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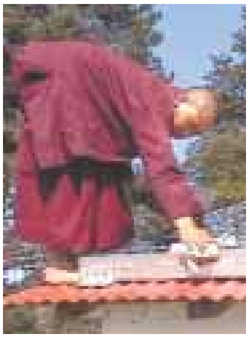
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #91 October / November 2002

Features



More Features

Things that Work!

Cover: Buddhist Monks at the Chiwong Monastery in Nepal celebrate their new PV system.

Solar Thermal

Guerrilla Solar

GoPower

Columns

More Columns

Regulars

Access and Info

Access Data

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Advertising:
Phone: 800-707-6585
or 541-512-0201 Outside USA
Fax: 541-512-0343

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Paper and Ink Data

Cover paper is Aero Gloss, a 100#, 10% recycled (postconsumer-waste), elemental chlorine-free paper, manufactured by Sappi Fine Paper.

Interior paper is Ultra LWC Glossy, a 45#, 100% postconsumer-waste, totally chlorine-free paper, manufactured by Leipa, an environmentally responsible mill based in Schwedt, Germany.

Printed using low VOC vegetable-based inks.

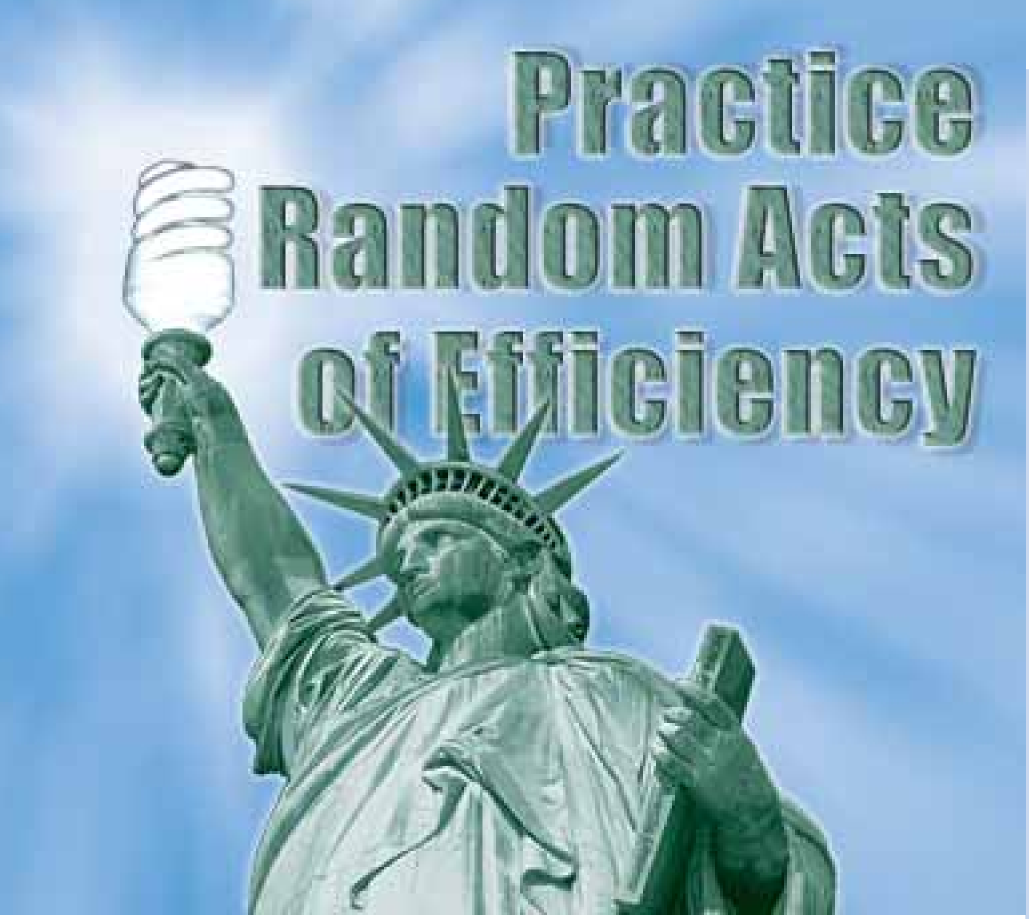
Printed by

St. Croix Press, Inc., New Richmond, WI

Legal

Home Power (ISSN 1050-2416) is published bi-monthly for $22.50 per year at PO Box 520, Ashland, OR 97520. International surface subscription for US$30. Periodicals postage paid at Ashland, OR, and at additional mailing offices. POSTMASTER send address corrections to *Home Power,* PO Box 520, Ashland, OR 97520.

Practice Random Acts of Efficiency



A motley crew of RE nerds left the Midwest RE Fair in Custer, Wisconsin this June, re-energized to spread the renewable spore. With compact fluorescent lightbulbs onboard, we initiated a new breed of guerrilla action on our way home to the West Coast.

Incandescent lightbulbs use about four times the energy of standard compact fluorescents (CFs). Because of their inefficiency, incandescent lightbulbs also produce a great deal of heat, increasing the cooling load in summer. CFs save energy and reduce pollution. If every household in the United States replaced four incandescent bulbs with compact fluorescent bulbs, it would be like removing seven million cars from circulation (www.wifocusonenergy.com).

Dining in a restaurant in the American West, the *HP* crew brought a CF in and replaced a wasteful, pollution-producing bulb with a high-tech, long lasting, and efficient CF. We left the original bulb, along with the CF packaging, so the the recipient of our efficiency gift can learn how to save energy and dollars, and reduce pollution.

Want to join the fun? See page 22 of this issue for our first efficiency guerrilla profile. It's the new wave of renewable energy activism, and we invite you to help.

Check out the new section on our Web site, with a map of efficiency guerrilla successes. We'll add yours to our Web site map when we receive reports of your guerrilla action. Let your inspiration flow as you dream up new ways to share energy efficiency with your friends, neighbors, and community.

Send your submissions to ge@homepower.com, or snail mail to *Home Power* Guerrilla Efficiency Profiles, PO Box 520, Ashland, OR 97520. Include photos and text if you want to be written up in *Home Power.*

On our Web site, you'll find a PDF of our efficiency guerrilla calling card for you to download and print. It will let the beneficiaries of your guerrilla acts know about your gift, and encourage them to take further efficiency measures.

Practice random acts of efficiency and sensible acts of conservation!

– Ian Woofenden, for the *Home Power* crew,
and for efficiency guerrillas everywhere

People

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Shari Prange
Dennis Ramsey
Benjamin Root
Connie Said
Joe Schwartz
Roy W. Tonnessen
Michael Welch
John Wiles
Dave Wilmeth
Ian Woofenden
Solar Guerrilla 0022

"Think about it…"

"I'm a vampire babe,
sucking blood from the earth

I'm a vampire babe,
I'll sell you twenty barrels worth

Good times are coming,
But they're sure coming slow"

– Neil Young, Vampire Blues, 1974

Green Hospitality

Rob Harlan

The Little River Inn implemented an aggressive energy conservation and production plan, including this 8.6 KW, utility-interactive PV system. They reduced their annual electrical bill by US$18,000.

The northern coast of California has a long, loud history of energy activism. It goes back to the successful resistance to the siting of a nuclear power plant in Point Arena in 1970, and through more recent ongoing battles to stop oil drilling off its pristine coastline. So when one of the largest inns on the Mendocino coast contacted me, looking for ways to "go solar," it was no surprise.

By California standards, the Little River Inn is an old-timer. Its original building was built around 1864 to house the elite of the lumber industry, which supplied the raw materials to build San Francisco. It sits on 225 acres overlooking the rugged Pacific coastline, and is a favorite spot for visitors from all over the world.

While many California lodging facilities were responding to the "energy crisis" by adding an "energy surcharge" to the cost of their rooms, the Little River Inn chose instead to try to reduce its overall energy consumption by 20 percent. The goal was to mitigate the impact of the inevitable rate increases, and to educate their many visitors through a program they could be proud of.

After meeting with Larry Miller, the inn's head of maintenance, I felt confident that they could do it. The inn had owners, managers, and a maintenance staff who were all philosophically committed to the project. They had a large monthly utility bill—US$5,500—which provided them with great investment payback possibilities. They had eleven separate utility meters, some of which were good candidates for time-of-use metering.

Although they had already instituted a number of load reduction measures, major opportunities for energy conservation and appliance efficiency upgrades remained. An environmentally conscious image could increase business. There were many possible applications for solar hot water systems. They also had several 100 percent solar access sites within reach of utility meters.

Staff Support

A staff meeting was called to discuss the energy situation. Each person was asked ahead of time to bring three ideas to reduce energy usage. Head of maintenance, Larry Miller, who they dubbed the "energy czar," enthusiastically reported that "it was an energetic meeting!"

The maintenance staff began a program of acknowledging staff's energy-saving behavior. Each month, the energy czar bestowed the "Golden Light Globe" award upon the department with the most laudable energy reduction accomplishments. Any department dragging its feet got the dreaded "Black Globe" award. All awards are impressive spray painted sculptures crafted from obsolete incandescent bulbs.

A US$60 award was set aside every two weeks for a two-month period to give to the member of the housekeeping staff who most consistently turned off room lights, turned down thermostats to 60°F (16°C), and switched off refrigerators in each room. Through these programs, the entire 125 member staff became aware of the energy program, and was encouraged to cooperate.

Lighting

The Little River Inn began switching to more efficient lighting ten years ago. At present, 100 percent of the exterior lighting is compact fluorescent or high-pressure sodium vapor. And 85 percent of interior lights are compact fluorescent bulbs or highly efficient T-8 fluorescent tubes. The last 15 percent are lights on dimmer switches or spotlights in very demanding applications. Even these holdouts will eventually have more efficient bulbs.

Larry is constantly trying out new types of compact fluorescents as they come onto the market. These bulbs are now available in a variety of physical shapes, sizes, and intensity, as well as color hues (called Kelvin ratings, from warm to cool). Larry reports that there have been zero guest complaints about lighting levels or quality. He says, "I guarantee you that if it had been an issue, we would have heard about it." A walk through this elegant inn reveals that fluorescent lighting can indeed look great.

The maintenance staff discovered another advantage of the compact fluorescent bulbs—they last significantly longer. In a facility with more than one thousand lightbulbs, there is a noticeable reduction in bulb changing time. The date of installation is marked with a felt tip pen on each bulb. This will give the maintenance crew information about which manufacturers are producing the most durable products.

Larry Miller holding the prized "Golden Light Globe" and the dreaded "Black Globe" awards.

The Inn changed their standard T-12 fluorescent lights to T-8 fluorescent bulbs. They use 20 percent less electricity while providing 25 percent more light. T-8 bulbs also have reduced mercury levels. (They are not classified as hazardous waste in most states, as standard T-12 bulbs are.) T-8 bulbs cost a little more, and when retrofitted require a one-time US$23 ballast replacement. Maintenance Warehouse sells Sylvania Octron T-8 tubes in a choice of Kelvin ratings from warm to cool.

All exit light fixtures were retrofitted with 25-year-life LED lights. The US$15 retrofit kit by Area Lighting Research, Inc. replaces the original two, 15 to 20 watt incandescent bulbs with LED bulbs that draw a total of only 1.8 watts. The cost savings of LED retrofits in this application are phenomenal, especially when the labor costs of standard bulb replacements are factored in.

“Solar tube” skylights reduced lighting loads at the inn.

A very popular aspect of the lighting program is the ongoing replacement of lights with “solar tube” skylights. These are small, bright skylights, which can be retrofitted between rafters to shoot light into a room. They are particularly well suited to task lighting applications, such as desks or cash registers where the full spectrum natural light is really appreciated.

A number of brands of these skylights are now available. Some have rigid reflective shafts, while others come with bendable reflective shafts that can be worked down two stories if necessary. The Little River Inn experimented with some that include backup lightbulbs, but found that no one ever turned on the bulbs.

Most exterior lights at the inn are now on timers or photocells to ensure that they are not left on during the day. Lights in public bathrooms have been put on occupancy sensors. The inn management also decided to reduce the number of outside lights used to advertise the facility at night.

Laundry

To reduce the amount of water and fuel used in laundry operations, a no-laundry option is now provided to guests. The ecological impacts of the hotel industry practice of changing sheets and towels every night is explained. This program is entirely voluntary.

Inn records to date show a 20 percent participation in this program. This is below participation levels reported by linen and towel reuse programs at other hotels. *The Innkeepers Guide For Dealing with the Energy Crisis* reports participation levels of 70 percent. At a recent meeting of the housekeeping staff, it was determined that guests were often not understanding the program. A nice looking, custom made, laminated sign will be made up for each bathroom to back up the verbal explanation that guests are given.

Refrigeration

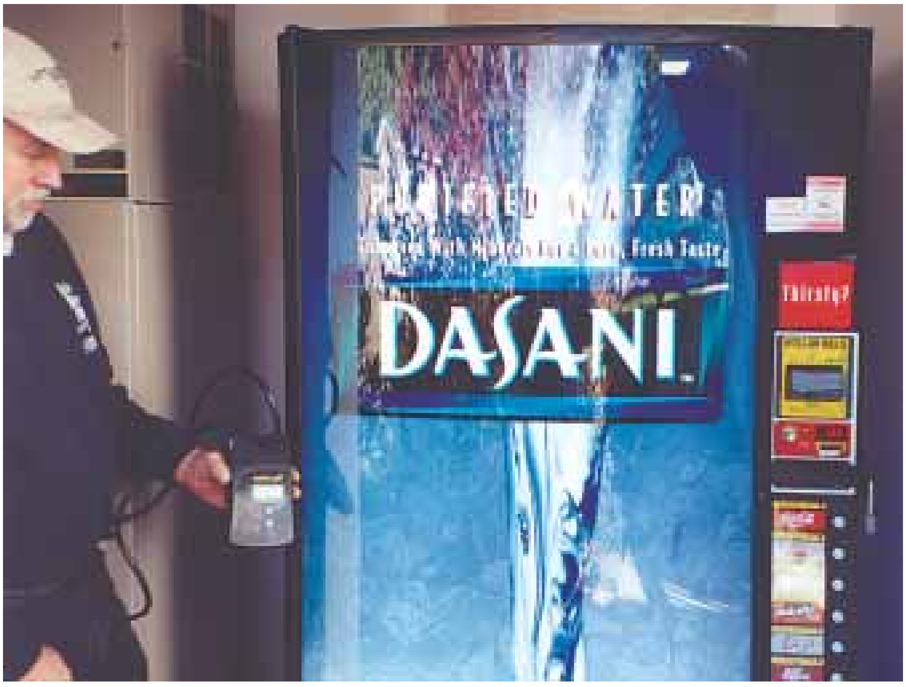
The Little River Inn provides a small refrigerator in each of its 65 rooms. The housekeeping staff is now instructed to turn off all room refrigerators after guests check out. Simple written instructions are provided to guests on how to turn their refrigerator on if needed. Records show that half of the guests chose not to use the refrigerator in their room.

All of the room refrigerators as well as the kitchen refrigeration systems had their coils cleaned to increase efficiency. Refrigeration temperatures were monitored and thermostats raised where appropriate.

The Treasure Hunt

The maintenance department purchased a watt-hour meter, and the hunt for phantom loads began. One surprising discovery was that each soft drink machine consumes 9.7 kilowatt-hours per day. This translates into an energy cost, per soda pop machine, of at least US$744 per year at current energy prices. Three of these soda machines are actually consuming more than the output of the entire

Thirsty? This pop machine is thirsty for electricity—9.7 KWH per day and US$744 per year. Is it worth it?



Little River Inn solar-electric system! These machines are outside. The testing was performed during winter with an ambient temperature of 60°F (16°C). We expect summer consumption levels to be greater. Because of the popularity of the pop machines, the inn is not yet sure what to do with these monsters.

At this point, the phantom and always-on loads in each room are limited to the following 24 hour consumers: one clock at 3 watts, one TV/VCR with surge protector at 11 watts, one smoke detector at 8.5 watts, and one GFI outlet at 0.5 watts. The total draw of these devices is probably less of an ongoing load than many hotel rooms have, yet it still represents more than US$2,640 in annual costs in the facility's 65 guest rooms.

All four of these devices are considered necessary for each room. The maintenance staff has been working on a tasteful looking toggle switch that can be mounted near the TV/VCR switch, which would be turned off as part of the room cleaning process. I tested four brands of GFCI outlets and the best, Pass and Seymour brands, drew a constant 0.48 watts.

The phantom load of this TV/VCR setup was measured at 11 watts. A switch on each unit is planned.

Renewable Energy

You can save a lot of kilowatt-hours through conservation and investments in efficient appliances. But there comes a time when you choose to produce some of your own energy. The Little River Inn is proud of its solar-electric system. It has printed up a handout to provide to guests, which not only explains the system—it encourages visitors to try it out on their own homes.

For utility-intertie systems, a decision has to be made early in the design process regarding batteries. The only compelling advantage of a battery-based system is the blackout protection that it provides. Batteryless systems are less expensive, more efficient, simpler, safer, have less ongoing maintenance, less depreciation, and are more environmentally benign. The Little River Inn already has a backup generator in place, so the decision to skip the batteries was an easy one.

California permits time-of-use metering on intertied solar-electric systems. This can be a powerful tool in the battle to make photovoltaics cost effective. In the case of the Little River Inn, we had a number of utility meters to choose from for a utility intertie. During peak demand periods (May 1 through October 31, Monday through Friday, noon to 6 PM) the rooms are often unoccupied.

This corresponds with a period of high solar output, so we chose a meter that serviced guest rooms instead of the kitchen or the golf course store. We also chose a service panel with a nearby 100 percent solar access site. The site does not obstruct anybody's view of the ocean, and yet it is visible to guests. The management wanted to proudly display not only the array of solar modules, but also the kilowatt-hour meters.

This smoke detector's power draw was measured at 8.5 watts.

The 8.6 KW PV array has 100 percent solar access.

Larry Miller dialing in the PV summer angle.

System Components

Top-of-pole racks were chosen because they are good looking and easily adjustable. The maintenance staff will be adjusting the array angle twice a year. Direct Power and Water racks were the mount of choice because, in our experience, they manufacture the sturdiest top-of-pole racks for large arrays. We found that we had to add paint to the steel components of these racks to control rust in this coastal climate.

As a rule, we design 8 inches (20 cm) of pole length below grade for every 12 inches (30 cm) above grade. The 10 foot (3 m) poles stick out of the ground 6 feet (1.8 m), and have 4 feet (1.2 m) buried in a 24 inch (60 cm) diameter cylinder of concrete. We lined up the poles by setting up strings. As we suspended each pole with a backhoe, we filled in the bottom of the hole with pea gravel to obtain consistency in pole heights before bracing the poles in place for the final concrete pour.

It is very tricky to make these large racks look good when they are this close together. A slightly out of plumb pole or a poorly welded or machined rack can lead to visual chaos. We worked for quite a while to get them looking as good as they do. This included shimming the rack sleeves and redrilling a few holes in rack angle supports. Siting the racks farther apart from each other would be more aesthetically forgiving.

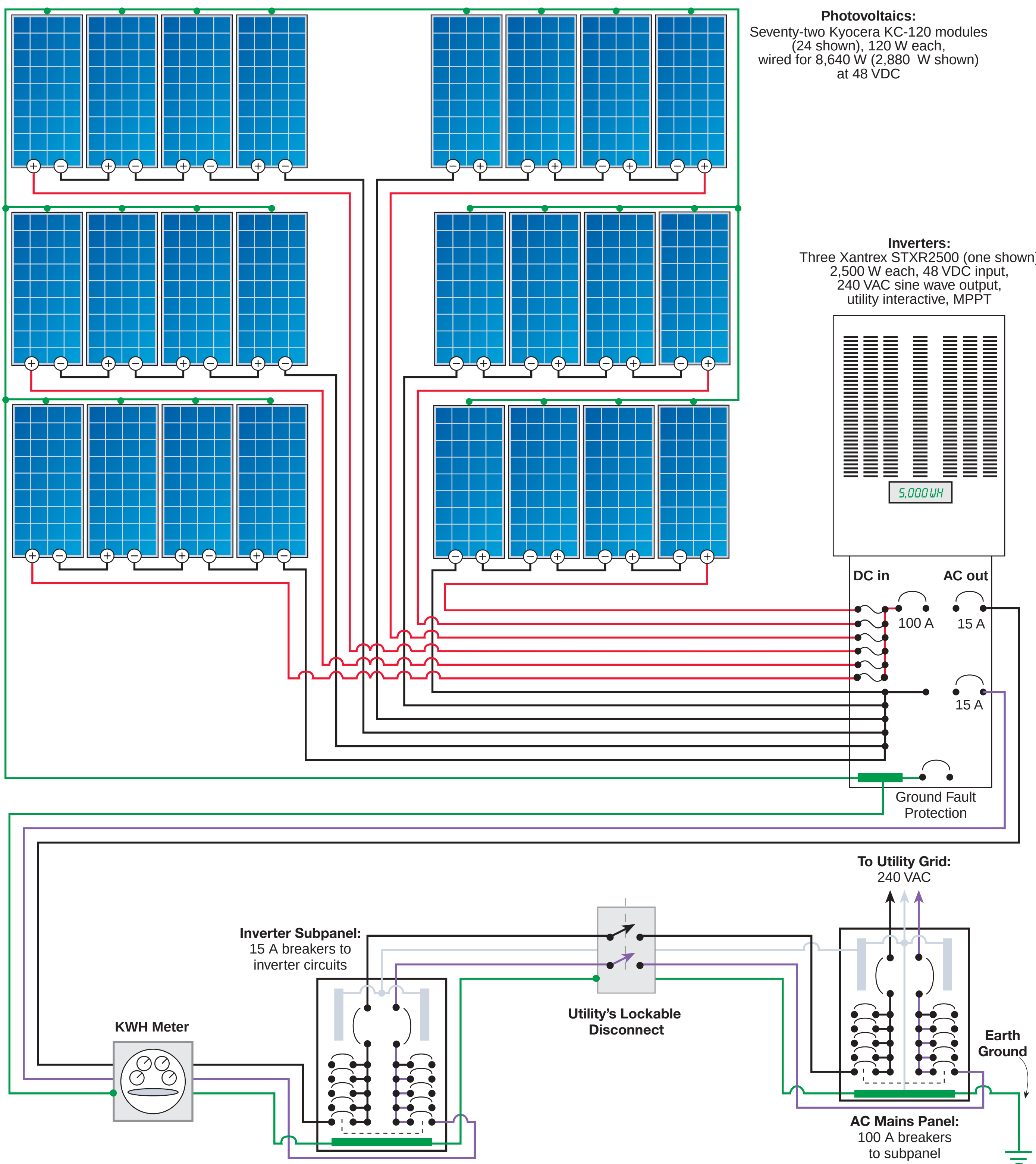
Kyocera KC-120 modules were chosen because we wanted large building blocks. Polycrystalline panels were also considered to be the most aesthetic choice in this case. There are 72 modules, with a dozen on each of six, top-of-pole mounts, for a total of 8,640 peak rated watts.

We had some trepidation about using the Trace Sun Tie inverters because of some inadvertent beta testing we had done with earlier versions of the Sun Tie at another site. Two months into operation at the Little River Inn, two of the three units appeared to be performing fine. The third was observed to periodically shut down in full sunlight, causing it to produce 90 percent of the daily output of either of the other two.

An advantage of a system with multiple, identical units operating under identical conditions is that any malfunctioning components can be easily identified. After some tests, we found that the underperforming

Three Xantrex Sun Tie XR inverters pump green electricity into the utility grid.

Little River Inn's Utility-Interactive PV System



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

inverter was consistently reading utility voltage 2.5 volts higher than the readings on a Fluke 87 multimeter. When it falsely read utility voltage to be above its acceptable window, it would shut down and wait five minutes before restarting. Xantrex acknowledged that its ST inverter calibrations have not always been accurate, and agreed to send a replacement inverter.

Little River Inn System Cost Analysis

Item	*Amount (US$)*
8.64 KW grid intertie system, total installed cost	$66,238
California Energy Commission rebate $4.50/W x 72 modules x 105.7 W x 0.94 inverter efficiency	-32,192
Federal 10% business investment tax credit ($66,238 - $32,192) x 0.10	-3,406
15% California state tax credit ($66,238 - $32,192 - $3,406) x 0.15	-4,596
Fed. 5 yr. accel. depreciation savings @ 34% tax rate ($66,238 - $32,192 - ($3,406 ÷ 2)) x 0.34	-10,997
California state depreciation savings @ 6.5% tax rate ($66,238 - $32,192 - 4,596) x 0.065	-1,913
Net cost	$13,134

Simple Payback

Recorded system production levels	7,200 KWH/year
Present cost of electricity	$0.21/KWH
Payback at present cost $13,134 ÷ (7,200 x $0.21)	8.7 years
Projected cost assuming 50% increase	$0.32/KWH
Payback at projected cost $13,134 ÷ (7,200 x $0.32)	5.7 years
Simple payback, not considering TOU benefits	5.7 to 8.7 years

The replacement inverter was indeed calibrated better, and did not shut down at higher utility voltage levels. Three months later, we experienced a permanent shutdown of this inverter. Xantrex, with the help of Schott Applied Power, agreed to replace all three ST inverters with their new XR series. So far, the XRs have been trouble free. As of press time, we do not yet have comparative production data. But the XRs are much more consistent in their maximum power point tracking, which will probably translate into higher production levels. They are also quieter than the STs.

Keeping Track

A dedicated KWH meter measuring PV system output is a standard item in all of our installations. The meter not only provides the owner with an easy way to monitor cumulative system production, but also helps us generate real-world system performance data for the various microclimates in our service area.

Schott Applied Power sells both 120 and 240 VAC KWH meters refurbished by the Hialeah Meter Company for under US$75. We mark the installation date on the meter after we install it in a system, and pick up readings from each meter when we are in the area.

This system also has a bidirectional, commercial time-of-use meter. This must be a rare item in Pacific Gas and Electric's territory because it took them three months to install it. Five months after the installation, the inn has still not received a utility bill for that particular meter.

The average output of the Little River Inn solar-electric system has been 600 KWH per month during its first year of operation. We are happy with this production, given the proximity of the system to the ocean (500 feet; 150 m away). This is a foggy summer and rainy winter part of California.

In full sun, with an ambient air temperature of 75°F (24°C), system output is 82.5 watts per 120 watt module, or 69 percent. This corresponds with data collected from other batteryless systems we've installed. In our experience, actual system output for batteryless PV systems is typically 65 to 70 percent of the "standard test conditions" (STC) rating on the module nameplate. This is significantly lower than the "PVUSA test conditions" (PTC) numbers used by the California Energy Commission in its Emerging Renewables Buydown Program. The CEC predicted a performance of 82.8 percent of STC for this module and inverter combination.

Each inverter has a KWH meter to keep track of the system's energy production.

Little River Inn System Costs

Item	*Costs (US$)*
72 Kyocera KC120-1 120 W modules	$37,152
3 Xantrex STXR 2500 inverters	6,600
Labor	6,132
6 Direct Power & Water top-of-pole mounts	5,880
California state sales tax	3,922
Concrete, rock, & gravel	1,167
Shed materials	1,038
Shipping	870
6 pipes, 10 ft. x 6 in. galv. steel sch. 40	840
Commercial, bidirectional TOU meter	443
Wire	322
Square D DU323RB lockable disconnect	320
Backhoe work	300
Conduit & fittings	287
Building permit	265
Circuit breakers, junction boxes, etc.	260
3 KWH meters, including bases	225
Equipment rental	215
Total	$66,238

The Little River Inn energy program has been very successful, and represents a model for the hotel industry. The entire facility's monthly energy consumption is 85 percent of what it was a year ago. This represents savings of 86,000 kilowatt-hours or US$18,000 per year.

Their efforts also qualified four of their meters for the California 20/20 program. This is a program introduced during the California "energy crisis" that rewarded customers who consumed 20 percent less electricity than used the same month a year ago. Total 20/20 program rewards were US$1,441 for the inn. The facility also received US$1,043 in utility rebates for its installation of T-8 fluorescent tubes, LED, and compact fluorescent lighting; occupancy sensors; photocells; and timers.

Investment in Renewable Energy

I generally do projects either for clients who want to use solar electricity because they are too far away from utility lines, or for clients who chose to because of a deep environmental commitment. It is satisfying to install a system that also pencils out in terms of cost. The simple payback for the Little River Inn photovoltaic system is projected to be between 5.7 and 8.7 years. (See cost analysis table.)

This payback does not factor in the time-of-use metering, which we have not been able to quantify yet. The commercial time-of-use schedule is quite complex. It contains peak, partial peak, and off-peak periods during varying times of the day, and this changes from summer to winter. The schedule also changes on weekends and holidays. We believe that time-of-use metering is advantageous for the inn because we often observe the meter running backwards during peak periods.

Future plans for the Little River Inn include at least one more 10 kilowatt utility-intertie system to be installed on a meter dedicated to another set of rooms. Several drainback solar hot water systems are planned to service domestic hot water and spa requirements. A microhydro installation is in the works to harvest some of the energy in a 3 inch, 100 psi water pipe that gravity feeds into a pond on the golf course.

There are also plans to set aside several rooms as "green rooms." These would specifically demonstrate energy and resource conserving technologies, and have their own solar-electric and solar hot water systems. The inn's commitment to energy efficiency and renewable energy is a model for other visitor lodging facilities in California and beyond.

Access

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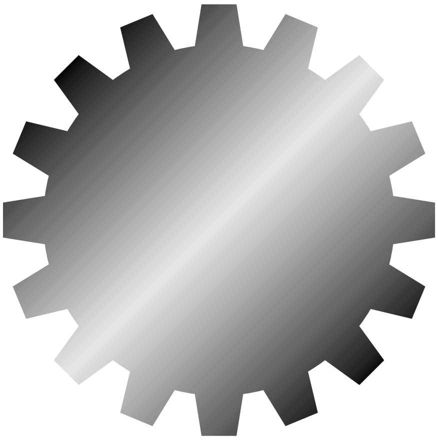

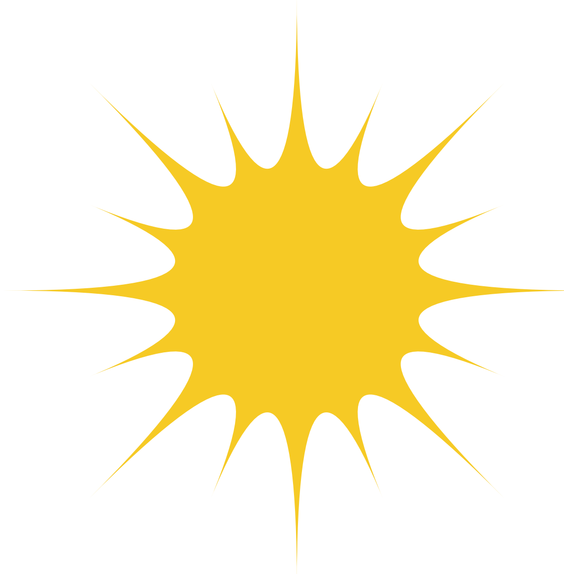

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Guerrilla Efficiency:

Fearless in Fargo

Joe Schwartz

Driving across the U.S. at night and seeing the amount of energy Americans consume to light up their lives can be mind boggling. Whole hillsides and valleys are ablaze at 2 AM. We light up unpopulated front yards and empty parking lots. We light up the sky until we obscure the stars. And most of this lighting is inefficient, incandescent technology that hasn't changed much in more than a century.

Road Trip

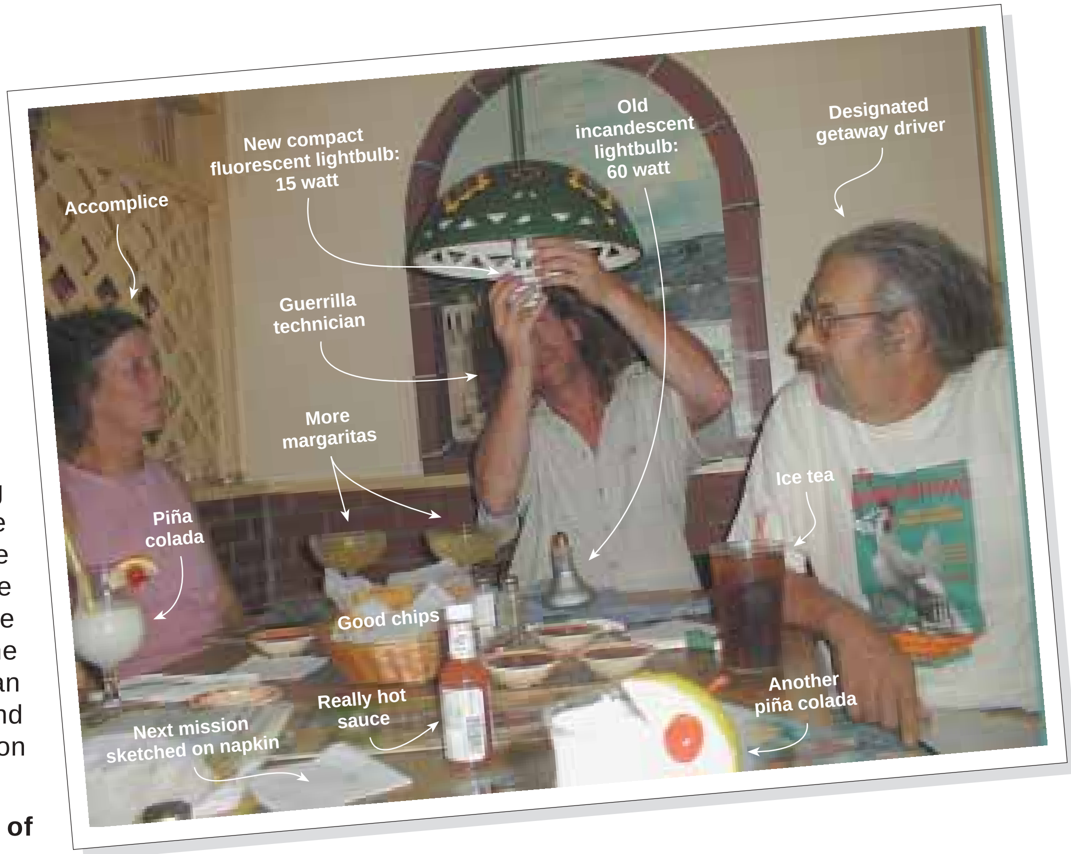
For the last thirteen years, the *Home Power* crew has traveled from Oregon to central Wisconsin for the Renewable Energy and Sustainable Living Fair. Our route takes us through Fargo, North Dakota where, being creatures of habit, we stop every year to grub down at the Mexican Village restaurant. We always have big appetites for Mexican food and margaritas. But this year, we weren't only hungry, we had an agenda.

Our plan was to simply swap out the incandescent lighting at our dinner table. Being the generous guy that he is, Don Kulha, *Home Power's* CD-ROM and video nerd, kicked down a compact fluorescent (CF) bulb he picked up at the fair. The CF was made in China, and we were eating Mexican, but we eventually laughed our way through this dilemma and got down to business.

Fun with Efficiency

How many efficiency freaks does it take to screw in a lightbulb? Well, on this occasion it took seven. While the waitress was helping out some hungry looking Fargo folk at another table, we popped out a glaring, 60 watt

Practice random acts of efficiency and sensible acts of conservation

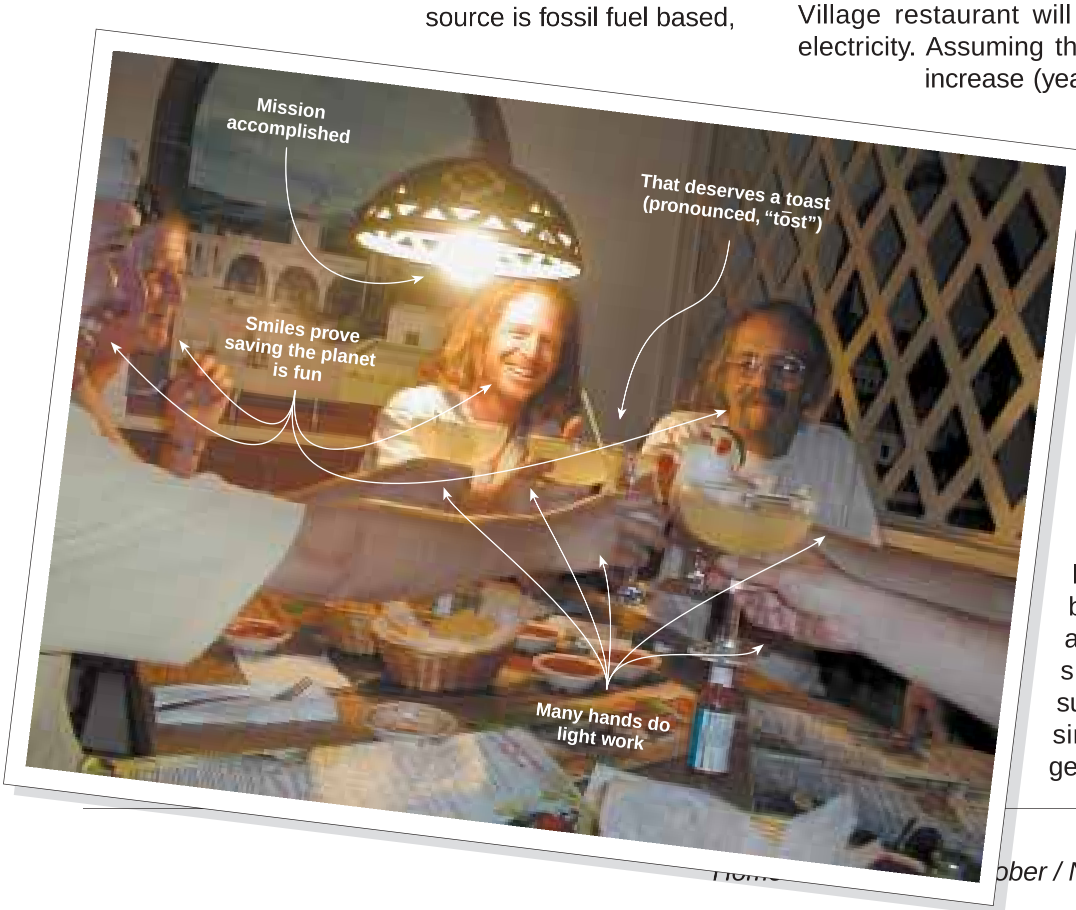


incandescent bulb and replaced it with a 15 watt compact fluorescent. We toasted our hard work with another round of margaritas, and several rounds of laughter.

