States. A big loophole for the automotive industry was extended until 2012. Auto makers that build dual fuel vehicles are given fuel savings credits for the supposed gasoline savings these cars can have. Those credits allow them to decrease fuel mileage in other vehicles. Since very few gas stations sell alcohol fuel, most dual fuel vehicle owners end up burning gasoline. So making these nongas alternative vehicles actually increases gasoline consumption by an additional 9 billion gallons over the life of the extension.

And in a tactic designed to delay fuel efficient vehicles from reaching showrooms, the conferees decided to order another costly study on automotive mileage to be done by the National Academy of Sciences. Once again, powerful corporations including those in the automotive industry, are calling the shots on issues that affect the health and economic vitality of the world.

Public Utility Holding Company Act

The Public Utility Holding Company Act (PUHCA) was designed to ensure that utilities would not invest rate monies in companies outside of their fields and outside of their operating areas. This legislation is being attacked by the very same companies that are under investigation for gouging ratepayers and manipulating the California energy market. As of this writing, the final outcome of this provision has not been determined by the conference committee. But it is still newsworthy and of interest because the attack has been going on for a while, and will probably continue in some way, even if it is left intact by the new energy bill. This information comes from a report issued in September by Public Citizen.

The point of the PUHCA is to make sure that electricity service remains reliable, and that costs are kept down. The fear was that a utility would divest itself of its energy assets any time something else looked more profitable, even if only in the short term.

"Members of Congress declare themselves to be tough on corporate crime when the camera is rolling, but behind closed doors, they are trying to make it even easier for rapacious energy companies to rip off the public and investors," said Joan Claybrook, president of Public Citizen. "The energy giants that are being investigated for rigging the California energy market are the same ones that are lobbying behind the scenes to get rid of the Public Utility Holding Company Act. Rather than protecting ratepayers and shareholders, Congress is preparing to strip away any vestige of accountability and transparency there is left."

According to Public Citizen, US$44 million was spent by the energy industry in lobbying Congress on the PUHCA and other issues in 2001 alone. US$16 million more has been contributed to federal candidates since 1999, according to the report. This includes lobbying by individual companies and their trade associations, such as the Edison Electric Institute and the Coalition to Repeal the PUHCA Now!

Companies like American Electric Power, Duke Energy, CMS Energy, Southern Company (and its recent spin off, Mirant), and Xcel, all of which are under federal or state investigation for fraudulent trading and/or price gouging, are pushing hard to abolish the PUHCA via the energy bill conferees.

"The repeal of PUHCA would have devastating consequences for consumers and investors by leading to more Enron-style meltdowns, further industry consolidation, and the creation of complex corporate structures that reduced transparency and accountability," said Tyson Slocum, research director for Public Citizen's Critical Mass Energy and Environment Program. "We need to demand that these energy companies be good corporate citizens, but it's clear they will not do it without strict standards of accountability. Government oversight is an indispensable measure needed to maintain an affordable and reliable energy market. Congress should be strengthening PUHCA, not ditching it." Let your legislators know that you agree.

Parting Scoop

You heard it here first. California's famous Emerging Renewables Buydown program is examining the possibility of changing from being rebate-based, to becoming a system of rate-based incentives. I am told that the money available would be the same, but it would be paid out based on real system output. I am also told that this proposal will probably sail through the California Energy Commission.

I am not sure that I like or even understand how this would work. It sounds like system owners would receive funds over a much longer period of time. If that is the case, then this may end up being a significant deterrent to folks taking advantage of the funds. Time will tell how this finally plays out.

Access

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Third Party Certification for PV Installers

Don Loweburg

Written almost nine years ago, Article 2 of IPP's statement of incorporation as a nonprofit organization reads, "The primary objectives and purposes of this corporation shall be to promote and encourage the use of renewable energy by developing opportunities for end user ownership of renewable energy generation sources and encouraging a professional installation infrastructure adhering to recognized standards so as to encourage maximum confidence in and use of renewable energy to the spiritual and environmental betterment of the planet."

Since its inception, IPP has supported customer ownership of renewable generation technology, and advocated for net metering and simplified interconnection policies supporting this goal. IPP also encourages organizations such as Solar Energy International (SEI), which trains solar installers and designers. A trained installing infrastructure is a critical component of a PV future. Consistent with this goal, I support the efforts of the North American Board of Certified Energy Practitioners (NABCEP) to develop certification for solar installers. I am also on the board of directors of NABCEP. This is a personal endorsement, however, since a minority on the board of IPP opposes this endorsement, as do some of our members.

The discussions of certification and standards for technical issues and hardware have been, generally, much less fractious. Industry consensus has been achieved regarding standards and certification for inverters (UL 1741 and the designation "non-islanding inverter"). The interconnection standard IEEE 929 provides a technical framework so that utility engineers, inverter manufacturers, and local jurisdictions can share a common technical perspective for utility-connected PV.

I can't think of anyone who takes the position that these technical standards have harmed the industry and should be abandoned. The opposition of some to installer certification is a bit curious in that it is generally unrelated to any specific content of the NABCEP program. Nor does that opposition address the lack of installer competency that is beginning to be an issue as the PV industry grows.

The certification proposed by NABCEB is voluntary. Certification of installer competency would be based upon the successful completion of a test. Elements of that test would be based on PV-specific knowledge such as array siting, safety, the effects of temperature on system output, inverter types, DC voltage drop and wire sizing, etc. A test candidate would qualify for the exam in a number of ways, including on-the-job PV experience.

The program has numerous access options, and is designed not to exclude qualified candidates. A list of candidate prerequisites, a task analysis outlining the test's content, and a sample study guide are available on the NABCEP Web site. Readers interested in knowing more about NABCEP and its board members and technical advisory committees are encouraged to fully inform themselves.

Some feel that state licensure (electrical contractor's license for example) is sufficient to assure competent PV installations. A state contractor's license may fulfill the legal requirements to do PV work, but it certainly does not guarantee that the license holder knows PV.

Readers interested in just how disastrous this assumption can be should read Bob-O Schultze's article in *HP81*. Likewise, competency certification does not bestow the legal right to do work regulated by the states. Licensure and certification are totally different issues.

Who are the people behind NABCEP? The board members of NABCEP represent an extremely diverse range of backgrounds and constituencies including manufacturers, solar industry associations (state and national), wrenches, national research laboratories, the U.S. Department of Energy, electrical unions, interstate renewable energy advocates, and educators. My experience on a personal level, based in some cases on almost ten years of association, is that these people are totally committed to a future of renewable energy. They have made renewables their life's work. In that regard, they share a common vision with the readers, authors, and publishers of this magazine.

[Editor's note: A guest editorial opposing NABCEP certification is located on page 112.]

Solar Legislation in California Wins!

In what was truly a legislative cliff-hanger, three very important solar energy bills (AB 58, 1 MW net metering; SB 1038, five more years of the CEC buydown program; and SB 1078, renewable portfolio requirements for utilities) passed out of the California legislature and were signed by Governor Davis at the last moment.

Intense, last-minute dealmaking resulted in a harrowing final three weeks. Each bill was periodically in jeopardy due to attachments, riders, and other unsatisfactory changes. In each case, large numbers of letters were generated by the solar energy community. A network of e-mail communications and online letter writing tools were very effective. Additionally, a series of press articles throughout the state alerted the public to the attacks being made by the utilities on the state's very successful solar energy programs. This should be a big lesson to all solar energy advocates everywhere—get organized.

Additionally, CALSEIA and its lobbyist, Lynch and Associates, were instrumental to this successful outcome. In this game, you need to pay to play. You can find a chronicle of the almost daily changes and updates posted on the California Solar Center Web site (www.californiasolarcenter.org), as well as archives of press articles.

IBEW Lockout Over

On August 15, 2002 IBEW electricians removed the locks from the disabled residential PV systems in the Los Angeles Department of Water and Power utility district. Though the end of the lockout is welcome, there are many questions surrounding this situation that suggest continued scrutiny (See *IPP91*). Graham Owen, a Los Angeles wrench, offers his disturbing insights into this event:

> The LADWP's four-month PV lockout has ended and department personnel removed the locks on August 15th. Hooray!
>
> There is a new five-step inspection process, which includes making an appointment with a department electric service representative to establish where the AC disconnect will be located—this is prior to the system installation. A second appointment is made upon job completion to verify compliance of the disconnect switch location. This may sound like a waste of valuable contractor time, but the way I see it, I am happy to be installing systems again in my backyard. It means less drive time, substantially lower permit fees, much less hassle with non-L.A. building and safety departments, and of course the higher financial incentive for my customers. I am very pleased that this unfortunate scene is over.
>
> Now I feel a need to quickly rant about what I have, at times, perceived as possibly going on in L.A. Last year, my company installed the first PV system under the Green L.A. program. Numerous times in the past year, I had a feeling that maybe some people at LADWP didn't really want to achieve their publicly stated goal of 100,000 solar rooftops by 2005. There have been constant glitches and delays, which have kept the pace of installations at a lower level than was achievable. Only about 330 residential systems are installed so far. Perhaps it's not a conspiracy, just old fashioned bureaucratic inefficiency, but it makes me wonder.
>
> Since deregulation of electricity in California, 2.85 percent of ratepayers' utility bills are diverted into a public benefit trust fund for environmentally friendly projects that benefit the public. LADWP lobbied to get these funds under their control from the City of Los Angeles for the Green L.A. program. A predetermined amount was set aside for a solar energy incentive. The problem is the wording in the program. "Buydown funds not spent each year may be used for department solar photovoltaic projects." That is, the LADWP gets the money for their own use.
>
> It appears that some at LADWP may want to use as much of these funds for their own projects as possible. I believe the reasoning behind this is that the department will not have to credit ratepayers for solar generated electricity. In effect, they get the

ratepayers to subsidize solar electricity for their grid without having to deduct the amount generated from incoming revenue. Perhaps having the "equivalent solar power of 100,000 residential roofs" on LADWP roofs, sold as Green Power, at higher prices, could allow for a higher revenue stream as opposed to a reduction.

The problem with this scheme? It costs the department about US$17 a watt for union prevailing wage installations, compared to US$9 per watt average nonunion contractor cost.

I believe that the solar subsidies were initiated for environmental reasons, period. More solar-electric panels can be installed by nonunion labor than can be installed by union labor for each block of funding. This is something politicians should be able to comprehend, and I hope future renewable energy subsidy programs will not have loosely worded documents with obvious conflicts of interest.

Sizable contractors that use the skilled labor of union electricians have a place in large, commercial PV system installations where increased labor costs are offset by lower material costs resulting from bulk purchasing. When I see the labor union interests flow over into the residential solar market, I see storm clouds on the horizon.

Perhaps I'm misreading the situation. Conspiracy theories are seldom factual, but can provide for stimulating reading. I do know that I look forward to helping more homeowners in Los Angeles to go solar. Graham Owen, GO Solar Company

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Growing Questions about Munis

One of the disturbing and unexpected changes in the net metering law was the option for public power companies (munis) to not allow net metering for systems greater than 10 KW. In fact, special wording in the net metering law just passed exempts LADWP from all net metering! This information in light of recent events reported about LADWP (the lockout and Graham's letter) leads me to wonder what's up with LADWP? I'm sure there will be more to report in future articles.

In *IPP80* ("What Is SMUD Doing?"), I asked a similar question about the Sacramento Municipal Utility District (SMUD). At that time, I questioned the very low prices SMUD claimed they could offer. Even more questionable was SMUD's plan to market PV systems outside their own district. Quoting from *IPP80,* "Outside SMUD's territory, low prices, based on municipal tax subsidization and customer rate basing, looks like unfair business practices."

This criticism and several others have surfaced recently in a *Sacramento Bee* article of September 6, 2002 by Carrie Peyton Dahlberg, titled "Solar Woes Shock SMUD." She wrote, "Solar installations outside SMUD's area were mistakenly priced below cost, in essence making SMUD customers subsidize people in Davis and elsewhere." Other problems revealed include a 2002 budget overrun of 100 percent, severe installation backlogs, and the abrupt departure of the SMUD Solar director, Don Osborn.

Not So Independent

In *IPP90* I mentioned independent PV companies—independent meaning that they were not owned by large oil companies or utilities. Among the companies listed was ASE. Mark Hammonds of BP Solar responded, "You describe ASE and Astropower as independent photovoltaic companies. For the record, ASE is owned by RWE, Germany's largest utility, which owns coal and nuclear power stations in Germany and elsewhere. The company is also involved in water supply, and is finalising purchase of American Water Works, which is one of the largest publicly traded water corporations in North America." Thanks, Mark, for setting the record straight.

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Sacramento Bee article on SMUD:
www.sacbee.com/content/news/story/4289785p5309526c.html

NABCEP—Do We Need It?

Chuck Marken

The North American Board of Certified Energy Practitioners (NABCEP) is mentioned in Don Loweburg's *IPP* columns in *HP87, HP90,* and *HP92.* You may have heard of this "voluntary" nationwide certification for PV installers from those columns or somewhere else. I pose two questions: Do we need national certification? And if so, is there a better solution than NABCEP?

Solar Business Community

The solar energy industry (both heating and PV) is quite a bit different from the gas, oil, coal, and utility industries. Other than the manufacturers of PV modules and a few balance of system (BOS) manufacturers, everyone we (at AAA Solar) know in the industry is relatively small. This "get it done" part of the industry is overwhelmingly made up of companies with fewer than 20 employees, and many with only one or two. We are part of this solar small business community, which seems to differ a good deal from the giant traditional energy companies.

The PV industry has a section in the *National Electrical Code* book, and other than that, there isn't much for national standards. Many people say that because we are all such an independent lot, PV installations vary quite a bit as to their safety and code compliance. Some say that building officials and inspectors are confused about PV installations because they don't have enough training to inspect systems properly. Are all these PV installations as bad as people say, and is the existing infrastructure of electrical inspectors so inept that they cannot understand the electrical code and apply it to PV installations? I think not.

The people that we know in this industry are, by and large, caring professionals who take great pride in their workmanship. So why all the commotion? The buydown programs in California, perhaps? Yep.

Every time there has been a significant tax or utility incentive during the twenty-three years that I have been in this industry, poor controls have meant some bad installations. Tax incentives draw fast buck people into our otherwise small and dedicated community. They sell free electricity and low interest financing. The product is secondary, just a means to the end—a fast buck to be made while the gettings are good. Poor work inevitably follows.

A New Bureaucracy

Enter the NABCEP. They have the solution to this bad side of tax incentives. Their solution is to create a new bureaucracy to implement certification and continuing education, on a purportedly voluntary basis.

Fine, if it's voluntary. But, the NABCEP certification is already being considered for implementation in some state incentive programs. Is it then voluntary if you can't offer your customer a fifteen percent tax credit on the system they hire you to install? Obviously, if you don't have the certification, you are at a real disadvantage in selling and installing systems in areas that recognize the national certification. It's just common sense that when NABCEP certification is a requirement for incentive programs, it becomes a mandatory certification. What about homeowner do-it-yourselfers—will they also need to be certified practitioners?

Is a mandatory certification, administered by who knows whom, good for our industry? There are many, many opinions throughout the U.S. about this. Many supporters of the certification have a reverent belief in the program. People in opposition are not organized to any great degree and have been clamoring to make their voices heard.

The NABCEP started by drafting a program for PV installers. This will include a written test along with certain, as yet undetermined, requirements of experience. That may not seem to be too stringent a requirement for a growing industry. Or is it? Is the NABCEP well enough funded to follow through with good, timely administration of the program? What about the facilities to take the test? Will these be easy for people to avail themselves of? What about reference texts to prepare for the test? What will it cost to become certified? How can we possibly judge the value of the program until we know these things?

Conflicting Interests?

Predating the NABCEP is the Institute of Sustainable Power (ISP). According to their Web site, this organization was founded in 1996, and has a primary objective of worldwide education and training. Now, to me, this is a good organization with a good purpose. Education is what the solar industry has always lacked.

Other than manufacturers' training classes, we only have a few places where people can learn about PV in a classroom environment. Solar Energy International (SEI) and the Florida Solar Energy Center are probably the best known. Sol Energy and SEI both have online courses that make things a little easier for computer savvy people. ISP accredits institutions like this. Both SEI and FSEC are listed as accredited on the ISP Web site.

Although the NABCEP and ISP are different organizations, they seem to be joined at the hip, if not the brain. The NABCEP address (listed in the Access information in Don's columns) is the same as the address for the ISP (listed on their Web site). The ISP predated the NABCEP formation by a few years, but maybe not the idea. How will people prepare for the NABCEP test? What training is required? ISP accredited training organizations are perhaps the answer. Preparation for and maintenance of the certification will increase the need for PV installer training.

If the NABCEP is the cure for the bad installs, is the cure worse than the disease? It is easy for me to conjure up an image of a poorly run program. Why? The first thing is the NABCEP board. Three seats of a thirteen member board are held by the electrical union (IBEW), the union apprentice training program (NJATC), and the organization of union contractors (NECA). Our country is split as to the value of unions, and it isn't my point here to debate pro or con union. The point is that the unions have never had much involvement in the solar industry.

Why the sudden interest? Don's *IPP* columns in *HP91* and *HP92* spells this out to some extent. It's a money deal for them. But why do they have so many seats on a board that might regulate an industry they know very little about? Why would someone pick them, over more small, independent contractors? Don Loweburg seems to be the only member of the NABCEP board, as this is written, who is a licensed electrician with PV experience. Why not have more like Don on this board? I've asked, but don't yet have an answer.

For the sake of argument, let's say there's a good reason for the union to have three board seats. The next problem with past NABCEP actions is their single survey of the industry. They call this a "call for comments." The first draft of the program went out about a year ago and they had about three hundred and fifty people respond. The NABCEP has used the results of this survey in phrases like "overwhelming support" for the program. Well, that calmed down a lot of folks in the industry who thought, "Looks like most people want this, even if I don't."

The problem is that 280 of the responses were union—80 percent. Is that a true polling of the solar industry? I don't think so. How about you? This failure to do a simple survey correctly must be the result of incompetence or lack of funds. It takes but a few minutes on the Internet to find the majority of state solar energy industry associations in the U.S.

The NABCEP had plans of implementation in 2002. It now looks like everything has slowed down considerably. They will probably be doing a new survey that promises to be more inclusive of the real solar industry. Let's hope this happens, for a start.

Do We Need It?

Now the big question—do we need any type of national certification at all? Even if the NABCEP is properly funded and runs a good program, is this the answer? If the organization is not competent or the program is not funded properly, its cure will surely be worse than the disease. Certification could be an answer, but probably the worst choice. It is probably the toughest thing to do right, and there *are* choices. Here are a few, in order of their ability to be the least onerous:

- No national certification, no national standards for the PV industry, just what we have now. Many people will not be satisfied with this. Many industry professionals think we need to run a tighter ship, but here again, opinions are about as numerous as people.
- National standards for the PV industry that each state or local jurisdiction incorporate into their existing or future programs as they deem necessary. This is much less intensive and probably much less costly than national certification. Perhaps the NABCEP could be convinced to change from a certifying organization to a standards organization. National standards are something local building officials are familiar with—organizations like UL, codes, and such.
- National certification like the NABCEP purports to be. Voluntary certification to give an individual or organization some extra credentials to promote in their business. Many industries have these voluntary programs and they are used as guidelines for things like new employment and assurance of quality work.
- National certification that is mandatory. This is what the NABCEP becomes if the certification is incorporated into incentive programs. This alternative is so questionable that it is tough to find any industry that would accept it. The building trades have certainly never seen the likes of it.

The NABCEP program is still in a very formative stage. A rather feisty group of industry members in opposition to the program has many questions and suggestions that they want to be addressed. Just the name “practitioner” is a bone of contention. Who thought that up? Why not certified energy professional or something that fits and one can be proud of? This little question might seem to be a quibble, but I think it’s indicative that the people currently in the NABCEP don’t know this industry very well.

Is there a need for standards in our industry? I think that if you are forward looking, the answer is yes. Standards mean standardization and that usually means more product being produced and installed. What standards are necessary? I have my opinion and you probably have one too. One thing’s for sure—the people in the industry should be the ones to decide, since our livelihoods depend on it. Interested, knowledgeable people from the general public should be in on this too. There is no present seat on the NABCEP board for our customers.

Take a look at the board members below. How many of their incomes will be negatively affected if the NABCEP certification causes fewer sales and installations? How many really know the problems in the industry from the standpoint of a manufacturer, dealer, or installer?

NABCEP Board Members

Les Nelson (Chair), California Solar Energy Industries Association

Peter Lowenthal (Vice-Chair), Solar Energy Industries Association

Jane Weissman (Secretary), Interstate Renewable Energy Council

Jack Werner (Treasurer), Solar Rating and Certification Corporation

Ezra Auerbach, Xantrex Technology

Mark Ayers, International Brotherhood of Electrical Workers

Ward Bower, Sandia National Laboratories

Ignacio Corral, Shell Solar

Roger Ebbage, Lane Community College

Lynne Gillette, U.S. Department of Energy

Christy Herig, National Renewable Energy Laboratory

Geary Higgins, National Electrical Contractors Association

Don Loweburg, Offline Independent Energy Systems

A.J. Pearson, National Joint Apprenticeship and Training Committee

Marcus Roper, AstroPower

The NABCEP has two new directors as of late September 2002, representing photovoltaic manufacturers. Marc Roper of AstroPower and Ignacio Corral of Shell Solar should add a better balance to the board. I hope Marc and Ignacio will be joined in the future by other members of the industry with backgrounds in solar businesses. People like this are needed to help evaluate this certification from the standpoint of market limitation and better alternatives.

Do we need any type of national certification for PV installers? Here, I think my answer will always be no. Why don’t all the trades have this already? The plumbers, builders, roofers, and the rest of the “get it done” people have no national certification. The reason is simple—states, counties, and cities run these programs. A national program, other than standards, would just not be acceptable. Call it a balance of power, states rights or whatever—if it was a good idea, other trades would already have it.

Standards that are reasonable can have a positive influence on an industry, or they can be an onerous speed bump. Making standards too restrictive is easy to do. Making them reasonable, if needed at all, is a task that should be taken in small bites, and there is no substitute for the past industry experience of the people drafting the standards. The NABCEP, as it now stands, appears to be navigating in uncharted territory with a compass that needs some significant adjustment if they are going to find some ground that is worth anything to the solar industry.

Access

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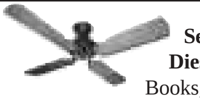

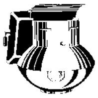

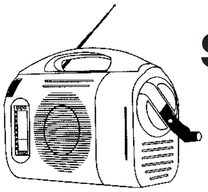

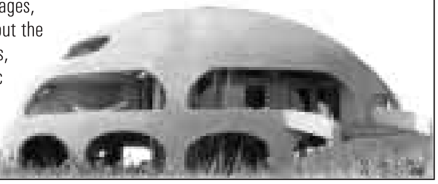

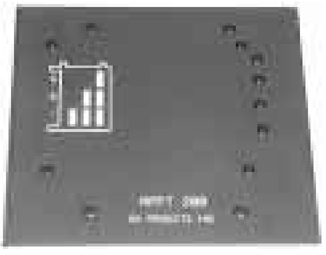

Resources

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

To design a safe, cost effective, durable, and reliable photovoltaic power system, you need a number of resources. In this column, I will discuss some of the print and Web resources I use in PV system design and installation, what they contain, and where they may be obtained.

Design Information

How much sun? The first thing you should do when designing a system is to determine the solar resource available in the particular location. The amount of solar energy available will have a direct bearing on the system size and cost for any specific size of load. Local airports that have weather stations may have records of the solar resource. Newspapers sometimes publish and even record the daily solar radiation.