We wanted to get our friends at the Mexican Village connected with a new lighting technology that will save them some bucks down the road. So we packaged up the old incandescent bulb in the box from the CF. We left the box on the table so they can check out the energy and money savings information printed on the box.

All the Light—A Quarter of the Energy

The Mexican Village restaurant is open seven days a week, for a total of 85 business hours per week. The single, 60 watt incandescent bulb at our dinner table consumed about 265 KWHs each year. Replacing this bulb with a 15 watt compact fluorescent of the same light intensity (lumens) will reduce this annual KWH figure to 66 KWH per year—a 75 percent reduction in energy use. If the energy source is fossil fuel based, a quarter of the energy means a quarter of the pollution. In this case, the use of a single compact fluorescent lightbulb will result in a 436 pound (198 kg) reduction in CO^2 emissions every year.



In terms of dollars and cents, there’s big savings too. The cost of electricity in Fargo averages about US$0.05 per KWH (there’s coal aplenty in these parts). By replacing a single incandescent lightbulb, the Mexican Village restaurant will save about US$10 a year in electricity. Assuming that the costs of electricity don’t increase (yeah, right), our guerrilla efficiency move will save the Mexican Village restaurant US$70 over the seven year operational life of the CF bulb.

And remember, this is just one lightbulb at one table! Mexican Village has about forty tables. If one incandescent bulb over each table was replaced (some of the fixtures had six bulbs) the restaurant would save US$2,800 over the seven-year life of the CFs, and there would be 61 tons less CO^2 in the atmosphere. They would also substantially reduce their summertime air conditioning bills since incandescent bulbs generate more heat than light.

Efficiency Works

The effect of strong conservation efforts can be astounding. While Enron was busy creating an energy crisis in California, Californians were busy conserving. In a matter of months, Californians reduced the state's electrical demand by somewhere between 15 and 20 percent through conservation measures alone. Increased public awareness of energy efficient technologies made this huge reduction possible.

Our guerrilla efficiency effort in Fargo will save our friends some bucks and result in a little less pollution, and it provided us with some great dinner time conversation. But more important, it helped familiarize people with efficient technologies. Even if some men in high places think that conservation is a sign of personal virtue and not a basis for a sound energy policy, we're all for making it happen anyway, one table at a time.

Many hands make light work. Are you into lending a hand? Send your guerrilla efficiency stories to ge@homepower.com, or snail mail to *Home Power* Guerrilla Efficiency Profiles, PO Box 520, Ashland, OR 97520. If you include photos, you just might find your story published in *Home Power.*

Access

Joe Schwartz, *Home Power,* PO Box 520, Ashland, OR 97520 • 541-512-0201 • joe.schwartz@homepower.com

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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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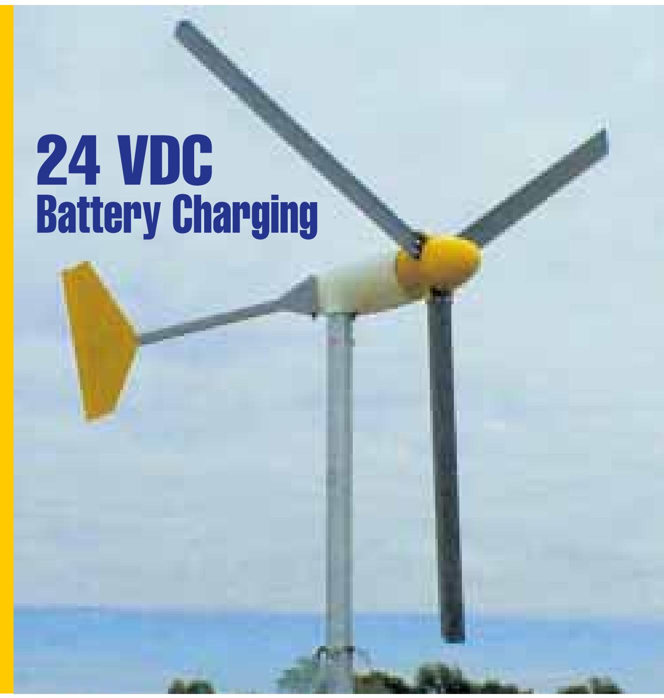

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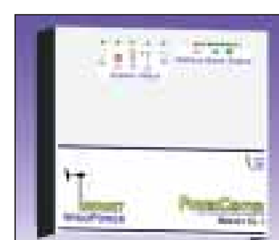

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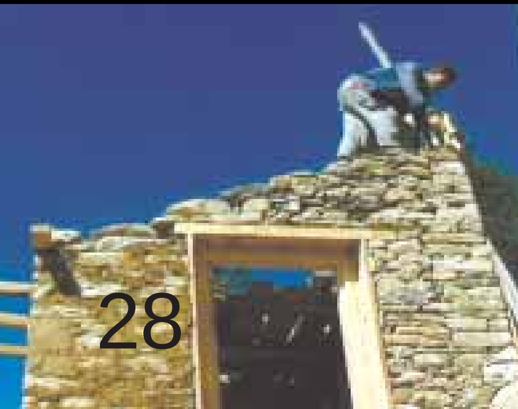


Sun Horse

PV Lighting in a Nepalese Monastery

Dennis Ramsey

Chiwong Monastery was built in 1923, and is the primary religious institution for a large Buddhist community in the shadow of Mt. Everest. In October 1999, Renewable Energy Development International (REDI) installed a PV system and 108 lights in the large compound. With a crew of fifteen electricians, masons, and laborers, we finished the work in the three weeks leading up to the full moon.

The number 108 is the most auspicious number possible to Buddhists, because the texts indicate that Lord Buddha has 108 incarnations at work in the material world. It was pure happenstance that the final number of lights required for the complex equaled 108. Interestingly, the array size is one horsepower, and prayer flags here are known as wind horses. Thus the title "Sun Horse." We began the long design process for the Chiwong Monastery project by looking at the monastery's need for light, and their community's ability to provide support.

Social Impact

Sherpas are a Tibetan ethnic group who inhabit the high altitude regions near the highest mountain on earth. The social structure of the Sherpas has changed dramatically since about 1955, when Nepal's tourism and mountaineering industries began. This has brought wealth to the community. But unfortunately, the beneficiaries usually move to Kathmandu where they have access to amenities such as telephone, fax, Internet, electricity, and better schools for their children. Their social and financial contributions to their home communities have been nullified, and this leaves the poor and the old behind to tend the remnants of Sherpa culture.

The primary reason for installing solar-electric light in Chiwong monastery was to improve public health in this bastion of religious learning. Next to intestinal parasitic diseases, the second most dramatic class of illness is caused by burning kerosene for lighting in closed rooms. The incidence of respiratory ailments, ulcers, and eyestrain is quite high.

Research among the monks and nuns here reveals that they collectively burn about 90 liters of kerosene per month, at a cost of about US$1,000 per year. Over the projected life of the solar-electric system, they can avoid the adverse health and environmental impacts of burning 36,000 liters of kerosene, and will have saved US$30,000. This is one-third more (US$10,000) than the cost of system installation.

The social impact of this change in living standards at the area's primary religious institution will make it a more attractive destination for young people seeking education and social betterment. The monks themselves often speak of the modern amenities of Kathmandu, particularly electricity, and of how much harder life is in the mountains.

A small amount of electricity can make a huge difference in living standards. In the 18 months since this system was installed, the residents have noticed that they inhabit more of their own space. They can read anytime and anywhere, the cooks can better see the food they prepare, no one stumbles on the way to the outhouse at night, and the ceremonies are smoother and more precise because the monks can see their texts clearly. One of the nuns informed me that it is also keeping outsiders honest. If someone comes in the night who shouldn't be there, they can now be seen. The dogs bark much less with fewer mysterious visitors.

It is the improvement in the ability to see and to read, and the removal of burning hydrocarbons that do the most to improve the personal environment. Every aspect of life is affected: education levels, food quality, public health, social intercourse, community pride, and ultimately, out-migration. In addition, the cash that was previously spent on kerosene is available for other needs.

System Planning

Planning for this installation was rather involved, because several specific issues had to be addressed. My main concerns were to create a system that answered its users' needs for simplicity, invisibility, low maintenance, limited local expertise, and adequate electricity supply.

My survey of the monastery complex indicated they needed about 100 lights in a mixture of public spaces and 24 private residences, spread across 4 acres of hillside. Because the general public, who are not users of electricity, find the bulbs and switches so fascinating, we had to devise a method of avoiding "curiosity damage."

Tamper-proof outdoor fixtures were chosen for all public locations where lights were within reach. For public areas where the fixtures were high and quite visible, we selected tasteful and refined globes. All switches for the public lights, as well as all breakers for separate wire runs, are in locked boxes so that only authorized monks have access.

The greatest concern was that the system be safe, particularly from fire. It would be tragic if, in this attempt to bolster cultural survival, we inadvertently destroyed this repository of history and community. We chose to build a stand-alone powerhouse, which allowed us to avoid mounting any equipment on or in the monastery buildings. We also provided two industrial fire extinguishers, one in the powerhouse and one in the main building.

I wanted this system to be as unobtrusive as possible. I have seen a gorgeous community marred by a tastelessly installed satellite dish someone thought to donate. And electrical wiring, carelessly strung and dangerously low, is the norm everywhere a small local grid is located. My





resolution was to "hide" the solar array, bury all the transmission wiring in conduit, and string all indoor lines above the ceilings, so that nothing would be visible.

I felt that it was important to respect the original ambience. In only two cases did we need to run a line as an overhead, because trenching through the jungle was impossible. Those two overheads were disguised with Tibetan prayer flags, which are a common feature here. No one notices that these two lines of flags are actually electrical cable until we mention it.

Nontechnical Users

Another very important issue to address was that the users are unsophisticated about electricity. They don't distinguish between voltages, AC or DC. It's a common occurrence in this region for someone to try to plug an incompatible device, such as a 12 VDC motor, into a 220 VAC receptacle. If the plug doesn't fit, it gets cut off, and the stripped wires are jammed into the receptacle.

The solution was to install a closed system, without receptacles for plugging in appliances, TVs, etc. But then the question was what to do about freelance splicing into the distribution wiring, or the possibility that a smart individual will go to the bazaar and buy an adapter for the bulb socket? Solving this problem was a little more involved.

In every private space, a locked J-box with a 0.5 amp breaker was installed at the point where the wiring leaves the conduit and enters the home. In a 220 volt system, this gives each individual about 110 watts of supply. This is more than adequate to operate three, 15 watt compact fluorescent (CF) bulbs, and allows for ballast surges.

If for any reason the load goes above this small amount, the breaker trips. The monastery's Lama must be called to reset it, and to investigate. Honesty is highly valued here, but some mechanism must protect against the occasional misuse. Small individual breakers ensure an equitable distribution of electricity to all users. This strategy ensures long life, equal availability, and obviates conflict over use of the resource.

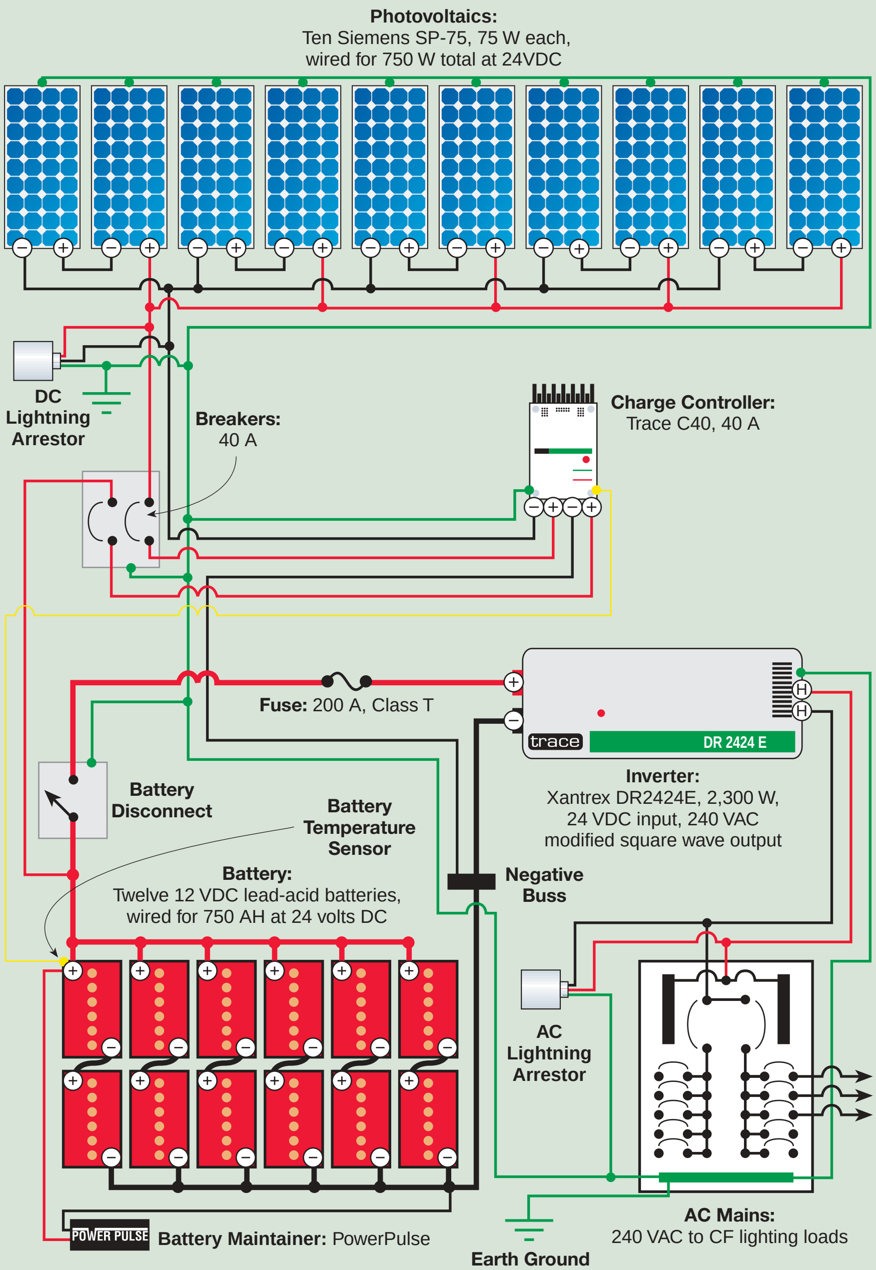
We chose modern compact fluorescent bulbs for the installation because they provide good luminance and spectrum at 25 percent of the energy consumption of incandescent bulbs. They dramatically lowered our overall system size and costs.

A further concern was that it would be quite easy for individuals to go to the bazaar and buy standard Indian incandescent bulbs for use in their fixtures. Even a small, 60 watt bulb from the bazaar would pull four times the specified 15 watt CF bulb load. If quite a few of these bulbs were used, the load would be unacceptable.

A simple solution was to use standard U.S. type, screw-base, pull-chain fixtures. The integral switch avoided the extra wire runs for wall switches. And the much-feared local incandescent bulbs have Indian-style bayonet bases, and won't fit in a screw-base fixture.

The issue of screw-base bulb supply in this Indian-dominated market would be a problem if not for the fact that the Chinese domestic market uses U.S. standard screw-base fixtures, at 220 volts. In addition, they make a large variety of modern CF bulbs, so we were able to order bulbs from the Chinese traders at the border crossing with Tibet, at US$1 each. Quality control is poor, as you might imagine, but 65 percent of them work as they should.

Chiwong's PV Lighting System



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

The CF bulbs are a mix of wattages ranging from 9 to 15 watts. We noticed that the users really like the 15 watt bulbs, and since they have enough energy, that's what they use. The lights are never all on at once, and the average nightly peak load in festival season is about 40 amps at 24 VDC, which is about 960 watts of lighting, or about 65 bulbs on at once. Their nonfestival nightly load averages about 375 watts of lighting (25 lights) for three to four hours.

The community here uses quite a few small batteries for flashlights and radios. When these are exhausted, they are often thrown on the ground. Along the margins of many communities, batteries are even found amongst the crops. To help stop this low-level pollution, we installed two Saitec smart chargers in the kitchen pantry, and provided 100 each of D and AA NiCd cells. One of the most purchased items here, after kerosene and food, are batteries for flashlights and radios. This money can now be saved.

Let the Games Begin

The staging of the installation took place during the three weeks of preparations at the monastery for their annual masked dance festival. The Mani Rimdu is performed each fall in all of the major monasteries in this region. It is a medieval morality play about the struggle of Buddhism over the earlier Bon religion of Tibet. Their replaying of these events each year reasserts their bond with the ancestors.

Because the Sherpas arrived here from Tibet more than 400 years ago, theirs is an early and orthodox form of the religion. The dance expresses what was recent Tibetan history at the time of their migration to the southern slopes of Mt. Everest. Our own choreography began by discussing with the monks and nuns where the lights were to be placed, assembling the workers, deciding where the trenches would be dug, and building the powerhouse.

Local boys were quite willing and capable of digging trenches all day long, and were generally cheerful to have around. A joint Nepali/Swiss hydroelectric utility some kilometers away allowed me to hire seven of their electricians to lay the wire and set the fixtures. They were very experienced, and needed only basic instruction in how I wanted it done.

I brought along a set of tools for each electrician who worked on this job, since they can’t get and can’t afford the right tools locally. When the job was done, they got to keep their set. The tools were: wire stripper, multi-tip screw driver, razor knife, linesman pliers, two rolls of Scotch T-40 electrical tape, and a pocketful of wire nuts.

All of our equipment came by truck from Kathmandu to Jiri. We then hired fifty porters to carry the entire lot for four days to deliver it to the monastery. This amounted to 200 person-days of wages injected into the local economy. The alternative was a 45 minute cargo helicopter trip from Kathmandu, and the cost would have been almost exactly the same. However, the money would have gone into the pockets of the private transport company.

Powerhouse & Control Center

I contracted a group of Tamang tribal masons from a lower village to build a 9 by 9 foot (2.7 x 2.7 m) stone powerhouse with a south-facing corrugated roof at a slope of 5 degrees greater than the latitude. They were able to put the little house up in five days because we had the stone delivered in the weeks before.

We chose a site on an unused portion of the extreme north end of the compound. The solar exposure is excellent, and the array is almost unnoticeable. One day last November, I clocked the sun at 13 cloudless hours, for a total input of 230 amp-hours at 24 VDC nominal, or about 6 KWH. The altitude is 11,000 feet (3,350 m), and it’s cool and breezy, so the energy production is often above rated array output.

Rather than buy and import a preassembled power control center, we built ours on the spot from components. I chose a Trace C40 controller with digital metering and battery temperature sensor, combined with a Trace DR2424E (24 VDC input, 240 VAC, 50 Hz output) inverter. Since there is no intention to ever run anything but lighting from this system, this modified square wave inverter does the job at reasonable cost.

Both the controller and the inverter are oversized for the load and input, so the monastery has the ability to easily expand their system at a later date.

Chiwong Monastery System Costs

Item	*Cost (US$)*
10 Siemens SP-75 modules, 75 W	$5,940
Wire, conduit, & misc. equipment	2,729
Transport & portage	2,300
12 Volta batteries, 12 V, 120 AH	1,950
Labor	1,500
Contingencies	1,500
Trace DR2424E inverter	1,450
Lights and fixtures	1,350
Powerhouse	900
Trace C40 controller	250
400 A battery disconnect	185
Tools for electricians	140
Fire extinguishers	130
Lightning arrestors	90
Class T fuse block with fuses	86
Power poles	80
Square D breakers	50
GFDI (surplus)	40
Total	$20,670

Although I don't feel that Trace products are the best choice, I used them because Lotus Energy, the local dealer in Kathmandu, handles nothing else of comparable size, guarantees these products for two years, and provides good service after warranty.

In the nearby township, I had a carpenter build two airtight boxes—one for the control center and one for the batteries. We drilled and vented them both for air flow. The control center was assembled and mounted to the powerhouse wall, and the transmission lines were brought in via steel conduit, through the flagstone floor. All was done to U.S. code standards.

Mounting the array of ten Siemens SP75s was nearly a disaster, but we had to have at least one scary moment, after all. After assembling and wiring the array while it leaned against the powerhouse wall, eight people of various dialects had to delicately move it 20 feet (6 m) along a ledge, turn it 90 degrees without breaking it, and heft it onto a 7 foot (2.1 m) roof.

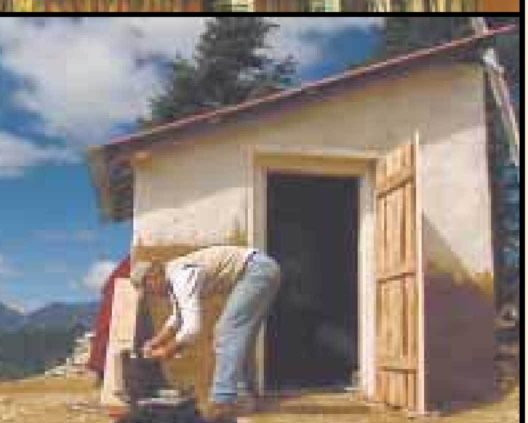
This was oddly difficult for our little crew, and we realized later that some of the guys were shouting mistaken cues at the tribal masons. Trying to speak a language they didn't know in a difficult moment, they mixed up the words for right and left. The whole array nearly went over the side.

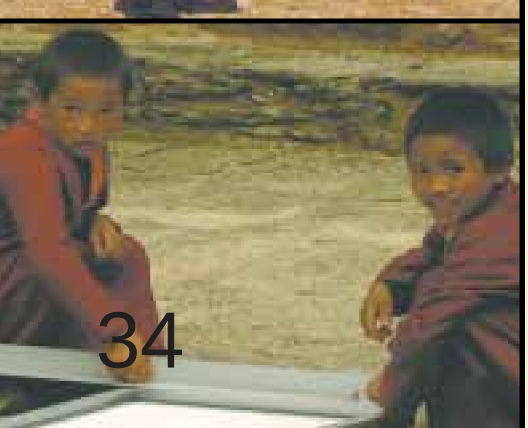
Battery Installation

The finishing touch, on the nineteenth day of the project, was battery installation. The battery bank consists of twelve, 120 amp-hour, 12 VDC, tubular plate, deep-cycle batteries. The batteries are wired in series and parallel for a nominal system voltage of 24 VDC. Limiting daily cycling of the batteries to a 50 percent state of charge (SOC) gives us about 360 AH of effective energy storage.

These batteries weigh about 75 pounds (34 kg) each with electrolyte, and they were carried on the backs of single porters for four days to arrive at Chiwong. Each porter was given a packet of baking soda to neutralize any acid spills, and strict instructions to keep his load upright.

When a monk takes vows and enters monastic life, one of those vows is celibacy, and another is to not till the soil or otherwise engage in "earthly" pursuits, such as commerce or labor. Their realm is the spiritual. But one thing they were able to do to help with the project was carry batteries to the hilltop powerhouse from storage. They were very anxious for the lights to come on, and wanted to participate.





They took time off from their preparations for the dance, and very sweetly formed a grand procession and hefted all twelve batteries for us, since they could see we were wearing down. And it was fitting and auspicious that they should all have a direct hand in the final act before the lights went on.

We wrapped each battery in plastic so their robes wouldn't be burned. This gave them some immediate contact with the realities of the system, since they are the ones who were later trained to do battery maintenance. The assembled procession then watched us intently for an hour while we wired the batteries and finished up.

Support—Present & Future

Renewable Energy Development International is an educational nonprofit I founded in 1993. REDI previously has installed PV lighting systems in three other important monasteries in the region. (See *HP45* and *HP56*), as well as hydronic heat for the regional dental clinic (*HP75*).

The participants who funded and supported this project were many. The Jean-Pierre Michaud Fund of Geneva, Switzerland provided 95 percent of the financial support, with the other 5 percent coming from the Eugene/Kathmandu Sister City Committee of Eugene, Oregon.

Mr. Phuri Lama of the Saleri/Chialsa Electricity Company (SCECO) was extremely generous in allowing REDI to hire his electricians. Mr. R.P. Lama of the Hotel du Sherpa in Phaplu helped enormously with communications and contract arrangements for local work. Mr. Tenzin Tsering Lama, Chairman of the Chiwong Preservation Committee, arranged for the establishment of the maintenance fund for the system. Mr. Kul Narayan Shrestha of SCECO was an extremely talented foreman and leader of the electrician crew. And my assistant, Ongel Lama, learned enough to later wire three local homes with solar-electric lighting systems all by himself.

Long-term maintenance of a remote stand-alone system like this can be problematic. Even though we took precautions to limit the use of the system to avoid the most obvious bad practices by the users, future battery replacement, as well as potential electronics meltdowns, needed consideration.

We met with the Chiwong Preservation Committee, which is a board of ten local stakeholders who oversee the monastery. Many of them are relatively wealthy. They were already very pleased that REDI was initiating the project, so we appealed to them on the maintenance issue. They agreed that it wouldn't do to let the lights go off from laziness or poverty. They established a maintenance fund of US$2,000 in member donations, which will accrue interest until it is needed. At that time, only the interest will be used.

By projecting ten years into the future and considering buying a new battery bank, the interest on the principal is adequate. All other maintenance costs will be covered by the fund, and three signatories are required to access it.

Like Flowers Blooming

The community's vision of electrifying Chiwong has finally been realized. The remoteness of this important public institution had doomed it to slowly fade into history while the world around it hurtles through the time barrier.

Chiwong and other monastic centers like it throughout the world are true sanctuaries. Chiwong's Buddhist religious culture has long lived out of

contact with the western time machine. We now find it utterly refreshing to meet so many here who are so honest, so charming, and so deserving of support. Dramatically improving their personal and collective environments through simple electric lighting has fostered renewed community interest in the institution's primary functions.

The residents can now see inside their homes after dark. The collective space can be lit during gatherings long into the night. And monks, teachers, and students are able to clearly see and read their texts. These simple realities all augment and strengthen the community's basic values.

But just as important, the monastery will no longer need to buy and porter kerosene, or buy and maintain lamps. Eyestrain, ulcers, and respiratory problems resulting from burning kerosene are all gone with an extinct technology, along with the slow ruin of the murals and ancient texts from soot.

Who would have thought that the creative application of modern silicon technology could catalyze social cohesion and cultural survival in a remote, traditional community? This is technics-based community development at its best. As Sonam, the head nun, said to me, "When the light came, it was like the rhododendron flowers blooming in the jungle."

Access

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Xantrex PROsine 1000

Joe Schwartz & Eric Grisen

In the U.S. renewable energy market, the availability of affordable, sine wave inverters is making modified square wave inverters obsolete. With a list price of US$890 for the 12 VDC version, Xantrex's PROsine 1000, sine wave inverter falls into this category. It's an excellent choice for small systems, and a smart upgrade or addition to systems running modified square wave inverters.

Inverter Overview & Options

In October of 1999, Xantrex acquired the manufacturing and distribution of Statpower's line of inverters and battery chargers. Initially, Xantrex was distributing Statpower inverters solely to the mobile market. In 2002, they began ramping up their distribution of these products to the residential RE market.

The PROsine 1000 has a high frequency switching topology for DC to AC power conversion. This specific design produces a high quality sine waveform that is well suited for household electronics. The inverter produces 1,000 watts continuous, and surges to 1,500 watts for up to 5 seconds. Both 12 and 24 VDC nominal versions are available. AC output is 120 VAC, 60 Hz. Export versions with 230 VAC, 50 Hz output are also available.

The PROsine 1000 is not equipped with an AC battery charger. But if your application requires an AC charger, you have options. Along with the PROsine inverters, Xantrex also acquired Statpower's excellent line of TrueCharge AC battery chargers (check out the review of these chargers in *HP48,* page 32). In addition, *Home Power* is currently testing a 2.0 KW PROsine inverter with an onboard, three-stage, 100 amp AC charger.

The PROsine 1,000 watt inverter we tested is equipped with two GFCI receptacles for distributing AC power to the loads. An AC hardwire model for conduit-ready, code compliant installations is also available. A remote interface kit (list price, US$50) can be purchased that allows the inverter's on/off switch and status display to be mounted up to 50 feet (15 m) away from the inverter.

An additional option for the AC hardwire version is an integral, automatic AC transfer relay for grid backup applications. This allows the inverter to operate as an uninterruptible power supply (UPS). The transfer time from grid to battery/inverter powered backup is typically one cycle (16.6 milli-seconds), with a maximum transfer time of two cycles (33.2 milli-seconds). This transfer time is fast enough to keep most computer systems online during the transfer. But you should provide your equipment dealer with the specifications of your computer hardware to ensure compatibility.

At startup, the inverter's LCD control panel displays battery voltage, and AC voltage and frequency. During operation, battery voltage and DC

Xantrex PROsine 1000 Manufacturer's Specifications

Item	*Specification*
Continuous output power	1,000 W
Surge capability (5 seconds)	1,500 W
Peak output current	25 A
Peak inverter efficiency	89%
No load draw (search mode)	< 1.5 W
No load draw (inverter idle)	< 22 W
Output frequency	60 Hz, ±0.05%
Output waveform (resistive loads)	Sine wave < 3% THD, 1% typical
Input voltage range (12 VDC)	10–16 VDC
Output voltage (no load)	120 VAC RMS, ±3%
Output voltage (over full load and battery voltage range)	120 VAC RMS, -10% to + 4%
Low battery cutout (12 VDC)	10 VDC (5 sec. delay)
High battery cutout (12 VDC)	16 VDC
Transfer time (grid to inverter)	2 cycles maximum
Transfer time (search to AC output)	< 2.5 seconds
Operating temperature range	0–60° C (32–140° F)
Electromagnectic classification	FCC Class A

input current are displayed along with a power scale that graphically corresponds to inverter AC power output. A system diagnostics function displays error conditions including AC overload, overtemperature, and over/under DC voltage. The LCD panel can easily be removed and rotated to match the mounting orientation of the inverter.

Installation & Programming

The PROsine 1000 is compact (15.4 x 11.0 x 4.5 inches; 39 x 28 x 11 cm) and lightweight (14.5 pounds; 6.6 kg). It's actively cooled with a single-speed fan, and the inverter can be mounted in any of three different orientations without affecting the cooling.

Unlike the DC cable interface of some small, sine wave inverters, the PROsine's DC connection terminals are safely isolated from one another and are convenient to access. These terminals accept battery cables from any direction in a 180 degree rotation. The cables can come from above, behind, or below the inverter and still be easily connected. The DC terminals are threaded studs, and require lugs on the cables for connection to the inverter.

The only programming required relates to the search/idle parameters. The on/off switch is used to program the inverter for search (Power Save) mode or continuous on. The inverter's 16 page manual takes you right through the installation, programming, and operation process.

A top view of the PROsine 1000. Its battery terminals are designed for convenient installation.

System Overview

We installed the PROsine 1000 in a small PV system with 300 rated watts of PV and 210 amp-hours (20 hour rate) of absorbed glass mat batteries wired for 12 VDC nominal. Two, 12 inch (30 cm) lengths of #2/0 (67 mm^2) CU welding cable connect the battery to the inverter. The battery's parallel connections are also #2/0 CU welding cable. Cable lugs are crimped and soldered. Overcurrent protection is provided by a 110 amp, DC-rated, classT fuse. An amp-hour meter monitors battery state of charge.

The system powers a Macintosh computer system at Eric Grisen's home office. Eric does graphic design and coordinates article submissions for *Home Power.* The computer system is used 10 hours a day, 5 days a week. When the battery state of charge (SOC) drops to 50 percent, the loads are manually transferred to the grid. Additional system loads are audio/video equipment, and a 19 inch (48 cm) fan used occasionally for air circulation around the house. The system has been in daily use for 12 months.

Test Setup

Battery voltage, battery current (via a 50 mV/500 A shunt), peak AC output voltage, and AC output current were measured using four, Fluke 87 digital multimeters. AC voltage (RMS), frequency, total harmonic distortion, and power factor were measured using a Fluke 43B AC Power Quality Analyzer. Battery temperature during testing was 68°F (20°C).

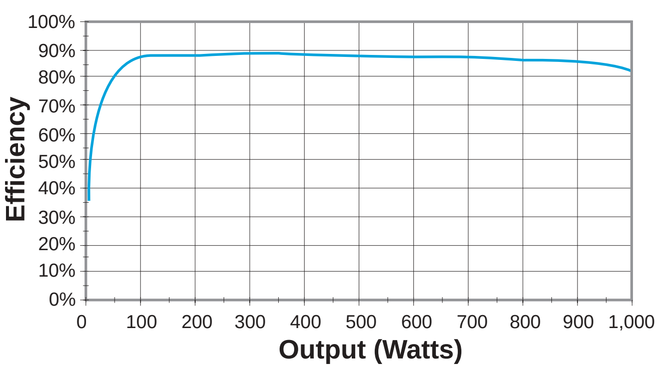
Interpreting the Results

The PROsine 1000 peaked at 89.2 percent efficiency at 300 watts (resistive load). Both peak AC voltage and RMS AC voltage were adequately regulated. When the inverter was fully loaded (1,000 W output), the peak AC voltage and RMS AC voltage dropped close to, but

Xantrex PROsine 1000 Test Data

Battery Side			AC Side						
Volts	*Amps*	*Watts*	*Vpp*	*Vrms*	*Amps*	*Watts*	*Eff.*	*THD*	*Load (W)*
13.23	0.15	1.98	Search mode						
13.18	0.90	11.86	Idle mode						
13.17	1.30	17.12	172.0	122.6	0.05	6.1	35.8%	0.7%	4
13.07	2.20	28.75	171.6	122.6	0.14	17.2	59.7%	0.7%	15
12.96	3.00	38.88	171.4	122.5	0.23	28.2	72.5%	0.7%	25
12.88	5.20	66.98	171.6	122.4	0.45	55.1	82.2%	0.7%	50
12.75	9.20	117.30	171.2	122.2	0.84	102.6	87.5%	0.6%	100
12.60	18.20	229.32	170.4	121.8	1.66	202.2	88.2%	0.6%	200
12.48	27.80	346.94	169.6	121.3	2.55	309.3	89.2%	0.6%	300
12.45	36.70	456.92	168.8	120.7	3.36	405.6	88.8%	0.7%	400
12.35	46.80	577.98	168.0	120.2	4.25	510.9	88.4%	0.7%	500
12.28	56.20	690.14	167.6	119.7	5.08	608.1	88.1%	0.7%	600
12.18	66.20	806.32	166.8	119.2	5.93	706.9	87.7%	0.7%	700
12.07	76.00	917.32	166.0	118.7	6.72	797.7	87.0%	0.7%	800
11.86	87.00	1,031.82	165.6	118.2	7.53	890.0	86.3%	0.8%	900
11.77	102.00	1,200.54	164.8	117.6	8.50	999.6	83.3%	0.8%	1,000

Xantrex PROsine 1000 Efficiency



never below, the standard AC electrical values for these parameters (164.4 VAC peak and 117 VAC RMS).

The quality of the AC waveform was excellent. We never recorded a total harmonic distortion (THD) of more than 0.8 percent over the inverter's AC output range when powering resistive loads. During our testing, the idle draw of the inverter was 11.9 watts, significantly lower than the manufacturer's maximum specification. AC frequency was 60 Hz throughout the test.

The manufacturer's less than 3 percent THD specification is based on resistive loads. We also ran several reactive loads during the test, and came up with much higher THD figures. For example, a single, 20 watt compact fluorescent lightbulb, manufactured by Lights of America, with a power factor of 0.52, resulted in 1.7 percent THD of the inverter's waveform. Four of these bulbs running simultaneously (80 watts, 0.65 power factor) resulted in 4.0 percent THD of the inverter's waveform.

The Macintosh G3 computer and 21 inch (53 cm) Radius monitor had a combined power factor of 0.70, and resulted in 5.8 percent THD of the inverter's waveform. Modified square wave inverters typically have waveforms with 25 to 40 percent or higher THD. For comparison, grid THD at the test site was 1.2 percent, averaged over three days with a maximum THD of 1.5 percent. (We have seen grid THD as high as 15 percent.)