Lacking those local sources, the next best source of solar radiation data is the National Renewable Energy Laboratory solar radiation Web site, http://rredc.nrel.gov/solar. Solar radiation data in formats used for PV systems (KWH/m^2) is found at http://rredc.nrel.gov/solar/old_data/nsrdb/redbook. Solar radiation data for solar thermal heating systems (BTU/foot^2/day) is found at http://rredc.nrel.gov/solar/old_data/nsrdb/bluebook. The 30-year averages of monthly data are most useful. These spreadsheets show not only the solar radiation, but also the temperature averages and extremes, which can be used in code and performance calculations.

In many cases, the local microclimate where the PV system is being installed may differ from the climate at the nearest weather station. Elevation differences may affect temperatures. Fog, smoke, or blowing dust may reduce the solar insolation. Nearby mountains may cause shading part of the day.

A site survey should be conducted using one of the sun-angle charts (available from vendors advertising in *Home Power*) to determine if there is any significant shading. I have seen people attempt PV installations on $^1/_4$ acre homesteads surrounded by 90 foot tall pine trees. This may not work well, unless the pole mount system is very high.

When you are designing your system, make sure you check for state and local incentives. A minor change to your system could determine your eligibility for substantial financial help. Check this Web site for a state-by-state summary of the various rebates and other financial incentives for PV: www.dsireusa.org.

Handbook

Stand-Alone PV Systems: A Handbook of Recommended Design Practices from Sandia National Laboratories shows you how to properly use the solar resource data to size a PV system. Although the title implies designing a stand-alone PV system, many of the techniques and methods presented are also applicable to utility-interactive (U-I) systems and U-I systems with battery backup. The book can be ordered from the Sandia Web site. The site includes information on both utility-interactive and stand-alone systems, as well as technical papers related to the testing of PV systems and modules. All are available at no cost.

Bill Brooks and the other engineers at Endecon Engineering produced a good book, *A Guide to Photovoltaic (PV) Power Systems Design and Installation*, for the California Energy Commission that covers designing utility-interactive PV systems. It can be downloaded in PDF format from the CEC Web site: www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF

Several of the PV module manufacturers and the larger PV distributors that advertise in *Home Power* also have software, spreadsheets, and other design tools.

Loads: Stand-Alone & Utility Interactive

Previous articles in *Home Power* have discussed how to estimate loads. Some *HP* advertisers market small, plug-in power meters that can be connected to appliances for a week or so to monitor and record the actual energy used. This energy use can be used to refine any energy use estimates from the nameplate ratings found on electrical devices.

Code Information

As you might expect, I consider the *National Electrical Code* and the *National Electrical Code Handbook* as absolute musts for anyone designing and installing PV systems. Familiarity with the code at the design stage will allow many potential installation, safety, and durability problems to be avoided or at the very least minimized. These books are available from most electrical supply houses and the National Fire Protection Association (NFPA).

The first four chapters of the *NEC* contain general information, and subsequent chapters modify that material for specific applications. Article 690 in Chapter 6 covers the specifics for PV system installations. Chapter 9 contains tables that define conductor parameters (resistance for voltage-drop calculations, and conduit fill tables, for example). These sections of the code are a must, and depending on the particular application, other sections may also apply.

All of my past *Code Corner* columns as well as the *Photovoltaic Power Systems and The National Electrical Code: Suggested Practices* manual can be found on the Southwest Technology Development Institute (SWTDI) Web site. A print copy of the manual can also be ordered from Sandia on their Web site.

The Florida Solar Energy Center (sister organization to SWTDI) has significant amounts of information about installing and inspecting PV systems on their Web site: www.fsec.ucf.edu/PVT/Education/training/inspgcps/handbook/index.htm

The IAEI Ferms Fast Finder is a large, spiral-bound manual published by the International Association of Electrical Inspectors (IAEI). It indexes and cross references nearly every term used in the code. It also provides substantial amounts of supplementary information useful to people installing electrical systems. Local electrical codes may differ or supplement the *NEC*, so they and the local building codes should also be reviewed.

Grounding

The IAEI Soares Book on Grounding is the definitive source for information on grounding electrical systems. It covers all the grounding methods and techniques found in the *NEC*, and it is profusely illustrated.

For those wishing to debate whether or not PV systems should be grounded, this book is a must because it summarizes many of the arguments that were put forth around 1900 when the grounding requirements for the U.S. electrical system were formulated. As philosopher George Santayana wrote, “Those who cannot remember the past are condemned to repeat it.”

Get Educated

The well-read PV system designer, integrator, or installer is in a better position to understand the physics of PV systems, and the safety, performance, and durability requirements than a person who does not read, study, and understand. The material is readily available, much of it is free, and the cost of documents that are not free is a very small percentage of the cost of a PV system—particularly one that doesn’t work as expected.

In the next *Code Corner,* I will show all of the calculations required by the *NEC* for an example stand-alone PV system.

Grounding Correction

In the *Code Corner* for *HP90,* I offered some possible methods of grounding the DC side of a utility-interactive PV system. Further research into the *NEC* grounding requirements has shown that those methods may not meet *NEC* requirements. To properly ground the DC portion of a utility-interactive PV system, two methods are available.

In the first method, a grounding-electrode conductor is run from the identified DC grounding point (usually in the utility-interactive inverter) to a separate (from any AC grounding electrode) DC grounding electrode. *NEC* Section 250.166 determines the size of the DC grounding-electrode conductor. The smallest allowable size is #6 (13 mm^2) when a “made” ground rod is being used. This DC grounding electrode must be bonded to the AC grounding electrode to make a grounding electrode system per *NEC* Section 250.52 and 250.53. The bonding conductor can be no smaller than the largest grounding electrode conductor, either AC or DC.

The second method does not require a separate DC grounding electrode. The DC grounding electrode conductor is routed and connected to the AC grounding electrode. The size is as described above.

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, e-mail, or write. 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 multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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wibower@sandia.gov • www.sandia.gov/pv

The 2002 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301
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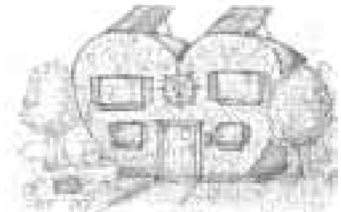
International Association of Electrical Inspectors (IAEI), PO Box 830848, Richardson, TX 75080 • 800-786-4234 or 972-235-1455 • Fax: 972-235-6858
athomas@iaei.org • www.iaei.org

Home & Heart



Kathleen Jarschke-Schultze

While I was experiencing my first brush with wildfire and all its ensuing drama, Bob-O was having fire-related adventures of his own. He had taken his brushing crew for a week's work at Happy Camp. Happy Camp is a small mountain town on the Klamath River, about 20 miles away as the hawk flies, but more than two hours by truck.

Wake-Up Call

Bob-O and his crew of seven local men had been driving to the job when the lightning storm passed over them. By the time they pulled into a large turnout on Elk Creek to set up camp, it had turned into a quiet, mild evening. They went to bed early, thinking they would get up early, hit the woods, and get to work.

Before dawn, a Forest Service rig pulled into their camp. The brushing inspector told Bob-O that the woods were closed because of fires caused by the lightning the afternoon before. They would not be able to work.

A brushing crew works for a logging company to clean up after a logging operation. It is their job to clear streambeds of debris, clear the ground of large debris, and pile it for burning in the winter. It is also their job to dig fire lines around the perimeter of the timber sale acreage. They prepare the area for the tree planters to replant with seedling trees. Their main tools for this kind of work are chain saws, McLeods (a wide hoe combined with a wide-tined rake), shovels, and their backs.

All Dressed Up...

Bob-O and the men drove down the hill into Happy Camp. Bob-O called his boss at the logging company and told him they couldn't work because of the fires. His boss was angry. "Do you want this job or not?" he asked. Bob-O told him, "The woods are shut down Dwayne. There's nothing I can do about that."

Hearing about the down strikes in town, the crew decided they could help fight the fires rather than do nothing till the woods opened up again. They went to the Forest Service station and volunteered their services. They were sent up Slater Butte outside of town to work a fire there.

They worked all day under Forest Service supervision, digging fire lines. Fire line digging means "three feet wide, bare dirt." It is backbreaking work under any circumstances.

Later that afternoon, Bob-O went to the crummy (crew truck) to take a break and eat his lunch. As he sat in the truck, he turned on the CB to listen to any chatter going on. It was tuned to channel 18, the Forks road and contact channel. He was totally surprised to hear Nancy at Eddy Gulch Lookout, back on the Salmon River, talking about fires there.

Apparently, since Bob-O was on Slater Butte at an elevation of approximately 4,000 feet (1,200 m) and Nancy was at Eddy Gulch lookout at about 5,000 feet (1,500 m), with no mountain peaks between, she was coming in loud and clear. Bob-O picked up the mike and keyed it. "Nancy, this is Bob-O. Can you hear me? I'm on Slater Butte."

"I hear you clear, Bob-O."

"What the heck's going on over there, Nancy?"

Nancy filled him in on the fires happening on the Salmon. Sitting in our radio shack, I could hear Nancy, but not Bob-O. I could tell from Nancy's end of the conversation that Bob-O was coming home. My relief was huge.

We're Outta Here

Bob-O went to the Forest Service guy and told him, "Our families need us—we're leaving." He then rounded up all the men and told them what he knew of the down strikes on the Salmon. They jumped in the crummy and drove down off of Slater Butte. Shortly after that, the fires had spread so far as to block any exit off the butte. No one was hurt, but no one was able to leave Slater Butte for the next 24 hours. Bob-O and his crew were the last people to get out.

It was already dark that evening when I heard Bob-O calling the mile markers coming up the river from Forks. He was dropping the crew off as he came, so it took a very long time to make the eight miles from town. As he drove, he could see the glow of several fires on the mountainsides. He was glad to be coming back to Starveout.

The last person he dropped off was Philbo at Woody and Carol's house, where the Godfrey Ranch road and the river road meet. Philbo could not go home since the firestorm earlier in the day had left the road blocked by debris that was still burning. He didn't know if he had a home to go to yet.

Back Home

The next morning, Bob-O went up the mountain behind our cabin and checked on the down strike fire there. I had not returned after my first venture. (See my column in *HP91.*) I figured if the fire came down the mountain, I would walk across our swinging bridge, get in the truck, and drive away. End of story—no heroics for me.

It turned out that the fire had gone out, just as the Forest Service crew, sent that first evening, had told me would happen. So Bob-O went down to the Forest Service compound at Forks to see if he could volunteer to fight fire.

He found the fire coordinator and told him he had a crew of locals who wanted to sign on. The guy said that before he could sign them on, they would have to drive out to Yreka, a couple hours away to apply for work. Bob-O demurred. The guy gave Bob-O a phone number to call to get some sort of answer. Bob-O pulled his two meter handheld radio off his belt. His punched in star-2 to open our radio phone line and punched in the number he had been given. The Forest Service guy watched dumbfounded. "It's busy," Bob-O said, hanging up by punching star-2 again.

"You have a phone?" The Forest Service guy was incredulous, "*We* don't even have phones yet. Who the hell are you?"

Bob-O explained again that he was a local with a crew of men who were familiar with the country, worked in the woods for a living, and had worked the Hog Fire years earlier. "We can't use you," was the only answer he got.

Fire Camp

Bob-O went to find his crew in the fire camp. The Forks school had shut down, and because it's so close to the Forest Service compound, it was natural to use its large, open sports field for the fire camp. The fire camp was growing rapidly. Fire crews were being sent in from all over the country. The people and equipment to support the crews—kitchens, laundry, showers, etc.—were all being coordinated at the same time.

The whole population of the Forks of Salmon area, including Forks, Sawyers Bar, and Cecilville, numbered probably several hundred at best. At the peak of the fires of 1987, the fire camp population was more than four thousand. There were fire crews from every state in the union. We even had an all-female Navaho crew, for which I had great admiration.

Because he hadn't eaten since the day before when he was on Slater Butte, Philbo had gone to the fire camp kitchen so he could fuel up before going to fight more fires. He was getting his plate filled by Nancy, a local woman working in the kitchen tent, when Bob-O found him. A Forest Service employee came up to Philbo and asked if he was on a crew. Philbo answered, "Not yet."

The Forest Service guy grabbed the pork chop off Philbo's plate and threw it in the trash. "You're not eating here then," he fumed. "Get outta camp."