With a 1,500 watt surge rating, this inverter isn't appropriate for loads with high startup current. Make sure to research the surge of any small power tools or motor loads you'd like to run on the inverter.

Great Choice

If you're running home electronics including computers and audio/video equipment, sine wave inverters are the smart choice. The PROsine 1000 is a great inverter for these applications, or wherever up to a kilowatt of high quality AC electricity is required. It's well thought out from an installer's perspective, and simple to program and operate from a user's perspective.

Access

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Utility-Intertie Inverter Comparison:

Xantrex ST2500, Xantrex STXR2500, and SMA SB2500U

Henry H. Cutler

Henry Cutler's wall of inverters includes a Xantrex ST2500 (right), a Xantrex STXR2500 (upper left, mounted on top of one of the original ST2500s), and an SMA SB2500U (lower left).

It has been a dream of mine for as long as I can remember to have an energy self-sufficient home. I finally made the plunge in May 2001, purchasing solar-electric (PV) panels. My home is now running totally on solar electricity. It's grid tied, and cost significantly less than a battery-based system.

My experience in electronics includes more than 20 years in the computer industry. I have broad knowledge in digital and analog design and software. For the last five years, I have been an independent consultant in application specific, integrated circuit (ASIC) and field programmable gate array (FPGA) design.

I live in Lakeland, Florida, which is located in the middle of the state. Lakeland is a midsized city, but you only have to travel a few miles out of downtown to be in a rural area, which is where my home is located on a two-acre lot surrounded by trees. I had to clear a considerable number of trees to allow unobstructed sunshine on my arrays from 9 AM to 5 PM. There is some shading in the early morning and late afternoon. I calculated that this shaves about 700 watt-hours per array per day off my available generation, compared to if the array was unobstructed from sunrise to sunset in the summer months.

Large, Identical PV Arrays

My solar-electric system is really two identical systems. Each has 24 Kyocera 120-1, 120 W rated panels, on homemade, aluminum, four-season adjustable racks. Each array feeds a utility-interactive inverter. PV to inverter home runs are #6 (13 mm^{2}) copper in PVC conduit, and are about 75 feet (23 m) long. The first 24 modules went online in August of last year.

I then decided to double the system, and in November 2001, the second system went online. Each system fed a separate Xantrex ST2500 inverter. I did all of the installation work myself. In my county, home owners are allowed to do electrical work, with building department inspection and sign-off.

The weather in Florida is subtropical, and clouds are a way of life. The AC output of my ST2500s in sunny weather (no clouds) was fairly constant, at about 12 KWH per day. In partly to mostly cloudy weather, the performance was only about 60 percent of this.

Performance Lacking

In the months leading up to the comparison testing, I had identified three different issues with the ST2500's MPPT software. I logged energy production and measured panel temperatures in detail. I found an excellent Web site (www.infomonitors.com/pv_demo.htp) that allowed

Manufacturers' Specifications for ST2500, STXR2500, and SB2500U

Item	*ST2500*	*STXR2500*	*SB2500U*
AC output voltage	211 – 254	211 – 264	211 – 264
Rated efficiency	94%	94%	94%
Operating temperature range	-39°C to 45°C	-39°C to 45°C	-25°C to 60°C
Continuous output in watts	2,500*	2,500*	2,500**
Max PV input, DC volts	125	125	600
MPPT range, DC volts	42 – 85	42 – 85	234 – 550

* 25°C
** 25°C , 1 m^2 wind (same as STC PV standards)

me to compare data from my site (insolation, sun hours, and panel temperature) to a PV system located at Disney World, which is 40 miles (65 km) away. I used this data to calculate how much energy my system should generate.

When I tracked down all the variables and couldn't account for 15 to 20 percent of the energy, I was convinced that the problem had to be with the ST2500s. I contacted my dealer and Xantrex, and got no satisfactory answers. I then contacted SMA America via e-mail, writing to the president and explaining my problems. John Berdner responded almost immediately and agreed to loan me an SB2500U so I could verify where my production problems were.

Caveats

I am technically proficient, and I have more test equipment than most people, or even some companies. But I need to point out that I am not a certified lab with equipment calibrated monthly. I have invested hundreds of unpaid hours to provide this information to anyone who intends to purchase a grid-tied inverter and wants to listen.

I do not claim absolute accuracy, but I am confident that my findings are within 2 to 3 percent. I compared the numbers from both inverters with a calibrated watt-hour meter, and the inverters were each run on both arrays and over an extended period. It's also important to note that different climates, PV module types, and other installation specifics directly affect system performance. What's needed is comprehensive and coordinated independent testing in varied locations.

I freely admit that I can and do make mistakes. Please keep this in mind, and as with everything in life, you are ultimately responsible for your own decisions and opinions. The tables and text show all the tests I ran, the data I collected, and my technical judgments of the two products and their differences.

Inverter Testing Environment

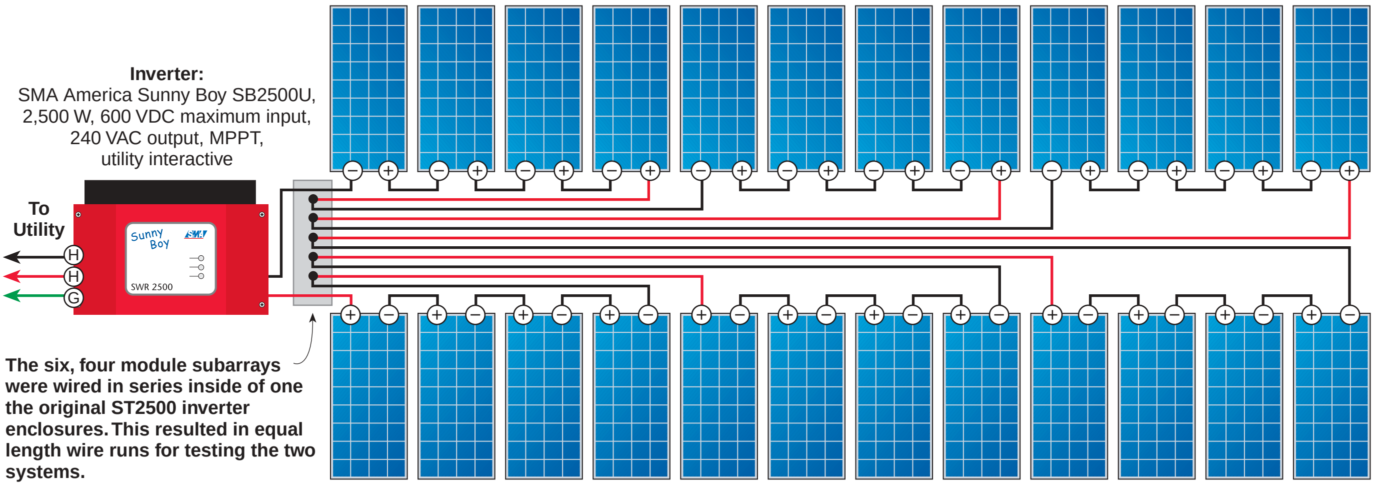
The testing was done between April 16, 2002 and May 30, 2002 at my home in Lakeland, Florida, latitude 28 degrees north. The weather was a good mix, ranging from mostly cloudy to 100 percent sunny weather. I did not record insolation data, so my irradiance classifications are very subjective.

The two identical arrays—each has 24 Kyocera 120-1, 120 watt panels.

Three units were tested—Xantrex ST2500, serial number 0116003006, manufactured in August 2001; Xantrex STXR2500, serial number 428635, manufactured in May 2002; and the SMA SB2500U, serial number 844101264, manufactured in April 2001. All the units tested are current models running the latest software revisions.

I have an ideal installation for testing the inverters. My two identical systems, consisting of twenty-four KC120-1 panels each, originally fed two ST2500s. The only change required to install the SB2500U was to rewire the PV leads inside the enclosure of one of the ST2500s. For the ST2500, the array was configured into six series strings of four modules each that were paralleled at the inverter combiner board.

Photovoltaics: Twenty-four Kyocera KC-120, 120 W each, wired for 2,880 W total at 600 VDC maximum



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified. Equipment grounds not shown.

The SB2500U is often referred to as a string inverter. For my location and climate, I simply wired all twenty-four, 12 VDC nominal panels of the other array in series. SMA recommends series strings of twenty-two to twenty-four modules in most locations. The maximum DC input voltage for SB2500U inverters cannot exceed 600 VDC. The number of modules in series dictates array voltage, which is temperature dependent. As a result, the appropriate number of modules in series must be calculated for each specific installation. I reused the existing wiring when connecting the SB2500U. This resulted in over 75 percent more wiring than is necessary, but it made the comparisons apples to apples.

ST2500 vs. SB2500

The Sunny Boy arrived at about 1 PM on April 15, 2002. I disconnected one of the Sun Tie inverters, and installed the Sunny Boy in its place. Within an hour, I had the unit connected to a temporary frame, just under the now disconnected ST2500. I removed the #6 (13 mm^2) array wires from the combiner board, and using blue wire nuts, wired the array in series.

I now had a single series string operating at approximately 420 VDC. The only problem I had was that the largest wire size that the SB2500U's terminals will accept is #10 (5 mm^2). I had wired everything on the ST2500 with #6, so I had to pigtail the AC and DC connections inside the SB2500U, using #10 (5 mm^2) wires.

In a permanent installation, the use of #6 for the array is overkill for the SB2500U because it operates at a significantly higher DC voltage. The circuit's current is one-sixth of the original ST2500 circuit, even though the same level of DC power is being delivered to the inverter. I should also note that a DC disconnect is required by code, and SMA informed me that a Square

This screen shot shows the computer interface during data collection.

D #HU-361R is the appropriate device to use. I skipped this step since the configuration was for testing only. When I rewired the arrays, I put tarps over the panels for safety.

I connected the Sunny Boy's internal RS232 connector to the DB9 connector on my computer, and made my first attempt to use the Sunny Data software. It took about another hour to get the software configured and communicating. The SB2500U reported more than 2,000 W being generated at just after 3 PM. The ST2500 was running in the 1,600 to 1,700 W range.

I spent the rest of the day checking the connections, putting the covers back on the units, and making sure everything was weathertight. I also configured the Sunny Data software on the PC to log all available information between 7 AM and 8 PM automatically.

I was only gathering the end-of-day performance information from the ST2500, since it has no provisions for data logging, only the info on the LCD display. Not happy with this, I went to Best Buy and bought a cheap US$29 Web cam, and downloaded software from www.supervisioncam.com. This allowed me to take pictures of the Sun Tie's display every 6 minutes—a poor man's data logger.

On a few days, I increased the picture-taking interval to match the SB2500U data capture of every 7 seconds. I did this to observe the exact difference in output, and how each inverter's MPPT reacts to different weather conditions. This allowed me to get better information on the daily performance of the MPPT.

For the next two weeks, I collected data, noting the conditions every day. Then I swapped the inverters so I could confirm the data using the other arrays and average the results. The performance of the two arrays was nearly identical, which speaks well for the KC120-1 panels.

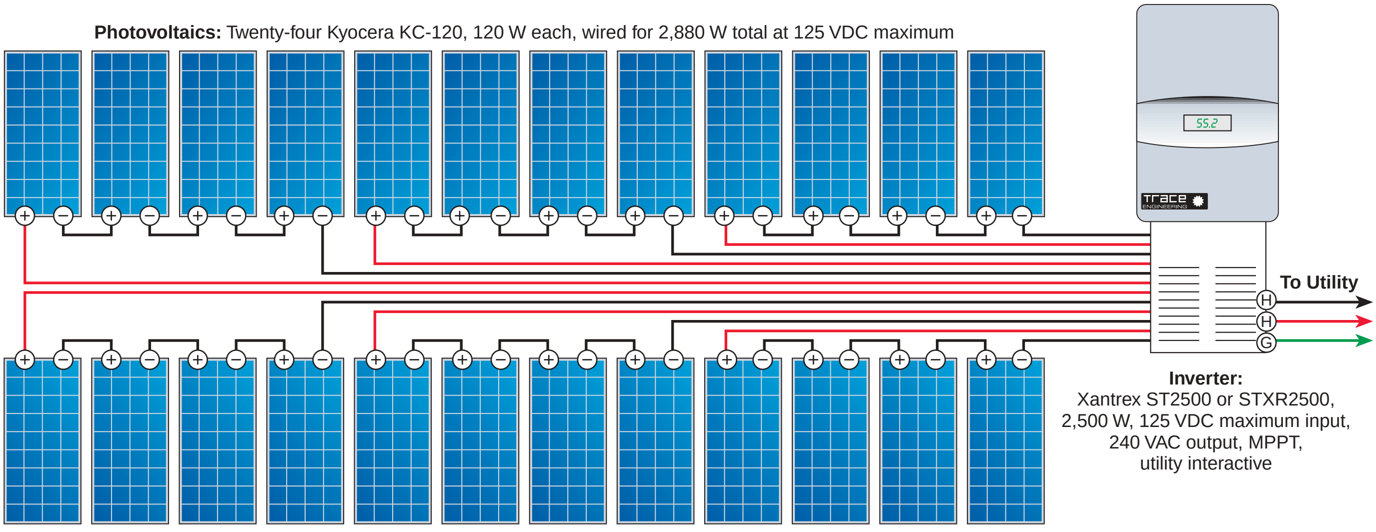
In these weeks of testing, I captured data that confirmed each of the three MPPT problems the ST2500s had been experiencing over the 9 months I had owned them. These are poor wakeup performance, tracking voltage 4 volts above true maximum power point, and inverter output collapse in variable cloudy conditions. I did an efficiency test to confirm that the ST2500 peaks at 90 percent, and I reran the max power test to verify that the ST2500 is not capable of 2,500 watts output in my particular system configuration and location.

STXR2500 vs. SB2500

At the end of almost four weeks, Xantrex heard that I was working on this article. The STXR2500 had just been released the week before, and they asked if I wanted to try it. I agreed, and the next morning, two new STXR2500s arrived, complete with rain shields and remote monitors.

On Sunday, May 11th, I started testing the STXR2500. I installed the inverter, and when I turned it on, it no longer displayed the technical info that the earlier version had—just the message, "Producing Energy Today." The ST display showed AC volts, frequency, DC volts, and AC amps. The SXTR now only shows KWH total. I read the manual and found the remote monitor could display the technical info, so I proceeded to hook up the remote display, which took about 30 minutes.

For my first test, I wanted to see if they had resolved the maximum power output issue, so I wired the output of both arrays to the STXR. Much to my disappointment, the unit would perform at only about 2,000 watts. With both subarrays (5,760 W STC), the inverter should run at maximum for hours.



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified. Equipment grounds not shown.

At this point I rewired the inverters for side-by-side testing. The results were very disappointing. The STXR2500 was performing similarly to the ST2500 in generation totals, but a new problem was observed. In reaction to an irradiance change, the XR's output would go to zero and then slowly recover. I dubbed this the "COLIC" problem, for "crash on large irradiance change."

I spent the next few days collecting data. I made graphs comparing the two inverters exactly, down to 7 second intervals, so I could show the problems to Xantrex. I made a detailed cross-comparison between this data and the data I'd collected from the Sunny Boy, and forwarded this information to Xantrex. They stated that they had not seen this type of problem anywhere else.

I found out that the Florida Solar Energy Center (FSEC) had a brand new STXR2500 running in their test site. Within three days, I was given access to the FSEC database on their test system. After comparing their system's output to mine, it was obvious that the FSEC STXR2500 had the similar COLIC problem I had been observing. Their AC power output and cumulative energy figures indicated that the STXR was behaving almost identically to the ST2500.

A Visit From Xantrex

I informed Xantrex's engineering department that there were still issues with the units. We had a very open and frank discussion, in which they confirmed that my data was valid. They were very interested in seeing my system and how I was collecting data. They asked if they could visit, and I agreed.

On May 29, 2002, an engineering project manager and a market manager (both responsible for the STXR products) spent the day at my residence. They brought data loggers and a curve tracer, a device that characterizes the solar-electric array.

A few days before their visit, they had sent me a program they call "AC Meter" which allows a PC to log data from the ST/STXR units. I was sternly warned that this was *not* for public use, and after using it, I could see why. The program logs data in a text file on the PC, and displays AC volts and AC power.

I had to write two perl scripts to make the data usable in cross-comparing to the Sunny Boy data, but when the Xantrex representatives came, I had 4-second samplings of the previous day's performance, which also happened to have the biggest gap between the ST and the SB. I wish I had the AC Meter program when I started this. Xantrex really should consider providing a cleaned up version for ST users so they can log their own data as I have.

Trace ST on West Array vs. Sunny Boy on East Array

	Inverter on Array			
	West	*East*		
Date	*ST2500 AC KWH*	*SB2500 AC KWH*	*Difference*	*Conditions*
4/28/02	12.430	14.650	15.2%	Mostly sunny
4/29/02	9.747	13.400	27.3%	Mostly cloudy
4/30/02	8.800	11.600	24.1%	Mostly cloudy
5/01/02	10.900	14.400	24.3%	Partly cloudy
5/02/02	9.900	14.400	31.3%	Partly cloudy
5/03/02	12.700	14.800	14.2%	Full sun
5/04/02	11.100	13.700	19.0%	Partly cloudy
5/06/02	9.050	12.700	28.7%	Mostly cloudy
5/07/02	10.124	12.800	20.9%	Partly cloudy
5/08/02	10.715	13.000	17.6%	Partly cloudy
5/09/02	13.101	15.100	13.2%	Full sun
5/10/02	11.646	14.400	19.1%	Partly cloudy

Note: Data was not recorded for 5/05 due to maintenance on data logging computer.

Both Xantrex representatives were very open and honest about the product's performance, and they seemed very genuinely concerned that the product was still not performing as it should. We got into detailed discussions of why the MPPT still had issues, and I at this point agreed that these details would remain in confidence. The average user doesn't usually care about the details of why a product is performing below expectation, just that it is. Xantrex verified that my logging was within 2 to 3 percent, and they verified that the west and east arrays were close to identical in performance.

The Data Speaks

I performed efficiency tests to confirm the manufacturers' efficiency specifications. I connected Valhalla Scientific 2100 power meters to the DC input and AC output of the inverter under test. Using the Webcam, I captured the values displayed by the meters during the day. In my system and climate, the STXR peaks at 90.1 percent efficiency, and the Sunny Boy peaks at 94.8 percent. The Xantrex inverter is almost 4 percentage points below their published specification, while the Sunny Boy actually exceeds their spec.

The MPPT has been the Achilles heel of the Xantrex ST/STXR2500 inverters since their inception. I do not doubt that engineers are hard at work at Xantrex attempting to resolve the issues. I believe that the root cause isn't simply a code issue, but lies in how the ST/STXR2500 attempts to implement MPPT tracking from a hardware perspective.

The cooling of the ST/STXR2500 is an engineer's nightmare. The design attempts to push air though the

Sunny Boy on West Array vs. Trace ST on East Array

	Inverter on Array			
	East ST2500	*West SB2500*		
Date	*AC KWH*	*AC KWH*	*Difference*	*Conditions*
4/16/02	7.300	10.100	27.7%	Partly cloudy
4/17/02	7.900	11.100	28.8%	Mostly cloudy
4/18/02	8.600	12.600	31.7%	Mostly cloudy
4/19/02	10.300	14.100	27.0%	Partly cloudy
4/20/02	8.900	12.700	29.9%	Mostly cloudy
4/21/02	8.900	11.400	21.9%	Partly cloudy
4/22/02	11.180	14.200	21.3%	Mostly sunny
4/24/02	10.600	13.500	21.5%	Partly cloudy
4/25/02	11.600	14.300	18.9%	Mostly sunny
4/26/02	8.900	12.100	26.4%	Mostly cloudy
4/27/02	11.800	14.300	17.5%	Mostly sunny

Note: Data was not recorded for 4/23 due to inverter comparison testing to calibrated WH meter.

unit and out very constricted paths. The rain shield further increases this back pressure. This path has no filters, and my two units are clearly showing what happens when you blow unfiltered air into a device. Bugs, dirt, and grime build up in the unit. This will no doubt affect long-term reliability. This is in contrast to the SB2500U, which has no fan and is a sealed design so no contaminants can get inside the unit.

The STXR has undergone design enhancements, such as larger openings on the intake, more rigid internal baffling, and the addition of a variable-speed fan.

The ST/STXR2500 provides no option for data logging. If you want to know what the unit is doing, you have to physically look at a display. On the new STXR2500, they have dumbed down the information to "reduce the load on tech support" (their quote). I have been told that the unit is capable of providing data, but that it is used internally by Xantrex, and not offered for customer use. I have been firmly warned not to connect a computer to the STXR DB9 port. It is not standard pin out, and will damage the serial port of a computer.

This isn't in the spec, but the ST/STXR2500 uses energy when it's off. The AC filter draws about 12 watts, so overnight, you will lose 120 to 140 watt-hours.

The SB2500U is not without faults. Because it is air cooled (passively), it is dependent on the airflow around it. It is a true 2,500 watt inverter, but achieving this output requires a 1 meter per second air flow at 25°C (77°F, same as STC PV testing). High temperature performance is very variable, due to the passive cooling. My test unit reported thermal derating seven days out of forty-four during the testing.

Sunny Boy vs. Trace STXR

	Inverter on Array			
	West STXR2500	*East SB2500*		
Date	*AC KWH*	*AC KWH*	*Difference*	*Conditions*
5/13/02	9.700	12.400	21.8%	Partly cloudy
5/14/02	10.500	13.900	24.5%	Partly cloudy
5/15/02	11.200	14.100	20.6%	Partly cloudy
5/16/02	7.560	10.500	28.0%	Mostly cloudy
5/17/02	10.800	14.000	22.9%	Partly cloudy
5/18/02	9.050	12.200	25.8%	Mostly cloudy
5/19/06	4.400	5.600	21.4%	Mostly cloudy
5/20/02	7.300	9.400	22.3%	Mostly cloudy
5/21/06	11.600	14.700	21.1%	Mostly sunny
5/22/02	11.750	14.900	21.1%	Mostly sunny
5/23/02	9.536	14.350	33.5%	Partly cloudy
5/24/02	11.950	14.600	18.2%	Mostly sunny
5/25/02	8.900	12.900	31.0%	Mostly cloudy
5/26/02	11.100	14.100	21.3%	Partly cloudy
5/27/02	4.669	7.300	36.0%	Mostly cloudy
5/28/02	9.164	14.000	34.5%	Partly cloudy
5/30/02	10.648	12.600	15.5%	Mostly sunny

Note: Data recorded for 5/29 is not listed due to confidentiality agreement.

I asked SMA some very tough questions, and bombarded them with e-mails. Most were answered within one day, if not sooner. The SB2500U, for UL rather than design reasons, must limit the heat sink to a maximum temperature of 80°C (176°F). The unit starts derating at 65°C (149°F). The algorithm that the SB2500's processor uses works like this: For every degree above 65°C, the unit derates the maximum allowable power by 166 watts. So for example, if the unit's heat sink is at 70°C (158°F), the maximum allowed output would be 2,500 watts minus 830 watts—1,670 watts.

The maximum heat sink temperature my unit ever reported was 67°C (153°F), and this was on a 35°C (95°F) day with power in the 2,100 watt output range. I made thermal measurements and found that my unit was off by 10°C (18°F) on reporting actual temperature. (The SB was reporting temperatures 10°C hotter than actual temperatures measured with my test equipment.) This, combined with the derating curve, confirmed that with my 2,880 watt array in 35°C weather, there was no actual derating.

SMA has told me that it will update the firmware to only report when actual power is being reduced, and not report that it's reducing the maximum allowed, as it does now. The company has also informed me that a new temperature sensor is being used in all new production units to address the issue of sensor accuracy.

Increase in AC KWH Production—SB2500U vs. ST2500/STXR2500

SB2500U vs. ST2500

	Overall	Mostly Cloudy	Partly Cloudy	Mostly Sunny
SB on east array, ST on west array	24.5%	29.3%	24.4%	19.2%
SB on west array, ST on east array	21.1%	26.8%	22.2%	14.2%
Combined average	22.8%	28.0%	23.3%	16.7%

SB2500U vs. STXR2500

	Overall	Mostly Cloudy	Partly Cloudy	Mostly Sunny
SB on west array, STXR on east array	24.5%	27.7%	25.7%	19.1%

The Sunny Boy requires the use of higher input voltages than the Xantrex inverter. Personally, I treat 80 volts DC the same as 480 volts DC. The actual wire, conduit, connectors, and connections are identical, and safety concerns still apply. Once the system is installed, I couldn't care less what is traveling inside the conduit. But this is *my* opinion, and the increased danger of high voltage is something to consider.

SMA agrees with me that an external fan should be offered for people who are in hot climates or would like their inverters in an indoor location (like a garage). A simple box fan that could be mounted on top of the inverter's heat sink is a needed accessory. The SB2500 does not use energy at night. It has a relay that disconnects the unit completely from the AC lines when there is no DC input from the array.

Real World Comparison

The performance difference between the Xantrex inverters and the SMA inverter is staggering, at least in the conditions here in Lakeland, Florida. I know of an installation in California that has had similar results to mine (see sidebar).

The Sunny Boy SB2500U has the benefit of more than 40,000 units installed, and a huge engineering team behind it. The company is proactive, responsive, and will answer the tough questions.

The Xantrex ST/STXR2500 was not sufficiently tested under varied climactic conditions before it was made available to the consumer. If it had been, several design flaws could have been identified and corrected. In my personal experience, a quality engineering organization puts forward multiple ideas and designs, and then has internal checks and balances to make sure a good product emerges. This didn't happen at Xantrex, and this, unfortunately, is too common in our small industry.

Another ST vs. SB Test

Sierra Solar is my renewable energy business in Grass Valley, California. We've been in business since 1980. The PV system at our office includes 48 Kyocera KC-120-1, 120 watt PV modules, a Xantrex STXR2500 inverter, and an SMA Sunny Boy 2500 inverter, both with digital displays. We installed these two utility-intertie inverters side-by-side for comparison purposes.

Both units are MPPT inverters rated at 2,500 watts maximum output. Both manufacturers specify peak efficiencies of about 94 percent. Each inverter is connected to 2,880 watts of KC-120-1 PV modules. We had every reason to expect similar performance from each unit.

We had originally installed an ST2500, and like many owners of this original ST model, we experienced problems. Its output didn't seem to match the specs, especially in hot weather. To their credit, Xantrex dispatched a team of engineers who came and replaced the board. They attached data loggers to both the Sunny Boy and their own inverter. About two months later, the ST2500 was replaced with the new, improved STXR2500. While the results improved somewhat, the STXR still lags behind the Sunny Boy.

The Sunny Boy feeds approximately 10 to 15 percent more energy back to the grid. During cloudy conditions, the difference is even greater. This is independent of time of day or season. While the Sunny Boy often peaks at more than 2,200 watts, the STXR generally peaks at only 1,900 to 1,950 watts.

The array, when configured for the high voltage DC input required for the Sunny Boy, is much less affected by a lower power producing panel. In a series string, the bypass diodes take over if a panel, for example, is shaded. The same effect on parallel arrays could take out four panels, even if there is only a small amount of shading on one panel. While the STXR2500 is a quality unit, it is our overall conclusion that the Sunny Boy is superior at our site.

—Jonathan Hill, owner, Sierra Solar Systems

The author working on his inverter comparison.

It is a black eye to the American PV market that Xantrex is still selling this product. The ST/STXR series is technically and algorithmically flawed. Xantrex has the responsibility of the ST/STXR line, and has serious decisions to make.

I have been asked why I went through all of this, and it is very simple. I bought the ST2500 based on the product specifications on Xantrex's Web site, which are still being proffered but are factually wrong. I want to get my test results out there so that others who are planning to purchase a utility-intertie inverter will have a source of information independent of the manufacturers.

I want to thank all the people I have met, both via e-mail and in person while researching and executing this project. There are *many* people who believe that PV and RE are important for our future as a country and world. Even with the challenges that I have faced, I would do it again. My system is now performing better than ever, and last month's electric bill was US$4.

I believe that open, accurate, and freely available information is what is needed in our industry. At my own expense, I have started a Web site (www.solar-guppy.com) that hosts a discussion-based forum that will provide information on solar products. I have also received commitments from both SMA America and Xantrex that they will monitor the discussion board and use it as an online help site for users of their products (mainly grid tie, initially). Feel free to take a look.

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Solar en España

Danny Fenyvesi

Maggie Nolan on the veranda of her solar powered bed and breakfast in Andalusia, Spain.

During a recent European backpacking trip, with excursions through the castles, forests, caves, and grand old buildings of eastern Europe, I began looking for ways to reconnect with my solar interests. A conversation with a few organic farm workers at a youth hostel in Prague alerted me to an international network, Willing Workers on Organic Farms (WWOOF), whose participants call themselves—what else? Woofers.

After surveying WWOOF Web sites on the Internet, I was excited to learn that many of the organic farms are powered, at least in part, with renewable energy. I missed the purposefulness of my life in renewable energy. Prior to my trip, I had been installing solar-electric systems with Occidental Power in San Francisco, and before that, I had been an intern at the Institute for Solar Living in Hopland, California.

Knowing some Spanish, I zeroed in on Spain. After making a single phone call, I hitchhiked from Budapest to Vienna, took several trains, and eventually ended up at Maggie Nolan's small, solar powered, organic farm in Andalusia, a southern province of Spain. A British expatriate, Maggie was once an actress who played a "Bond Girl" in the James Bond film, *Goldfinger.* Now she is a yoga instructor who raises an assortment of vegetables, cultivates an orange grove, and runs a bed and breakfast.

I spent three weeks with Maggie, two chatty Australian Woofers (Jasmine and Louise), and Maggie's ever-mellow and kind boyfriend Dave. While most of my time was spent digging around cow-sized rocks to allow for plantings of flowers and cacti, and creating a terraced vegetable bed, I still managed to get in quite a bit of time to study Maggie's off-the-grid setup and its German wiring, which was unfamiliar to me.

On the Farm

My exploration of Maggie's solar-electric system began earlier than I expected. The night I arrived, I was unsettled by the system's battery voltage—21 volts. At first I didn't know if it was way too high for a 12 volt system or dangerously low for a 24 volt system. Since Maggie was not home, I suggested to the Australian women that we should not use electricity until we figured out the voltage question.

The following day, Maggie showed up and gave me an enthusiastic tour of her farm. She gave me permission to examine the solar-electric system and draw up a system schematic. When the sun rose, a quick look at the panels showed a 24 volt setup. My tinkering revealed that the positive wire from the charge controller had slipped out from the wire nut connecting it to the batteries. In addition, the system was not wired to take advantage of the charge controller's low voltage disconnect.

Fearing for the batteries' health, we banned the use of electricity until the voltage came back up to between 27 and 28 volts. The controller's preset float voltage is 27.4 volts, and the bulk charging voltage is 28.8 volts. After three days of bright sunshine and nightly candles, the system revived.

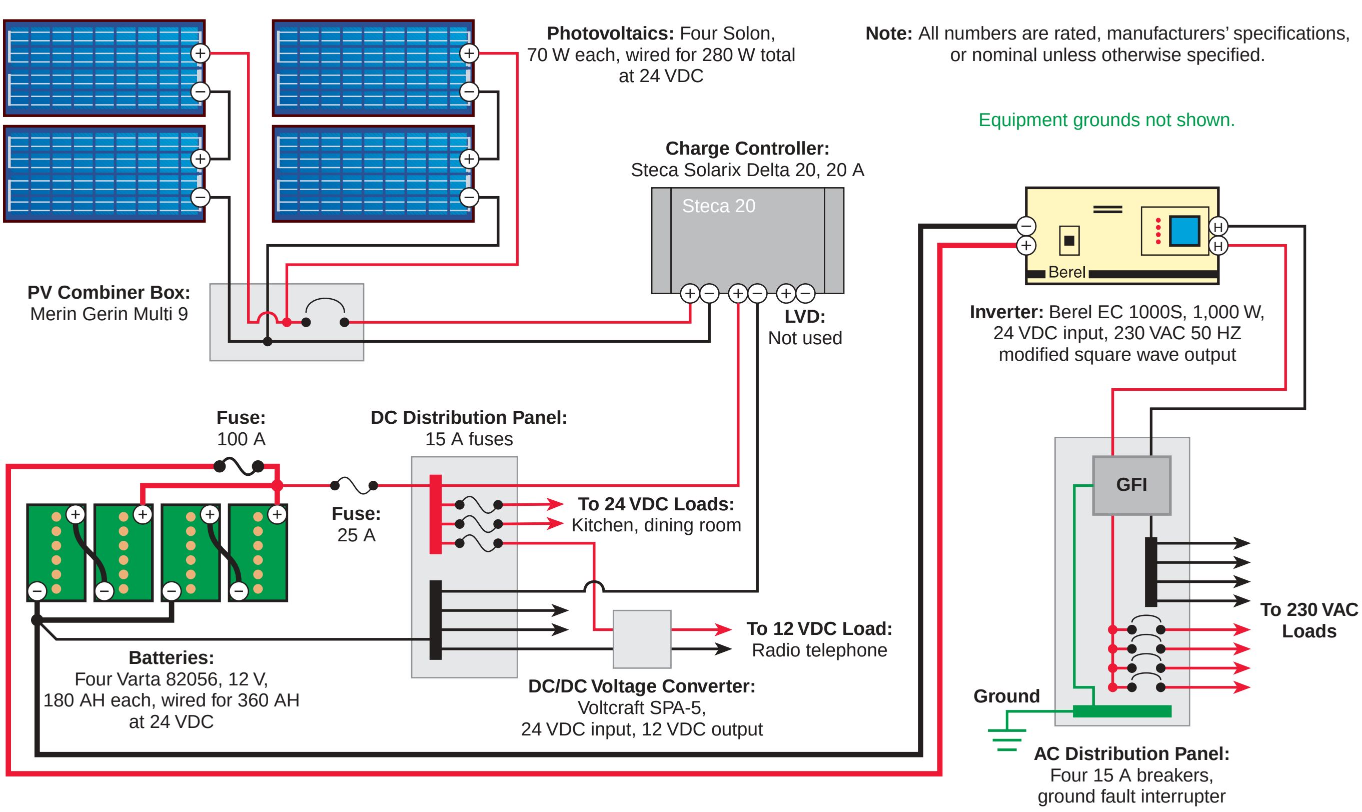
Ideally, we should have waited to use any electricity until the charge controller had finished its equalization charge of the batteries to 29.4 volts. The charge controller automatically begins its equalization cycle when it detects that the state of charge (SOC) has dropped below 40 percent, which would have occurred when the batteries reached 23.4 volts if the wires had been connected properly.

Off-Grid in Sunny Southern Spain

Spain's southern province of Andalusia is rural, poor, and dominated by the Sierra Nevada Mountains. Hidden in the high valleys of the Western Alpurras—the local mountain range—are small, isolated communities of farmers. Farmers raise pigs in pens, wizened old men herd goats with bells, and every farm boasts trees loaded with olives, oranges, pomegranates, almonds, figs, and lemons.

In the past, the vast majority of the farmers did without the luxury of electricity. However, the recent immigration that the EU (European Union) laws are facilitating has attracted convenience-minded northern Europeans. The wave of English, Dutch, Scandinavian, and German immigrants has brought with them the desire for electricity, as well as the familiarity with and the funds for renewable energy gear. This is not to say that Spain

Maggie Nolan's Photovoltaic System



has no RE industry. In fact, it has a very vigorous one, but it has yet to reach into the rural and predominantly poor, mountainous regions of Andalusia.

When Maggie and her two small sons first moved to the farm in 1990, they had no electricity because it was still a traditional Spanish farmhouse, known as a *cortijo.* The 100-year-old house was built from local stone, had a thatched roof, and the walls were whitewashed every year. Being close to Africa—about 150 kilometers (95 miles) as the crow flies—and at an elevation of 1,100 meters (3,600 ft.), there is little need for heating beyond that which a woodstove can easily supply. It never snows, and only once in every few years is there a light ground frost.

In addition to a woodstove, Maggie furnished the formerly appliance-free household with a refrigerator, stove, and water heater—all of them running on bottled propane gas. Water is gravity-fed from a tank on the hill above the house that is filled via a hose from a nearby spring. With the propane appliances, many flashlights (or as the British say, “torches”), and large stashes of candles, Maggie’s family was able to do without electricity for a year or two. However, the family’s needs grew, and Maggie started to accept guests for a bed and breakfast business that grew quickly. It soon became clear that a little electricity would be welcome.

Adding a Small Solar-Electric System

The evaluation of electrical needs was the first step toward solar independence. Lights were needed for the four bedrooms, the living and dining areas, and the bathroom, which is supplemented by a composting toilet in the garden. In addition to the lightbulbs, electricity for a small, 50 watt stereo and TV/VCR was planned for.

All the loads added up to an average consumption of just under a kilowatt-hour per day. It was estimated that the house could get by in wintertime with four, 70 watt, German-made, single crystal, Solon panels. In the summer, these modules produce well over the needed kilowatt-hour per day. Maggie’s farm is located in a high, dry, region, with a climate like Colorado’s. I was told that they receive about 3.5 peak sun hours per day in winter, and 7 in the summer.

The 12 volt panels were mounted on the south face of the second story roof and wired in series and parallel to produce 8.4 amps at 24 volts. To avoid penetrations in the aging roof, the steel mounting channels were seated in eight, basketball-sized concrete lumps attached to the roof.

The two, 33 mm^2 (#2 AWG) PV leads are outdoor rated and run without conduit for about 20 meters (66 ft.), where they end up inside the house, at the ground floor “solar closet.” The positive and negative PV wires end at a fused disconnect. From the disconnect, the wires run into a Steca Solarix Delta, 20 amp charge controller. From there, the wires connect to a fused power line into the bank of four, 12 volt, 180 amp-hour, flooded, lead-acid, Varta 82056 Solar batteries, wired in series and parallel for 360 amp-hours at 24 volts.

The system powers several DC loads in the house. Two, 15 amp circuits provide service to the kitchen and dining area lights. These circuits power eight, 12 volt, 10 watt halogen bulbs over the sink and cooking area. The lights are wired in series in four, 24 volt pairs. Two, 25 watt

Maggie Nolan’s System Loads

AC Loads

Item	*Qty.*	*Watts*	*Total Watts*	*Avg. Hrs./Day*	*Avg. WH/Day*
Compact fluorescents	5	12	60	3.0	180
Incandescent lights	3	40	120	1.0	120
Stereo	1	50	50	3.0	150
TV/VCR	1	50	50	0.5	25
				Total	475

DC Loads

Item	*Qty.*	*Watts*	*Total Watts*	*Avg. Hrs./Day*	*Avg. WH/Day*
Halogen bulbs*	7	20	1	2.0	280
Radio telephone	1	5	5	24.0	120
Incandescent lights	2	40	80	1.5	120
				Total	520

*Fourteen, 10 W halogen bulbs, wired in 7 series groups.

Maggie Nolan’s System Costs (1990)

Item	*Cost Spanish Pesatas*	*US$**
4 Solon panels, 70 W	280,000	$1,556
Berel inverter, 1 KW	140,000	778
Misc. wires, conduit, fuses, electrical boxes, & labor	100,000	556
4 Varta batteries, 12 V, 180 AH	80,000	444
Steca Solarix Delta charge controller, 20 A	25,000	139
Voltcraft SPA-5 voltage converter, 24 to 12 VDC	5,000	28
Total	630,000	$3,500

*180 pesatas = 1 US$

incandescent lights are also wired in series to serve as dining room overhead lighting.

I questioned Maggie about why the lights were wired in series, since this would cause both bulbs to go off if one burned out. The installer had chosen to wire the 24 volt system like this because it was easier to obtain 12 volt bulbs. The third DC circuit is wired to a Voltcraft SPA-5, 24 to 12 VDC voltage converter so that it can power the 12 volt radio telephone/answering machine.

Unlike the DC circuits, all four AC circuits have low voltage disconnect, via the 1 KW Berel inverter. Between the inverter and the batteries is a 100 amp fuse. The inverter's AC output is routed to a small, four-circuit fuse box with a residual circuit device, which in the U.S. is called a ground fault interrupt. From the fuse box, the wiring becomes a standard European house job with two hot wires and a ground, all run in conduit. All the AC circuits are wired with 5 mm^2 (#10 AWG) cable. In Spain, the standard, nominal voltage for AC is 230 volts at 50 Hz.

The AC system powers receptacles in three upstairs bedrooms, the entrance room, and the spare downstairs bedroom. Each room has an overhead light, either a 15 watt compact fluorescent or a 40 watt incandescent.

Maggie's only complaint about her solar-electric system is the lack of a low voltage disconnect (LVD) for the DC circuits, which to fix requires a little bit of rewiring. It should have been part of the original design, to preserve the health of the batteries. Maggie and I debated as to why the system was wired without this feature. We ended up calling the installer. He explained that he felt it was important always to have some DC electricity available in case of emergency. Although Maggie might have agreed at the time—which is now a bone of contention between her and the installer—she now wants to rewire the system's DC loads and take advantage of the controller's LVD capabilities.

Contented Solar Expatriates

Maggie's neighbors, all expatriates, are also solar powered. They are quite a collection of eccentrics. Tony and his wife have a family of 38 cats and 6 dogs. He's a talented musician who plays both saxophone and keyboards with three local bands.

Danny, who is also British, is a DJ. He's into gardening and tinkering with RE. He has a 75 watt wind turbine and a solar-electric panel or two. He runs his little music studio off the RE. Another couple works on the land, tending a lovely organic farm. Others raise goats and make cheese every bit as good as the cheese made by the natives. One South African neighbor is building a yurt.

Overall, Maggie is pleased with her solar-electric system. She now realizes that a successful solar-electric system starts with a well-thought-out design and competent installation. Using energy from the sun fits in with her ecologically minded lifestyle, and also impresses her sun-starved guests from the rainy British Isles.

Access

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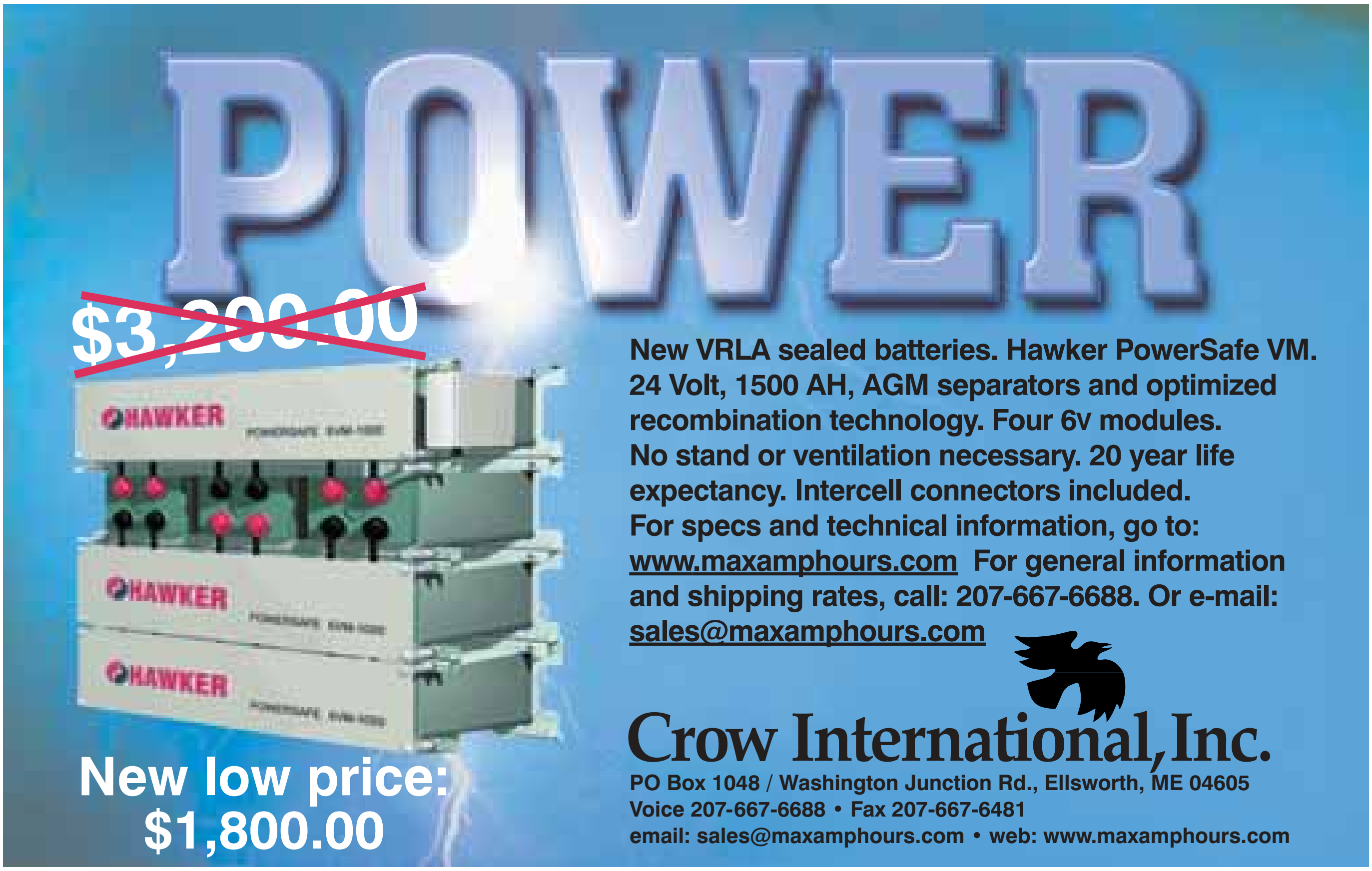
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Solar Water Heating in Iowa

Roy W. Tonnessen,
Photos by Dick Arnold

Roy Tonnessen's self-installed solar hot water system supplies all his family's DHW needs many months of the year.

Using the sun to heat your domestic water is one of the most practical and least expensive applications of solar energy. We installed a solar domestic hot water (SDHW) system for our two-person family in the small town of Fairfield, Iowa toward the end of 1999. During the year 2000, we turned off our natural gas water heater for nine months, from mid-February to mid-November. We got all of our domestic hot water—for clothes washing, dish washing, bathing, showers, etc.—from three solar water heating collectors.

A properly designed and installed SDHW system will provide enough savings to pay for itself quickly. It consists mainly of tried and true traditional plumbing parts, and it can be expected to last for 20 to 30 years. The sooner you invest in an SDHW system, the sooner you will be able to enjoy basically free hot water. Solar water heating is right for the environment. Pollution is reduced. Solar water heating will make you and the nation more self-sufficient.

Capability & Cost

In the summer, a properly sized SDHW system can meet 100 percent of your water heating needs in most parts of the United States. During the winter, depending on where you are located, it may only supply a portion of your needs, and can then function as a preheater to your backup water heating system.

During some summer days, the water/glycol mixture coming from my solar collectors reaches 190°F (88°C), and the temperature in the hot water storage tank is regularly at 160°F (71°C). I often shade one or two collectors, since we can't make use of all the hot water. At 9:30 AM, one sunny morning last winter, the outside air temperature was -6°F (-21°C), and the temperature of the water/glycol mixture coming from the solar collectors was 85°F (29°C). At noon when the outside temperature was 0°F (-18°C), the incoming water was 110°F (43°C).

During the coldest days of winter, I see the temperature in the storage tank moving from 57°F (14°C) (the temperature of the city water) in the morning, to 80°F (27°C) at noon. The solar collectors clearly help to preheat my domestic water, and cut down on the time the natural gas water heater needs to run during the winter months.

What does it cost? The Department of Energy (DOE) estimates that a professionally installed SDHW system of this size will cost US$2,000 to US$3,000. The parts for my system cost about US$900. I obtained several Yazaki, 3 by 6 ft. (0.9 x 1.8 m) collectors from a large, dismantled system. Since I had some extra used collectors, I traded with my neighbor Fred. He got three collectors in exchange for designing and installing my system. I provided my labor assistance for both his and my system.

We bought most of the other parts from a local plumbing supply store. They ordered some of the items for us, but most were in stock. We bought a stock tank (normally for watering cattle) to use as the solar hot water storage tank, and built the heat exchangers into it. We bought the sheets of insulation for the tank from a local lumberyard. I bought my differential thermostat from Kera Technology in Canada, and a few items from AAA Solar.

Conservation

There is no cheaper, cleaner, or greener energy than energy that you don't use—energy that doesn't need to be produced. Before you consider installing an SDHW system, determine what you can do to conserve water and energy. I installed two insulating blankets around my natural gas water heater. I also cut to fit and installed a 2 inch (5 cm) thick sheet of insulating board on top of it. (Be careful not to obstruct air passage around the draft hood at the bottom of the flue.)

I turned the water temperature setting on the water heater down to 120°F (49°C). The only negative result of the lower thermostat setting was that the soap in the dishwasher didn't dissolve completely. We chose to keep the thermostat setting low and turn on the electric temperature booster that is built into our dishwasher. We thus use a little more electricity, but have had no more problems getting dishes clean and free of soap residue.

We insulated our hot water pipes and installed good quality, low-flow shower heads to cut down on the volume of hot water used. When my natural gas water heater gives up the ghost, I will probably install a natural gas, tankless, on-demand water heater. Some models are specifically designed to work with SDHW systems.

Our Solar Water Heating System

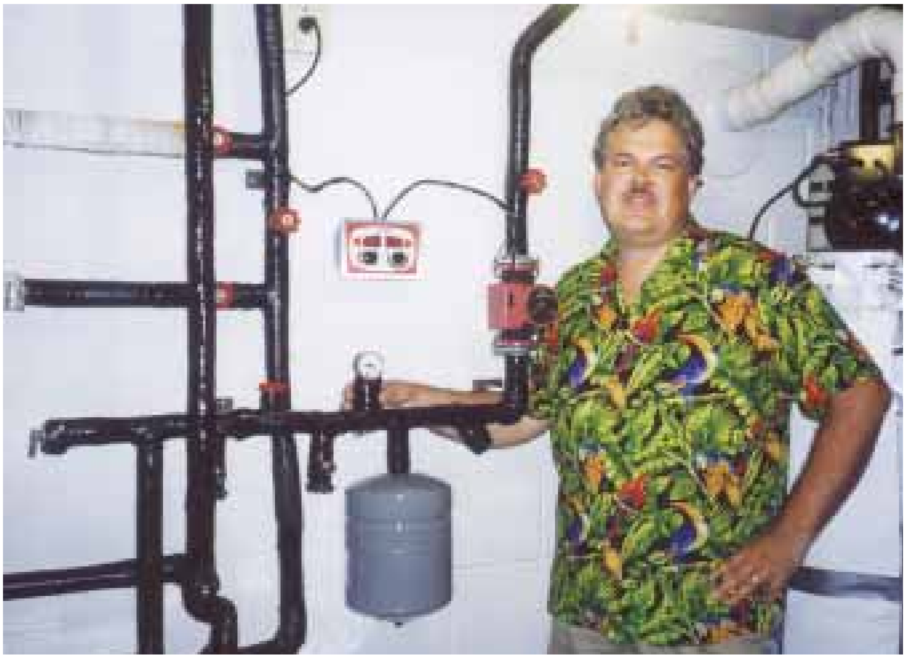
We have an active, closed loop, flat plate collector system. This system is appropriate for a climate with freezing temperatures. It can be switched to be either a one-tank or two-tank system.

It is called "closed loop" because it has an antifreeze, heat transfer fluid that moves through the solar collectors in a circle or loop. It is called an "active" system because a small, electric pump moves the fluid through that closed loop. "Flat plate" collectors are the most common type of solar hot water collectors. They consist of a flat, insulated, weatherproof box containing a dark absorber plate. The antifreeze liquid runs through passages in the absorber plate, where it absorbs the heat from the sun.

The five major component groups in our solar hot water system are:

- The solar collectors (panels). They capture the solar energy.
- The storage tank. Here a reservoir of water is heated by one of the heat exchangers, and the heat is stored there for immediate or later use. A conventional water heater can be used for additional water storage for most of the year, and as a backup during the winter.

At the works—Roy's maze of pipes is actually quite simple.



The single, AC powered, Grundfos circulating pump.

- The liquid-to-liquid heat exchangers. These transfer the sun's heat into your domestic hot water system. In my setup, one heat exchanger extracts the heat from the water/glycol mixture in the collection loop and transfers it to the water in the storage tank. The other heat exchanger warms the city water in the delivery system by transferring the heat from the water in the storage tank to the hot water we use.
- The plumbing system. It moves the heat, captured in a fluid mix of water and nontoxic glycol, from the collectors to a heat exchanger.
- The differential thermostat/controller. This regulates the operation of the circulation pump.

How Do the Panels Work?

When you open a car door on a warm summer day, you feel a blast of hot air, and the seats are too hot to sit in comfortably. The car is basically a box of metal with openings covered by glass. The sun's rays pass through the glass and heat up the inside of the car. The car acts as a solar collector.

The flat plate solar collector works similarly, but better. The sun's rays pass through the glass cover and hit the dark metal absorber plate below. The temperature on the metal surface may reach 250°F (121°C). The water/glycol mixture circulating through the absorber plate picks up heat. The insulated, glass-covered collector helps contain the heat. If you turn off the circulation pump in an SDHW system on a sunny day, the water/glycol mixture in a flat plate collector can easily reach boiling temperatures.

With most common collectors, many thin water pipes are sandwiched between two sheets of metal absorber plate, usually running vertically. In my system, a small, Grundfos UPS 15-42, circulating pump pushes the antifreeze mixture of distilled water and nontoxic propylene glycol very slowly through the pipes. As the fluid exits the top of the solar collectors, it has picked up quite a bit of heat from the metal sheets.

The liquid continues from the solar collectors outside my house to the liquid-to-liquid heat exchanger at the bottom of the water storage tank located in my basement. As the hot liquid passes through the heat exchanger, some of the heat circulating through it is transferred to the water surrounding it in the water storage tank.

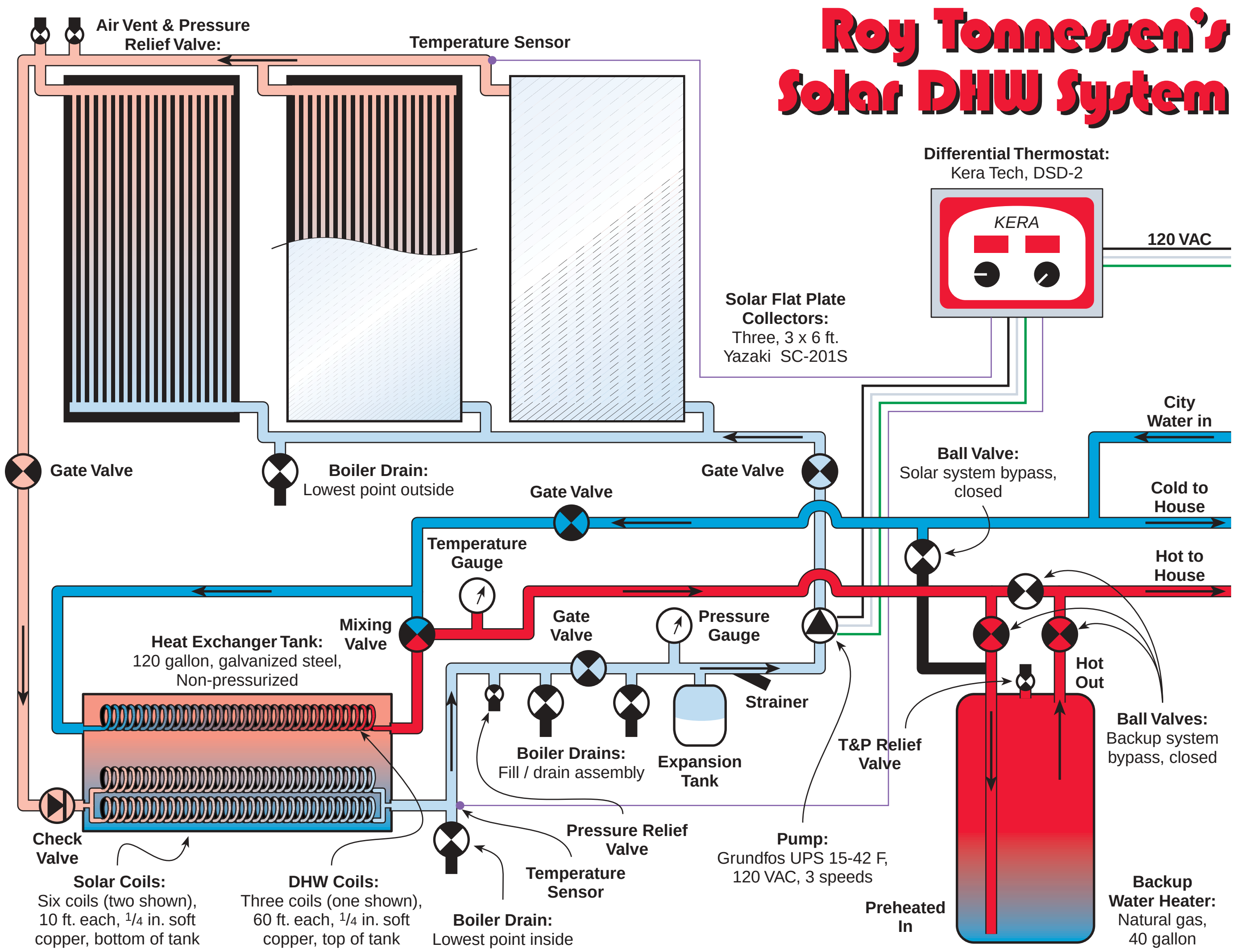
The fluid is cooler after it has passed through my homemade heat exchanger, and is then pumped back to the solar collectors. If the sun is still shining, the cycle starts all over again, continuing to heat the water in the storage tank. All of this happens in a closed loop where the water/glycol mix runs in a circle, and never mixes with the water in the storage tank. This part of the system is often called the collection or solar loop.

Differential Thermostat

The controller or brain of our system is a Kera Tech DSD-2 differential thermostat (DT). The DT is used to turn the circulation pump on and off at the appropriate temperatures.

A differential thermostat is not like the household thermostats you may be familiar with. It measures the *difference* in temperature between two points, based on readings from two heat sensors. The two points are the temperature at the outlet of one of our solar collectors,

A Kera differential thermostat controls operation.



and the temperature at the top of the solar hot water storage tank. If I set the DT at 19°F (11°C), it will search to see if the temperature in the solar collector is higher than the temperature in the storage tank. When the water/glycol mixture in the collector gets to be 19°F warmer than the water in the storage tank, the DT will start the circulation pump.

The DT will continue to register the difference in temperatures. The pump will be turned off when the temperature in the solar collector is down to 6°F (3°C) warmer than in the storage tank. Our DT allows us to select any temperature differential from 3°F to 22°F (2–12°C) to start the pump. We can choose to let the circulation pump be turned off when the temperature difference is at any point between 2°F (1°C) and 12°F (7°C).

Our unit has two digital displays, which alternate to show four different readings. At a glance, I can see the temperature of the water/glycol mixture in the collectors, the water temperature in the storage tank, and the two temperature differentials I have selected. On my DT, a light comes on when the circulation pump is running. The pump is so quiet that I usually cannot hear it.

Tank & Heat Exchanger Details

An expansion tank automatically absorbs the changes in liquid volume and pressure. An air vent is installed at the highest point of the loop at the collector outlet. A check valve in the solar loop prevents reverse thermo-syphoning of the antifreeze mixture at night when the collectors become cooler than the storage tank. This swing check valve does not have much restriction to flow, and opens easily. It must be mounted in a vertical position so it is normally closed by gravity.

A nonpressurized solar hot water storage tank houses the two heat exchangers. We used a galvanized steel cattle watering tank. It is 5 by 2 by 2 feet (1.5 x 0.6 x 0.6 m), and holds roughly 120 gallons (455 l) of water. For most of the year, when I turn off the gas water heater,

Tonnessen SDHW Costs

Item	Cost (US$)
3 Yazaki SC-201S panels, incl. plumbing, insulation, etc. (used)	$259
Kera DSD-2 differential thermostat with sensors	152
Grundfos UPS 15-42 F circulation pump, 3 speed, $^1/_{25}$ hp	110
Heat exchangers, homemade	100
Stock tank, 5 x 2 x 2 feet, approximately 120 gallons	66
Extrol #15 expansion tank	50
Watts mixing valve, $^3/_4$ inch, brass	48
Propylene glycol, 3 gallons (nontoxic)	47
2 Adjustable pressure relief valves	39
Air vent, float type	11
Pressure gauge	10
Check valve	10
Total	$902

we use the solar hot water storage tank for storing the water heated by the solar collectors before it enters my super-insulated, conventional, 40 gallon (150 l), natural gas water heater. I then have a storage capacity of 160 gallons (605 l). We have enough hot water stored to go without sunshine for two days. Our system is plumbed so that I can bypass the gas water heater tank if needed.

My fabulous neighbor Fred is a master plumber. He designed and installed my system and one for himself, including the two liquid-to-liquid heat exchangers in each system. It is important to have appropriately sized heat exchangers. Otherwise you may get disappointing results.

Since the water/glycol mixture coming from the solar collectors will be warmer than the water in the supply line from the city, the heat exchanger in the solar loop is placed at the bottom of the hot water storage tank. This heat exchanger consists of six coils, each 10 feet (3 m) long, made from $^1/_4$ inch (6 mm) soft copper refrigeration tubing that the solar heated water/glycol mixture has to pass through.

Some of the heat contained in the 50/50 glycol/water mixture is transferred to the water in the storage tank. The warmer water rises toward the top of the storage tank where the second heat exchanger is placed. If we consume a lot of hot water, this will lower the temperature in the storage tank, but it is amazing how fast it jumps back up again on a sunny day.

The heat exchanger in the delivery system is very similar. It consists of three coils, each 60 feet (18 m) long, $^1/_4$ inch (6 mm) soft copper tubing, that the cold city water coming into the natural gas water heater has to pass through. This heat exchanger sits in the upper part of the water in the storage tank that has been heated by the heat exchanger in the solar loop. This setup has worked extremely well so far.

The amount of copper tubing we used in the heat exchanger is a major reason for this system working so well. You need to have enough surface area for the cold water to travel through, so it can pick up a lot of heat from the water in the storage tank. The heat coming from the solar collectors is transferred more easily, so its heat exchanger has less copper tubing. Since I have a two-tank system, 40 gallons (150 l) of hot water sits in the natural gas water heater, ready for use at any time. My family can take two showers and also use another faucet at the same time without any problems.

The plumbing code dictates that you have to use a double-walled heat exchanger, so two pipes will have to fail at the same time before there is any chance of contamination of your drinking water. My setup with two single wall heat exchangers submerged in a tank filled with nonpotable water should fulfill this requirement, since there is still double protection. Nevertheless, you do not want to use traditional automotive antifreeze (ethylene glycol) in your solar hot water system, since it is very toxic.

The hot water delivery system consists of:

- A homemade liquid-to-liquid heat exchanger installed toward the top of the water storage tank.
- A pressurized 40 gallon (150 l) high-efficiency natural gas water heater.
- A $^3/_4$ inch mixing valve.
- Various valves, copper pipes, fittings, and pipe insulation.

The mixing valve is used to add cold water to the flow of water from the storage tank when the water exceeds a selected, preset temperature, to avoid scalding. Mine is adjustable. The heat-sensing element of a mixing valve must be removed before soldering, and reinstalled afterwards or it may be destroyed.

Natural Gas Backup

I have a direct-vent, high-efficiency, natural gas water heater. The ironic part of having this so-called high-efficiency unit is that an electric fan is needed to force

The heavily insulated, backup, natural gas water heater.

air into the burn chamber when it is running. The good thing is that this allows me to put the fan motor on a timer, which shuts down the heater. I have chosen to set it so that our natural gas water heater, during the months that we use it, is turned off between 9:30 PM and 7:30 AM, which fits our lifestyle and daily routine.

This alone will prevent the water heater from running unnecessarily about 40 percent of the day, and there is no downside that I know of. You just need to allow the water heater to start 30 minutes before you need hot water in the morning. The cost of the timer will be paid for in savings in just a few months.

For part of the year, we turn off our natural gas water heater completely. When I open a hot water faucet, the cold water from the city moves through a liquid-to-liquid heat exchanger immersed toward the top of the solar hot water storage tank. After it has been heated there, it passes through the natural gas water heater tank and continues on to the faucet. So every time we use warm water, it circulates through the traditional water heater tank, unless I have switched it to bypass the tank. In effect, I have two hot water storage tanks. The water can get so hot in the summer that after it has passed through the heat exchanger, the mixing valve mixes in some cold water.

During the coldest winter months, everything functions much the same, except that the backup natural gas water heater is on. When I open the hot water faucet, the water is preheated by the heat exchanger in the solar hot water storage tank, and continues into the natural gas water heater, where the temperature is boosted as necessary to meet the thermostat setting.

If the water is colder than the water heater thermostat setting, the natural gas heater will be activated and heat the water. If the water, preheated through the heat exchanger in the solar hot water storage tank, is warmer than the water heater thermostat setting, no backup heating is necessary, and it will flow through to the faucet, just as it does during the summertime. The collection loop collects and transfers the heat from the sun, and the delivery system receives the heat and delivers it to the house in the form of hot water.

System Sizing, Location, Collector Orientation, & Tilt Angle

We have enough hot water storage capacity to get us through two days without sunshine. That works very well in our climate. The average hot water consumption in the US is 20 gallons (76 l) per person per day.

We placed our solar collectors on the top of railroad ties dug partially into the ground. The collectors are leaning up against the south-facing wall of the house, high enough off the ground to avoid rain splash and snow. The collectors are anchored to the wall and to the railroad ties. We kept outdoor pipe lengths to a minimum to avoid energy losses.

Natural Gas Savings

Year 2001 with SDHW, compared to 1999 (last year before solar)

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
Reduction	27%	40%	88%	86%	100%	100%	100%	100%	100%	85%	83%	54%

Year 2001 with SDHW, compared to 6 year average before SDHW system

Reduction	72%	80%	92%	91%	100%	100%	100%	100%	100%	85%	91%	64%

Solar water heating panels may collect about twice as much energy during an hour in July compared to January. So we have plenty of sunshine available in the summer, but we need to catch every possible ray in the winter.

Solar collectors produce the most energy when their collection surfaces are perpendicular to the sun. Tilting collectors to match a particular site's latitude will produce the greatest amount of energy on an annual basis. But the sun's path is lower in the sky during the winter months, and there's less solar energy to collect. Setting the collectors at a steeper tilt angle gives us a leg up during the winter because the panels are more perpendicular to the sun's path.

The three Yazaki panels are anchored to railroad ties.

Tips from the Pros

Home Power magazine is rooted in the spirit of do-it-yourself ingenuity and systems that work. In recognition of the fact that there are many right ways to design a successful system, we have asked industry professionals to offer their comments, critiques, tips, and techniques for the benefit of readers inclined to homebrew their own solar hot water system. In some cases, opinions may differ from the installation presented here.

Heat Exchanger Design
The heat exchanger used in this system performs well under conditions of low demand. Generally a single pass of the domestic hot water (DHW) through a heat exchanger can result in poor performance if the DHW demand is high, such as when a shower and a washing machine are running at the same time.

The great length and narrow diameter of copper pipe used in this system is absolutely necessary to overcome the inherent inefficiency of this single pass heat exchanger. Although the three, 1/4 inch coils provide plenty of surface area required for an effective heat exchanger, most residences subject to the Uniform Plumbing Code are required to have a total cross-sectional area of pipe equal to that of a 3/4 inch pipe serving a domestic water heater. Check with your local building inspector to be sure of requirements.

Most closed loop systems use a much smaller but more efficient counter-flow heat exchanger configuration. Two pumps are used to circulate the two fluids simultaneously in opposite directions through the heat exchanger. This allows for the DHW to pass through the heat exchanger many times and the stored water is always available for times of high demand. The added cost of the additional pump, commercial heat exchanger, and electricity pays off in better performance over the life of the system. The exception is applications with a very low DHW demand.

Air Vent
Automatic air vents can be problematic in solar closed loop systems. They often fail under high temperature and pressures associated with solar water heating systems. Manual coin vents are generally adequate for household-sized, closed loop SDHW systems.

Pressure Relief Valves
Closed loop SDHW systems generally use pressure relief (PR) valves rated at about 50 to 75 psi. Temperature/pressure relief (T&P) valves, normally found on a hot water tanks, are not used in solar closed loops. They are generally rated to open at 210°F (99°C) or 125 psi. Temperatures of solar closed loops may regularly exceed the 210°F rating.

Pipe Insulation
Buried insulated pipe should be encased in 4 inch PVC pipe or suitable protection to keep the insulation from compressing and losing its insulation value.

Chuck & Smitty, AAA Solar,
Albuquerque, New Mexico

Temperature Stratification
Maintaining a high degree of temperature stratification within the solar storage tank can improve system efficiency significantly. The hottest water near the top of the tank is the optimum source for hot water delivery. The coolest water at the bottom of the tank is the optimum source for supplying the collectors. These heat exchangers are optimally located to take advantage of this principle, but would be even more effective in a taller tank with a higher degree of temperature stratification. The tank sensor is best located at the bottom of the tank in order to sense the coldest water in the tank. This will allow the system to operate longer each day to collect as much useful heat as possible.

Ken Olson, SoL Energy & *HP* solar thermal editor

Fairfield, Iowa, is located at 41 degrees northern latitude. To optimize our system for the winter months, we installed our collectors at a 56 degree angle. This has turned out to work very well. In our climate, this steep angle also helps keep the collectors free of snow. We used a simple angle indicator, available at the local hardware store, to install the collectors at the desired angle. More details on collector siting, angle, etc. can be found in Ken Olson's articles that are referenced in the Access section.

Collector Shading

We used a Solar Pathfinder (reviewed in *HP16* and demonstrated in a video clip on *HP's* Solar1 CD) to locate the collectors so that we would avoid shading between 9 AM and 3 PM. It is an ingenious contraption. For each month of the year, it shows you how many hours the sun will shine on any location where you are considering placing solar collectors. It shows you any obstructions from buildings, trees, hilltops, etc. that might appear in the path of the sun for that specific location.

You can create a simple chart for each location and quietly sit down afterwards and calculate what percentage of the possible 100 percent you will be able to catch at each specific location. For example, if you move your collectors a few feet, you may be able to clear the shadow from a building nearby and thereby increase the output of your collectors.

Efficient Use Patterns

When you install an SDHW system, you may find that you have a different attitude, and feel more connected with nature. You will look out the window in the morning and see that it looks like a bright day, and then use your clothes washer or dishwasher. You may hold off doing your laundry for a few days if it is overcast, and then try to squeeze in several loads when you have a bright, sunny day.

You need to work with nature to get the most out of your solar water heating system. You also have to bring your family or house mates into the process before installing a solar water heating system, since you will benefit if everyone is willing to change their routines now and then.

If possible, use your dishwasher and clothes washer between 10 AM and 3 PM on days when the sun shines brightly. The hot water you use will then be easily and quickly replenished by the sun, without any need for help from your gas or electric water heater. You will then have a nice reservoir of hot water to last you through the sunless evening and night, and keep you comfortable if the sun should hide behind a cloud for a day or two.

Solar Hot Water System Maintenance

Weekly

- ❏ Check that system pressure is 15 to 30 psi.
- ❏ Check that pump is operating when it is sunny.
- ❏ Remove snow if necessary.

Monthly

- ❏ Check for a distinct temperature differential between the supply and return pipes in the collector loop (15–20°F; 8–11°C is typical). A noticeable difference in temperature with bright sun is a good indication that everything is fine, the pumps are working, and the heat exchange is good. Solar pros do this with one hand on each pipe if the system isn't too hot. Caution! Test the pipe with a wet finger like you do an iron before using your hands. If it's too hot or you want really accurate data, use a thermometer.
- ❏ Check for leaks in the system and home—pressure relief valves, temperature pressure relief valve on the storage tank, faucets, bath, and shower.
- ❏ Confirm that there is no shading of the collectors between 9 AM and 3 PM.
- ❏ Check that the collectors are clean so that the sun can easily reach the dark absorber plate; clean the glass if necessary.

Annually

- ❏ Lubricate the circulating pump according to the manufacturer's recommendations (unless they are sealed bearings).
- ❏ Check insulation on pipes and tank.
- ❏ Look for signs of leaks at roof penetrations.
- ❏ Review energy bills to confirm savings.

Every Two Years

- ❏ Check the domestic water side of the heat exchanger for scaling. De-scale if necessary. (This can be done with a mild solution of muriatic acid and water or even vinegar if the scaling is not pronounced. A symptom of heat exchanger scaling is bright sun and pump(s) working, but little or no temperature differential between the supply and return pipes in the collector loop.
- ❏ Check the pH (acidity or alkalinity) of the propylene glycol heat transfer fluid. A pH of below 7 is a good indication that the mixture needs to be changed.

Plumbing Details
We used mainly 3/4 inch, type L sweat-soldered copper pipes and some flexible, type M copper pipe, because it is easy to bend. We used a 95/5 tin-antimony solder in the solar loop, and brazing solder for the heat exchangers. These have higher temperature ratings than 50/50 tin-lead solder. The 50/50 solder contains lead, and should not be used on domestic water lines. We used Rectorseal #5, yellow, soft-set, pipe thread sealant. Standard joint compounds for threaded fittings will not prevent leaks in pipes filled with a water/glycol mixture.

We placed gate valves on both sides of major components to allow us to service them without draining the whole system. They should not be installed in a way that can isolate the solar collectors from pressure relief valves and the expansion tank. Otherwise, the collectors could burst during stagnation conditions, such as if the circulation pump fails on a sunny day while the ball valves are closed. We installed the circulation pump after the heat exchanger, where the water is cooler, to put less stress on it.

We grounded the collectors to prevent damage from lightning. To make a continuous electrically conductive connection to ground, a copper wire jumper connects the collector frame to the copper pipe of the solar collector loop. Another ground wire is connected from the copper pipe to a suitable ground, such as ground rod. It is important to jumper around any dielectric unions, typically found on hot water heaters, or any other interruptions in the electrical continuity between collectors and ground.

The copper pipes in the solar loop and hot water delivery are very well insulated outside and inside the house. To shield the insulation from UV rays and provide some protection from birds and rodents who might otherwise love to use it as nesting material, I chose to wrap all my insulation with black tile tape (for joining and waterproofing tubing).