Word of what became known as the "Pork Chop Incident" spread faster than the wildfires in the mountains around us. Coupled with their refusal of local help, the Forest Service's rudeness had insulted and pissed off the very people who knew the territory better than any of them ever would. It was not a good way to interact with the locals.

Bob-O found his crew, and they set off to clear defense lines and fall dead snags around local cabins on their own. They knew that even if the Forest Service wouldn't use their willing talents, their community could.

Post Script: It was very odd to write about the 1987 fires, while we were surrounded by smoke from this year's Florence and Sour Biscuit fires in the Illinois Valley of southern Oregon. At times, the smoke was so thick, we could not see across our nearby creek. Eventually, the two fires merged and became the largest wildfire in Oregon history.

Access

Kathleen Jarschke-Schultze is hoping for rain with no lightning at her home in Northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com

HAPPENINGS

Send your renewable energy event info to happs@homepower.com

ENERGY FAIRS
See: www.homepower.com

INTERNATIONAL

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

El Paso Solar Energy Association bilingual Web site. Info en Español on energy & energy saving. Free download of PV Systems book. www.epsea.org/esp

Green Empowerment finances microhydro & other RE projects in Nicaragua, the Philippines, & Borneo. Volunteers needed. www.greenempowerment.org

Solar On-Line (SoL) Internet courses. Year-round. PV Technology & Opportunities: A Qualitative Overview; PV Systems Design: Basic Course; PV Systems Design: Professional Course; PV System Installation: Hands-On! Solar Homes; Healthy Buildings; & Solar Energy for International Development. SoL, PO Box 217, Carbondale, CO 81623 Phone/Fax: 720-489-3798 info@solenergy.org • www.solenergy.org

SEI Internet courses. PV Design, Jan. 13–Feb. 21. Solar Home Design, Jan. 27–Mar. 7. See COLORADO for SEI contact info.

AUSTRIA
Mar. 5–7, '03. World Sustainable Energy Day, Wels, Austria. Forums & speakers mostly on European & international energy trends. Info: Christiane Egger, O.Oe. Energiesparverband, Landstrasse 45, A-4020 Linz, Austria +43-732-7720 14386 • Fax: +43-732-7720 14383 • office@esv.or.at • www.esv.or.at

BAHAMAS
Jan. 24–Feb. 14, '03. Ecological Design & Build Courses. Cape Eleuthera Island School, Eleuthera, Bahamas. Sustainable development, incl. solar pumping & biodiesel production. Permaculture Designer's Course (with certification) & Ecological Architecture course. Info: Ben Falk, benfalk@islandschool.org www.islandschool.org

CANADA
Alberta Sustainable House; open house 3rd & 4th Saturdays, 1–4 pm. Cold-climate features & products for health, environment, conservation, RE, recycling, efficiency, 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

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

CUBA
Jan. 4–18, '03; RE Study & Tour. Learn what Cuba is doing in RE. Info: Global Exchange, 415-575-5531 • rachel@globalexchange.org www.globalexchange.org/tours/forms.html

ITALY
Apr. 10–12, '03, EOLICA EXPO, Naples. Wind energy exhibition. Info: Eolica Expo 2003, Solar Energy Group Srl, Via Gramsci, 63-20032 Cormano, MI (Italy) • 02-66301754 Fax: 02-66304325 • info@eolicaexpo.com www.eolicaexpo.com

NEW ZEALAND
Feb. 15–16, '03; Canterbury Sustainability Expo, Christchurch. Alternative energy, building, heating, efficiency, Gov. info, composting toilets & greywater, alternative transport, education, speakers, demonstrations, & exhibits. Info: John Veix, PO Box 6302, Christchurch, New Zealand 64 25 576 527 • john@gosolar.co.nz www.gosolar.co.nz

NICARAGUA
Jan. 7–17, '03; Managua. Intro to PV for developing countries. Lectures, field experience, & eco-tourism. Taught in English by Richard Komp & Susan Kinne. Info Barbara Atkinson, 215-942-0184 • lightstream@igc.org www.grupofenix-solar.org

SCOTLAND
Feb. 22–Mar. 21, '03. Ecovillage Training; Findhorn, Scotland. Transfers tools & techniques for creating sustainable communities. Info: Findhorn Foundation, The Park, Findhorn, Scotland IV36 3TZ +44 0 1309 691653 • Fax: +44 0 1309 691163 bookings@findhorn.org • www.findhorn.org

WALES
Feb. 21–23, '03 (again May 23–25). Intro to RE Weekend Course, Univ. of Wales, Aberystwyth. RE technology, incl. solar, wind, & hydro. Info: Green Dragon Energy, 01974 821 564 • dragonrg@talk21.com www.greendragonenergy.co.uk

NATIONAL U.S.
Pollution prevention videos. Appalachia: Science in the Public Interest offers 42 videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar-Powered Automobiles, Quilted Insulated Window Shades, & more. 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 Assoc. Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

State & Fed. incentives for RE info. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 Fax: 919-515-5778 • www.dsireusa.com

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

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

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

Stand-Alone PV Systems Web site: design practices, PV safety, technical briefs, battery & inverter testing. Sandia Labs www.sandia.gov/pv

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! 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center • 321-638-1017 www.fsec.ucf.edu

ARIZONA
Jan. 23–25, '03. Solar Hot Water & Radiant Heating Wkshp.; Sedona, AZ. Design & build solar & radiant heating systems. Info: Peter Biondo, USA Solar, 928-282-5140 info@usasolar.net • www.usasolar.net

Tax credits for solar in AZ. Info: ARI SEIA, 602-258-3422

Scottsdale, AZ. Living with the Sun; free lecture series, 3rd Wed. each month, 7–9 PM, City of Scottsdale Urban Design Studio. History & current concepts, design, applications, solar heating & cooling, architecture, landscaping, PV, & cooking. Info: Dan Aiello, 602-952-8192; or AZ Solar Center, www.azsolarcenter.org

CALIFORNIA
Feb. '03; Energy & Environmental Summit 2003; dates & venue TBA. Show institutional energy managers how to save energy & reduce pollution. EES2003, 1065 Fresno Street, #18, San Diego, CA 92110 619-298-5554 • Fax: 619-220-7368 jack@ees2002.com • www. ees2003.com

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State Univ. Wkshps. & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA

95521 • 707-826-3551
ccat@axe.humboldt.edu
www.humboldt.edu/~ccat

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm. • 800-555-7794 or 916-654-4058
renewable@energy.ca.gov
www.consumerenergycenter.org/buydown

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

Solar e-Clips, free weekly e-mail newsletter. CA news & info solar energy. Subscribe: www.californiasolarcenter.org

COLORADO

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

IOWA

Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. All welcome. Call for changes. IRENEW, PO Box 355, Muscatine, IA 52761 • 563-288-2552
irenew@irenew.org • www.irenew.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
606-453-2105 • aspi@kih.net
www.kih.net/aspi

MASSACHUSETTS

Mar. 12–15, '03; Building Energy 2003 Conference & Trade Show; Boston. Green building & RE. See below for NESEA info.

Greenfield Energy Park. Ongoing energy demos & exhibits. NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051
Fax: 413-774-6053 • nhazard@nesea.org
www.nesea.org

MICHIGAN

Intro to Solar, Wind, & Hydro. West Branch, MI. First Fri. each month; System design & layout; on or off grid; for homes or cabins. Info: 989-685-3527 • gotter@m33access.com

MONTANA

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

NEW MEXICO

Feb. 6–Mar. 6, '03. Intro to Home Made Solar Electricity. Mimbres Valley Learning Center, Deming NM. Info: 505-546-6556 x 103

NEW YORK

RE Loan fund: low interest financing: NY Energy $mart Program, NY State Energy R&D Authority • 518-862-1090 x 3315
Fax: 518-862-1091 • rgw@nyserda.org
www.nyserda.org

NORTH CAROLINA

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

OREGON

Feb. 21–23, '03. Successful Solar Businesses; Ashland, OR. All aspects of small RE business. Richard Perez, Bob-O Schultze, & Bob Maynard. Info: see display ad in this issue.

Mar. 1–2, '03. Conscious Living Expo, Deschutes, OR. Business, lifestyles, & the arts. Incl. some RE stuff. Info: Green Guides, 557 NE Quimby, Bend, OR 97701
541-388-9040 • Fax: 541-318-6169
editor@colivingnow.com
www.colivingnow.com

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 8 weeks, 4 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424
541-942-0302 • apro@efn.org
www.efn.org/~apro

RHODE ISLAND

Energy Co-op provides RE, energy efficiency & conservation services, & group purchases of EnergyStar products. Erich Stephens, 401-487-3320 • erich@sventures.com

TENNESSEE

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

TEXAS

El Paso Solar Energy Association: meetings 1st Thur. 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 months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 • jferrill@ev1.net
www.txses.org/hreg/

VIRGINIA

Info & services on practical solar energy apps in VA. VA Solar Energy Assoc., the VA Solar Council, & the VA SEIA. Info: VA Div. of Energy • 804-692-3218

WASHINGTON STATE

Apr. 5, '03; Intro to RE workshop, Guemes Island, WA. Intro to solar, wind, & microhydro for home owners. US$75. Lecture and tours. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448
ian.woofenden@homepower.com

Apr. 7–12, '03; Solar-Electric (PV) Design & Installation workshop. Guemes Island, WA. System design, components, site analysis, system sizing, & hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden
360-293-7448
ian.woofenden@homepower.com

Apr. 14–19, '03; Homebuilt Wind Generators with Hugh Piggott, Guemes Island, WA. Learn to build wind generators from scratch, including carving blades, winding alternators, assembly, & testing. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448
ian.woofenden@homepower.com

Apr. 21–24, '03; Microhydro-Electric Systems workshop. Guemes Island, WA. Classroom and lab sessions are followed by tours of systems, including a tour of Canyon Industries, hydro turbine manufacturer. US$450. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden
360-293-7448
ian.woofenden@homepower.com

WISCONSIN

June 20–22, '03; RE & Sustainable Living Fair (a.k.a. MREF); Custer, WI. Exhibits, workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids' Korral, entertainment, keynote speaker. See below for MREA access.

MREA wokshops: Solar Space Heating, Wind System Install, PV Installs, Straw Bale, Masonry Heaters, Sustainable Living. Info: MREA, 7558 Deer Rd., Custer, WI 54423
715-592-6595 • Fax: 715-592-6596
mreainfo@wi-net.com • www.the-mrea.org

the Wizard speaks…

Why?

Why does the human race appear to be so unenlightened? It's as if we have a collective death wish. Many of the problems facing us and the planet have at least temporary solutions that can be implemented now. Yet we continue not to take advantage of them. Some of these solutions are rather self-evident. They include wind and sun for energy, hydrogen for fuel, and hemp for paper.

Why don't mainstream scientists at least consider the possibility of energy generators that apparently put out more energy than is used to activate and drive the device? There is enough information out there to justify investigation. Are they afraid of a new scientific paradigm, or are they just plain stubborn?

Perhaps the explanation for such behavior lies in our genetic makeup. It is quite probable that we have been programmed by the process of Darwinian selection to take a conservative, short-term, bottom-line position. However, we must overcome these tendencies, whatever their cause. If we do not, we might not be around in the future to wonder why.

Guerrilla Efficiency Works!
Dear Joe, I would like to thank your for the nice article you wrote on the Mexican Village in *HP91*. I would like to request more information on the bulbs you use, like cost and where to order them. Would they provide better lighting and not be as bright as the lighting we're using now? Thank you, Carol, Manager, Mexican Village Restaurant

Hello Carol, The lighting in the Mexican Village is very bright (and hot)! But that's obviously not enough to keep us away from the great food. In the single bulb fixtures, a 15 watt, reflector-style compact fluorescent (CF) bulb will work great. In the light fixtures with multiple bulbs, small, covered, 5 watt candle style CF bulbs would probably do the trick, and cut down the glare significantly.

These days, CF bulbs are often available locally, but the selection may be limited, depending on the store and location. For a wide selection of CF lightbulbs, check out www.bulbs.com and other Web sites that sell CF bulbs. CF bulbs cost US$5–15 each, depending on the style. But as I pointed out in the article, they'll significantly reduce your electric bill and save you money over time. My suggestion would be to order a selection of various CF bulb styles and see what you like best, before placing a large order. Please note that some inexpensive CF bulbs out there have very high failure rates. You get what you pay for. Take care and see you next year. Joe Schwartz joe.schwartz@homepower.com

Rent an EV!
Dear *Home Power* Editor, Your October issue had a very thorough and informative article on electric and hybrid vehicles. However, given the number of factors involved in making such a distinction, it might be helpful for prospective buyers to test these vehicles out in some real-world situations. Fortunately, for those in or travelling to major metropolitan areas, there is a car rental company renting these vehicles. Their Web address is www.evrentals.com. Christopher Erickson

Saving Energy & Bucks Already
I like your in-depth articles, and find them very informative and up to date. I also like your link pages. I found several Web sites there that did not come up on the search engines. Just from the information I received by visiting your Web site, I have already been able to reduce my overall electric consumption by 24 percent! For our household, that comes to about US$50 per month. Can't wait to get my first issue of my new subscription to *Home Power*! sold_on_iti@hotmail.com

Adventures with Solar Water Heating
I enjoy the magazine very much. I am just getting into renewable energy. I installed a solar water heating system and the savings were immediate. I just bought a used solar hot water panel and a used 40 gallon water heater (tank). I built a wooden framework to support a passive solar water heating system. The tank is on an 8 foot stand that has the 10 foot by 4 foot solar water panel attached to it facing south and at a 45 degree angle. I bought enough copper pipe to install the system about 100 feet away from my house behind some trees. The pipe is insulated and runs underground to the house. I still have my electric water heater on line if it becomes necessary to use it.

I set it up so that the water can be heated by the sun, or by the sun and grid electricity, or by grid electricity alone. It works great. I don't expect that I will have to use grid electricity to heat water again. I am going to add another solar water panel to boost the heat from the winter sun. I am going to put insulation on the outside of the tank and enclose it to help keep the water hot during the winter. This experience has been so good that I now plan to use solar heated water to heat my house in the future by putting solar water panels on a hillside about 60 feet from the house.

I have some small PV panels that I use to keep the batteries charged on farm equipment. I am currently installing a solar powered fan in my kitchen. We have a lot of wind, which I would like to harness for electricity. I have a well pump that I would like to run on renewable energy soon. I am debating about whether to put energy back into the grid or use batteries. Articles in *Home Power* will help me to make that decision.

Your magazine is brim full of ideas that I would like to explore, and has helped to increase my enthusiasm about renewable energy. I look forward to receiving *Home Power* magazine to read the stories about what other people are doing with renewable energy. Gene osogrande32@yahoo.com

Hi Gene, Thanks for the great stories about your solar thermal adventures. Looks like you are about to embark on some solar electric ones too. Good luck, and always *remember that we love it when readers send us articles with photos about their RE adventures! Michael Welch michael.welch@homepower.com*

Metering Guerrilla Solar

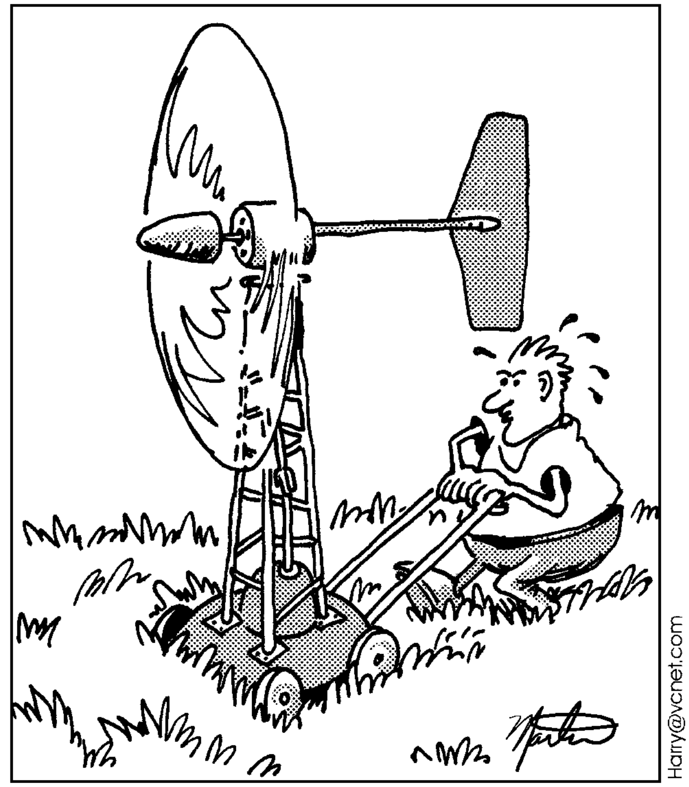
I read your “Things That Work!” article concerning the P3 Kill A Watt device. I ordered one for US$39 and found that it works backwards with my guerrilla solar project. The Kill A Watt watt-hour meter shows me the real-time watt output and also the KWH produced! This makes my guerrilla solar project that much more satisfying. I used to have to go out in the backyard, crawl under my panels and listen to the inverter hum to see if it was working. I now just go and look at the meter, and there it is! Thanks for the “Things That Work!” article. Your magazine continues to impress! Solar Guerrilla #0020

That’s great news! Finally, a KWH meter that is cheap and works with guerrilla solar. Michael Welch michael.welch@homepower.com

PV vs. SUV

The August/September 2002 issue of *Home Power* had a lot of useful info. The articles on computer efficiency, LED flashlight conversion, and Cold Lights (www.coldlightbybruce.com) may well reach many more people than articles on larger/higher-cost applications (though I enjoy those also). Which brings me to the “PV vs. SUV” article. The emissions comparison may well be an earnest effort. I can’t really comment on the accuracy of either the emissions or avoided cost presented for the PV or SUV. I have not used RETScreen (http://cedrl.mets.nrcan.gc.ca/e/412/retscreen/).

However, the value column makes no sense to me. If a PV system had a 50 year life, at 20 years it would have 30 years of life remaining. That would leave the remaining value at 60 percent of the original cost ($29,499). That is US$15,923, *not* US$26,539. That reduction in value is without even considering whether 50 years may be a bit optimistic for the life of the solar-electric panels. Another fly in the ROI ointment would appear to be the life of the inverters (the article did indicate a “grid-tied” 5 KW, PV system). If the Sandia Labs figure of five-year MTFF (from the “Independent Power Providers” article) is accurate, at least some of the inverters will need to be replaced or repaired several times over 50 years. Back on the positive side of ROI, very high efficiency (30 percent) solar-electric panels may be on the horizon: www.spectrolab.com, as mentioned in *Technology Review* magazine, Sep. 2002, page 88, “Triple-Junction Solar Cells.” Though with such a new combination of materials, it may be some time before cost is reasonable (or a 50 year life is feasible). Promising progress for one form of distributed power, though. Scott Maley



Things that don’t work: The wind powered lawn mower.

Hi Scott, You are right, I was somewhat unfair in my comparison of the SUV value and PV system value. I used the Bluebook for the Jeep, but no “PV Bluebook” exists, and I simply devalued it based on a very optimistic loss of power percentage, not zero-ing it out at 50 years. I appreciate you taking the time to think through the details, but you may have missed my point, which is that no one treats automobile economics in this way, so why should we do it to personal energy production systems? After all, my customers are not utilities, could care less about how utilities “think,” and will not analyze their PV systems the way utilities would. They are just happy to be making the cleanest electricity imaginable without the baggage of hidden or socialized costs that all the other energy sources must carry.

As for the longevity of modern inverters, time will tell, Sandia’s good work notwithstanding. I have a 30-year-old stereo receiver that I use every day, and it contains big transformers and semiconductors as well as other components that are similar to what you will find in an inverter. It has survived just fine, even the string on the tuning dial, and will probably keep working for another 30 years. Sure, we don’t know how robust the latest crop of power electronics really is, but I refuse to cave in to the kind of negative thinking that has plagued this industry since its inception. But thanks for your comments, anyway. Have a sunny day! Jeremy Smithson

How to Change the World
The way to change the world today is for more grid connected homeowners to set up net metering. That should be the major focus of the magazine. Limit the negative stuff about nuclear and other mistakes. Let's move positively in the area that makes the most sense. Solar-electric modules connected to the grid are hassle free, and so compatible with modern lifestyles—no batteries, no charging, and no safety issues. This is the area where cost and installation are the major hurdles. People need options and ideas about what works and what is affordable. tomjones@ieee.org

Low-E Windows
Dear *HP*, While most of the recommendations in "A Passive Solar Design Primer" in *HP90* are good, and are consistent with my experience in designing passive and active/passive solar homes, I do have a question regarding the recommendations on low-E glass for solar gain.

I have used Pella windows with their Insulshield IG Glazing. This is a double-pane, argon-filled system with low-E coatings, consistent with the generic recommendations in the article. Unfortunately, when I analyzed the radiation performance of the Pella specifications, it was apparent that these windows would specifically not have the performance characteristics claimed in the article.

In general, the low-E aspect is a UV blocker that is addressing the fading of furniture, floors, and fabrics. Insulshield, for example, has a UV Transmittance of 17 percent versus 56 percent for Clear IG (non-low-E) glazing. Since plain, uncoated glass is largely opaque to infrared (IR) radiation, this being the basis of the greenhouse effect in a passive solar house, any glass (single, double, etc.) provides some advantage in solar gain since it traps the IR radiation trying to escape the house after the energy enters in the UV and visible spectrum. The article tells us that the low-E coatings are responsible for the trapping of IR radiation. This is not consistent with my experience, nor my analysis of the Pella technical data.

Based on my past evaluations, I have recommended non-low-E, uncoated, Pella Clear HA IG glazing in sunspaces to maximize solar gain, and used low-E Pella Insulshield IG in areas of the home that required only lighting (east, west, and north) and where I wished to minimize solar heating. This system worked quite well from a subjective point of view.

Following construction, I have also tested the energy transmittance of the two types of glass using a solar energy meter. The low-E aspect of the Insulshield was quite dramatic, with a ratio of available (outside the window, vertical orientation) to transmitted (inside, same orientation) energy of 200 BTUs per square foot to 20 BTUs per square foot, a factor of 10 reduction. The clear non-low-E glass, in the sun space, had a ratio of 200 BTUs per square foot to 150 BTUs per square foot. In short, by *not* using low-E glass in the sun space, I achieved a factor of 150/20 or 750 percent increase in effective insolation.

The tests that I conducted, confirming the Pella technical data, were also confirmed by subjective tests. In short, the spaces that were glazed with Insulshield low-E glass were well lighted but never overheated...the sunlight was essentially "cool." The sun spaces, equipped with thermal mass and air movers, were always quite warm, with a large excess of energy to be moved into the home by convection and stored in the thermal mass. The difference in the feel of the spaces was dramatic.

While I agree with the premise that "an ideal window maximizes solar heat gain in the winter and minimizes solar heat gain in the summer," it has not been my experience, nor does the Pella low-E technical data support, the conclusion that low-E, double-glazed windows with argon actually do what is suggested in the article.

Since these tests were conducted, I have been recommending that my clients avoid low-E glass in sun spaces or south-facing windows of passive designed solar homes. Regards, Larry J. Mott, PE, Consulting Engineer, President, GES Tech Group, Inc. gestech@gestech.net

Larry, Thank you for your comments regarding low-E surfaces and their application. You are quite correct and specifically more accurate than we were in our article. Our statements were made in a more general sense regarding insulated glass units incorporating low-E surfaces. Some clarification is in order: Single and double-insulated glass is opaque to infrared radiation with or without low-E. In general a low emittance surface re-radiates much less infrared radiation than black body surfaces. The application of this concept varies in the use of low-E surfaces in windows. Low-E comes in many varieties and may also be combined with various other features such as tinting, reflective surfaces, and gas-filled cavities.