We used Rubatex elastomeric pipe insulation with 1 inch (25 mm) and in some places 1/2 inch (13 mm) wall thickness. In retrospect, I wish I had used insulation with 1 inch wall thickness wherever possible. We did not install the pipe insulation until we had pressure tested the system. Smitty at AAA Solar recommends painting the Rubatex insulation with a product called Ruf Snow. It is a white rubberized paint used to coat and seal mobile home roofs.

We installed the sensor wires for the differential thermostat running outside the insulation, to protect them from the high pipe temperatures. The wires are covered and protected under the black tape that I wrapped around the insulation. The sensors are installed in wells, special plumbing fittings that are made to accommodate these sensors. They allow you to remove or replace the sensors without losing system pressure or fluids. They also protect the sensor from corrosion by avoiding direct contact with the liquids.

Change Your World
Solar energy is wonderful because it is democratically distributed to the rich and the poor alike throughout the world. It is basically ours for the taking. One major challenge is how to efficiently collect, use, and store this energy. I have shared with you how we successfully installed our solar water heating system for a cold climate.

If you are inspired to run out and start purchasing plumbing parts to build a solar water heating system, please take some time and learn more about the different types of SDHW systems, heat exchangers, etc. that are available. The system I have described has worked extremely well for my family, with our pattern and level of hot water consumption, in our climate, with our level of sunshine. But it may be that another system or setup will fit your situation better. You owe it to yourself to do some research to find the system that will work best for you.

Margaret Mead’s well-known statement has been an inspiration to me: “Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed it is the only thing that ever has.”

Access
Roy W. Tonnessen, PO Box 1443, Fairfield, IA 52556

Installation Guidelines for Solar DHW Systems, U.S. Department of Housing and Urban Development, May 1980, HUD-PDR-407(2), by Franklin Research Center, Philadelphia, Pennsylvania • Good, clear, drawings, explanations, definitions, checklists, & suggestions Available via government depository libraries

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

Build Your Own Solar Water Heater, by Stu Campbell with Doug Taff, Garden Way Publishing, ISBN 0-88266-129-9 • Covers why and how different types of collectors work • Available used

HP84, page 44, and *HP85,* page 40, articles by Ken Olson. • Outstanding information, nice illustrations

HP25, page 37, and *HP27,* page 64, articles by Tom Lane. • Savings, payback, and sizing for SDHW systems

AAA Solar Supply, Inc., 2021 Zearing NW, Albuquerque, NM 87104 • 800-245-0311 or 505-243-4900 • Fax: 505-243-0885 • info@aaasolar.com www.aaasolar.com • Educational & informative Web site; SDHW components

Ken Olson, SoL Energy, PO Box 217, Carbondale, CO 81623 • Phone/Fax: 720-489-3798 info@SoLenergy.org • www.solenergy.org

Kera Technology, Andy Lukas, 1320 Midway Blvd., Unit 21, Mississauga, ON L5T 2K4, Canada • 905-566-0823 Fax: 905-566-9036 • keratech@interlog.com www.interlog.com/~keratech/thermsd2.htm • DSD-2 differential thermostat

Things *That* Work!

Tested by Home Power

Morningstar's ProStar PS-30 Solar Controller

Richard Perez

The ProStar PS-30 is a solar-electric charge controller capable of handling 30 amperes of PV current at either 12 or 24 VDC. It is computerized, easy to use, and very reliable.

This controller provides solar-electric systems with sophisticated PV regulation by using an onboard microprocessor. It is very easy to install and use. The installer only needs to set a simple, three-position, rotary switch to the desired battery type. Features include an optional LCD numeric display, which allows the metering of virtually all PV/battery functions; LED status indicators; battery temperature compensation (with optional remote temperature sensor); pulse width modulation (PWM) power control; and load power control with low voltage disconnect.

The PS-30 offers a high level of electronic protection for the PV/battery system. The following items are protected by the controller: short circuits in both the PV and load, overload in either PV or load, reverse PV polarity, reverse current at night, high voltage disconnect, high temperature disconnect, lightning and transient surge protection, loads protected from voltage spikes, and automatic recovery for all fault protection conditions.

In addition to all these protection features, the ProStar PS-30's microprocessor is capable of system and self-diagnosis. If there are faults in the system or in the controller, the PS-30 will find and display the fault condition on its LCD display.

In spite of the high level of electronic sophistication, the ProStar PS-30 is simple to set up. The user has only one item to program—battery type (gel cells, sealed AGM, or flooded cells). That's it. The PS-30 even selects the battery voltage, either 12 or 24 VDC, automatically. It's wonderful to see high technology that's user friendly.

The physical dimensions of the ProStar PS-30 are 6 inches wide by 4.5 inches high by 2.2 inches deep (152 x 114 x 55 mm). It weighs 12 ounces (340 grams). The controller is suitable for use in tropical climates and unconditioned spaces. It has stainless steel connections, the aluminum heat sink is anodized, and the circuit board is conformal coated to protect it from moisture. The controller is rated to operate from -40°C to 60°C (-40°F to 140°F) and at 100 percent humidity (noncondensing).

The PS-30 employs nonadjustable voltage limits for its four-stage charging process—bulk charge, PWM regulation, float, and automatic equalization. The controller has two different automatic equalization

Morningstar ProStar PS-30 Voltage Set Points

Regulation Type	*Gel*	*Sealed AGM*	*Flooded*
Bulk	14.00	14.15	14.40
Float	13.70	13.70	13.70
Equalization	N/A	14.35	14.9/15.1
Load disconnect	11.40	11.40	11.40
Load reconnect	12.60	12.60	12.60

cycles. One is based on calendar days (25 day cycle), and the equalization voltage is 14.9 VDC. The second automatic equalization cycle is based on battery history or depth of discharge, and equalization voltage for this mode is 15.1 VDC. If the battery voltage falls below 11.7 VDC, this cycle is initiated. The voltage regulation of the PS-30 is super tight, with no more than 60 mV deviation from the setpoints.

The PS-30 is also very efficient; it draws less than 30 milliamperes. Since the controller uses a field effect transistor (FET) to control the PV array and doesn't use a blocking diode, the forward voltage loss through the controller is less than 0.25 VDC. Due to the high voltage regulation accuracy, up to ten PS-30s can be wired in parallel, making it easy to expand the PV array to up to 300 amperes.

Documentation & Installation

The ProStar PS-30 comes with a 17 page operator's manual. This manual is thorough and complete. I can't imagine needing any more data than is supplied by this manual.

Joe Schwartz installed the ProStar PS-30 in January 2002. The installation site was *Home Power's* remote and unattended radio telephone (R/T) power shed. This system powers our two-line, Carlson OptaPhone VHF radio telephone, and as such it provides essential service—we cannot tolerate any outages here. This system uses two Siemens SP75 PV modules as an energy source, and three, 12 volt, 105 ampere-hour, Concorde AGM, sealed, lead-acid batteries for energy storage. Joe said that installing and programming the ProStar PS-30 was straightforward and clearly explained in the controller's manual.

ProStar PS-30 Applications

This charge controller is ideally suited for use in cabins, RVs, and in systems installed in developing nations; its simplicity of installation and use makes it a natural for these sorts of systems. Its high reliability and fault tolerance make it applicable for high reliability systems and systems that are not easily accessed for maintenance—remote cabins, communications installations, and systems such as our R/T site, which do not receive regular maintenance.

Since this controller is neither UL listed nor conduit ready, its application in systems that must be inspected is problematic. The ProStar features nonadjustable voltage limits, which is just fine for sealed batteries. I think that voltage limit adjustability is a desirable feature for flooded, lead-acid cells. The lack of adjustability in the voltage limits makes installing the temperature compensation feature a necessity.

High Reliability Controller

The list price of the Morningstar ProStar PS-30 controller is US$152. The model we tested, which includes the optional digital display, has a list price of US$219. The optional remote temperature sensor sells for US$29. The PS-30 is an excellent value, and is easy to use and install. This controller is a high reliability unit and carries a five-year warranty from its maker. Complete controller specifications and the operator's manual are available for download from Morningstar's Web site.

The Morningstar PS-30 is an excellent choice for unmaintained PV systems. Its high reliability, self-recovery from most faults, and ease of use make it an

The ProStar PS-30 is working flawlessly, without supervision, at *HP's* remote radio telephone power shed.

excellent controller to use in developing nations. Morningstar gets a big thumbs up for the ProStar PS-30!

Access

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2. The product must be durable and last in actual service.
3. The product must offer good value for the money spent on it.

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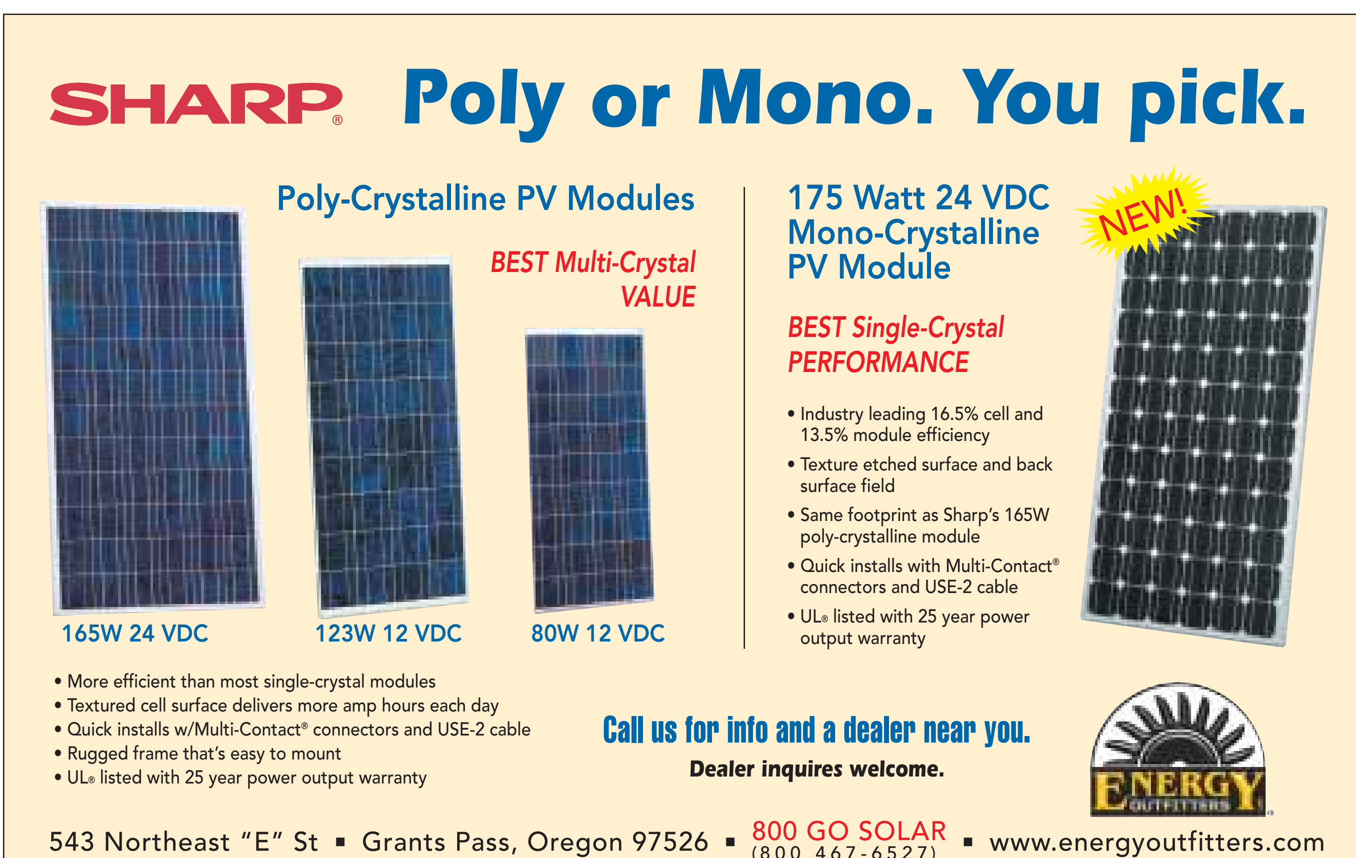

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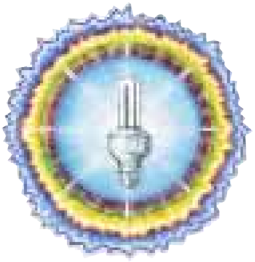

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TOP SECRET

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

PROFILE: 0022

DATE: June 2002
LOCATION: Northern Hemisphere
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 1,000 watts of PV, 1,600 rated watts of wind
PERCENT OF ANNUAL LOAD: 95%
TIME IN SERVICE: 3 years

I have two wind generators and 1 KW of PV. Together, they can produce more energy than I need for my home load. What to do with it? Might as well backfeed it into the grid...

My first wind generator is a Whisper 600 on a homebuilt, 45 foot (14 m) tower. I recently installed a Bergey XL.1, 1,000 W turbine on a 100 foot (30 m) tower. My PV array consists of eight Uni-Solar 64 modules, four Siemens SM55 modules, and a few miscellaneous modules.

The inverter is a Vanner 24RE4500, which is a very robust inverter. It has a problem or two to be worked out, mainly because of the IEEE 1741 standards, but I've been very happy with it. At times, I can see 1,000 watts going back into the grid on each leg of this 240 VAC inverter. I have twelve L-16H batteries, so I can keep my loads going when the grid is down.

I have done the usual load analysis and efficiency measures, so my home is not wasteful. My load is light, with compact fluorescent lighting, a ConServ freezer, and a high-efficiency DC fridge. This gives me plenty of surplus energy that I'm happy to send back into the grid.

I checked with the local utility, and everything that I had read in Home Power about the negative attitude and obfuscation was true. They tried to block my way at every step. I went to a meeting with all the head honchos at my local utility, so I had a chance to go from one honcho to the next, asking how to connect my system legally. I knew I was talking to the right people.

At every step of the way, it was just pure obstructionism. Finally, at the last honcho, the words were so similar to what I'd read in HP: We will sell to you for 8.7 cents a KWH, and we will buy back from you (bless us!) for 2 cents. They have no interest in working with the little guy.

And being a little guy, I don't feel like fighting them. So what's the simple thing to do? Go guerrilla. Push the little button and make the meter go backwards.

I am careful to not generate more energy than I use. I pay attention to the utility meter so that I end up at around zero by the end of each month. I figure that I can pay for a few kilowatt-hours a month without raising any flags.

I don't know exactly how many KWH I use per month. The utility meter can stay on the same number for a month, so it's hard to tell. It gives me great pleasure to go out when the wind generators are screaming and watch the utility meter smokin' backwards.

How did I get started in renewables? Unfortunately for my wallet, somebody introduced me to Home Power many years ago. Since then, the magazine has cost me a whole lot of money, but that's fine with me. The equipment I've bought keeps on working. If I chased little white balls around a golf course instead, all I'd have would be a bunch of receipts. Instead, I have a renewable energy system that keeps on going, and going, and going.

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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Windpower 2002

American Wind Energy Association Conference, Portland, Oregon

Ian Woofenden

In early June, I caught a train south to Portland, Oregon. I hooked up with *HP* Tech Editor Joe Schwartz to attend the annual conference of the American Wind Energy Association (AWEA). Joe and I left a few days later, impressed with the state of the wind industry.

Both big and small players in the wind energy market attended AWEA's 2002 conference in Portland, Oregon.

The Windpower 2002 conference was primarily focused on utility-scale wind energy, as is AWEA. And the utility-scale wind energy industry has been booming. Attendance at the conference doubled, compared to the 2001 conference, with more than 2,000 people registered, and an additional 350 visitors on the one afternoon that the exhibition hall was open to the public.

Renewable Transition?

Standing in line for one of the catered meals during the conference, I found myself next to a gentleman from Shell Oil. I asked him what Shell was doing in wind energy, and his quick and emphatic reply was, "Making money!" While this might be a bit challenging to some laid-back, cooperatively minded, renewable energy activists, it's a sign that wind energy has attracted serious attention, and is no longer a small-time proposition.

In fact, at times I wondered if I was at an oil conference, considering the number of cowboy hats and suits there. Maybe wind energy is part of that new oil patch the world has been looking for.

Big Toys

I've been playing with small-scale wind generators for about 20 years. And though I've been next to utility-scale turbines before, I'm still awed by the scale of these machines. A Bonus 1.3 MW generator head was on display, and it required a stairway and platform to allow folks to view the innards. The generator and gearbox are enormous. This is a machine that wouldn't fit in your garage, unless you have more cars than you ought to. And that's just the generator head. The blades for this machine are almost 95 feet (29 m) long, and the complete rotor weighs 76,000 pounds (34,400 kg).

Big wind turbines need support industries. Three or four companies in the exhibit hall were selling only the airplane warning lights that sit on top of utility-scale turbines. These lights are as big or bigger than the generators we work with in the home-scale RE industry, and they cost as much, too—US$3,000 to 5,000. Other companies specialized in equipment to torque the bolts that hold the towers and turbines together, and still others sold only oil filters for the turbines' gearboxes.

Education & Encouragement

Joe and I attended the preconference workshops, one of which focused on the market for small wind and the other on wind energy fundamentals. These workshops were introductory in nature, with a cast of prominent wind energy speakers. They catered to employees of companies getting involved in wind energy, people who want to work in the industry, and others wanting to get up to speed in the field.

The opening reception was a good time to make connections. At one point, Joe and I found ourselves in a circle of five RE journalists—funny how birds of a feather flock together. We also met publishers, manufacturers' reps, and long-time wind energy fanatics. We gave out some copies of *Home Power,* and found a healthy interest in small-scale RE among folks working in large-scale wind. I guess it makes sense that if your paycheck comes from the big wind industry, you start to think about applying the technology at home.

The opening session was impressive. The speakers included the governor of Oregon, an assistant U.S. energy secretary, and the chairman of the Federal Energy Regulatory Commission (FERC). All spoke very positively about wind energy and RE in general, and I think they even meant a lot of it. AWEA's executive director Randy Swisher and president David Blittersdorf talked about how much big wind has grown in the last year, and what the hurdles are for the future.

A Place for Small Wind?

The only disappointment at the conference for me was the lack of venue for the small wind industry. Booth space at next year's event is almost US$3,000 for a minimum booth, and the registration fee for attendees is several hundred dollars. This puts the average, small wind enthusiast out of the running for this conference.

No small wind generator companies were represented on the exhibit floor, even though I ran into people from all the major U.S. manufacturers roaming the conference. This conference does not draw their customers, so it is not cost effective for them to pay for exhibit space. The focus was on big wind, and the booth and registration fees are big too.

The preconference workshop did cover small-scale wind, and a few of the conference sessions were also applicable. A small wind committee meeting was held one evening, led by Mike Bergey of Bergey Windpower. It was a who's who of small wind, with representatives from manufacturers, suppliers, the media, and others. It was great to see these folks working hard to improve the climate for small-scale wind energy in the U.S.

I wonder if AWEA would consider a separate conference for small wind, with price tags that would allow people in the home-scale wind energy industry to come. Perhaps it could be a day before the main conference, but even then, I'm not sure folks in our end of the industry can afford to support the fancy venue and trimmings that Windpower 2002 sported.

The Answer, My Friend

Though I felt a bit out of place in a modern convention hall with megabucks sponsors and professional convention fixtures, it was good to see wind energy at this level. Renewables will not be widespread until they are big business, and large-scale wind is on its way.

The United States now has over 4,265 MW of wind generating capacity on line, and 1,696 MW of that was installed in 2001. Wind farms of various sizes are popping up in all regions of the country. AWEA's 20 year goal is for wind to provide 6 percent of the electricity in the U.S., which would require about 100,000 MW of capacity.

Bonus' 1.3 MW generator head display.

Big wind—really big gearbox!

Wind farms can run into opposition, and they should certainly be sensitively sited. But U.S. electricity consumers need to make a real comparison between wind energy's advantages and disadvantages, and those of nonrenewable technologies. Wind energy, as a no-fuel, minimal pollution option, looks pretty good when you compare *all* the costs (not just the visible ones).

I think it's a very positive thing to see major corporations and high-powered businesspeople focusing on this clean energy technology. AWEA's conference was a high quality, professional event that promoted wind energy as a viable, environmentally sound, and economically sensible part of the country's energy mix.

Access

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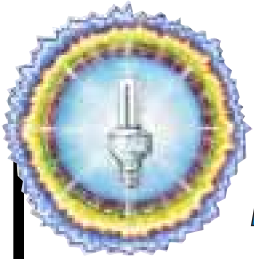

Successful Solar Businesses—2003

A three-day seminar in Ashland, Oregon, taught by Richard Perez of *Home Power*, Bob-O Schultze of Electron Connection, and Bob Maynard of Energy Outfitters on how to start and operate a successful renewable energy business.

Installing dealers will receive specific strategies on how to build their existing businesses. Would-be entrepreneurs will get a jump-start from the "lessons learned" by those who have "been there and done that." Gain instant contacts with major solar energy manufacturers and distributors right at the workshop!

Topics include: how to start a small business, renewable energy career choices, managing a small business, managing employees, marketing renewable energy, legal and tax issues, and using computers. A detailed seminar outline is available at: www.homepower.com/files/ssb00net.pdf

The dates are February 21–23, 2003. The cost is $350 and includes three lunches and a Saturday night banquet.

Seminar size is limited, so contact Rue Wright at 800-707-6585, 541-512-0201, or richard.perez@homepower.com to reserve your place. Reservations accepted for a nonrefundable $100 deposit, with the $250 balance due by 2/1/03. Interest is very high in this seminar, so reserve early if you wish to be sure of a place.

Lodging is available at discounted rates for seminar participants. The location is the Windmill Inn and Suites in Ashland, Oregon, www.windmillinns.com/ie40/ash/ash.htm or call 800-547-4747 or 541-482-8310. The nearest airport is in Medford, Oregon (MFR) and Windmill Inn offers free airport shuttle service.

We hope to see you there, and look forward to helping your solar business prosper.

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Can an EV Do the Job for Me?

Shari Prange

If you need to drive 80 to 125 miles (130–200 km) or more on a charge, the Toyota RAV4 EV is a good choice.

You're considering candidates for your next car, and you're intrigued by the idea of an electric vehicle (EV). You like the fact that they are clean, quiet, low maintenance, economical to operate, and petroleum free. But you're just not quite sure whether an EV can meet your needs.

Let's compare what you need and what you have to offer with what the car needs and what it has to offer, and see if we can make a match. We'll divide the subject into five general categories:

- Performance
- Driving Conditions
- Charging Infrastructure
- Mechanical Ability & Involvement
- Budget

Within each category, we'll look at several factors. If all or most EVs can handle an item, I'll call it a "Yes." If some EVs can handle it, but not others, or only up to a certain limit, it's a "Maybe." If no EVs (or very few) can deal with it, it's a "No." Some of these categories interact with each other, but by the time we're finished, we'll have the whole picture. You can use the accompanying table to follow along, and see where you fit in each category. So grab your pencil and let's find out how an EV scores for you.

Performance

This is the car's job description. For many people, range on a charge is of primary interest. A typical compact car conversion can travel 60 miles (97 km) or so before needing a charge, under good conditions. (We'll talk about bad conditions a little later.) A heavier vehicle might only get half that much. On the other hand, a high performance sports car conversion might get 80 miles (129 km) or up to 100 miles (161 km) on a charge—under good conditions.

Not a lot of options are available at the moment in commercially manufactured EVs, and many of them are limited to California. The Toyota RAV4 EV, with its high end, nickel-metal-hydride battery pack, claims 126 miles (203 km) on a charge. Micro cars, also known as city cars and neighborhood electric vehicles (NEVs), such as the Th!nk and the Gem get 30 to 50 miles (48–80 km) on a charge.

You need to determine your real life, daily range needs. The best way to do this is to keep a mileage log for at least a month. You also want to add some safety margin into your range capabilities in case of surprises.

A pickup conversion can make a good light-duty work vehicle.

If you need 30 miles (48 km) or less, even a city car or NEV could do the job for you. This is a definite "Yes." If you need up to 60 miles (97 km) on a charge, most EVs will still be able do the job, so this is also a "Yes." If you need 60 to 125 miles (97–201 km), this is a "Maybe." Some EVs will do the job, under some conditions. More than 125 miles (201 km) is a "No."

If you find that you have only an occasional day that exceeds the mileage of an EV, there are other alternatives. Do you have a second car you could use for those longer mileage days? Would it be economical to use a taxi, public transportation, or a rental car for part or all of your mileage on those days, if they are infrequent?

If you regularly exceed the range of an EV, you can extend that range by plugging in and recharging at your destination. A full day's recharge while at work will

An Electric Vehicle for You—Yes, No, or Maybe?

Item	*Yes*	*Maybe*	*No*
Range	< 30 miles: Almost any EV	60–100 miles: Top conversions	> 125 miles: Go hybrid
	30–60 miles: Most EVs	80–125 miles: RAV4 EV	
Speed & acceleration	25 mph, low acceleration: NEVs	Up to 90 mph, exceptional acceleration: High performance conversions	
	Up to 75 mph, good acceleration: Most conversions & factory EVs		
Payload	2 passengers: NEVs & sports EVs	Moderate cargo: EV pickups or VW vans	> 4 passengers, heavy cargo, or towing: Go biodiesel
	4 passengers & small cargo: Most conversions & factory EVs		
Terrain	Flat to moderate hills	Lots of hills, very steep or long hills	Mountains: Go hybrid or biodiesel
Traffic	Light or smooth	Heavy stop-and-go	
Weather	Heat or rain	Moderate cold & snow	Severe cold: Go hybrid
Road conditions	Good paved: All EVs	Bumpy, dusty, gritty	Off-road or serious mud: Go biodiesel
Charging	Garage or outdoor	Apartment	
		Off-site or off-grid	
Hands-on factor	Minor maintenance to build it yourself: Conversions	Drive it, plug it in, forget it: Factory EVs	
Budget	All ranges		

greatly increase your daily available range. If none of these options will meet your needs, you might want to look into the Toyota or Honda hybrids, which are high mileage, electric-assisted gas cars.

Two other related aspects of performance are speed and acceleration. Your needs will be determined by your local traffic conditions. On the low end, NEVs are limited to 25 mph (40 kph), but on the high end, a sporty EV conversion can reach 90+ mph (145 kph). Most fall in the midrange of 65 to 75 mph (105–121 kph). The top speed on the RAV4 EV is listed as 78 mph (126 kph).

Acceleration will vary from model to model. It's determined primarily by the current limit on the speed controller. Most full-fledged EVs can merge comfortably onto the freeway, and if you really need drag racer performance, it's available. In short, there is an EV out there to satisfy almost anyone's speed and acceleration needs. This is a "Yes."

A final part of the vehicle's job description is payload capacity. How many passengers, or how much cargo, do you need to carry? Sporty EVs and NEVs may only carry two people and a small amount of cargo. Most compact conversions can carry four people, and many have substantial trunk space as well. Vehicles designed to carry more than four people are generally too heavy to be good candidates for conversion. Up to four people and a few groceries is a "Yes." Very few EVs can carry more than four people comfortably, so we'll call that a "No."

Light pickup trucks can be good conversions. They can carry loads for short distances, but be aware that heavy cargo will diminish speed, acceleration, and range. Older, air-cooled VW vans can make good conversions, but the newer, water-cooled Vanagons and minivans by other manufacturers are generally too heavy.

More cargo than a few bags of groceries is a "Maybe." It depends on the EV in question, how heavy your cargo is, how far you need to take it, and under what conditions. Serious cargo hauling on a regular basis, or towing, is a "No." If you need to carry a lot of people or a lot of cargo regularly, you might want to investigate a truck or minivan that runs on biodiesel instead of an EV.

Driving Conditions

This is the environment in which the car must do its job. We mentioned in the previous section that conditions affect range. The most significant factor here is terrain. As you might guess, flat roads are best, but a few gently rolling hills or freeway overpasses are not a problem. This is a "Yes." If your drive is moderately hilly, most full-fledged EVs (not NEVs) will still be able to handle it, but it will reduce your range. For most people, this will still be a "Yes." If you have a lot of hills, or some very steep ones, it can cut your range in half. This moves into the "Maybe" area. Mountain passes and EVs are generally incompatible, a definite "No."

If you have very steep hills, or very long continuous grades, these will reduce your speed as well as range. Some EVs will be able to handle some of these situations, while others will not. If hills are a significant part of your driving, you should consult in detail with the EV seller, or someone who has knowledge about the kind of EV you are considering. This falls into the "Maybe" range.

The next biggest factor is probably traffic flow. Light traffic, or traffic that flows smoothly, is clearly a "Yes." Just as stop-and-go driving is hard on gas mileage, it's also hard on an EV's range. Every time you tap the brakes, you are wasting momentum that you spent amp-hours to achieve.

You can compensate somewhat for this kind of traffic with your choice of route and your driving style. But if you are stuck doing a lot of this, you will need to adjust the car's expected range downward. Whether or not the EV can still do the job for you will depend on how far you need to go, and how many other negative factors (such as the aforementioned hills) you have to deal with. It's a "Maybe."

After traffic, the most common concern is weather. A hot climate may mean you need an EV with heavy duty components or additional cooling. It might mean that you need to water your batteries more often. (We'll talk more about that later.) But EVs tend to like hot climates better than cold ones, so this should not be a problem. Call it a "Yes."

EVs can work perfectly well in places that get real winters. Electric heating systems can draw from the battery pack. However, cold reduces range—directly by lowering battery capacity and indirectly if you have passenger heat drawing from the batteries. So this might affect your choice of which EV to get.

How much range you lose will depend on how cold the batteries get, and how much you use the heater. It could be as little as 10 percent, or as high as 50 percent. Driving and charging daily will help keep battery temperatures warm and the driving range high.

Fully enclosed battery boxes, possibly insulated or heated, will be a plus. Usually, battery boxes are only heated while the car is charging, using commercial battery heating blankets made for heavy diesel trucks. The heaters are plugged into an external AC source so they do not drain the battery pack. The pack itself is a substantial heat sink, and once warmed, it will hold its heat well, particularly if the boxes are insulated.

If you live in a severely cold climate, an EV is probably not for you. As with hills, if cold is a significant issue for you, consult with someone knowledgeable about EVs. Mild to moderate winters are a "Maybe," depending on your other factors. Severe winters are a "No."

Rain and snow are not deal breakers. EVs don't short circuit in the rain, but it's not advisable to ford deep puddles that will immerse components. Slippery roads will require a little more care, since EVs are heavier than comparable gas cars. Also, crunching through inches of snow will reduce range. Mere rain is a "Yes." Snow is a "Maybe."

Finally, the condition of the road itself is relevant. A potholed dirt or gravel road will reduce range, and components (especially the motor) should be shielded from excessive dust and road grit. EVs are not recommended as off-road vehicles. Good paved roads are a "Yes." Lumpy or dusty and gritty roads are a "Maybe." Off-roading or serious mud is generally a "No." (Note: there is a small electric utility vehicle called the Gorilla, which resembles an ATV more than a passenger vehicle. I am not including it in this blanket prohibition.)

Charging Infrastructure

The ideal situation is a dedicated electrical outlet for charging inside your garage—a definite "Yes." If you buy a factory EV like the RAV4 EV with its special offboard 240 VAC charger, this arrangement is essential.

For conversions, outdoor charging can work. One woman, who had no garage or driveway, trenched across the yard, laid conduit, and installed a weatherproof outlet next to the curb. This is still a "Yes."

If you live in an apartment, you need to have an assigned parking space that you can rely on, and a cooperative apartment manager who will allow you to install the necessary outlet. Investigate this and get it in writing before you commit to the EV. Mark this one "Maybe."

As we mentioned in the first section, some people will need a daytime recharge at work to get enough range. For a factory EV like the RAV4 EV, you will have to locate a factory charging station. For a conversion, you only need a normal, household, 120 VAC outlet. If you snoop around, you may find that such an outlet already exists at work, and all you need is permission to use it. Another "Maybe."

Finally, if you are off-grid, you will need to be sure that your renewable energy system has enough capacity to do the job, at the time of day when you need to charge. Most EVs are driven by day and charged by night. On the grid, this represents surplus capacity time. But for an off-grid, solar-electric system, this is when you are operating on your household battery bank.

The RAV4 EV would not be an option here, with its 240 VAC charger, unless your system uses stacked inverters or a transformer for 240 VAC output. Conversions can be charged off-grid with the right system and planning. The most common chargers take 120 VAC input at 15 to 20 amps. The charge starts out at a high current and tapers automatically. A typical conversion uses about 0.4 KWH per mile under good conditions. If you have any of the adverse conditions mentioned above, adjust this number upward, but probably no more than 0.7 or 0.8 KWH, worst case. With this information and the mileage you expect to drive, you can calculate how much juice your car will need to recharge. Off-grid charging is also a "Maybe."

Mechanical Ability & Involvement

This is the "hands-on factor." There are two parts to it. The first is acquiring the car. On one end of the scale, you can walk into a Toyota dealership and buy an RAV4 EV without ever getting your hands dirty. On the other end of the scale, you can buy a donor chassis and a drive system and build the car yourself. In between these extremes are the options of having a conversion built for you by a mechanic, or by a school auto shop class, or simply buying a used conversion that's already built. There are EVs for every level, so they are all "Yes."

The second part is maintenance. A factory EV requires very little care, and you have the dealership to take care of this for you. This is a definite "Yes." A conversion requires a little more attention, although much less than a gas car. But you cannot afford to skip that little bit that it does need—battery maintenance. If you don't pay attention to it, you will murder your battery pack.

If you have flooded, lead-acid batteries, as most conversions do, they will need to be checked periodically for equal voltage across the pack, as well as for fluid levels and clean, tight connections. It is recommended to do this once a month for at least the first six months. In hot climates, you may need to continue at this rate. In milder climates, you may find that the batteries only need attention every two months or so.

Sealed batteries, which are less common, don't need watering. However, they do require a special charging profile, with individual regulators on each battery in the series string. These regulators monitor each individual battery's state of charge, and drop them out of the charging circuit when they reach full charge to prevent overcharging. This is important with sealed batteries because they will vent if overcharged, but there is no way to replace the lost electrolyte, so this shortens the battery's life. If abused, sealed batteries are easy to kill. They are used mostly by serious EV performance geeks.

If you are the type who wants to just drive it, plug it in, and forget about it, you should stay away from the sealed batteries unless you get a factory EV with them. That sounds counterintuitive, but experience shows that the people who are successful with these batteries are the ones who monitor them a lot and are very careful about their charge/discharge profile. One NEV manufacturer switched to flooded batteries for their standard pack, with sealed only as an option, because customers were destroying the sealed packs by abuse and neglect.

With flooded batteries, if you tend to procrastinate and avoid simple chores like battery watering, you should make arrangements with a local mechanic to do the battery service for you, much like an oil change. Then follow up with your mechanic faithfully. If you can't do that, you'd better stick to factory EVs. Battery service is a "Maybe," depending on your ability to carry it out religiously.

Budget

As with many of the other topics we've discussed, there is a range of options. On the high end is a factory EV. The RAV4 EV's sticker price is US$42,510. Various federal, state, and local incentives can knock about 25 to 30 percent off that number, but it still is not cheap.

In the midrange, you can have a conversion built for you for US$15,000 or so. Lower down on the scale, you can build your own for US$6,000 to $10,000. Finally, you can shop on the Internet for a used EV. These will run from a US$1,000 fixer-upper with dead batteries to a US$15,000 or $20,000 custom, high performance EV in good running condition. Overall, the EV is a "Yes" for any budget level.

Does the EV Get the Job?

As you can see from reviewing this list and the table, only a few circumstances make an EV totally unsuitable. Some situations are clearly well-suited to an EV. Others will suit some EVs but not all.

Compare your needs and circumstances with those we've talked about here. If you don't have any of the "Absolutely No" conditions, take a look at the "Maybes." Too many marginal conditions can stack up and become a "No." But if you only have a few iffy conditions, there is probably an EV that will do the job. A lot of people are surprised to discover, if they really get down to specifics, that the final answer is "Yes!"

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Buying a Used EV, Part Three

Putting It All Together

Mike Brown

In my last two columns (*HP89* and *HP90*), I've talked about how to evaluate the body, chassis, electric drive components, and batteries in a used EV. This time, I'll wrap it up by covering what to look for in the conversion job itself.

The design, construction, and installation of the battery racks and boxes are the most important parts of the conversion process. No other component or group of components has more potential for danger and injury.

The batteries must be held securely in place against ordinary bumps from rough roads, as well as the forces at work in the case of a collision. Any part of the battery pack that shares space with passengers must be in a sealed box that is held in place with a rack and hold-down system that will resist the forces of a collision or rollover. The battery box must have a ventilation system to prevent the accumulation of gases during battery charging by venting them outside the passenger compartment.

The battery racks should be fabricated from steel stock that is at least 1/8 inch (3 mm) thick. Angle iron should be at least 1 x 1 inch (25 x 25 mm), and flat stock should be at least 1 inch wide, although 1 1/2 inch (38 mm) would be better. The racks should be welded together by a competent welder. Examine the welds in the racks of your potential EV. The weld should be one smooth continuous bead, not interconnected gobs of metal. Racks made of thin, galvanized angle stock with rows of holes punched in it, and held together with ordinary hardware store nuts and bolts will not do.