Low-E coatings consist of microscopic metal and metal oxides deposited onto glazing surfaces to diffuse radiated heat by reflecting it. The placement of a low-E surface varies with the orientation and climate in which it is used. For heating-dominated climates, the low-E surface faces inwards and reflects interior radiant heat back inward. For cooling climates, the low-E surface faces the exterior to reduce the solar gain. For applications where maximum solar gain is the *predominantly desired feature, a low-iron, double-glass insulated unit without low-E is optimum. Any variety of low-E will have a reduced solar gain by comparison.*

There are, however, other low-E options that have far more solar gain than the Pella window you have used for comparison. Heat Mirror 88, for example, claims a solar heat gain coefficient of 0.57 compared to 0.75 for clear, double-insulating glass. While the heat mirror still has less solar heat gain than double-insulating glass, it has a much lower U-value, which is a great advantage in terms of heat loss.

Low-E is a good choice in all locations where lighting and thermal efficiency are the primary concern. Non-low-E, double glass is an appropriate choice for a solar gain application like south-facing windows and engineered passive solar gain spaces. This is particularly true where maximum solar gain is the principle design objective, such as sun space applications where high mass and supplying excess daytime heat to adjacent spaces are common design objectives.

Our one-page treatment of super windows introduced the general concepts. The subject is definitely worth a complete article to do justice to modern window technology. Ken Olson, Solar Thermal Editor ken.olson@homepower.com

Hydro Questions
I'm working on a mini hydro-electric system. I have 50 feet of head with water filling 300 feet of a 3 inch ABS pipe, producing about 19 gpm at 30 psi. I have based my turbine design on the Pelton style, using a 4 inch ABS pipe cap as a hub. To serve as fins, I sliced fifteen, 1 1/2 inch ABS pipe caps down to 1/4 inch, put a V-shaped notch in the bottom edge, and glued them to the hub at a 160 degree slant. I have four, 3/8 inch nozzles that apply the water, which I angled downward to encourage the splash to clear the turbine after it strikes the fin.

I had a local auto electric store assemble a Delco car alternator that would generate at the lowest possible spin rate (about 900 rpm), resulting in a 25 amp output. The problem is, my turbine is not strong enough to bring the alternator up to the minimum speed needed for it to generate. I was wondering if an alternator or brushless generator exists that produces around 7 amps, and would offer less resistance and or generate at a lower spin rate, say 500 rpm. If so, how much is it and where can I get one.Thank you for any insight you may offer. Bruce, Washougal, Washington

Bruce, Your e-mail is kinda full of conflicting information and not really enough of it. First, you say you have 19 gpm at 30 psi. OK, but then you say you run four 3/8 inch nozzles in your design. Hmmm...a single 3/8 inch nozzle squirts about 21 gpm @ 30 psi. Just one of them will run you out of water.

You say you would like to find an alternator/generator to produce 7 amps. At what voltage? I'll assume for the moment that you are charging a 12 V battery. A 25 A Delco with external adjustable regulation (a rheostat) will do that and maybe a bit more with an efficient Pelton runner. If the Delco is internally regulated or if you are using the Delco external regulator, we've possibly found your problem. An alternator regulator in a vehicle is kind of a "fully on" or "fully off" device. If it needs to grab a horsepower or three from the engine, it just does it. That's why you can hear the engine pull down in rpm when you turn your lights on at idle. With a hydro situation, you don't have that kind of input power. You have whatever the gpm/psi torque provides, and that's it. To keep the alternator running at enough rpm to generate, we have to be able to feed the field wire at a limited current, hence the rheostat.

As to your runner, while I love a good homebrew, yours is probably pretty inefficient. In the classic Pelton runner, the cups are notched in the center so that you can get the nozzle close in and point it at right angles to the runner. They also use a double cup design with the water being split to push on both cups. Sounds like you've taken a shot at the notch, but are using a single cup sort of design. It will probably work, but at a greatly reduced efficiency. Have you put a mechanical tachometer on the runner and run it unconnected to the alternator? Assuming your runner is somewhere between a 4 and 5 inch pitch diameter (two times the distance between the center of the hub and where the water strikes the wheel), I'm guessing you should see close to 3,000 rpm unloaded and about 700 rpm loaded to the power peak. If either are way below that, you might want to rethink your design. Try pointing the nozzle at right angles to the cups for starters.

To give you something to shoot for, the latest permanent magnet field alternator/Pelton runner offered by Harris Hydro will give you about 135 watts, given 19 gpm at 30 psi. In a 12 V system, that's about 10 amps at 13.5 VDC. Hope this helps. Good Luck, Bob-O Schultze econnect@snowcrest.net

Response from Xantrex
Dear Editor, In the "Independent Power Providers" column in *HP89,* a strong stand was taken in the section called "UL vs. Xantrex—The Aftermath." While there are some good points made, we at Xantrex would like to offer our view in order to set the record straight.

We certainly wish the situation leading to last November's safety alert could have been worked out with less negative impact to our customers and to us. We inherited these issues from a predecessor company, issues that were created by engineers who no longer work at Xantrex. Faced with the situation, however, as an industry leader, we moved decisively to do the right thing and rectified the situation at significant cost to us. We regret the inconvenience that resulted for some homeowners and for our distributors and dealers. We are committed to working with UL to make sure a similar situation will not happen in the future.

Over the years, important standards bodies such as UL and CSA have made significant contributions to the solar industry. We remain committed to supporting the major testing labs. Without these standards, it would be difficult to imagine a successful grid-tie solar market in the U.S. The solar industry needs strong technical standards and enforcement to ensure that solar-electric systems and key components gain acceptance by the mainstream, which will benefit the entire industry as well the environment. Sincerely, Greg Brown, President & COO, Xantrex Technology Inc.

Hooked Already
I just picked up *HP90* at the local newsstand. Two days later, I am impressed enough to subscribe, even though I'm new to RE. You've got me hooked—this magazine is just plain fun to read!

My wife and I will be moving to the mountains in the near future, and we're currently designing our new house. We've already made some changes based on what we read in your magazine, and I'm sure we'll find more good ideas from *HP* in the months to come.

Here are some things I especially liked about *HP90:*

- Very good ratio of articles to ads; actually, there's so much "meat" in the issue, I probably wouldn't mind a few *more* ads.
- Great variety of articles: solar, wind, vehicles, etc.; plenty to keep me interested and subscribing for a long time!
- Unpretentious and practical "feel" to the magazine; no snobby attitude, just good information that I can use.

Here are some things I'd like to see more of:

- Hybrid vehicles & other energy efficient appliances and products; of course, the magazine is "Home Power," not "Home Energy Conservation," and you've got to draw the line somewhere, but information on those types of products would certainly be useful for people generating their own electricity. It also might help act as a bridge for a new class of readers to get interested in true home power generation.
- Information on dealing with utilities, such as how to sell back, how to get incentives for home power generation, etc. Some of the articles in *HP90* said that utilities make this very difficult. I certainly believe that, but I'd still like to see some details. Maybe there are some (relatively) good utilities out there; featuring them would give us some sorely needed optimism for our future.

Anyway, thanks for creating *HP,* and I hope you keep the magazine as fun as it is now. Brad Johnson

(Rejected) Letter to the *New York Times*
To the Editor: I was dismayed to read of so many voices raised against an efficient and clean form of energy in "Windmills On Their Minds" (Metro Section, *New York Times*, August 27). When travelling to visit friends and family, I have, by chance, been to see large installations of windmills all over the United States (most recently, western Kansas, Texas, western Minnesota, and Mackinaw City, Michigan) and have been impressed by many things.

Among these are: The fact that once the windmills are in place, a farmer can continue to use all the land to produce food right up to the mast's foundation; the enormous power output from the wind, which is something that we do not have to send any of my relatives abroad to defend; the fact that towns *do* benefit from the locally produced energy, since there are fewer transmission line losses thereby increasing efficiency; and the incredible beauty of the machines.

From a distance outside Pipestone, Minnesota, the windmills looked like children turning cartwheels on top of the corn fields. Up close, they were surrounded by corn, redwing blackbirds, and at least one mammoth snapping turtle, and one could not hear them until very close. At a picnic table in Kansas, we ate an early dinner in the shadows cast by the tall masts and spinning turbines of a wind farm. This was the only shade for miles and I was grateful for it as well as for the clean electricity. As we crossed the Mackinac Bridge in Michigan, we saw two, 360 foot tall masts with turbines generating electricity for hundreds of homes. (Just two of them!)

I would far prefer to live in sight of a wind farm than in sight of a single cell phone tower. Perhaps these preservationists, if they do not want to find a clean way to maintain their 21st century existence, should voluntarily return to the 18th century technology as used by the characters of James Fenimore Cooper's novels. Very truly yours, Sarah Johnson, New York, New York

No Free Energy—No Exceptions
Hi, I am a great fan of your magazine. Each issue is comprised of thoughtful, useful information, and I greatly look forward to its arrival in my mailbox. In view of the typical high quality of your publication, I was quite surprised with the "Wizard Speaks" column on "Magnetic Energy" in *HP90*.

There is nothing magical about the solid-state physics taking place in photovoltaic cells. The technical information you disseminate is all based on hard, difficult, painstaking research conducted by scientists over a long period of time. All of this technology is founded on well-established scientific principles (conservation of energy, the laws of thermodynamics, etc). On top of the science is all the hard work, and the information people have learned about how to implement the solid-state physics-based PVs.

Contrary to what the "Wizard" says, there is no such thing as a "magnetic energy generator" that creates free energy. All of human experience in physics strongly indicates that there never will be such a machine. The patent office screwed up by issuing a patent for this goofy thing (the Patent Commissioner has ordered a reexamination of this patent, #6,362,718, and the Patent Office is also changing the way it recruits examiners). That a few PhDs have associated themselves with this is not grounds for uncritical acceptance. Nor is the approval of a huge governmental bureaucracy grounds for acceptance.

I would like to suggest that you take a more skeptical stance towards kooky things like this (anything where you get something for nothing). It is a complete waste of your time and that of your readers—particularly when it misleads people.

There is one mildly skeptical statement in the column: "Often 'free energy' devices like these are highly touted, but in the end fail to live up to their promise." It should have read: "They have *always* failed to live up to their promise; there has never been an exception. Regards, Keith Hartman, Redwood City, California

Battery Revival Warning

Hi, I found your Web site following a search on Google. I live in New Zealand and have a car battery that doesn't seem to be holding its charge. I've yet to determine whether it's a problem with the car, but read with interest the articles about reviving lead acid batteries with EDTA. I contacted a local chemical supplier who can supply me with a small quantity, but he suggested that baking soda would do the job just as well, since it contains EDTA, and to use a quarter of a tablespoon per cell.

This is obviously preferable to EDTA or a new battery, but have you heard of this, and is it volatile in any way when added? I forwarded your details to a friend in the UK who is very interested in renewable energy. Regards Chris Goff

Hi Chris, Don't do it! *Find a new chemist. Baking soda will neutralize at least some of the acid in the cells. These are lead-acid batteries, and they need the acid they have in the electrolyte.*

I have never heard that EDTA is contained in baking soda, but there is a lot I do not know. Baking soda is sodium bicarbonate, a base. EDTA is ethylenediaminetetraacetic acid.

EDTA will help batteries, but I suspect your car battery is far enough gone to where EDTA treatment won't help as much as you'd like. Give (real) EDTA a try, and keep it in the back of your mind that it is a good thing that car batteries are relatively cheap. Michael Welch michael.welch@homepower.com

Cost of Energy

Home Power magazine is terrific—I can't wait for each issue. I had the pleasure of sitting in on a battery class given by Richard Perez at the Midwest Renewable Energy Fair in Madison a couple of years ago and am dying to learn more.

I've recently put 3,000 miles on my 2002 VW Jetta TDI with 100 percent biodiesel (virgin, but I would be happy to try recycled), which I bought from a budding energy subversive in Texas City (probably the biggest petroleum refinery town in the lower 48). I noticed a very slight loss of power, and mileage went from high 40s per gallon to low 40s per gallon. But can you believe this? I poured vegetable oil (!) that went through one simple chemical reaction into one of the most advanced, computer controlled diesel engines on the market, drove off down the highway, and barely noticed the difference! Imagine if the car had been tuned for biodiesel instead of petroleum diesel?

This has profoundly affected my life. The alternatives are right there in front of us, and I found out about this one from *Home Power* magazine! I had two friends killed in the twin towers and an old Marine buddy killed in Afghanistan. The hidden costs of petroleum *must* be accounted for at the pump, but Americans won't change until they see the dollars (even the Trade Center disaster didn't have an effect). I guess we'll have to keep working hard to make a lot of dough so we can buy some politicians for the renewable energy biz. Will Semmes • wsemmes@email.com

Hi Will, Thanks for your very interesting and thoughtful letter. Sorry to hear that you had friends lost in the WTC tragedy and the following war. It would be nice to figure out how to buy (or at least rent) some politicians. Too bad our vote isn't enough. Michael Welch michael.welch@homepower.com

Utility Interactive System Efficiency

Hi, I enjoy the mag, and thanks to all for putting it together. I have a couple comments on Rob Harlan's article in *HP91*. He says, "batteryless systems are...more environmentally benign." This comment disregards the recycle value of batteries and echoes the petroleum/nuke power guys.

I suspect the greatly reduced delivered power he reports is due to the inverter not being able to process all the DC input except at sine peaks. In fact, as the sine wave crosses zero 120 times per second, there would be zero utilization of DC input.

A small battery bank would absorb that missed DC input and allow for continued output as clouds temporarily obscure solar cells and even a bit after sun angle drop-off at sundown. Efficiency would likely increase significantly and decrease payback more than enough to offset the small battery bank cost. Bob Payne

Hi Bob, Batteries are one of the most highly recycled products in the U.S. But if system owners don't require battery backup, no batteries means less resource use.

There's a range of factors that affect inverter efficiency including basic design topology, PV temperature/voltage, inverter temperature, and the effectiveness of the inverter's maximum power point tracking software, which varies widely from manufacturer to manufacturer. The power delivered is the area under the curve, not just at the peaks. Capacitors or inductors are typically incorporated into power conversion electronics to "store" charge during processing.

A couple of other thoughts: First is that right now, the battery based, UI inverter market is limited by available hardware. The most popular battery based UI inverter on the market, the Trace SW series, always keeps the batteries at a constant float voltage. At night, grid electricity is used to do this. There are no settings that allow the user to defeat this function.

At my last place, one of the systems I was running was a Trace SW2512 with 400 W rated of PV in UI mode. The lack of control of the inverter's charger overnight consumed 40 to 50 percent of the daily output of my PVs on average. I was in a location where utility outages weren't a problem, so this system efficiency loss drove me crazy.

Technically, maximum power point tracking (MPPT) is more effective in systems without batteries. The inverter's MPPT software has a much larger voltage range to track, since it doesn't have to reference battery voltage. Array voltage drops as temperature increases. In battery based systems, the charging voltage always needs to be higher than the battery voltage. In batteryless UI systems, this variable is eliminated. Thanks for writing, Joe Schwartz joe.schwartz@homepower.com

PM Motors Not an Energy Source
Hi. I would like to ask you if you have any useful info in your magazine about permanent magnet motors. I have a couple of your magazines, but there is nothing I can find, even on your Web site. This is very good magazine about wind, hydro, and solar power, but there is nothing about PM motors as an alternative power source. Can you please let me know if there is any *Home Power* magazine issue or Web links where I can find some info on this? Thank you so much. Mike Steffek

Hi Mike. Permanent magnet motors are not an energy source. Something needs to spin them in order for them to make electricity. Wind, hydro, and internal combustion engines can be used to spin them. Permanent magnet generators are sometimes used in this way. Michael Welch • michael.welch@homepower.com

Passive Solar Design Flaw
My wife and I read your excellent Web bonus article, "Passive Solar Basics" and had a question. The house plan on the second page shows four windows on the north side, with one of them a large circular bay window in the master bedroom. I told my wife that it was a poor design to put a large bay window on the north side, but she thinks I am wrong and wants to incorporate one on the north side in the passive solar home we are planning to build here in Utah in the near future. Please help me! Do you endorse this plan? Why did you put this plan in your article? Many thanks, Steve Crowley, Provo, Utah

Hello Steve, Home Power *used our plans for the article art (with permission), and asked me to respond to your letter. While windows on the north side of homes receive no solar gain, they do solve other code requirements of windows in bedrooms for both light and emergency egress as well as the desire for natural light, ventilation, and sometimes beautiful views. You could probably eliminate one of the three windows in the bay and still meet code requirements.*

In a one story plan, which many people prefer, it is nearly impossible to create a home with no windows on the north. Our homes at www.sunplans.com are not zero energy homes, since they take a more holistic approach to home design. Passive solar is just one aspect. This is further described at the bottom of this page on our Web site: www.sunplans.com/html/passive_solar_overview.php3. While all of our house plans are passive solar, there are many other factors that go into the design of the homes such as function, views, light, natural cooling, etc.

The passive solar guidelines available at www.sbicouncil.org that we follow allow for many variables in design and for up to 4 percent of the floor area in north glass. For our 2,217 square foot Equinox home shown in the article, that is 88 square feet of allowable north glazing. The actual north glass is less than this. If a home requires more north glass than 4 *percent (usually due to the home owners' requirement to take advantage of a view to the north direction), we may sometimes need to increase the R-value of other elements such as roof, walls, or glazing to make up for the additional heat loss.*

All of our plans meet the same energy standard heat loss of 4BTU/SF/HDD maximum (and usually much less) net heat loss in the initial energy analysis. That figure accounts for solar gain. We are used to balancing the needs of people who want both energy efficiency and an attractive home with light in all rooms. In our Equinox plan, we chose to put a bay window on the north since most of our clients want light and some other special design feature in the master bedroom. Debbie Coleman, Architect, Sun Plans Inc., 18250 Tanner Rd. Citronelle, AL 36522 • 251-866-2574 info@sunplans.com • www.sunplans.com

Solar South

Dennis Donohue's method of finding true south in *HP90* is one way. Here's another. The sun traverses 360 degrees in 24 hours or 15 degrees per hour or 4 degrees per minute. If you know your longitude from a good map, it's easy to figure out what time the sun is at its local zenith or true south from you.

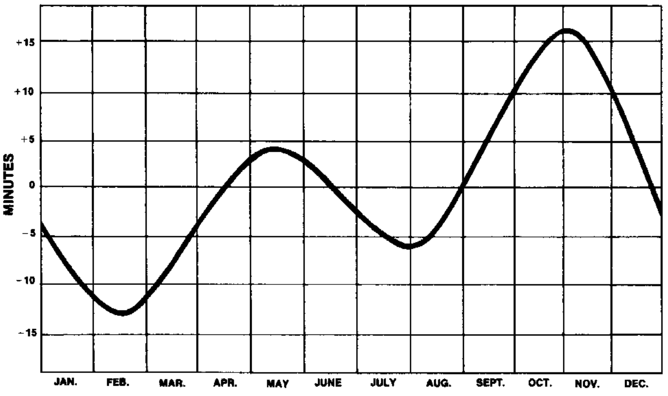
For example, my solar-powered house is at about 78 degrees, 58 minutes, and 10 seconds west longitude. Since one degree is plenty accurate for pointing a solar array, let's call it 79 degrees. In the eastern time zone, noon is when the sun passes over the 75th meridian (0500 GMT) or 5 x 15 degrees from Greenwich. At 79 degrees west, it is due south (local noon) at 4 minutes x 4 degrees or 12:16 EST (13:16 EDT).

To find true south, you need only a fairly accurate clock, a carpenter's square, and a spirit level. Tape the spirit level to the long leg (24 inch) of the carpenter's square and set the short leg on your solar array with the long leg kept absolutely vertical. When the shadow from the long leg is dead on top of the short leg at local solar noon, the square is pointed due south.

This is the best method I have found to point my arrays dead south. I have never seen recommendations in *Home Power* for the best elevation angle, however. An old Real Goods catalog says plus 15 degrees from local latitude for summer and minus 15 degrees for winter with local latitude being used for spring and fall. Can you add anything? Ivan Riley

Hi Ivan, your method for finding true south is pretty good. The meridians used to set clock time in the U.S. and Canada are: 75 degrees for Eastern Standard; 90 degrees for Central Standard; 105 degrees for Mountain Standard; 120 degrees for Pacific Standard. As you said, add four minutes for each degree that your location is more than the defining meridians, or subtract four minutes for each degree less. Then, of course, add an hour if you are observing daylight savings. This final adjusted time will be pretty close to solar noon. But there is one more variable to take into consideration.

Because the earth's orbit is elliptical, it speeds up when it's closer to the sun and slows down when farther away. This too affects sun time in relation to clock time. The graph shows the variation between clock and sun throughout the year. Careful—when the sun is ahead of the clock (positive numbers on the graph) you would need to subtract minutes from your clock time for solar noon. Conversely, when the sun is behind clock time (negative numbers on the graph), add minutes to clock time for solar noon.



Of course this all requires that you know your longitude. A compass and an awareness of the magnetic declination in your area can work just as well to determine true south.

We have published information on appropriate tilt angles for solar arrays many times. There is a full article in HP36, *but the gist of it has become a mantra round here. I think that you (or Real Goods) have your numbers switched. Add 15 degrees to your latitude for winter—steeper angles catch lower winter sun. Latitude minus 15 degrees for summer—flatter panels catch high summer sun. Set your panel's tilt angle to match your latitude in spring and fall. Tilt angle is measured from horizontal. The best dates to adjust? Mid-February, mid-April, mid-August, and mid-October. Ben Root ben.root@homepower.com*

Ozonal Notes

Join Together & Try

Richard Perez

In this modern world, we don't have to do much for ourselves. We're surrounded by experts, professionals who will do for us what we need done. We have economists to manage our economy, lawyers to pass our laws, politicians to ensure our freedom, utilities to supply our energy, psychiatrists to manage our psyches, pathologists to handle our pathos....

Whatever we need done, there is a professional to assure us that we aren't competent to do it for ourselves. We have entered an "age of professionalism," which attempts to render us all incompetent and powerless. Well, I'm here to say that the power lies in each and every one of us. All we have to do is join together and try.

Global Futility or Fertility?
In this age of mass markets and globalization of economies, we are lulled into thinking we are powerless. Who are we? We're just individuals. What can we do? How can we possibly know better, or do better, than the mega-corporations and governments that are attempting to supply us with all we need?

We know what we want. Every time we buy a product, we are using our economic power. Now, whether I buy a loaf of bread from the "Supermarket of the World" or from my local baker is my vote, my contribution to our collective future. While where just one of us buys our bread isn't important in the big picture, where we all collectively buy our bread is what enables global corporations, or local bakers, to exist. Put your money where your hopes and dreams are. Support what enables the power in all of us.

Power is determined by perception. If we don't think we can do something, then we can't. If we don't try to do something, then most certainly we will never accomplish it. Mass media lulls us into dependence on the experts. Professionals do things, and we watch the reports of what they do, in our names, on television. Democratic government relies on an informed electorate. Mass media has turned democracy into a tyranny of a misinformed majority. Use what little political power we have to build the world you want your children to inherit. Think for yourself and vote accordingly.

The same global communications being used to lull us into the enslavement of perceived incompetence can lead us to power, and thereby to freedom. The Internet is the greatest weapon for freedom ever—far better than the Kalashnikov AK-47. We should use it to communicate, to share information, to organize, and to assert our inherent right to be what we want to be. Join together and try.

Do It Yourself!
What we can do for ourselves, we should do for ourselves. Only in this way, can we stop creeping global professionalism. Only in this way, can we secure power and freedom for future generations. Grow a garden. Fix your own car. Build your own home. Bake your own bread. Speak, and vote, your mind. Don't accept that anyone, other than yourself, knows what is best for you.

And since renewable energy is a freely offered gift from nature—make your own energy. Technology has given us the tools. It's up to us to wisely use them. All we have to do is join together with nature and try.