Battery racks should be secured to the chassis frame with bolts, using holes put there by the factory if possible, or holes drilled by the builder. Or they can be welded in place by a competent welder. Bolts used to hold battery racks in place should be at least grade 5 quality. Racks bolted to the thin sheetmetal of a unibody chassis should be held in place by many small bolts. The body metal should be sandwiched between the flange of the rack on the top and a 1/8 inch thick reinforcing plate on the bottom.

Battery boxes can be made of fiberglass, 5/8 inch (16 mm) plywood, or welded polypropylene plastic. However, boxes made of these materials should be enclosed by a welded steel frame. For the whole story on battery racks and boxes, see my articles in *HP79* and *HP80.*

High Voltage Cables

Aside from the battery box and rack system, the cables that connect the batteries to each other and connect the battery pack to the other conversion components have the most potential for causing problems. These problems can range from the car sitting dead on the side of the road due to a failed connection, to sitting on the side of the road in flames.

All battery interconnect and component interconnect cables should be #2/0 (67 mm^2) welding cable. This cable should be made up of 3,300 strands of #34 (0.02 mm^2) copper wire enclosed in soft flexible insulation. Check this by finding a short run of cable, 1 foot or more long, and see how easily it flexes. If it is stiff and hard to move, it is probably made up of fewer strands of larger wire. The insulation should be soft enough to give easily when pressed with a thumbnail, but should not show any indentation after you release it. A hard, slick-feeling plastic insulation usually goes with the cable with fewer, large strands.

The lugs that attach the cable to the batteries or components should be commercially made lugs of the proper size for the cable, and have a closed barrel (the part of the lug that is crimped over the end of the cable). The lug should be crimped to the cable with a crimping tool that leaves a deep indention in the barrel of the lug. A nice touch is a short length of shrink tube over the slight gap between the lug and the cable's insulation.

The cables that connect the battery pack to the EV components, and the components to each other, should be supported by tie wraps to the existing wire loom, or with cable hangers installed for that purpose. If the front and rear battery packs are connected by cables that run under the car, they should be enclosed in a flexible housing to protect them from the weather and possible damage. Take the time to give all the cables a good visual check before you agree on the price of the car. Some adjustment of the price might be in order if some of the cables need to be replaced.

Beware of batteries in the conversion with the universal style terminals, connected by cables whose lugs are placed over the threaded stud sticking out of the top of the battery terminal, and then held in place with a spring-type lock washer and a nut. This type of connection is doomed to failure and should be replaced at once. The price of the car should be adjusted to compensate for the cost of new interconnects (about US$15 per battery). You might not see this type of interconnect because failure usually occurs soon after installation. For a more in-depth discussion of this subject, see my article “Electric Vehicle Battery Layout and Interconnection” in *HP82.*

Small Gauge Wiring

The small gauge wires include the vehicle’s original wiring loom, and any wires added as part of the interface between the existing wiring loom and the EV components. They also include any wires that carry battery pack voltage at low amperage to things like high voltage volt meters or DC-to-DC converters.

One of the most important things about small gauge wiring is how it was installed. Are all of the added wires gathered together into a tidy loom that follows the path of the original loom wherever possible? Or does each new wire go its own way, giving you the “explosion in a spaghetti factory” look? Are different colored wires used to make a color code, or are all the new wires the same color? Beware of any conversion with one-color wiring. When something goes wrong, troubleshooting the various circuits is very hard, if not impossible.

Are the connectors crimped to the ends of the wires the right size for the wire and properly crimped? Is the car’s fuse block supplemented by another fuse block to protect the circuits that have been added? Small gauge wiring is more prone to failure and has just as great a potential to cause damage as the high voltage cables. See my column in *HP76* for more detail on small gauge wiring and interfacing the high and low voltage systems.

How’s It Sitting?

Now is the time to step back and take a look at the EV from a distance. Is one end of the car high and the other end low? Does it sit level but have a “low rider” look, or does it look like it did when it was a gas or diesel vehicle? All of the above attitudes (that’s a technical term for “stances” or “positions”) are signs of whether or not the conversion’s suspension was modified to support the additional weight of the batteries.

Suspension modification is one of the hardest parts of the conversion process, but it is critical to the driving safety and comfort of the converted vehicle. If the previous owner/builder hasn’t taken care of this part of the conversion, you should. Adjust the amount you are willing to pay to suit. Suspension modification is a lengthy topic to cover in detail, and since I have already done it in *HP73,* I am going to stop here.

Check Before You Buy

Make & Model

- ❏ Popular car or truck
- ❏ Dealership in your area
- ❏ Newer is better for replacement parts availability

Paint & Body

- ❏ Appearance: excellent, average, or shabby? You have to live with it
- ❏ Badly repaired damage can cause problems
- ❏ Rust never sleeps; don’t buy it

Interior

- ❏ Needs seat covers or carpet: OK, but get price reduction
- ❏ Needs padded dash or headliner: don’t buy it or get really big price reduction

Mechanical Condition

- ❏ Amateurs need not apply; have a pro mechanic do a checkout on brakes, steering, universal or constant velocity joints; road test

EV Parts

- ❏ Quality parts equal quality conversion
- ❏ Motor: appropriate type, good brand, right size
- ❏ Controllers: modern, good brand, factory support
- ❏ Motor-to-transmission adaptor: keep the clutch
- ❏ Battery charger: factory, not homebuilt
- ❏ Gauges: battery pack voltmeter and ammeter as minimum; should be automotive style and quality gauges
- ❏ Batteries: suitable pack size and type, check expected lifespan, age and condition, and replacement cost

Conversion Quality

- ❏ Battery racks and boxes securely made from appropriate materials
- ❏ High current cables: proper size, type, routing, and connections
- ❏ Small gauge wiring: gathered into looms, color coded, and fused
- ❏ Suspension: modified for battery weight and level stance
- ❏ Overall quality

Documentation

- ❏ Complete color-coded wiring diagrams for all systems
- ❏ Parts list and list of suppliers
- ❏ Conversion notes

The next few topics are not as much about hardware as those discussed already, but are more subjective. However, your feelings on these matters should be given as much weight as the hardware concerns. If you decide to buy a certain car, you are the person who has to live with it.

The Quality of the Installation

When you open the hood of the conversion, what is your first impression? Does the installation seem logically planned and well executed, or do the various components look like they were put where they would fit without regard to energy flow and function?

A well thought out, carefully done conversion will be more reliable and easier to repair if something goes wrong. I have seen homebuilt, one-off conversions that look like factory installations. And I've seen vehicles from "professional" batch converters that were so badly done, they were scary. I see more of the latter because I am often called in to repair them.

Documentation

The amount and quality of the documentation that comes with a conversion EV usually parallels the quality of the installation discussed above. What should be in the documentation package that comes with the EV? First, you should have a high voltage/high current drawing, showing both the battery pack layout and the rest of the circuit the battery pack is connected to. This is the schematic for the #2/0 cable part of the wiring. Second, you'll want a color-coded wiring diagram of the low amperage system (#16 to #10 wires), including both the low voltage circuit and the high voltage circuit, and how the two circuits interface. These two circuit diagrams are the bare minimum.

A parts list should also be included, with sources of all the parts (with the exception of fasteners) used in the conversion. This list is less important for the major components—it is primarily for the hard-to-find and unusual small parts that might have been used. The last document that might be good to have is the project notebook that was written as the conversion was done. The notebook might give the new owner insight into why the builder did something a certain way, and save some time-consuming reinvention in the future.

You Decide—Is It a Keeper?

I have tried to cover all the aspects of evaluating a used conversion for purchase, but space permits me to only touch on each area lightly. If you are not sure what to look for in any of these areas, try to educate yourself. If there is a chapter of the Electric Auto Association (EAA) in your area, attend some meetings. Look at the members' cars and ask questions.

If there isn't a local chapter of the EAA, or as an addition to attending their meetings, look in the back issues of *Home Power* for my columns. Over the years, I have written about almost every aspect of the conversion process. Electro Automotive Tech Papers, which are reprints of my columns and other EV articles from *Home Power,* as well as our *Convert It* manual, are available from Electro Automotive. Happy Hunting!

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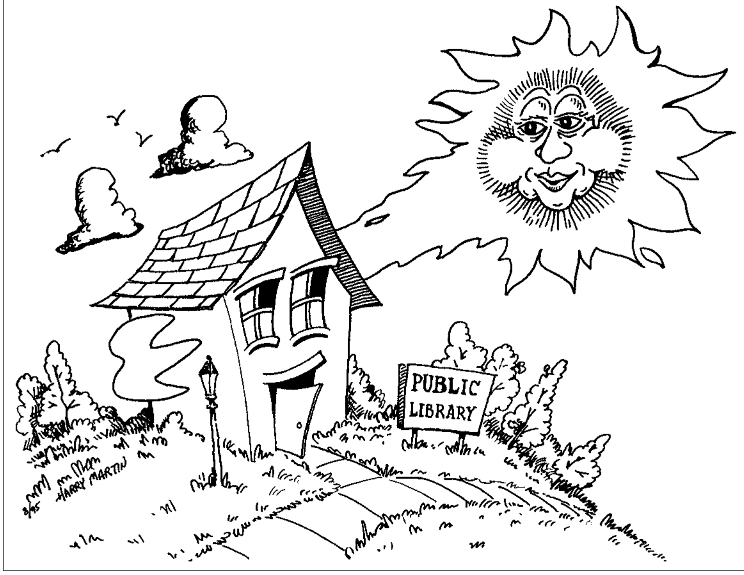

Adopt a Library!

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

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

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

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Renewable Energy Terms

Free—No Cost?

Ian Woofenden

Derivation: From Middle English freo, *and Gothic* frijon, *to love, applied to members of a family or clan, as opposed to slaves.*

How “free” is renewable energy? I often find that people have unrealistic expectations about renewable energy systems. There’s something about the “free” nature of solar, wind, and water power that leads people to expect it to be universally applicable, maintenance free, trouble free, and cheap.

What if we approached buying and owning a house with this attitude, and expected it to be cheap, maintenance free, and high quality? It’s true that RE systems don’t have fuel costs, but the energy-capturing equipment is far from free. In fact, it can look pretty expensive compared to government subsidized grid energy. And in our culture of buy now and pay later, paying for your energy 30 to 50 years in advance in the form of PV panels needs to be put in perspective.

When we buy a house, one of our first decisions is location. Do we disregard our need to live near our work, our favorite stores, or our preferred educational opportunities? If so, we might end up with a house that just won’t work well for our lives. Similarly, if we try to put solar-electric panels in the shade, wind turbines near the ground, or hydro turbines where there isn’t enough water, we’ll be disappointed.

We also need to decide what type of house is appropriate for our needs. It doesn’t make any sense to build an igloo in the jungle, or a palm-frond house in the Arctic. When it comes to renewable energy systems, we need to match the system to the resource. No matter how much we might like the idea of using wind energy, we’ll get nowhere with it unless our site has enough wind. A complete site survey will look at all resources available, and focus on tapping the most appropriate mix.

A single person doesn’t need a three-story townhouse, and a large family probably will not be comfortable in a studio apartment. In the same way, renewable energy systems should be sized to fit the users. Too often, people new to the field want to know what a system for an “average house” will cost. But the size of an RE system is tied not to the size of the house, but to the energy appetite of the occupants. This is why a thorough load analysis is step number one for designing a successful system.

Once we buy a house, we don’t expect it to be maintenance free. We have to clean it regularly, heat or cool it, and deal with other maintenance tasks. A renewable energy system is the same. Even PV modules, the most reliable component in these systems, require cleaning, and will suffer if abused. Wind generators, hydro turbines, and other mechanical equipment need periodic care. Batteries demand regular care, and will die prematurely if treated poorly.

Do all the parts of our house last forever? We expect to replace the roof, floor coverings, and furnishings at different intervals. Renewable energy systems are similar. Batteries are the most significant replacement item. Depending on the quality of the batteries and the care we give them, they’ll need to be replaced every 2 to 15 years. If we expect the system to give us “free” energy, the price of battery replacement will be a shocker. Other components may need rebuilding or replacement at times too, though most system components are very long lasting.

So how free is renewable energy? Once you make the initial investment, and plan for the maintenance and replacement costs, it looks pretty good. But you still need to deal with the weakest link in any renewable energy system—the humans.

Poor system specification or design can sink a system from the start. And unrealistic expectations can make the system unsatisfactory too. Every system is designed for a specific usage, and if you expect it to do more than it’s designed for, you’ll be disappointed. Renewable energy producing sources give us a certain amount of energy to work with, and we have to live within that budget. Treating a battery as if it’s an inexhaustible resource will leave you with a damaged battery that needs replacing.

Someone once said, “Freedom isn’t free,” implying that we have to work for it. The same is true of the “free” energy we harvest from the sun, wind, and water. Be realistic about what it takes to farm it, and you’ll be pleased with the bountiful crop.

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- 24, 36 or 48 Volt

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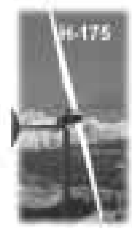
- EZ Wire I Wind/PV Controller
- 12, 24, 32, or 48 Volt

$1,907



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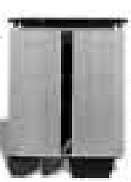

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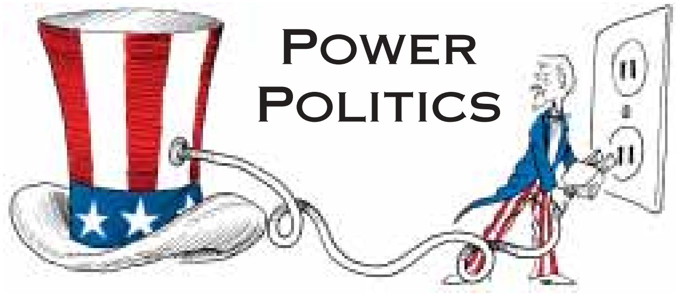

Yucca Mountain: It's Not Over Yet

Michael Welch

On Tuesday, July 9, the U.S. Senate voted 60 to 39 in favor of overriding Nevada's veto of the Yucca Mountain nuclear waste dump. Since the House of Representatives had already exercised their override vote, the July vote ended political debate on the siting of the repository.

The (marginally) good news is that with this vote, more Senators than ever before voted against this project. In the face of millions of dollars in corporate advertising and lobbying, the grassroots effort combined with the state of Nevada's publicly funded fight did pretty well.

But it is hard to overcome the nuke industry's clout. They have made donations of more than US$5 million to political action committees between 1997 and February of this year, according to Public Citizen's Critical Mass Energy and Environment Program (CMEP). CMEP thinks the pro-nuke vote was paid for, and expects that records will show even more contributions went into Senatorial campaign funds before the vote. Still, the Bush administration claimed victory, and said that the vote was an overwhelming endorsement of Mr. Bush's desire to open the dump. To many, it is a reminder of the amount of influence that big energy corporations seem to have over the Bush administration.

The fight against the opening of the Yucca Mountain repository is not over. Yes, the Department of Energy (DOE) now has permission to proceed, but the hurdles still in the way are large, and will be used by dump opposition both inside and outside of Nevada.

Facility Licensing

The DOE still must do what anyone else contemplating a nuclear power project must do—get a license from the Nuclear Regulatory Commission (NRC). The licensing process is supposed to begin right away, but it may not even be submitted until the end of 2004. Once the license is submitted, the NRC will have many questions, ultimately refining the application. Then there will need to be hearings on the license.

With nuclear power plants, these adversarial processes can take years. Intervenors in NRC licensing hearings generally represent the local communities in which the licensed facilities exist. But the Yucca Mountain project is so far reaching, that many more intervenors than usual are likely to participate. Citizen groups and utility organizations will bring their experts and attorneys to bear on the process.

The NRC will insist on seeing the proof that Yucca Mountain will be able to contain its 77,000 tons of high-level nuke waste for 10,000 years. (In spite of the fact that much of the waste will be dangerous for a million years, 10,000 years is the DOE's target length of time for keeping it safe.) While the DOE has already prepared an Environmental Impact Report, it still does not have a final plan to isolate the waste from the environment at the site. Also, the NRC will need verification for claims made in the report about site conditions.

Politics Still a Factor

The Senate vote was definitely a huge hurdle in the Yucca Mountain process. But other political hurdles must be overcome. First is the fact that this project would not be built until the next presidential administration is in power, and maybe not until the one after that. In the meantime, Congressional members will have been elected and unseated several times.

Right now, the winds of politics are blowing favorably toward the nuclear industry. But two years ago, the Clinton administration was holding up the Yucca Mountain process, and at the beginning of the Clinton presidency, the administration was strongly antinuclear. The political climate can be fickle to say the least, so who can predict what will happen in the next few years?

Another hurdle is the price tag for this gargantuan project. Already, the DOE has spent more than US$4.5 billion. Today's cost estimate for the complete project is US$58 billion. With the DOE's track record for overspending and underachieving, I would not be surprised to see that number double. Of course, every penny of this has to be appropriated by Congress before it can be spent, even if a little at a time. At what point will the politicians throw in the towel?

How Did Your Senators Vote on Yucca Mountain?

State	Senator	Party	Vote*
AL	Shelby	R	Yea
	Sessions	R	Yea
AK	Stevens	R	Yea
	Murkowski	R	Yea
AZ	McCain	R	Yea
	Kyl	R	Yea
AR	Hutchinson	R	Yea
	Lincoln	D	Yea
CA	Feinstein	D	Nay
	Boxer	D	Nay
CO	Campbell	R	Nay
	Allard	R	Yea
CT	Dodd	D	Nay
	Lieberman	D	Nay
DE	Biden	D	Nay
	Carper	D	Nay
FL	Graham	D	Yea
	Nelson	D	Yea
GA	Cleland	D	Yea
	Miller	D	Yea
HI	Inouye	D	Nay
	Akaka	D	Nay
ID	Craig	R	Yea
	Crapo	R	Yea
IL	Durbin	D	Yea
	Fitzgerald	R	Yea
IN	Lugar	R	Yea
	Bayh	D	Nay
IA	Grassley	R	Yea
	Harkin	D	Nay
KS	Brownback	R	Yea
	Roberts	R	Yea
KY	McConnell	R	Yea
	Bunning	R	Yea
LA	Breaux	D	Nay
	Landrieu	D	Yea
ME	Snowe	R	Yea
	Collins	R	Yea
MD	Sarbanes	D	Nay
	Mikulski	D	Nay
MA	Kennedy	D	Nay
	Kerry	D	Nay
MI	Levin	D	Yea
	Stabenow	D	Nay
MN	Wellstone	D	Nay
	Dayton	D	Nay
MS	Cochran	R	Yea
	Lott	R	Yea
MO	Bond	R	Yea
	Carnahan	D	Nay
MT	Baucus	D	Nay
	Burns	R	Yea
NE	Hagel	R	Yea
	Nelson	D	Yea
NV	Reid	D	Nay
	Ensign	R	Nay
NH	Smith	R	Yea
	Gregg	R	Yea
NJ	Torricelli	D	Nay
	Corzine	D	Nay
NM	Domenici	R	Yea
	Bingaman	D	Yea
NY	Schumer	D	Nay
	Clinton	D	Nay
NC	Helms	R	-
	Edwards	D	Yea
ND	Conrad	D	Nay
	Dorgan	D	Nay
OH	DeWine	R	Yea
	Voinovich	R	Yea
OK	Nickles	R	Yea
	Inhofe	R	Yea
OR	Wyden	D	Nay
	Smith	R	Yea
PA	Specter	R	Yea
	Santorum	R	Yea
RI	Reed	D	Nay
	Chafee	R	Nay
SC	Thurmond	R	Yea
	Hollings	D	Yea
SD	Daschle	D	Nay
	Johnson	D	Nay
TN	Thompson	R	Yea
	Frist	R	Yea
TX	Gramm	R	Yea
	Hutchison	R	Yea
UT	Hatch	R	Yea
	Bennett	R	Yea
VT	Leahy	D	Yea
	Jeffords	I	Nay
VA	Warner	R	Yea
	Allen	R	Yea
WA	Murray	D	Yea
	Cantwell	D	Nay
WV	Byrd	D	Nay
	Rockefeller	D	Nay
WI	Kohl	D	Yea
	Feingold	D	Nay
WY	Thomas	R	Yea
	Enzi	R	Yea

* Yea vote is pro-Yucca Mountain dump site

Public Opinion Can Still Help

Environmental and consumer advocate groups have been working on this issue for a long time. For the last couple of years, the biggest organizing tool has been the issue of transporting high-level nuke waste to Yucca Mountain. Nearly every major community in the country and many rural ones could be impacted by the shipment of nuclear waste. (If you are interested in finding out how close to you these shipments would be, try the www.mapscience.org Web site.)

According to the MapScience Center, a project of the Environmental Working Group, the DOE predicts that before the dump is full, there will be about 100 accidents involving the shipment of high-level waste, while the state of Nevada predicts about 400. The DOE plan assumes 80,000 shipments of radioactive waste by rail and truck to Yucca Mountain from commercial power plants, plus an additional 25,000 shipments from weapons and naval facilities.

Transportation is not the only issue. It just happens to be the one that could directly affect the most people. Just as important is the unsuitability of the Yucca Mountain site itself. This place was chosen, ostensibly, because it is geologically sound. Guess what! Earthquakes are occurring in the area on a regular basis. On June 14, there was a 4.4 Richter scale earthquake centered just a few miles away. About 10 years ago, there was an earthquake strong enough to damage a building on the DOE site.

Then there's the fact that water seeps throughout the mountain, and that underneath the mountain is an aquifer that serves a good-sized population. In reality, the Yucca Mountain site was chosen for political reasons—it was thought that Nevada would be the least likely state to effectively protest.

There are more issues, but the point is that there is still lots of room to rally the public around this project. I urge you all to keep informed about this really bad idea. Let your local representatives and the press know that you are against the use of Yucca Mountain and the shipment of radioactive waste through our communities. And be sure to let your senators know whether you liked or disliked their vote on this issue.

Save the Rails

Besides the transportation of nuclear waste, another important railroad issue is coming up in the United States. Our country seems to be of the mind that if you can't make a buck from it, it ain't worth it. Now, this idea and its corporate promoters are trying to gut what little national public transportation system we have. I'm talking about Amtrak.

The Bush administration is proposing the privatization of the rails. If successful, it will mean that a handful of corporations will own and operate the few passenger routes that can actually make money, and leave the rest to rusty rails. Amtrak and other local forms of public transportation already suffer from a lack of financial support. Other forms of shipping and transportation get huge subsidies, like money for building highways. Of course, those subsidies have corporate support from companies that would rather see us buy more SUVs and burn more gasoline than take public transportation.

The loss of Amtrak will mean dirtier air, more global warming, and more use of fuel. Instead of gutting Amtrak, we should be spending more money on it to increase services and help more people take advantage of it.

No public transportation system in the world that I know of makes money on what it does. There is hardly a more appropriate industry for the government to subsidize. Please contact your Congressional representatives right away, and let them know that we want *more* public transportation, not less.

Most Excellent RE Incentives

Back in the realm of home-scale RE, *Home Power* has recently heard of the first cases of high-paying, rate-based incentives in the U.S. (see *Power Politics* and a separate article in *HP44,* and *Power Politics* in *HP45* and *HP46*). Congratulations go to the Energy Cooperative, of Philadelphia, Pennsylvania for their program that offers the premium price of 20 cents per KWH for PV-produced electricity pumped into the grid. This price more closely matches the weighted national average of peak electricity market prices over this year to date, with a low of 18.9 and a high of 43.6 cents.

Congratulations also go to the Chelan County PUD in Wenatchee, Washington. They have a new program that provides a pool of money that is distributed to RE system owners on a per KWH basis. The maximum payment is US$1.50 per KWH, but the amount is dependent upon how many producers are participating, and how much is in the pool. The pool is obtained by customers paying a voluntary additional amount on their bills to support green electricity.

These utilities are demonstrating to us that decentralized renewable energy is worth more than other, dirtier sources. They are getting the ball rolling by trying to buy 100,000 KWH of solar electricity by the end of the year. They feel that their method will decrease the financial payback period of PV systems by up to 30 percent. What a great encouragement. I hope other communities will follow suit.

Access

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Environmental Working Group, 1436 U St. NW, Suite 100, Washington, DC 20009 • 202-667-6982
Fax: 202-232-2592 • mapinfo@mapscience.org
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Public Citizen's Critical Mass Energy & Environment Program, 215 Pennsylvania Ave. SE, Washington, DC 20003 • 202-546-4996 • Fax: 202-547-7392
cmep@citizen.org • www.citizen.org/cmep • Info on Yucca Mountain, nuclear waste transportation, & the gutting of Amtrak

The Energy Cooperative, Nadia Adawi, 1218 Chestnut St., Suite 1003, Philadelphia, PA 19107 • 215-413-2120
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Chelan County PUD, 327 N. Wenatchee Ave., Wenatchee, WA 98801 • 888-663-8121 or 509-667-4216 • Fax: 509-664-2880
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IBEW Shuts Down Residential PV Systems in Los Angeles

Don Loweburg

Since April 19, 2002, members of the International Brotherhood of Electrical Workers (IBEW) have been shutting down PV systems in the Los Angeles Department of Water and Power (LADWP) utility district. Reports are that without notification to the customer or the installing contractor, an IBEW worker shuts off the visible lockable disconnect that is required between the inverter and utility service entrance, and locks it in the off position.

This practice has halted the installation of PV systems in Los Angeles by reputable contractors. When their customers are informed of the potential lockout, they defer the start of the projects. Some not-so-reputable contractors do not tell the customer of this situation, and let them hang out to dry. Interestingly, commercial systems, which are typically union installed, are not being locked out.

What is the justification for this practice? Quoting from an April 25, 2002 letter from LADWP being sent to affected customers: "The department is in the process of enhancing its internal procedures pertaining to the interconnection of solar photovoltaic (PV) systems to our utility grid, in order to insure the safety of our field workers."

On June 24, 2002, I contacted Darryl Gordon, LADWP contact person designated in the letter. He confirmed that the lockout was taking place, affecting all residential systems installed after April 19, and that it would continue until at least August 15. He also stated that 23 systems had been locked out (as of June 24) and that the rate of residential system installation in the district had dropped. He added that the installation of commercial systems had picked up.

Possibly the most alarming information Darryl provided, though not mentioned in the letter, concerned the location of the lockable disconnect. He stated that, at the discretion of IBEW field inspectors, the lockable switch may be required to be *street* accessible. In the past, and in other utility districts, the lockable disconnect is usually required to be within 8 to 10 feet (2.4–3 m) of the main service panel and meter. This new requirement by IBEW would, in some cases, require extremely long wire runs. This could result in increased system cost and impaired system performance, such as frequent inverter shutdown, due to voltage drop issues. In some cases, the system would be vulnerable to shutdown by vandals. This new requirement by IBEW creates additional barriers, and has already discouraged some potential PV installations in the LADWP district.

The requirement for the lockable disconnect has a history. Initially, all utilities required a lockable disconnect, based on their experience with co-generation. These sources consisted of rotating machinery for which there was no way to quickly and automatically shut them down other than a physical switch. The inverters used in modern PV systems are entirely different. Being microprocessor controlled, they can respond very quickly to a wide range of conditions and, as required, disconnect automatically from the grid.

During the formulation of the current technical standards for interconnecting PV systems to the grid (IEEE 929, Non-Islanding Inverter—UL 1741 and NEC 690), a collaboration of utility and PV industry engineers developed rigorous tests and protocols for the safe interconnection of modern inverters to the grid. All inverters meeting these standards automatically disconnect from the grid under all possible required conditions. As a consequence, none of these standards require the lockable disconnect.

Sandia Laboratories also recognized the redundancy and non-necessity of the lockable switch, and clearly states this in their handbook on interconnection of PV to utility systems. And finally, a number of other groups, including the Solar Electric Power Association (formerly UPVG—Utility Photovoltaic Group), which is a coalition of utilities responsible for 50 percent of the nation's electricity generation; PV industry members; and others committed to the widespread inclusion of PV in the nation's energy supply, do not support the requirement of a lockable disconnect. Quoting from their October 2000 position statement regarding the interconnection of small PV systems to the grid: "Manual external disconnects should not be required for PV systems under 10 KW. For UL-listed, non-islanding inverters, which already have external AC disconnects, an additional external AC disconnect is redundant." (See Access.)

Not all utilities require the lockable disconnect for small PV systems. But many do, and given the overwhelming lack of technical support from their own engineers and organizations, the question is: why? Several years ago, before I and others in the PV industry caved in on this issue, I was told by a very credible person in the industry that behind the scenes, it was the IBEW position requiring the lockable disconnect that dictated utility requirements. Paraphrasing his view, "No utility was willing to go up against the IBEW, even if the union was wrong. The PV industry should get over it and move on." The mantra of capitulation went, "It's only a US$100 switch. What's the big deal?" I think it is clearer now what the big deal is.

This issue is not about safety, but about control. Of course this is not what the union says. They claim it is about not installing grid systems until the proper work practices and training programs are in place. My sources in Los Angeles counter this explanation, suggesting that the union is negotiating for raises, and using the PV safety issue as leverage.

The majority of the residential systems installed in Los Angeles and in the rest of the country are being installed by independents. Is the IBEW trying to muscle in and control the installation of PV systems? This could be the case. This conclusion is supported by the fact that the IBEW is not shutting down the commercial systems that their members have installed.

Additionally, statements made in IBEW publications could lead to this conclusion. Quoting from *The Quality Connection,* March 2001, "It's official: The IBEW and NECA (National Electrical Contractors Association) want to be the leaders in solar photovoltaics to take advantage of whatever opportunities this technology may yet offer. Together, electrical workers and contractors (union contractors) are preparing the necessary programs to ensure our industry's success. The goal is to keep under their joint umbrella all the work related to electrical construction, and photovoltaics; the conversion of the sun's energy into electricity, certainly qualifies!" And from the June 2001 issue of *IBEW Journal* we read: "It is becoming more and more feasible to install these solar systems on homes and commercial buildings," said Local 332 business manager Terry D. Tanner. "We need to make sure IBEW members are the ones doing this work." (See Access.)

In defense of the IBEW, I would note that they have made a significant commitment to PV. IBEW has installed PV on many of its union halls, and has set up a top-notch training program for their members. They are to be lauded for these actions. I believe the union and its members should be rewarded for their progressive and farsighted vision. Trained, certified, and knowledgeable union installers with hands-on experience should have no problem in a competitive PV work environment.

However, resorting to strong-arm tactics, like locking out nonunion-installed PV systems, should be avoided. They hurt the customer, other installers, and the PV industry generally. Tactics like the lockout will ultimately backfire, hurting the union and its membership.

PV Success Stories—Four Case Histories

Previous columns have discussed predicting PV system output and the importance of communicating this information to the customer (*HP65, 85, & 87*). Presented here are four systems installed last year. Each system has output metering, and the customers were willing to provide billing information to me. The systems might be characterized as: peak shaving, time of use (no batteries), time of use (batteries and array tracker), and super-efficient home. All four are grid connected.

Peak Shaving—Reyes System

I categorize this system as peak shaving because the PV system produces about 30 percent of the household's electricity demand. Because of the relatively high (1,687 KWH per month before PV) average consumption, the Reyes family paid an average of US$0.19 per KWH after the rate hike in California last June. After installing a grid-tied PV system consisting of thirty-two, 120 watt modules, their average monthly electricity use fell to 1,257 KWH per month, a reduction of 430 KWH per month.

Interestingly, the documented output of the PV system is about 515 KWH per month, meaning their daily load *increased* by about 3 KWH per day. The annual value of the PV electricity produced (figured at US$0.19 per KWH, multiplied by 6,200 KWH per year) is US$1,178. The Reyes family was eligible for the California PV rebate and a 15 percent state tax credit, making their out-of-pocket expenditure for the system US$13,695. Simple payback for this system is less than twelve years.

The Reyeses are very satisfied with the performance of their system. They successfully curtailed an escalating utility bill. If they had not installed PV, their utility bill, based on the new rates, would have averaged US$320 per month. With the PV system in place, their actual, average, utility-electric bill was US$226 per month. The reduction of US$94 per month equates to US$1,128 per year.

Time of Use—Zastovnik System

Time of use (TOU) billing charges more for electricity used during midday (on-peak) and less during late evenings and weekends (off-peak). Utilities offer this rate as an incentive to encourage customers to shift loads to off-peak times, thereby increasing the utilities' available capacity during the on-peak time. In California, the summer peak rate is about US$0.30 per KWH while off-peak is about US$0.08.

The California net metering law stipulates that utilities must offer the same rate as a credit to PV-generated electricity delivered to the grid during on-peak times. In other words, excess PV electricity delivered to the grid during on-peak times is worth US$0.30 per KWH. For net metered utility customers capable of deferring loads to off-peak times, TOU net metering is a very good deal.

The Zastovniks had a historical, average electricity usage of about 750 KWH per month. They decided to install forty-eight, 120 watt modules with the goal of matching, as closely as possible, their average monthly electrical consumption with PV. In addition, they opted to apply for TOU net metering.

Their TOU net metering began in October 2001. Billing information to date goes through mid-May. During this period, total charges for electricity are US$10. Since this does not reflect the upcoming summer peak period when TOU is particularly advantageous, it a safe bet to predict that the system will outperform initial expectations and deliver significant excess credits by the end of the summer.

Being conservative and basing the payback on the minimum yield of the system, 750 KWH per month at US$0.14 per KWH, this system takes about fourteen years to pay back in what I will call the California scenario (rebate, plus 15 percent tax credit). Given expectations of a significant excess summer generation, I believe payback will happen sooner. Ron Zastovnik has set up a Web site with photos, graphs, and some discussion giving his point of view. (See Access.)

TOU with Battery Backup & Tracker—Russell System

This system has twenty-four, 120 watt modules, but unlike the other grid systems profiled here, uses batteries and trackers. In general, I do not recommend batteries in grid-connected systems because system efficiency is lowered. However in this case, the Russells felt that backup was a critical requirement.

There were two rationales for this choice. First, utility outages are more frequent in the foothill region of central California. Second, Rob Russell is a programmer and developer of embedded computer systems, and works from his home. Downtime equals lost work. In fact, the Russells had been using batteries and inverters as part of a backup system for several years before the addition of PV modules.

They were also very comfortable with TOU, and had been load shifting during those two years. What they had been doing was charging the batteries at night (off-peak) and then disconnecting from the utility during peak rate times to operate the entire house off-grid. Using this strategy, they were able to reduce their utility bill by 33 percent.

Given the availability of the California rebate, they decided to install PV modules, and switch from load shifting to grid-tie mode. The use of trackers was based on two factors. First, being rural, the Russells had space for them. Second, trackers deliver their greatest benefit in the summer time, and this is when TOU rates are the highest.

Prior to the PV installation, the Russells' year 2000 average utility bill was US$73, and their average monthly electric consumption was 900 KWH. The PV modules were added to the system on January 1, 2001, and the system operated in backup mode, meaning the inverters were programmed in "Float" mode rather than "Sell," for 5 months. The reason for not operating in grid-tie ("Sell") mode was that the local utility took five months to get the net metering account set up.

During these five months, the Russells' average utility bill dropped to US$39, and the monthly utility-purchased electricity use dropped to 430 KWH. The system began operating in "Sell" mode with net metering TOU in June 2001. During the following four months, significant on-peak credits exceeded the off-peak consumption, giving the Russells a net credit for the summer through fall season of US$29. On June 15, 2002, the Russells received their annual bill for net electricity used during the first June-to-June year. The bill for that year's electricity purchased from the utility was US$85!

Super Efficient—Alvis Project

An Integrated Energy Smart Home, completed in May 2001, marries PV and super-efficient construction methods. Called the "Swift House" after the street in Fresno, California, where it is located, this project was built by the Alvis brothers (Mark, Marlin, and Lyle) for resale. Their philosophy was that a high quality, super energy efficient home with PV would be attractive in the marketplace, and could be built as an economic investment. Their progressive view was rewarded with the recent sale of the home at their asking price.

The walls of the home are constructed using insulated concrete forms (ICF). As the name suggests, these are hollow Styrofoam blocks that are assembled into walls and then have concrete poured into the hollow cavity. Functionally, the walls have the strength of a concrete wall wrapped in insulation, providing high thermal mass and a high R-value.

The outside and inside wall surfaces are clad in conventional building materials, stucco and drywall in this case. The roof is made of structural insulated panels (SIPs). SIPs have a Styrofoam core faced with 5/8 inch (16 mm) OSB (chip board). The 12 inch (30 cm) thick panels are very strong and offer a high R-value.

Other features of the home include high efficiency appliances, compact fluorescent lighting, and a high efficiency air conditioner. Architectural design features include generous eaves and overhangs that shade the walls. The roof-mounted PV array, installed during construction, consists of twenty-four, 120 watt modules.

The utility service is net metered using a standard tariff (no TOU). During the past year, the PV system produced an average output of 11 KWH per day (330 KWH per month) as measured by the onboard metering. Total purchased electricity for the year (June to June) was 415 KWH (35 KWH per month)! The total monthly consumption for the home during this period was 365 KWH (330 + 35).

Comparing this to the average consumption in Fresno, which is more than 900 KWH per month, the Swift house uses 60 percent less electricity. Keep in mind that the house used air conditioning, served as a residence for two people, was used as a sales office for Alvis Projects, and hosted numerous open house events. The cost for purchased electricity was about US$50 for the entire year. Alvis Projects has a Web site featuring a detailed history of the project. (See Access.)

The four projects outlined here differ from one another and represent varied ways PV can serve differing customer goals. It is important to understand that the value of PV is very customer specific. Good PV designer-installers listen to their customer's needs and then can suggest an intelligent solution.

Access

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www.i2p.org

IBEW Statement on PV
www.necanet.org/about/president/pd04_01.htm

Los Angeles Department of Water and Power (LADWP), Darryl Gordon, Solar Incentive Manager, PO Box 51111, Los Angeles, CA 90051 • 213-367-3250
darryl.gordon@ladwp.com • www.ladwp.com

Solar Electric Power Association's Interconnection Position • www.solarelectricpower.org/interconnection/position_statement.cfm

Ron Zastovnik's TOU PV System
http://psych.csufresno.edu/ronz/solar.htm

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The Front End

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

PV modules—the "front end" of a PV system—are usually the most expensive part of the system. They are also very long lived. Getting them connected safely and correctly should be a top priority for anyone desiring a safe, durable, and high-performance renewable energy system.

Live Long & Prosper

Crystalline PV modules can have a very long life. Modules produced in the last few years can be expected to have electrical output for the next 40 years or more. No, they may not put out full power, or even meet the manufacturers' expected output as the modules age, but they will probably be producing sufficient voltage and current to be useful. They will also still represent a source of electrical energy that may be hazardous if not properly installed.

PV system designers and installers should design the system and install and connect the PV modules so they function safely and reliably for many years with minimum maintenance. A number of issues must be addressed to accomplish this task. Some are related to the requirements of the *National Electrical Code (NEC),* some to good workmanship, and some to performance.

Inspectors & Instruction Manuals Are Your Friends

The local electrical inspector is a good person to keep informed about the design of your system. He or she will have ideas on how the installation should look, and may be able to offer valuable insights on how things are done locally. Foresight is a lot cheaper to implement than hindsight is to fix. Building codes may also affect the PV module or array installation.

It is beyond the scope of this column to go into detail about how and where the modules should be mounted. A general guideline is to mount all modules in the system pointed to true south, and tilted at an angle equal to the latitude.

Moving the PV array away from this ideal orientation will result in lowered output. Shading the entire PV array or part of it will also decrease the output. (This decrease can be significant if the array is made up of a single series string.) Installing the PV array in two or more locations with different orientations may result in a significant mismatch of array voltages due to variations in array temperatures, shading, and insolation. This will decrease output, especially if a single inverter is used. The California Energy Commission has a design document on their Web site that discusses some of these mounting issues. See Access.

The instructions that come with the module should be studied carefully to determine the proper way to mechanically connect the module to the mounting rack. The instructions will also describe the proper methods that can be used to electrically connect the module to the system. These should be reviewed along with the general and specific requirements established by the *NEC.*

Generally, the labels and instructions provided with a listed product supplement the *NEC* requirements found in Article 690 on PV systems. These two sources of information supersede any general requirements found in other sections of the code. Unfortunately, some manuals include errors that conflict with *NEC* requirements. Where a conflict is found, the manufacturer and the local electrical inspector should be contacted.

The longevity of crystalline PV modules (and possibly other module technologies) dictate that only the very best methods, materials, and workmanship be used in the installations. Stainless steel hardware is suggested for mechanical connections. The PV system may outlast the roofing materials, and the PV array may have to be removed to repair the roof—ease of disassembly some years down the road is a must. Lock washers and other appropriate hardware should be used to ensure that wind-induced vibrations do not shake fasteners loose over the years. If the module manuals list torque specifications for mechanical or electrical connections, by all means get and use a torque wrench; cost can be less than US$25.

Conductors

As discussed in *Code Corner* in *HP90,* the module manufacturer should provide specific instructions and hardware for connecting the equipment-grounding conductor to the module frame. A bare or sunlight-resistant conductor (USE-2) should be used. The circuit conductors require more careful consideration.

These conductors should be of the highest quality, and installed so that they can provide many years of reliable service. Although several different types of conductors meet the requirements of the *NEC* (see previous *Code Corners*), a conductor type marked USE-2/RHW-2, with cross-linked polyethylene (XLP or XLPE) insulation is generally considered one of the highest quality conductors commonly available. This specific insulation type can be used outdoors in sunlight and also installed in conduit outdoors and indoors. Most electrical supply houses have or can get it, and many PV distributors carry it.

PV systems running at 48 volts nominal can have open-circuit voltages that exceed 100 volts. String inverters like the SMA Sunny Boy 2500 may have open-circuit PV voltages up to 600 volts. While code-compliant, single-conductor, USE-2 cables are available that are rated for 600 volts, some thought should be given to the effect that sunlight, weather, and time can have on these exposed, single-conductor cables. Unfortunately, cable manufacturers are unwilling to disclose how their cables perform when time periods of 20 to 30 years are brought up. So we don't really know how well these cables will hold up in PV applications.

I have had #10 (5 mm^2) USE/RHW XLPE cables exposed on my hot, sunny roof in Las Cruces, New Mexico for twelve years on fixed racks and trackers, with no visible signs of degradation. This is an anecdotal observation on a 24 volt system, and the cables have not been tested in any way to see if they are still good for 600 volts and have not physically or electrically degraded.

At least one manufacturer, SMA America, suggests that conduit be used on any PV system where the open-circuit voltages may exceed 100 volts. The recommendation is made for installations where the single-conductor cables are readily accessible to unqualified people. If the conductors are secured under roof-mounted modules and cannot easily be reached, SMA America suggests that the use of single-conductor, exposed cables is acceptable.

The use of conduit for the higher voltage systems provides an extra layer of protection from shock should the cable develop a crack in the insulation. It also shields and protects the conductor from adverse weather and long-term UV exposure. Another option that might increase the safety and durability of the installation is to use a two-conductor, jacketed tray cable.

Neither of these suggestions represents code requirements, but the *NEC* hasn't dealt very much with consumer-type electrical generators that may last for 40 years without maintenance. See past *Code Corners* for more discussion about conductor selection and sizing.

If modules with pigtails and connectors are being used rather than junction boxes and point-to-point wiring, other considerations come up. Underwriters Laboratories (UL) has found that these connectors, when unplugged under load, create a small arc that compromises the insulation of the tip of the connector. The insulation chars and becomes conductive, and the connector is no longer "finger safe." UL is considering requiring these connectors to be "locking," so that a tool is required to disconnect them.

Connector manufacturers are developing designs that will lock. Until then, the installer using these connectors may elect to encase each with a length of heat shrink tubing to keep unqualified people from opening them. This is not a code requirement, just a suggestion that may increase the safety and reliability of the system.

Conductors must make mechanically and electrically sound connections with the PV modules. They must also be able to resist external stresses such as wind, snow, and squirrel loading. Conduit provides mechanical protection. Where exposed single-conductor cables or tray cable is used, it must be supported and provided with a degree of physical protection so that no strain is applied to the electrical connections. Exposed cable should not be allowed to run unsupported for more than a few inches. Conduit should be secured and supported. Both should be firmly fastened to a supporting structure at intervals recommended in the NEC for the wiring method being used.

Overcurrent Protection

The front-end design should address two areas of overcurrent protection, although they might both be accomplished by using a single device. The back of all listed modules has a label that shows, among other things, a value of the "Maximum Protective Fuse." This fuse is intended to limit the reverse fault current through a module to a safe level (one that cannot cause external fires). The reverse current could be caused by wiring faults or by faults within the module.

Since this overcurrent device (fuse or circuit breaker) must also carry the forward current from the module, it must have a value of at least 1.56 times the short-circuit current (Isc). If the labeled value for this fuse does not comply with this relationship with Isc, the module manufacturer should be contacted. Each module must have this overcurrent device if there are any sources of current in the system that can exceed the reverse current rating of the module (fuse rating). In systems where modules are connected in series, only one fuse is used to protect all of the modules in a particular string.

The circuit conductors connected to the PV module must also be protected by an overcurrent device located at the source of any potential currents. This device should also be rated at 1.56 Isc. Only the ungrounded conductor(s) are required to have this overcurrent device. Since the source of potential overcurrents that might damage the module or the circuit conductors is the same for both problems, a single overcurrent device can usually satisfy both requirements.

Sources of overcurrents are modules or strings of modules connected in parallel, backfed current from batteries through the charge controller, and backfed current from the utility through the inverter. These source locations dictate that the fuse be located at the combiner box where multiple modules or strings of modules are connected in parallel.

In systems with a combiner box, an additional fuse is generally required near the battery, charge controller, or utility-interactive inverter to protect the conductors between that device and the combiner box. Systems with no combiner box generally have an overcurrent device for each module or string of modules mounted in a power center or in a utility-interactive inverter.

Fuses and circuit breakers are rated for operation at an ambient temperature of 40°C (104°F). If the temperatures around the overcurrent device exceed this value, the device manufacturer should be contacted and temperature deratings obtained. For this reason, combiner boxes containing overcurrent devices should be mounted in the shade where they are not affected by solar radiation and heating. If the installation is in the hot Southwest, with daily ambient temperatures in the summer of 40 to 50°C (104–122°F), the overcurrent devices will have to be temperature derated.

Overcurrent devices may not be required in a few areas in DC module circuits. They all deal with installations where there are no sources of short-circuit current in excess of the rating of the module protective fuse. One type of system could have only one or two strings of modules connected to a water pump with no battery. Another case might be in a utility-interactive system with no batteries that uses an inverter that cannot backfeed currents from the utility. The SMA Sunny Boy 2500 is such an inverter. Two, and sometimes three, strings of modules can be connected to this inverter through an appropriate disconnect switch without overcurrent protection in the DC PV source or output circuits.

Quality Components & Good Workmanship Equal Safety & Longevity

PV systems can be installed so that you get years of trouble-free operation. Meeting the requirements of the *NEC* while carefully selecting components with the best durability will help to ensure that the system remains safe over the decades, and continues to deliver satisfactory performance with minimal maintenance.

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.

Access

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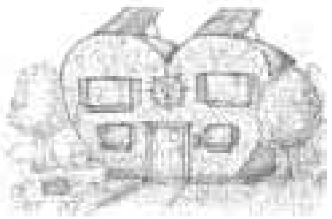
www.nmsu.edu/~tdi/pv.htm

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

California Energy Commission Report: *A Guide to Photovoltaic (PV) Power Systems Design and Installation* • www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF

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
custserv@nfpa.org • www.nfpa.org

Home & Heart



Kathleen Jarschke-Schultze

Living in the mountains, inside the Klamath National Forest, I had my first experience with wildfire. At the time, I was very glad to live in such a close-knit community. I've found that when tragedy and hardship strike, everyday people become heroes. Your neighbors can become your lifeline.

Guardian Angel

Every year around the end of May, Nancy Culbertson would arrive for her summer stint at the Eddy Gulch fire lookout. Nancy (wo)manned the Eddy Gulch lookout for 31 years before she retired. After settling in and dusting off, she would warm up the old CB radio and call out on channel 18, the contact/road channel, "This is Nancy at Eddy Gulch looking for a radio check."

Replies would come from both the south and north forks of the Salmon River. "You're coming in clear at the Jughead. Welcome back, Nancy."

"It's good to hear your voice, Nancy. We got you at Indian Creek."

"Hey Nancy, your signal is strong at the Prospect."

"We got you at Starveout, Nancy. Looks like it's gonna be a long, hot one."

"Hi Nancy, this is Main House. Welcome back."

"You're good at Matthews Creek, Nancy."

Nancy would answer each reply. We all felt safer with Nancy ensconced at Eddy Gulch looking out over us all. She knew us and she knew her territory.

Down Strike at Starveout

On a September afternoon in 1987, Bob-O left to take his brushing crew on a job in Happy Camp. Happy Camp is a small mountain town about 20 miles away as the hawk flies, but over two hours by car. He would be gone a week or so. A couple hours after he left, we had a terrific thunderstorm. No rain to speak of—just booming, roof-tin-rattling thunder and lightning. The huge dark clouds disgorging sound and fury were the kind that firefighters call "Cumulus overtimus."

Bob-O's son Allen was young, eight or so, and he was nervous about the thunder. I sat down with him and started to read a story. I did it as much for me as for him. Then I heard a police radio. I got up. How could I be hearing a police radio? Our cabin was at the same level as the main river road, but across the river. I went into the front yard. A green Forest Service truck was stopped in the road opposite our cabin. Several men were in it with the windows down, and I was hearing their radio.

I started down the trail to the suspension bridge, three planks wide, that crossed the river to the road. As I climbed the smaller trail up to the pavement, the truck pulled away. Allen had come with me, not wanting to stay alone in the cabin. Since we had left the cabin, all our attention had been focused on the truck out on the road. As we turned back to the cabin, the sight of the huge black plume of smoke on the mountain behind the cabin was shocking.

I thought I'd better go see what was actually happening on the mountain and just how close it was to us. I gave Allen the choice of waiting for me at the cabin or getting on his bicycle and riding three-quarters of a mile up river to the Jughead Mine and waiting with Herr Rise and Shine and his wife until I came and got him. He chose to go. I instructed him to let them know what I was doing and that I would call them on the radio when I got back to the cabin. I took his bike across the bridge for him and he left.

I grabbed the first pair of boots I saw and laced them on. I ran outside and the only fire tool I could find was a McLeod with its two middle teeth broken off. Bob-O had all the other tools because one of the jobs his crew did was dig fire lines. I started up the mountainside, taking the trail to our water ditch. This was an old flume ditch originally made and used for mining. We used it to run our microhydro and to fill our penstock for the house water system.

When I got to the ditch, the dog took off up the ditch, thinking I was going to clean it. I let her go; I didn't need the distraction of a dog. I jumped the ditch and headed uphill. At one point, I could tell the fire was to my right around the side hill. I moved through the loose duff and rocks as fast as I could on the steep incline.

As I rounded the side hill, I saw it. At least six, 30 foot trees were fully in flame. I expected the flame, but I was surprised by the noise. Fire is loud—frighteningly loud. I stopped in my tracks and tried to think clearly. I looked down at my feet to avoid looking at the fire, in an effort to calm myself. That's when I noticed the boots I had donned in such a hurry were Maine hunting shoes with rubber soles. Duh! I thought, that was dumb. I decided that I should try to clear a fire line around the trees.

I knew when Bob-O's crew dug fire line, it was "bare dirt, three feet wide." I walked to within 20 feet of the burning trees. I started clearing the duff with the broken McLeod. The mountainside was so steep that the burning duff under the trees was tumbling down the incline and smouldering lower down. The heat from the fire made my skin feel like I was sunburned, and I was sweating from fear and effort. I had a sudden thought. My brain said, "Mom doesn't want you here." I realized then that I was an amateur trying to do a professional's job. I didn't know what the hell I was doing, and the best thing I could do was leave. I did. To save time, I got down on my butt and slid down the mountainside to the trail at the water ditch. From there, I ran down to the cabin.

Lightning on the Mountain

I got to the cabin and the radio was busy. There had been down strikes all up and down the river. I tried to call Nancy to tell her about mine. She didn't answer. Otto from Prospect Mine called me back and told me that he could tell from his scanner she was way too busy on the Forest Service radio to respond to me. My strike had been reported by the truck I had seen out on the road. All I could do was wait.

About two hours (a century) later, a Forest Service crew of three guys, one chainsaw, and McLeods came across our bridge and climbed the mountain to the fire. They stayed there all night working on it. I saw them leave at about six in the morning. I asked if it was out. No, they said, but it was contained and should go out by itself. They had been called to another hot spot and had to go. I sent Allen to school on the bus with Norma, our bus driver, as usual. His mother picked him up after school, and took him off the river to his Aunt's for the duration of the fire.

Fire in the Air

California, Oregon, and Washington were hit by thousands of lightning strikes that day. Ours was not the only forest on fire. I sat in the radio shack and turned on the scanner so I could also listen to the Forest Service radio frequencies. That morning, our friends at Godfrey Ranch were threatened by a fire traveling toward them along the same route as the Hog Fire of ten years earlier.

I listened to the fire crews going into the Godfrey area to do hand work, while a water tanker went up to douse the houses there with water. Our friend Mahaj was at her house alone. Her husband Cedar played in a band and had been out to a gig in Scott Valley the night before. As soon as he got on the river, Cedar called from Cecilville on the radio. Was Godfrey Road clear of fire, or should he take the Bacon Rind Road, over Blue Ridge to get home? I was able to relay that Godfrey Road was open. I had heard this reported on the scanner. When Cedar got home, he learned that all eight homes located on the old Godfrey Ranch were being evacuated.

Someone reported the evacuation order over the CB. Neighbors from Matthews Creek, Main House, Blue Ridge, and the river called back. They were all heading out with their pickups to help the Godfrey families save what they could. I got on the CB and said I had Bob-O's pickup and I would come too. Fran, from Main House, called back and said, "Kathleen, you have to stay home. You have the only phone around here. Call this number and get hold of Tommy and Martha. They're visiting Martha's sister in New York. Tell them their house is going to burn down and find out what we should save. David is on his way over from Blue Ridge with his truck."

I picked up the microphone on our radio telephone and called the number. I told the person who answered the phone that I was a friend of Tommy and Martha's and I urgently needed to talk to one of them. Tommy got on the line. "Hey Kathleen," he says, "What's up?"

I took a deep breath, "Tommy, there were a lot of lightning strikes last night. A fire is moving towards Godfrey. Tommy, I am so sorry, your house is going to burn. What do you want out of it? David is on his way over with his truck."

A stunned silence, then, "You're kidding."

I started crying. "I would never kid about this, Tommy. I'm so sorry."

I heard his urgent aside to someone in the room. "Quick, get Martha. Now!" To me, "Tell me what's happening."

I filled him in on the fires I knew about. Martha got on another line and listened to my report. She said, "Tell David that in the closet under the staircase is a suitcase with all our papers and pictures in it. That's where Tommy's father's violin is too. We'll leave today to come home." We hung up and I relayed the message to David, who got their precious belongings out.

Tommy and Martha had previously lost their first house to a wildfire. That's why Martha was so prepared, with all her important possessions in one place, easy to find, and easy to move.

Fire Storm

Just about two hours later, a fire storm swept through the Godfrey. It happened faster than anyone expected. I could hear the Forest Service crews on the scanner, near panic in their voices, “Get everyone out! Get them out! Get them out now!”

Someone said, “Mahaj has turned around; she’s heading back!”

“Stop her, stop her!”

“She’s a hard one to stop!”

“Block the road with your truck! She can’t go back in!”

A minute later, “It’s okay; we turned her around. She’s leaving.”

The fire storm was so hot and fast that it baked the apples on Mahaj’s trees, but left them hanging. The grass underneath the trees was unburned. Six homes burned. Two were saved by the tanker truck dousing them with water right before they left.

Tommy and Martha lost their home; Cedar and Mahaj’s was saved. I asked Mahaj later what she turned back for. She had put a sprinkler on top of a drum of gasoline and had forgotten to turn it on.

A young man from the North Fork was packing supplies by mule into a remote fire lookout several ridges over in the Marble Mountains. He later reported seeing the fire storm swallowing the forest from that distance. He could see the trees actually exploding from the heat before the flames hit them.

Shacking Up

I sat in the radio shack with all our different radios on. I listened to the scanner for Forest Service news and the CB for community news given and taken. I also relayed messages and made calls with our phone/radio system on the 2-meter ham radio. At night, I used the 75-meter ham radio for emergency relays through Western Public Service System, a ham net. Now I knew I wouldn’t and couldn’t leave the radio shack. It was early afternoon on the second day of the fires.

[Next issue: The story continues as Bob-O and his brushing crew are roused out of their sleeping bags very early in the morning...]

Access

Kathleen Jarschke-Schultze just received her General class ham ticket from the FCC at her home in Northernmost California. She remains KB6MPI. 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
Oct. 9, '02. Energy Globe Award 2003 submissions deadline. Honors outstanding projects RE & efficiency. Prizes 10,000 Euro per category. Info: Margit Nagelstrasser, +43 732 7720 14386 • energy.globe@esv.or.at www.esv.or.at

PV Systems book, en Español. Free download: www.epsea.org/esp/biblioteca.html

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 in Spanish on energy & energy saving. www.epsea.org/esp

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

Solar On-Line (SõL) 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. SõL, PO Box 217, Carbondale, CO 81623 Phone/Fax: 720-489-3798 info@solenergy.org • www.solenergy.org

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. Learn aspects of 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

BRAZIL
Nov. 6–8, '02. REsolutions South America. São Paulo, Brazil. Trade show & conference. Info: Thorvald van der Zee • ++ 55 11 3873-7614 info@wbe.com.br

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

SCOTLAND
Oct. 15–17, '02. Renewable Realities, Orkney, Scotland. Practical reality of wind, wave, & tidal RE systems. Forums & technology exhibits. Info: SBI, Stromness, Orkney, KW16 3AW • +44 (0) 01856 850088 Fax: +44 (0) 01856 850089 enquiries@renewablerealities.com www.renewablerealities.com

UNITED KINGDOM
Oct. 22–24, '02. Sustainable Energy Expo 2002 & Energy Efficiency Expo. Conference & exhibition • www.sustainable-expo.org

Solar grants up to 40–65% of installed cost. Info: Energy Saving Trust • www.est.org.uk

NATIONAL U.S.
Oct. 5, '02. National Tour of Solar Homes. Tours in most states. Info: American Solar Energy Society, 2400 Central Ave. #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 ases@ases.org • www.ases.org

Oct. 5, '02. Green Buildings Open House, part of ASES National Tour of Solar Buildings. New England, NY, NJ, PA, & DE. 10 am–4 pm. Info: Meghan Houlihan, NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 x 22 or 877-44SOLAR • mhoulihan@nesea.org www.nesea.org

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. US$25 + S&H, broadcast-quality tapes available. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 606-256-0077 • Fax: 606-256-2779 aspi@kih.net • www.kih.net/aspi

American Wind Energy 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

Sandia's Stand-Alone PV Systems Web site: design practices, PV safety, technical briefs, battery & inverter testing, 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

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

ARIZONA
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
Oct. 5, '02; Solar Cooking Summit, Lindo Lake Pavilion, Lakeside, CA. Boiling Water Recipe Contest, share food, info, & oven innovations. Info & contest rules: Ian Zalewski info@deathvalleypizza.com

Nov. 7–8, '02. Renewable Energy conference for executives, Oakland, CA • CBI, 500 W. Cummings Park, #5100, Woburn, MA 01801

800-817-8601 • lorneg@cbinet.com
www.cbinet.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. E-mail with "Subscribe" in subject to: solareclips-request@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 • Phone/Fax: 606-453-2105 • aspi@kih.net
www.kih.net/aspi

MASSACHUSETTS
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. Reservations. 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
Oct. 17–Nov. 14, '02. Intro to Home Made Solar Electricity. Mimbres Valley Learning Center, Deming NM. Repeated in Feb. '03. 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
Nov. 16–17, '02. Small Wind Electric Systems, Appalachian State University, Boone, NC. Wind assessment, siting, equipment, towers, wind/pv hybrids, system sizing. Instructor: Mick Sagrillo. Info: Dennis Scanlin, 828-262-6361
scanlindm@appstate.edu

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

OHIO
Oct. 13, '02; Athens Area Sustainability Festival, Athens County Fairgrounds, Athens, OH. Recycling, solar & wind, watershed restoration, organic farming, alternative transportation, local artists, musicians, theater, food, educators. Info: 740-448-1016 • isbalkits@hotmail.com

OREGON
Nov. 2, '02; EORenew Annual Meeting; John Day, OR. EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • info@solwest.org
www.solwest.org

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
Nov. 12–15, '02. UPEx'02—The PV Experience Conf. & Exhibition. Austin, TX. With TX Renewables 2002 & USGBC's Green Building Conference & Exhibition. Info: Julia Judd, Solar Electric Power Assoc., 202-857-0898
SolarElectricPower@ttcorp.com
www.SolarElectricPower.org

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/

VERMONT
PV, Wind, & Solar Hot Water Basics wkshps. 1st Sat. each month, through Sep. Info: VT Solar Engineering, PO Box 697, Burlington VT 05402
800-286-1252 • Fax: 802-863-7908
www.vermontsolar.com

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

WASHINGTON, D.C.
Sep. 19–Oct. 9, '02; Solar Decathlon, on National Mall. College competition to design & build energy-efficient solar-powered homes. Info: Gary R. Schmitz, NREL, 1617 Cole Blvd., Golden, CO 80401 • 303-275-4050
Fax: 303-275-4091 • gary_schmitz@nrel.gov
www.solardecathlon.com

WASHINGTON STATE
Oct. 11–13, '02; Intro to RE Wkshp, Guemes Island, WA. Intro to solar, wind, & microhydro for home owners. US$200. Fri. evening free & open to public. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden
360-293-7448
ian.woofenden@homepower.com

Oct. 14–19, '02; PV Design & Install Wkshp. 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

Oct. 21–26, '02; Wind Power Wkshp with Mick Sagrillo, Guemes Island, WA. Design & install a complete wind-electric system. System sizing, site analysis, safety issues, hardware specification, & hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448
ian.woofenden@homepower.com

WISCONSIN
MREA Wkshps: RETScreen: Oct. 3, Madison, WI; Urban PV: Oct. 18–19, St. Paul, MN; RE for the Developing World: Oct. 21–25, Custer, WI; Masonry Heaters Intro: Nov. 2, Custer, WI. SOs half price. 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... Global Warming Revisited

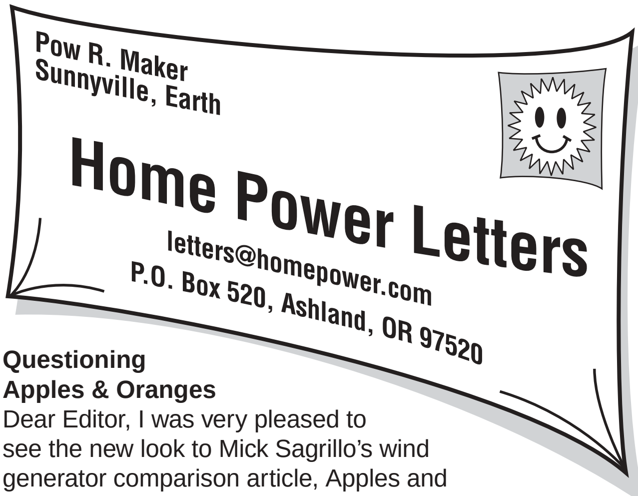
Many believe that global warming is a myth. Let's set the record straight. Not only is global warming very real, it must follow from the science of the situation. Here's how.

Carbon dioxide is a heat-trapping gas. Since humans first discovered fire, they have been putting elevated amounts of carbon dioxide into the atmosphere. Every year, the percentage of carbon dioxide in the atmosphere increases. As this occurs, more heat is trapped and prevented from radiating into space. Eventually, this excess heat must begin to raise the temperature level all over the world. Thus, we have global warming.

There are even more potent, heat-trapping gases in the atmosphere. As their percentage increases, global warming may begin to accelerate. One of these gases is methane. It is increasing in the atmosphere, due in part to more natural gas emissions and outgasing from the arctic tundra.

Let us hear no more from the naysayers. Global warming is real, and it is here now. Eventually, factors that offset global warming, such as the cooling effects of oceans, ice caps, cloud cover, and the occasional volcanic eruption, will be overcome. When this happens, we can expect more precipitous increases in global warming. Even the present U.S. administration has acknowledged the reality of the situation.

The only way to combat this warming and its effect on global climate patterns is to lower the percentage of heat-trapping gases in the atmosphere. If action is taken quickly, there may still be time to mitigate its worst effects. It's your choice.



Questioning Apples & Oranges

Dear Editor, I was very pleased to see the new look to Mick Sagrillo's wind generator comparison article, Apples and Oranges, in *HP90.* I was thrilled that the focus of the new article is swept area of the wind turbine, rather than rated output, since swept area is a much better way to compare turbines. I was looking through the estimated energy figures for the turbines, however, and found a couple that I question. The reason that energy production figures can be questionable is that they are based on a power curve, which the manufacturer creates. Some manufacturers can be generous in stating their power curves, and others can be conservative.

In focusing on the swept area of turbines, you would expect to see machines that have more swept area generating more energy (at least in low wind regimes, with the same type of alternator). The Proven WT 2500 and African Windpower 3.6 numbers given by the author did not fit what I was expecting. The WT 2500 numbers (as estimated by the author) looked too good to be true, and the AWP numbers looked conservative.

I actually have both of these machines installed on the same site here in North Dakota. My WT 2500 has not yet performed according to the manufacturer's specifications. It is only peaking at 1,600 watts, not 2,500. However, I am in contact with the manufacturer, and we are trying to remedy the situation.

I have been doing data acquisition on both of these turbines. I believe my numbers would roughly be within 10 percent of data generated according to the wind industry standards, so there is a little room for error in my numbers. I will include two numbers for the WT 2500, a number that uses my actual production figures, and a number that extrapolates the data to what it might be like if it actually gave me 2,500 watts of peak output. Sincerely, Michael Klemen • windy@bektel.com www.ndsu.nodak.edu/ndsu/klemen

Energy Output at Mike Klemen's Site: Proven WT 2500 & African Windpower 3.6

Average Wind Speed (mph)	*KWH/Month*		
	AWP (Actual)	*WT 2500 (Expected)*	*WT 2500 (Actual)*
8	119	101	101
9	149	142	142
10	179	191	187
11	208	244	236
12	235	302	285
13	260	362	334
14	283	425	381

Mike, Your statement that "some manufacturers can be generous in stating their power curves," is an understatement. And I agree with you wholeheartedly, and with your tactful use of words. I have taken a stab at projecting outputs of all the turbines listed in A&O '02. It's on Home Power's *Web site as an appendix to the article.*

Please note that I did not "estimate" the outputs of some of the turbines in the way that you apparently took it. And they are not my estimates; they are numbers supplied by the manufacturers.

In the case of Proven, I tried for several weeks to get monthly output numbers. I was eventually supplied with an annual energy output curve. When I persisted, I was told to estimate the numbers I needed from the curves. What I did was calculate monthly outputs from the curves they provided.

I also agree with you on your comparison of the Proven and the AWP. While I have not monitored the outputs of either machine, I have thoroughly disassembled both the AWP 3.6 and the WT 2500. Based purely on greasy observation, the Proven alternator appears to be a more efficient design. However, I don't believe that either will deliver the outputs the manufacturers supplied me with. I believe that the AWP is underrated, while the WT 2500 is overrated.

I would also like to compliment you on your work in verifying wind turbine outputs. I think it's great that you are gathering output data correlated to your wind speed. It would be terrific if we had more folks with the ability to do this type of turbine performance verification. Now, if we can only find a way for folks doing this work to be paid. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 • Phone/Fax: 920-837-7523 • msagrillo@itol.com

Safety & Lawyers with Grid-Tie

Dear *HP,* I've been following your ongoing discussion on guerrilla solar with great interest. I'm utility intertied with 1.2 KW of PV, so it doesn't really apply to me, but I did need to jump through all the hoops with our local utility, Arizona Public Service, to do the intertie, so I totally understand the motivation for guerrilla tactics. The response by Joe Schwartz to the letter "Puzzled Over Net Metering" (*HP90*) makes a very good point—utility linemen work under hazardous conditions all the time and know how to protect themselves. Since we did our intertie, we've had at least ten outages; our visible disconnect switch has never been used. I put a small piece of tape on the switch handle that would break if it was thrown, and the tape is still there. Why? Allow me to relate an interesting story.

I did all the wiring on our home, and learned to respect electricity at an early age. My dad, who was an electrician, taught me everything I needed to know. On one occasion I needed to do some rewiring, so as always, I turned on a light in that circuit, went to the panel and turned off the breaker, returned to the room to find the light off, as expected, and proceeded to wire.

Needless to say, I was surprised to get a jolt of AC while replacing the outlet! Turns out that sometime between turning on the light and returning to the room, the bulb burned out. And, obviously, on this same occasion I had turned off the wrong breaker. Lesson learned.

Now I always put a meter on the wires before touching them. Any lineman that does otherwise is risking a far larger hazard, given the voltages they routinely work with. At 480 V, I wouldn't even trust a visible disconnect switch! Common sense field practices make the visible disconnect switch unnecessary (as do modern inverters). I think the utilities know this. Certainly their linemen do. I suspect it's the lawyers that drive this requirement. Any linemen readers out there care to corroborate this? Dan Heim • dan@heimhenge.com

Civic Hybrid

Mr Perez, I have been reading your magazine off and on for about six years now and have only dreamt about alternative energy. My wife's car has 198,000 miles on it, and we figured we could use a new one. We have been watching the hybrid auto developments for quite some time, and were pleased to see the Honda Civic recently introduced. We test drove one on Saturday and bought it. Fifty mpg is going to be sweet.

On the plus side, the car is a full-size sedan. Other than two gauges indicating battery charging (such as during braking) and indicating that the electric motor is assisting the engine, and a blinking light when the engine shuts off at a red light, the darn thing feels like an ordinary car. At US$20,000, it is not even really all that much more than a regular Civic, especially since we get a US$2,000 federal tax credit, and considering that the regular Civic gets 35 mpg at best. We are going to do a lot of smiling when we pass gas stations. We pick it up on Wednesday. Can't wait!

Later that week...

So far we love the car. With air conditioning on and four adults onboard, we were getting 47.5 mpg. We managed to top 50 mpg on a trip to Hartford with two in the car. I recently checked out a Prius up close. Not to put those people down (because it was the first four-seater available), but the Civic is definitely a much more luxurious and comfortable car for the same price and about the same fuel economy. You wouldn't even know it was a hybrid until you look close, whereas the Prius has an "alternative" feel about it. This car is definitely going to change things. Friends of ours who rode in it were impressed with the power, comfort, and technology—like turning off three cylinders when coasting to reduce drag on the engine, shutting off at stops, etc. Cheers, Jim Kasper, Hamden, Connecticut • Kasper4269@aol.com

Collective Voice

Renewable energy (RE) is too good of an idea to let go. Widespread use of RE practices will have a profound effect on how we humans live and interact with each other. As individuals, we can take charge of our own energy needs, using nothing more than our ingenuity and our bare hands. It is entirely possible to live a thoroughly modern life, but without the negative drawbacks of creating pollution and furthering petrochemical dependency.

Breaking the vicious cycle of our societal oil habit will have long-term consequences on the world geo-political stage as well. Every person who says "no" to what the corporate utility complex tries to force on us is someone striving for a better answer, a better life, a better future. *Home Power* is among the first whisperings of this growing collective voice. Bill Chellis, Seymour, Connecticut • wmchellis@earthlink.net

Use It Up, Wear It Out, Make It Do, or Repair It!

The mantra for environmentalists seems to be "reduce, reuse, recycle." I think that there should be one more—repair! A few weeks ago, the dryer in my house stopped drying my clothes. I knew that the problem was the heating element, because for a few weeks, I had not been getting that warm, huggable feeling when I took clothes out. My clothes were in there spinning around in circles getting quite dizzy, but never getting dry.

One day (after I had run out of clean clothes), I took the back off the dryer and figured out where the heating element was. I took the element out, and took the numbers off of it, thinking that I could go to the local hardware store and find this pretty common replacement part. Wrong!

I went to the local monolith that has extinguished all life from every other "home improvement" center in the last several years. It was fairly easy to locate the appliance department, but quite impossible to find assistance. I eventually stopped the third smock-wearing individual who was walking by on some task far more important than assisting a customer. "Where might I find an element for a dryer?" I asked. His response was, "There are several elements in a dryer." He then proceeded to tell me that they had a limited parts selection. Then he tried to sell me a new dryer.

Dryers are not very expensive (though they do cost much more than the 50 feet of rope that I would have needed to make a clothesline). It would have been easy to buy it, have it delivered, and have them cart away the old one. (I would have been doing my laundry later that same day.) Unfortunately for the inept sales guy, I have this misconceived notion that durable goods (like home appliances) should be durable and repairable, not disposable.

If you are (un)fortunate enough to think the same way, and you have a problem, www.repairclinic.com is a great Web site that I found during my quest for parts. If you think that such a complex subject as which screws should be turned, and which way to turn them is beyond your grasp, you are wrong! The only tools I needed were a screwdriver and a pair of pliers. There are fantastic troubleshooting charts and step-by-step directions, right here on your computer waiting for you. Matt West, Reston, Virginia • matt@20percent.org

Proud & Thankful
Back in 1995, I was in Dallas, Texas, for a seminar, and happened to go to a bookstore just to browse. I came across your magazine on the shelf and bought it. After reading it over and over, I asked myself, “Can this really be done?” I spent the next year researching, took SEI’s PV Design & Installation workshop, and then took workshops with MREA. I designed, bought, and installed my own 1 KW PV system with a 900 watt wind generator. It’s my baby and I am proud of it. All thanks to you, *HP*. You have answered my several e-mail messages with the best of advice. God bless you all, God bless solar guerrillas, and may the sun continue to shine. Doyle L. Lonski, Antioch, Illinois • dllonski@cs.com

Computer Security
Dear *Home Power,* There is a serious flaw in your article about computing in a solar house in *HP90.* The author says, “We added a D-Link wireless router (Model DI 713P, US$140, 7 watts) that gives us the ability to use the laptop almost anywhere in the house. It also connects the two computers together, and provides good Internet security from hackers. Incidentally, software can provide good protection also, but it’s not as good as the hardware solution in a router.”