In the words of Phil Ochs, who understood the problems we face and expressed the solution far better than I can:

Now it's a sin and a bloody shame
'Bout the way they're pushing you 'round.
But when you decide not to take no more
You know I'll put my money down.

'Cause I've seen your kind many times before
And I'll see 'em many times again.
Oh but every bad thing that's happened to you
Has happened to better men.

So don't explain that you've lost your way
That you've got no place to go.
You've got a hand and a voice and you're not alone
Brother that's all you need to know.

And if you're still wondering what I'm trying to say
Let me tell you what it's all about.
Now nobody listens to a single man
When he's walkin' 'round down and out.

So if you're looking for an answer
He's standing there by your side.
And you'll never really know how far you'll go
'Til you join together and try.

That's What I Want To Hear, Phil Ochs, 1965

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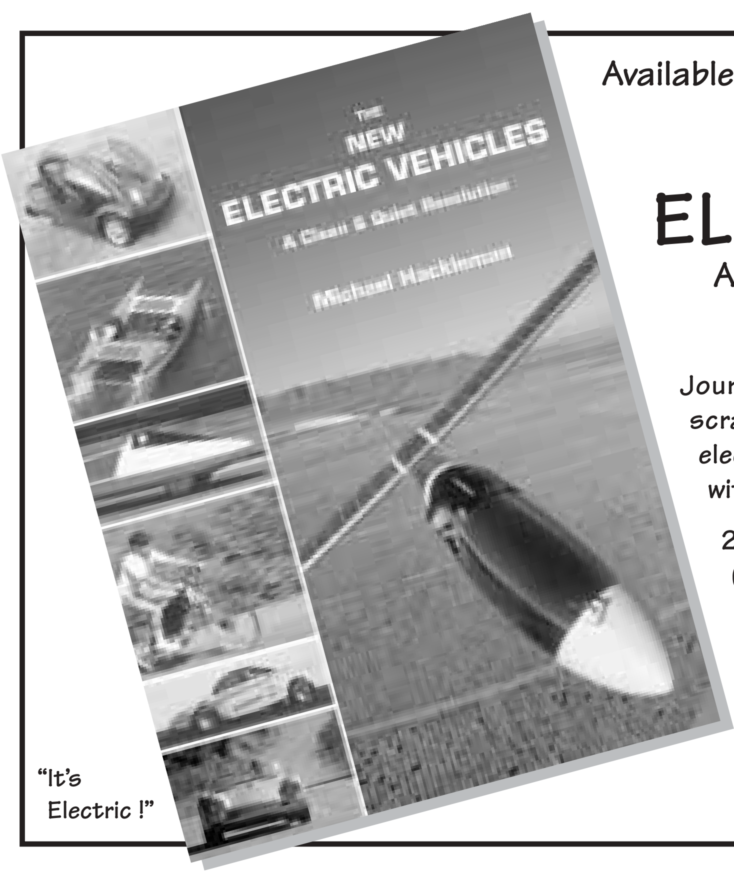

Q&A

Slowing Down a Fountain Pump
Hi folks, With our small solar and wind-electric system, we don't squander much energy on frivolity (movies and music being necessities in this context), but we *do* have this little pond with a waterfall powered by a 12 VDC bilge pump. We sit there with a beer of a summer eve and listen to the water. This small decadence could be improved upon if I could reduce the flow of the pump. Restricting the output of water would be difficult and inefficient, so can I use a conventional light dimmer in the circuit, or some other variable resistor? Will this lowered voltage be hard on the pump motor? Is there a better way? Thanks! Jim, Five Springs Farm CSA fivespringsfarm.itgo.com

Hello Jim, Yes, you can reduce the voltage to lower both the flow rate and the energy consumption. This will not harm the traditional brush-type DC motor that is commonly found in a bilge pump. You can use a ceramic power resistor. I did this for an evaporative cooler once, but it took some cut-and-try to get it right, and it will waste off energy as heat. A more refined and efficient way is to buy an electronic, DC speed control from Zane (see their ad in this issue) or some other supplier. It should work as well on a pump as it does on a fan. Windy Dankoff, Dankoff Solar Products windy@dankoffsolarcom

Dual-Use Solar Panels
After not paying attention to solar technologies for a *long* time, I have come to *Home Power* magazine to get caught up with the current state of the art. I am surprised that there isn't any mention of combined photovoltaic and solar hot water panels! It would seem a natural fit to have the PV in front getting hot and producing electricity, with a water jacket behind drawing off the heat for use indoors. From the sounds of what I've read so far, the PV is more efficient at cooler temperatures. Scavenging the heat may increase the output of the panels, and perhaps offset the draw of the pumps to circulate the hot water. The hassle of a rooftop installation would be well repaid with such a dual reward technology. Is there potential in this concept, or has it been shown to be folly? Best Regards, Steve Jacobson

Hi Steve. "Folly" is probably not the right word for it. "Problematic" might better describe it. It does seem like a perfect marriage, and it has been tried. First there is the potential problem of mixing water and electricity. It doesn't seem too hard to overcome that problem with good isolation.

Then, there is the added complexity, size, and weight. I think complexity is the biggie, though. If something goes wrong with the water heater, which is the relatively cheaper portion, you have to replace the whole thing, including the more expensive electrical portion. If something goes wrong with the PV part, what you have left is a very inefficient water heater. If the water portion quits working, you end up actually increasing the temperature of the PV due to the insulating properties of the water jacket.

The conventional thinking is that PV works well enough with adequate air space on either side. And silicon PV materials are not the best way to heat water—copper plates and tubes in solar H_2O collectors work much more efficiently. The conclusion is that it is more efficient and less problematic to use separate collectors for each process.

All that said, I personally have long been interested in this very idea, and look forward to seeing if the industry or experimenters come up with something that works well. Michael Welch • michael.welch@homepower.com

Another factor that Michael doesn't mention (and a huge factor, the biggest really) is temperature. PVs like it cool and solar DHW needs to be hot to be effective. If a dual collector gets hot enough to provide DHW, it's far too hot for the PVs to be effective. If the dual collector is cool enough for the PVs, the DHW is tepid at best. Richard Perez • richard.perez@homepower.com

Wind Basics
This may seem like a simple question to the experienced, but I'm fairly new to this and I'm having surprising difficulty finding out some basics. Regarding wind power, what exactly (bottom line) determines energy generation? Most articles refer to "swept area," but this relates to windmills and is obviously only for a purpose or required result. Is it simply the speed to the generator? And is this also subject to the size of the generator? What about resistance? Whether it's wind or water, the same principles would apply, but what am I trying to achieve when I turn the generator, and what are the limitations and restrictions on this?

For example: I could hook up one of those little carnival windmill toys that kids get, and it would rotate at an impressive speed, but I'm sure this won't power a city. Why? Is it because it's not strong enough to turn the generator—so am I looking at speed and force? If I hooked it up to a tiny generator that it can turn, does that then reduce the level of power generated? Would I then need to have hundreds of these tiny windmills to power my house, and does each windmill/rotor require its own generator, or is there a way to link multiple rotors to a single generator?

Sorry if this seems overly simplistic, but this is the level I'm at right now, and I'm having trouble getting past it. Thanks, Gus McKenzie, Melbourne, Australia

Hi Gus, There are several factors that play into the output of a wind turbine. First, there's the actual power available in the wind. The simplified formula for that is
$P = D \times A \times V^3 \div 2$, where P is power available in the wind, D is air density, A is the swept area, and V^3 is the wind velocity cubed. A turbine can't capture all the wind's energy, because then the air would stop moving behind the turbine and the next air would pile up against that air and slow down, reducing output (this is why a brick wall makes a lousy wind generator—it tries to stop all of the wind).

Once you get to the wind generator itself, several design factors affect output: Airfoil efficiency; governing method, governing wind speeds, and governing efficiency; generator efficiency; transmission losses, and other things.

Since there is no standardized testing of all wind generators, consumers are left having a hard time making comparisons. For a simple, general comparison, swept area is the best measure. Manufacturers can't exaggerate it—it's just the area that the blades sweep. Yes, one turbine can be more efficient than another, but the differences are not that large among products on the market today. The swept area is the "collector." If you buy two solar-electric modules, you will get twice the output of one. In the same way, if you double the collector size of a wind generator, you'll roughly double the energy output.

The size of the generator (or alternator) itself does play into the power and energy output, but most modern wind generators have generators that are well matched to their rotors (blades). It would be possible to make a poorly designed match and reduce output. But assuming that you've already made a proper match, increasing the size or maximum output of a generator will not get any more energy than the wind has available.

Speed needs to be matched to the rotor and airfoil too, but faster isn't necessarily better. It's the coils' speed as they pass the magnets in the generator that is critical, so a larger diameter generator can give you the same output with lower rpm. This reduces wear and tear on the machine, and makes it much quieter.

It's not generally practical to use multiple small wind generators linked together. In many cases, the cost of a tower to get a wind generator up where it belongs is higher than the cost of the machine itself. So it's usually more economical to put one larger machine on a tall tower than to use multiple smaller machines.

I hope you've seen the comprehensive article on choosing a wind generator in HP90*. The article is available for free download on our Web site. For more technical discussion of wind generator theory, see Hugh Piggott's book,* Windpower Workshop, *and Paul Gipe's* Wind Power for Home & Business*. Regards, Ian Woofenden*
ian.woofenden@homepower.com

Writing for *Home Power* Magazine

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

Informational Content
Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough that our readers can actually use the information. Name names, and give us actual numbers, product names, and sources.

If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article.

Article Style & Length
Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible.

We prefer simple declarative sentences that are short (fewer than twenty words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power.* After you've studied a few, you will get a feeling for our style.

We edit all articles for accuracy, length, content, organization, and basic English. You can help by keeping your sentences short, simple, and to the point. Our editing crew will make your text shine.

Photographs
We can work from good photographic prints, slides, or negatives. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs, since the ink can transfer to the front of the next photo. Please provide a comprehensive caption and photo credit for each photo. Include some vertical format photos—you might even find your system on *HP's* cover. People are nice in photos; a fuse box is only so interesting, even to solar nerds.

Digital photos should be at least 280 pixels per inch (ppi) at the final printed size. This means that a column width photo should be 1,000 pixels wide or more. A full page width photo should be at least 2,300 pixels wide. Basically, set your digital camera at its highest resolution, and crop thoughtfully. We prefer Photoshop files, but we can handle the following formats in descending order of preference—EPS, TIFF, and JPEG.

Art, Schematics, & Tables
System articles must contain a schematic drawing showing all wiring. Our art department can make gorgeous diagrams, charts, and schematics from your rough sketches. If you want to submit a computer file of a schematic or other line art, please call or e-mail us first.

For system articles, we require a load table listing all loads, with wattage and run time. We also require an itemized cost table listing each system component and its cost. We prefer to have the tables come to us in Excel format. But we can use them from any word processor or spreadsheet format if they are saved as "text only," with tabs as the delimiter between data.

Computer Talk
We can take text from most word processors. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use the "Save As Text" option in your word processor.

If you want to send files larger than 5 MB (such as digital photos), use removable media and snail mail it to us. We can read ZIP disks (either Mac or IBM) and CD-ROMs. You can also FTP your large files to us at ftp.homepower.com, to the "incoming" folder. Please e-mail us after you have sent files via FTP.

Putting It All Together
We get many more articles submitted than we can print. The most useful, specific, organized, and complete get published first. Here are the basic components of a great *Home Power* article:

- Clearly written, well organized, and complete text, with a strong introductory paragraph, subheads for each major section, and a strong closing paragraph.
- Photos (plenty) with comprehensive captions.
- Cost table.
- Load table.
- Other tables, charts, and diagrams as appropriate.
- System schematic.
- Complete access information for author, installers, consultants, suppliers, and manufacturers.

Have any questions? Give us a call Monday through Friday from 9 to 5 Pacific and ask. Or send e-mail. This saves everyone's time. We hope to see your RE project in *Home Power* soon!

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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

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RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ❑ Solar power
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- ❑ Hydro power
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- ❑ Other renewable energy resource (explain)

The GRID: (check all that apply)

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____% of my total electricity is purchased from the grid.

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(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

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❏	❏	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
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