Software (a firewall) would be better than a router. The D-link only opens and closes ports, and usually it leaves ports open. If you use a firewall, the software can usually tell when your ports are being scanned, and block access to some hacks. A wireless router will let hackers have their way with selected ports and allow them to open others. So where is this wireless system? I wouldn’t mind setting up a spam server on the computer (grin). Edd Thompson euphoriadj@adamswells.com

Hi Edd, Your comments on security are probably correct, since the software is continually getting better. I take no credit for expertise in this area. My actual experience is limited to setting up my own network. I do try to keep up with the research and expert opinion from reputable sources, like PC Magazine. *And over the last couple of years, what I said in the article seemed to be the message. Now it appears that the best overall advice is to have both hardware (router) and software solutions in place, as well as up-to-date anti-virus and even anti-spam software. Security is a continual challenge.*

When I wrote those couple of sentences in the article, I was sorting out whether to even mention security issues, since that was not the focus of the article and it was getting kind of long. I finally decided to make a brief mention, just in case some of the readers were not too aware of the need. In hindsight, I might better have said, “by all means do both; and keep your security software up-to-date.”

Of course, the best security is having the system, or parts thereof, turned off when not actively computing. We do it mainly to save energy. But if the radio and/or router are off, or if the computer is off or in hibernation, somebody can knock, but they can’t come in.

I recently found a good basic guide with lots of informative links at www.firewallguide.com. They look to be impartial, but do derive income from linked equipment sellers. A particularly informative link on wireless security is www.practicallynetworked.com/support/wireless_secure.htm Aloha, John Bertrand • caber@kona.net

Hi Edd and John, There are some excellent and well-performing hardware firewalls out there, and some routers also with good firewalls. While cruising around Internet security sites, I happened across some that will actually simulate an attack on your system for the purpose of reporting back to you any insecure situations that might exist in your hardware or software firewalls. Check out www.securityspace.com for both free and subscription security checks. For very basic but good tests, and good and interesting info, check out Shields Up at www.grc.com. The site www.hackerwacker.com also has both free and subscription security checks. Practice safe computing—use protection. Michael Welch michael.welch@homepower.com

Insurance for PV Grid-Tie
Back on February 23, you sent me an e-mail concerning my efforts to erect a wind turbine at my home. I gave up on that and had Andrew McCalla of Meridian Energy Systems in Austin, Texas, install a set of solar-electric panels on my roof instead, which worked beautifully for one day. We thought we had sufficient permission, but the Kerrville Public Utility Board (KPUB) came and shut us down and put their padlocks on the control switches. We (Andrew and I) were told that they would give us a list of their requirements so we could operate the system. They said that their main concern was electrocution of their staff through malfunction of the inverter, a Sunny Boy, which is certified to meet all the IEEE and UL anti-islanding requirements, but KPUB was not satisfied.

Six weeks went by and suddenly we learned that the KPUB board had passed a resolution (why was it ever needed?) to permit distributive generation—selling electricity back into the KPUB grid. Now I have been presented with a contract to sign, one provision of which is that I maintain US$1 million liability insurance policy payable to KPUB. I am fighting that at the moment. I am even considering in the meantime asking that I be able to connect the panels on a nonexport basis, which could at least save some money and not infect their precious grid.

Has your magazine ever published an article on this insurance issue? If so, would you send it to me? Or if not yet, would you consider running one? Andrew and I could write you one hell of an article! Regards, John Miller

Hello John, Sorry to hear your sordid tale. Unfortunately, we’ve heard it before. We’ve never published an article that specifically details insurance requirements of grid-tied RE *systems. Many states address the insurance issue in the text of the net metering legislation. When we were moving Oregon's net metering legislation through the state House of Representatives and Senate, we kept a close eye on the text that excluded any additional insurance requirements for grid-tied systems, making sure it wasn't altered.*

The first thing I would do is thoroughly review Texas' net metering legislation text. Is insurance detailed in the law? Is KPUB legally exempt from the legislation? The information I have states that both investor owned utilities (IOUs) and rural electric co-ops (RECs) are included under Texas' net metering law.

We'd love to see an article on your system and your policy struggles. It's exactly what we're looking for. We hope it has a happy ending. You're in good hands with Andrew on the job. Please let us know if we can lend a hand, and keep us posted! Joe Schwartz • joe.schwartz@homepower.com

Payback Distortion

I agree with many *Home Power* authors and readers that there's an enormous amount of government interference in the energy market, which destroys the ability to make a rational economic calculation of the payback of RE. Such government interference includes: tax credits for RE users, corporate welfare such as grants for RE technology research and subsidies for established energy providers, defense spending to colonize the Middle East, regulations prohibiting the unusual, price caps, prohibition of competition, speculation, and sales to the market.

These distortions in the market destroy the validity of the price system, a beautiful thing wherein all the minds on the planet cooperate to make the world's aggregate best guess at how to produce the amount of energy people want with the fewest costs.

But many people looking at renewable energy for the first time want to know, "What's the payback?" I would love to see a stab made at constructing a straight answer to the payback question, by detangling the elaborate web of forced payments and prevented choices. For instance, if the U.S. energy companies stopped trying to get the U.S. Army to colonize the Middle East so they can run an oil pipeline through it, how much would we save from the defense portion of our federal taxes? Would this be offset by higher prices from OPEC? Would voluntary OPEC sales made at voluntarily agreed upon prices have more moral legitimacy?

If all nonsafety barriers were removed from utility intertie, all residential visual aesthetic zoning rules were eliminated, and people believed the rules would stay the same for 30 years, how much long-distance energy transport would be replaced by local RE generation from rooftops, backyards, and vacant lots? How much would we save from eliminating long-distance electrical transmission losses? How much resistance to accidental power disruption would we gain by decentralizing generation? Would we transport natural gas long distances to neighborhood fuel cells instead of transmitting electrical energy, because the transmission losses would be lower?

The payback question is a very good one, and I believe it deserves an attempt at a straight answer. Brian, Massachusetts

Hi Brian, Indeed it does. How about an article on the subject after you do your research? Regards, Ian Woofenden ian.woofenden@homepower.com

How-To

I have purchased *Home Power* sporadically from newsstands during the last five years on impulse. This impulse was triggered by the practical nature of the technology featured in real world applications. To read almost any *Home Power* article dispels the myth that RE is available only to those with exceptional technical experience or large monetary resources. Many publications and organizations promote "We can all make a difference," but *Home Power* shows how individuals everywhere are actually and practically doing it. Thanks for providing the forum for sharing real RE information. Jim Vonderwahl vonderwahlj@yahoo.com

Saving with Battery Cables

Hey, Richard. You did a great piece of work in the article, "Make Your Own Battery & Inverter Cables" in *HP89.* It showed us a number of things:

1. We can do this! It isn't rocket science.
2. Good connectors don't have to cost an arm and a leg.
3. Good cabling can be tailored to each situation; long enough, but not too long, and they can be neatly done. Personally, I like the way the finished connector is sealed from contaminants.

You said, "It's a lot of work to make these cables." I disagree. It may take a little more effort, but the end product is better for the job *and* the long haul! The effort is really an investment. 73, Herb Lacey, W3HL • infomanag@aol.com

Grid-Tied Wind

Dear *Home Power,* I bought the June/July issue of your magazine with the idea of seeking out a roof-mounted wind generator to feed electricity back to the grid. I was happy to come across reader Gary McBurney's letter in Q&A regarding this subject, but was equally disappointed to find out that there is no current solution.

This seems like such an obvious method of simple electricity generation, why have manufacturers not developed a modern day solution (Mick Sagrillo mentions there used to be inverters that could do this)? I too, like Mr. McBurney, don't have a lot of money to spend, but would nevertheless like to contribute my part, and wind generation is appealing to me. Are there any solutions on the horizon? Can manufacturers and utilities step up and find a cooperative solution? Regards, Christopher Thale, Greenwood, Indiana

Hello Christopher, Yes it does seem like there should be a simple, inexpensive solution to grid-tying a wind system. Why doesn't it exist? Simple economics. Twenty-five years ago, the leading technology for home energy systems in the U.S. was wind generators. There were at least two *manufacturers of utility interactive inverters. Both were batteryless, SCR inverters. Some were even used on very early PV systems. They worked, more or less. Today they're considered old technology.*

Fast-forward twenty years, and wind energy has taken a back seat to PV as the leading technology for home energy systems. The main reason is the intrinsic simplicity of photovoltaics. The grid-interactive inverters available today are designed around photovoltaics as the "prime mover," not wind.

So what's the solution? Make your needs known to the inverter and wind generator manufacturers. Some movement is happening, but it is slow. For example, the 10 KW Bergey Excel uses a Trace Technologies Grid-Tec utility-intertie inverter. This inverter was specifically designed for the Bergey Excel, and is not available for any other wind system. In addition, the Jacobs 31-20 comes with its own SCR driven, grid-tied inverter. Like Bergey's Grid-Tec, the Jacobs inverter is designed for use only with their wind generator.

SMA, the makers of the Sunny Boy grid-tied PV inverter, have a grid-tied wind version they call "Windy Boy." It is in use with the Proven WT 2500 and WT 6000 in Europe. Unfortunately, this is a 240 volt, 50 Hz unit. Proven says they can provide 60 Hz chips for use in the U.S., but to date, no one has sold or bought one of these. Maybe if some of the inverter manufacturers out there see these letters, it will stir some movement towards the development of a batteryless, grid-tied inverter for wind turbines.

The Advanced Energy Incorporated (AEI) grid-intertie inverter is another option. I personally have not seen any wind systems with these inverters on line. I'd really like to hear from some dealers and users about their experiences with an AEI grid-tied inverter/wind turbine combo.

On another note, I'd like to discourage people from putting wind turbines on roofs. The problems with this practice range from little or no wind at the house roof to increased turbulence around the top of a building, both of which severely cut into production as well as turbine life. There are also structural considerations, since houses were not designed to handle the harmonic vibrations set up by the generator itself as it generates electricity. These harmonics are normally unheard vibrations, but when a wind turbine or its tower are attached to a house, they are transmitted through the structure and make audible noise inside the house itself. Virtually everyone I know who has attempted mounting a wind genny on their roof has complained about the noise, subsequently relocating the wind turbine to a real tower, where it belongs. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 Phone/Fax: 920-837-7523 • msagrillo@itol.com

Instant Renewable Gratification

I have been interested in RE for quite a long time, ever since I was a young'n and heard about biomass and PV panels. So when I got turned on to your magazine about a year ago, I started downloading issues right away. After I moved to the mountains and ended up with lousy bandwidth, I got a subscription. So now I'm getting paper copies to thumb back and forth through, and I get to support you guys. Now all I want is for the two months between issues to go by faster. Barring that, I ordered all the back issue CD-ROMs (1–7) that you have. Those should be able to satiate me for a little while. But now I have to wait for them to arrive, but only for a short time. Damn my need for instant gratification. So as you have probably guessed, I am quite pleased with your little subversive, new communist rag. I am looking forward to more articles on fuel cells and biomass. Other than the wait, it's all just grand. Keep it up, just make it come more often. skiracer@rkymtnhi.com

Only for the Rich?

I think the education that you offer to people is absolutely wonderful and gracious. But I began to cry when I realized that people in my income bracket will never afford the materials and educational tools that it takes to attain this sort of liberty. If people had the income, why wouldn't they choose wind turbines, solar-electric panels, and all the batteries and little knobs, and inverters? And why not a small piece of land somewhere where they could grow their own vegetables, and get milk from old Bessie, and dry their own food, and have a smokehouse, etc.? I'm sorry, I have always strived for these things and have not made progress because of the expense. It is just so sad to realize that only a select few will benefit. Lana Willis

Hello Lana, It is simply not true that using solar energy is only for the rich. I bought my first PV module when my annual income was below US$4,000. It's a matter of where you spend whatever money you have. Also, many of the concepts involved in using solar energy cost nothing at all—energy efficiency can be as simple and cheap as turning off unused appliances.

Some solar energy equipment is very inexpensive. We publish a book called Heaven's Flame *that shows how to build a simple solar cooker out of dumpster divings. Total cost is less than US$10, and it cooks whole meals! Consider a clothesline—totally solar powered, and it costs only a few bucks for a length of rope.*

While solar electricity for an entire average American home is expensive, not all homes are average. PV systems are going in at a rate of tens of thousands per year in Africa. These systems involve only a couple of PV modules and cost less than US$1,000 each. They provide lights at night and communications, such as a radio or a small TV. It's all a matter of proportion. Richard Perez richard.perez@homepower.com

Missing Capacitor

In the *HP90* Letters section, page 150, under the title "How To Fix that RFI Problem," two capacitors are referred to with values of 470 and 0.01 microfarads. Unfortunately, the diagram at the bottom of the page only shows *one* capacitor. What happened to the second capacitor? This scheme will solve a big problem for me. Thank you for considering my question and please keep up the good work in your magazine. I thoroughly enjoy my subscription. Alan Turof

Hello Alan, The second capacitor (which may not be necessary in most cases) is wired in exactly the same manner as the first one shown. The small capacitor (0.01 micro farads) acts a short circuit for RF energy (anything above about 1 MHz), and the larger 470,000 microfarad capacitor acts to reduce DC ripple on the line (very low frequency). Both are wired from plus to minus. Be careful with the larger capacitor, since it's an electrolytic capacitor and polarized (has a plus and minus side), while the small cap is nonpolarized. Holler if you need more info. Richard Perez • richard.perez@homepower.com

Comments on Three Articles

Dear *Home Power,* I enjoy your magazine, especially the Aug/Sep 2002 issue where I found articles on three little projects I have already done myself! Some thoughts:

The white LED flashlight could be made brighter with LEDs available from Digikey in Minnesota • 800-344-4539 • www.Digikey.com. They now offer two, 2,300 mcd white LEDs, #CMD333UWC-ND or 67-1604-ND, for US$3 each, with large-quantity discounts. However they do charge shipping, and there is a US$5 charge for orders under US$25, so this is only a good alternative for somebody who might want to make several.

John Gislason's approach is unconventional because it does not employ a current-limiting resistor in series with the LED, but he is right, it does work fine with a battery power source. It is easier to position the LED for focusing if you remove the circular base ring with a mototool or a hand file.

Homebrew yagi antennas perform great, and are cheap! Another construction method is to make the body out of PVC pipe and connectors, with plain old wire for the metal parts (where Bill Layman used a cut-up multiband yagi). The same dimension rules apply. In this case, as he points out, the tuned frequency will be narrow because of the wire's small diameter.

The Kill-a-watt meter that you review fills an important need, but there is a cheaper way! Clamp-on ammeters read current through an inductive loop. The cheapest source I have found for these is Harbor Freight Tools • 800-423-2567 www.harborfreight.com • Item 42397-1NTH, US$19.99

To use the meter, you need to clamp around a single conducting wire. This is very easy to do after buying something like a short air conditioner extension cord that has flat conductors, and separate off one conductor for a few inches with knife. If you accidentally cut through copper, cover with electrical tape. If you cut through flesh, use bandaids.

The meter has a peak hold feature, so this is an advantage that Joe Schwartz wished for. It does not display watts directly; for that you must multiply amps by volts, either assuming the voltage to be 120/240/etc., or by measuring on the voltage scale. I don't find this to be a disadvantage because for comparisons, knowing the amps has been adequate for me. Another potential advantage of the clamp-on meters is they usually have 1,000 amp maximum scales. On the low (20 amp) scale, there is plenty of precision to compare loads such as 15 and 25 watt lightbulbs.

One interesting thing I learned using this meter is that my computer monitors consume the same amount of energy in normal or screen saver mode. The screen has to be completely black for energy savings. I agree with Mr. Schwartz that knowing energy consumption is the first step towards reducing it.

I have not found in your magazine archives any discussion of AC power controllers (also called power planners) that you connect to an AC inductive motor appliance. These are the ones demonstrated in the larger hardware stores for about US$30. In my experience, they reduce energy consumption of AC motors 6 to 30 percent (depending on load). They offer no improvement with modern, conventional refrigerators, perhaps because the power-shaping circuitry is already built in, or the motor is so closely matched to the compressor load. They are often sold in 6 to 10 amp max load capacity, but I once found a Web site offering larger units that would seem appropriate for larger loads like heat pump compressors or whole-house ventilators. If there is any interest in such an article for *Home Power,* I might give it a shot, since my ideas for articles on LED flashlights, yagi antennas, and ammeters have already been taken! Keep up the good work. Doug Schaefer • dougschaefer@mail.uia.net

Mr. Schaefer, It has been nearly a year since I came up with the idea of converting my AA Mini-Mag to an LED lamp and three batteries. Since that time, I have discovered numerous additional sources for LED lamps. Of these, the highest output and least cost lamps come from the same source, www.lc-led.com. They offer two white LED lamps that I believe would be very well suited for use in projects such as this. The #500TSW4D (15 degree viewing angle) is rated at a nominal 8,600 mcd output at 3.5 VDC with an operating range of 7,900 to 9,600 mcd, and 3.5-4.0 VDC. The #500TW4D (30 degree viewing angle) is rated at a nominal 3,900 mcd output at 3.8 VDC, with a range of 3,500 to 4,800 mcd at 3.8-4.5 VDC. The cost is very low at about US$22.80 for 15 lamps (15 degree), and US$20.25 for 15 lamps (30 degree). I have 15 of each on order for evaluation and projects. As you pointed out, removing the collar at the base of the LED lamp does allow easier fitting, which is something I had not considered. John Gislason

Focus on Efficiency, Not Generation

In general, too much of the magazine content is geared to energy production rather than energy use reduction. Emphasizing production over efficiency is the same trap that the traditional energy system has fallen into. Please give more information and practical, cost-effective ideas for home energy conservation, since most of us waste energy, and conservation is the most important and least expensive step toward energy independence. Please don't forget those of us in the Northeast, where information on simple, cost-effective prioritized energy conservation steps for older homes would be especially useful. Bill Houston billeliz@inet.net

Thanks, and good comments. Many of our articles hit on efficiency. But you are right, it should be a major mantra. On the other hand, the conception of the magazine was to show folks how to produce the energy they need for their homes, hence the slogan, "The Hands-On Journal of Home-Made Power." Michael Welch michael.welch@homepower.com

Wiring Batteries

Hello, I put in a solar-electric system several months back, and just added another four batteries. My system is wired for 24 V, and the batteries are 6 V each, so in essence I have three batteries hooked together.

I'm curious as to which way would be best to hook up the new set—should I run the connecting wires to each end of the set (one at the beginning set of four and the other at the far end of the twelve) so that energy circulates more evenly (or so it would seem) through the batteries, or does it make a difference? I hope my question is not too obscure. Thanks, Mick O'Hara

Hello Mick, Couple of things:

1. *Don't mix and match the new and old batteries in the same series string. This will tend to overcharge the older batteries and undercharge the newer ones. Wire the four new batteries in a new series string.*
2. *You can simply parallel the new series string to the series string next to it.*
3. *The major positive and negative wires used for both charging and discharging should be located on opposing corners at each end of the battery bank. So you'll have one major positive terminal and one major negative terminal located on opposite corners (they will be on different series strings).This configuration will help to balance out both charge and discharge rates throughout the battery bank.*

Let me know if you have any additional questions. Joe Schwartz • joe.schwartz@homepower.com

Love Magazine, except Politics

I would love for the magazine to move to monthly. I await each issue anxiously, and it is a long wait between issues. However, I would rather have you stay at bimonthly than move to monthly and fail at it and then cease publishing (which happened with a totally unrelated mag I used to subscribe to).

I love just about everything about the mag, though I could do without the politics in most cases. I disagree with most of the political views that do get expressed in the mag, and think they are misguided and polarize a community that should focus on what they have in common—a belief in the value of renewables (for whatever reason) and a desire to make them more widespread.

The discussion from all the installers/experts on payback was interesting and I think more info along those lines would be good. I think the RE community often focuses on RE as a quasi religion (we must do this for mother earth/gaia, which I think is a crock), and if RE stays as a religion, it will never grow the way it should. The community needs to find a way to make a solid economic case to the public that they should do this now. I believe experience shows that the "we must do this to save the planet and our grandchildren's future" won't hack it. Most people live in the here and now; they can't be bothered to save for their own future retirement, let alone to make sacrifices now for some nebulous benefit for future generations.

If the technology can't support a solid do-it-now case to the public, then that is where the focus should be—what technology advancements do we need to improve efficiency and decrease manufacturing costs to make RE a no-brainer investment *now* for everyone (and oh by the way, it will help the environment and our national energy security).

The other piece that seems to need more work is maintenance. I love to tinker, and I'm happy with a system that requires frequent care and feeding, but that won't work for the public. We must have systems that can be installed and just work with minimal maintenance (like refrigerators, furnaces, air conditioners, etc. I have bought used equipment from a local installer who says a good portion of his business is removing equipment from houses that are sold, when the new owners would rather have the system removed than do the required maintenance (due to tech phobia, laziness, lack of time, etc.)

A good area for future articles might be on ways to automate systems—sensors and controllers to track performance, alarm systems that could dial a maintenance company with a trouble report so they could come and fix the problem before there was significant damage. This could even be a big RE business growth area, just like there are many alarm monitoring/maintenance companies. Overall, I love the mag—keep up the good work. Gary Hendel ghendel@aol.com

Thanks for the feedback, Gary. It is appreciated. Most of the folks on HP's *staff think differently than you about a couple of these things. For example, most of us believe that politics and RE are so closely linked that ignoring politics will handicap an RE future. Another place where we may need to "agree to disagree" are the reasons for using RE. There are lots of different reasons. Right now, early adopters are priming the marketplace. One reason for early adopting is because folks like to tinker (your reason, from what I read in your letter). Another is that it is better for the world environment (my reason).*

But, I really like what you say about automation. We definitely need to make RE as easy and simple (and also cheap) as possible—for the masses. As far as going monthly with HP, *that would be cool, but you'd have a bunch of burned-out* HP *folks on your hands. Michael Welch michael.welch@homepower.com*

Ozonal Notes

Data Junkie

Richard Perez

I've never been really satisfied with knowing that something works. I've always wanted to know exactly how well it works. I crave data. I'm a data junkie.

My unending quest for data really began at Portsmouth, New Hampshire, when my high school physics teacher, Mr. Walter Novak, showed me the power of precise measurement. He taught me that if you can accurately measure the performance of a device or system, you can improve it, tweak it, and make it work even better. I was hooked.

When I installed our very first PV module, I also installed an instrument panel to go with that single PV. I could easily measure the current produced by the PV and its operating voltage. I took this data hourly for the first few months and wrote it down on a clipboard. I guess I couldn't really believe that I was making electricity directly from sunlight until I measured it.

From this simple one-module system and its instruments, I learned the basics of solar electricity—module orientation to the sunlight, the effect of clouds, and the effect of temperature. If knowledge is power (volts times amps), understanding is like voltage, and data is like amperage.

Over the years, *Home Power* has published many of my data quests. See the PV democracy rack testing in *HP24, HP33,* and *HP49.* See also the many *Things that Work!* reports we've generated showing actual data for RE equipment operating in real world conditions.

As our system and my quest for knowledge grew, we began to get interested in computerized data acquisition (DAQ). There were simply too many things to measure too often to accomplish this job with a meter and a clipboard. In *HP49,* we first used a computerized DAQ system to measure performance of the PVs on our democracy rack. While this early DAQ system was crude, it had the advantage of playing directly into our Macintosh computers.

Over the last few years, we realized that we had totally outgrown our DAQ system. We now have all sorts of stuff to measure and report on—all the PVs on the democracy rack, inverters, appliances, solar hot water, and solar hydronic heating. I live with all this stuff and I know from direct daily experience that it works, but I won't be satisfied until I know exactly how well it works and can tweak it into working better.

So we're getting into a new DAQ system, and you'll be seeing the data it generates in the pages of *Home Power.* We had to abandon the Macintosh computer platform to get a state-of-the-art DAQ system. Sophisticated DAQ systems and software are simply not optimized for the artistic world of the Mac, but are instead the province of the Windows PC world.

When Joe Schwartz and I began dreaming up our new DAQ system two years ago, we figured we could pull it off in a few months for less than US$1,000. We soon realized that we didn't have the experience to design such a complex system. We sought help from an experienced professional—A. J. Rossman of Draker Solar Design. Without A. J.'s help, we'd still be floundering around in a sea of hardware and software. The final system's hardware cost, including the laptop, DAQ hardware, and software, came in at US$4,200.

Home Power's new DAQ system consists of a Toshiba Satellite 1800-S207 laptop computer with Windows XP, running National Instruments' LabVIEW 6.1 software. We're using a Measurement Computing DAS-16-16AO PCMCIA, 16 bit, multifunction DAQ board with LabVIEW drivers running on the Toshiba. The various measurement points are multiplexed using a Lawson Labs Inc. model 35B, amplified multiplexer and a model 17B multiplexer. We can make rapid measurements in many points of the systems without having to rewire or reconfigure the DAQ system. The Toshiba laptop and its DAQ system will talk to our Mac computers via 100 base T Ethernet, so we can crunch numbers and graph the data on our Macs.

This new DAQ system will be able to measure and log PV module current and voltage, solar insolation, PV temperature, battery voltage and current, wind speed, wind generator voltage and current, both inverter input and output current and voltage, solar hot water collector temperatures, solar hot water tank temperatures, hydronic heating collector temperatures, room temperatures, and solar slab temperatures. And that's just part of what this DAQ six-ring circus will measure and record....

Our first DAQ project using this system will be to do another data run on our aging democracy rack. Only this time, in addition to current versus voltage (IV) curves for all the modules, we will also have data about how much daily energy each module contributed to our system. Although they're still working fine, most of the PV modules on our democracy rack are no longer available for purchase. After this test on the democracy rack, we're going to assemble a new democracy rack with the latest models and begin testing them. Expect to see the data generated by our new DAQ system in *Home Power* next spring.

I want to invite all you other data junkies out there to contribute your data and experiments for publication in *Home Power.* Only by accurate measurement and analysis will we all learn exactly how these RE systems work in a very diverse world. For a data junkie, this is heaven!

Access

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Q&A

Battery Watering
Hi Richard! I have a question about battery watering. Do batteries suffer for a short period after adding water? I have a set of Trojan T-125 batteries in a 24 VDC configuration, and I notice that after I top them off, charging them the next day seems to take longer. I do the watering in the evening after being charged during the day, as has been mentioned in the magazine. Does the fresh distilled water disrupt the chemical process in the battery until it mixes with the older solution? I was just wondering about this because it seems to happen every time I water them. Let me know what you think. Dan Tassell, Magnolia, Texas

Hello Dan, As water is electrolyzed into H_2 and O_2 when the battery is charged, the sulfuric acid concentration in the electrolyte increases since water is being removed. When you add water, the reverse happens—the H_2SO_4 (sulfuric acid) concentration decreases because you are diluting it with water. This is normal and unavoidable in flooded cells. You can measure this effect with a hydrometer.

So the electrolyte concentration is diluted when you add water, and this decreases the cells' ability to accept charge. So just after you add water, the battery seems to take longer to recharge.

All this might make you think that we should keep the H_2SO_4 concentration higher than a standard 25 percent (specific gravity 1.26). Higher concentrations will make the battery perform slightly better (it will have higher capacity and accept charge more rapidly), but this radically decreases battery lifetime. So keep the electrolyte around 1.26 SG, and you'll get the best performance with the longest lifetime.

You have sharp eyes and a keen mind to notice this effect in your battery. I salute you! Most folks don't pay enough attention to their battery to notice things like this. Your battery is bound to live long and prosper because of the attention and care you give it. Richard Perez • richard.perez@homepower.com

Wind Generator Voltage
I have an SWWP Air 403 wind generator. I would like to know where the voltage should be set above 12 volts in order to put juice into the battery. My battery voltmeter reads 12 volts, and I don't see any increase in voltage when the wind generator is spinning. I would like to know if this is normal. Anthony

Hi Anthony, How big is your battery bank? Remember that this is a very small turbine, and it may not be capable of charging your battery fully. Also, just because it is spinning does not mean it is generating. Most wind turbines spin lots in low wind speeds before they reach charging voltage. With this small turbine and a large battery bank, you may not be generating enough to overcome the self-discharge of the battery bank. How high is the turbine, and what obstructions are nearby? Do you have any metering on the wind generator to tell you what it's doing? If not, you're flying blind.

You should set the machine's voltage wherever you want it to regulate (14.4 to 14.8 or higher depending on battery type). The Air wind turbine's voltage regulation is adjustable from 13.6 to 15 VDC. The turbine is factory set to regulate at 14.1 VDC. Twelve volts is the "nominal" voltage. Actual operating voltage ranges up to 15 volts or higher. At rest (no charge or discharge), 12.6 volts is a full battery. Under charge, a full bank of flooded, lead-acid batteries will approach 15 volts, or go higher during battery equalization. Regards, Ian Woofenden • ian.woofenden@homepower.com

Wind Generator & SW Inverter
I was reading in the June/July issue of *Home Power* your response on batteries with wind generators and problems with the SW series of inverters by Trace, using them for grid-tie. I have been having a problem with my Whisper 175 and Trace SW5548 and was hoping you can help or give some guidance on where to find the solution.

The inverter has been going into invert mode whenever I get strong gusts of winds. The grid remains on, and if I brake the wind generator, the inverter will go back on the grid and remain on the grid. If I turn the 175 back on, and the wind hits good gusts (about 55 amps on the EZ-Wire display), the inverter will often kick right back into invert mode.

The batteries should be sized OK—four Concorde PVX 12255s. I have the EZ-Wire regulator set to 2.4 volts per cell, which seems to keep the problem to a minimum. Higher settings (2.55, 2.50 etc.) caused this phenomenon to happen more frequently. I am using the GTI (new California requirements) and updated inverters—could this be the problem? Trace feels that I have a problem with the grid.

When I take the wind generator off the system, the inverter works flawlessly. (I now have eight BP Solar panels on the system as well, but the problem happened before I added these to the system.) I am in the process of videotaping the inverter data on the LCD in hopes of catching data when the system goes off. Of course, Murphy's Law has kicked in and the winds are not as strong now. Summer is taking over from spring, and the good winds are fewer.

Have you heard of this problem, with or without the new GTIs? I was also thinking that if I kept the inverter in "sell" mode all the time, the battery levels may remain lower. Trace says that if it was the battery, the battery error message would light, and I have zero error lights. Any input or guidance would be appreciated. I should mention that I do know of one other person with exactly the same setup and equipment. He has recently finished his installation, and he is having the same problems. Thanks for your time, Jim Yankovich jimyankovich@hotmail.com

Hi Jim, Here is the hypothesis that we have come up with: During wind surges, the inverter is being tasked with pushing high current. For the inverter to keep up, the voltage is getting pushed up. Voltage goes up, current goes up, and you're delivering more power. Sounds good right?

Well, maybe not. The inverter's upper voltage level may be getting hit just momentarily during high surges. When this occurs, the inverter disconnects. And this would make sense, because as stated in your letter, when you brake the wind genny, the inverter reconnects to the grid.

Here is an attempt to resolve the problem: raise the VAC sell volts setting as high as is it will go. It should go up to about 150 to 154. Please let us know if this helps resolve the issue. We would like to be able to help others with similar problems. Good luck! Tobin Booth, Program Manager, Distributed Power Markets, Xantrex Technology Inc. • 360-435-8826, Ext 2061
Fax: 360-435-3195 • Tobin.Booth@xantrex.com
www.tracegridtie.com

Sizing PV Arrays
Hello, I am a subscriber to *HP.* I have a relatively modest solar-electric system, but I love working with it. I have not been able to find a good answer to this question.

Assume a 12 volt PV array, charge controller, and battery bank. Also assume that the daily load is constant and that the battery bank is sized such that this constant daily load does not discharge the battery bank above 40 percent DOD after three days with no sun.

After those three days, doesn't the load have to decrease to allow the batteries to recharge, or shouldn't the relationship between the size of the array and the load be such that a certain percentage of the array output is not used by the load, above and beyond the allowances already made for losses in the system? If so, is there an accepted value for this relationship? For example, "The load should not exceed 60 percent of the array output, after allowing for losses, to allow the batteries to recharge after a period of cloudy weather." Does that make any sense?

My system consists of six Uni-Solar US-64 PVs, a Morningstar PS-30M controller, a bank of eight Trojan T-125s at 12 volts, a Trace DC disconnect, and a Statpower Prowatt 2500 inverter. I use the system to power a small workshop in the backyard. Thanks, Shane Kelly, Gadsden, Alabama
tskelly@cybrtyme.com

Hello Shane, I typically size the PV array to produce 130 percent of daily consumption (PV wattage based on manufacturers' published specs for 25°C). The array will spend most of its time at 40°C plus, and that amounts to a 15 to 25 percent power loss during the spring, fall, and summer months.

What happens in reality is that the user backs off on consumption during extended cloudy periods, and during the sunny periods after extended cloudy periods. This allows the battery to go farther and to recharge. If the system is an "overtime" system that doesn't allow the users to reduce consumption during cloudy periods, I further increase the size of the array to 150 percent of consumption. And in fact, almost all stand-alone PV systems employ a backup generator that runs less than 200 hours annually if the system is well designed and used. PV system design is as much art as science. Richard Perez • richard.perez@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 let ben.root@homepower.com know after you have sent us 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!

Access

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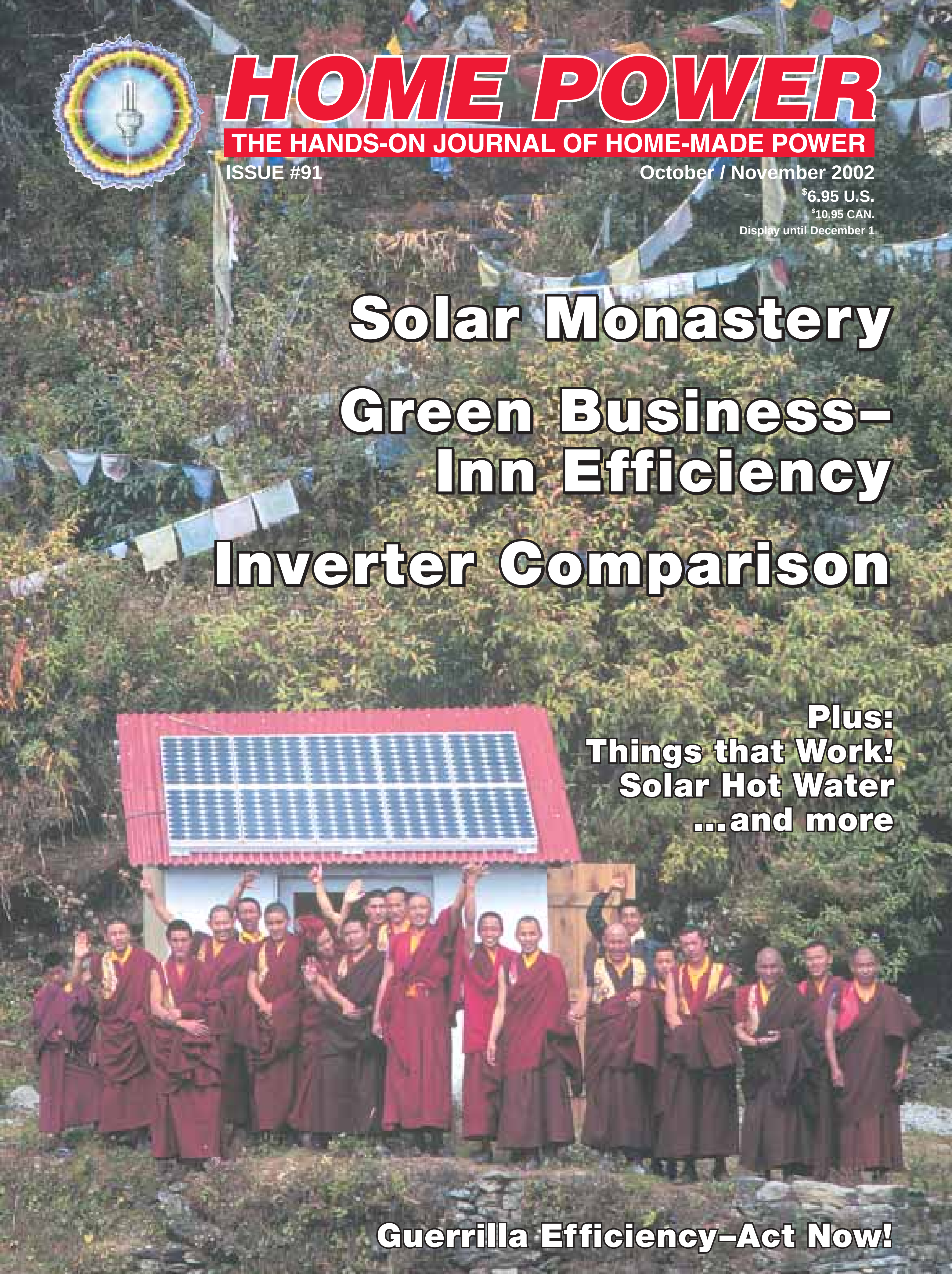

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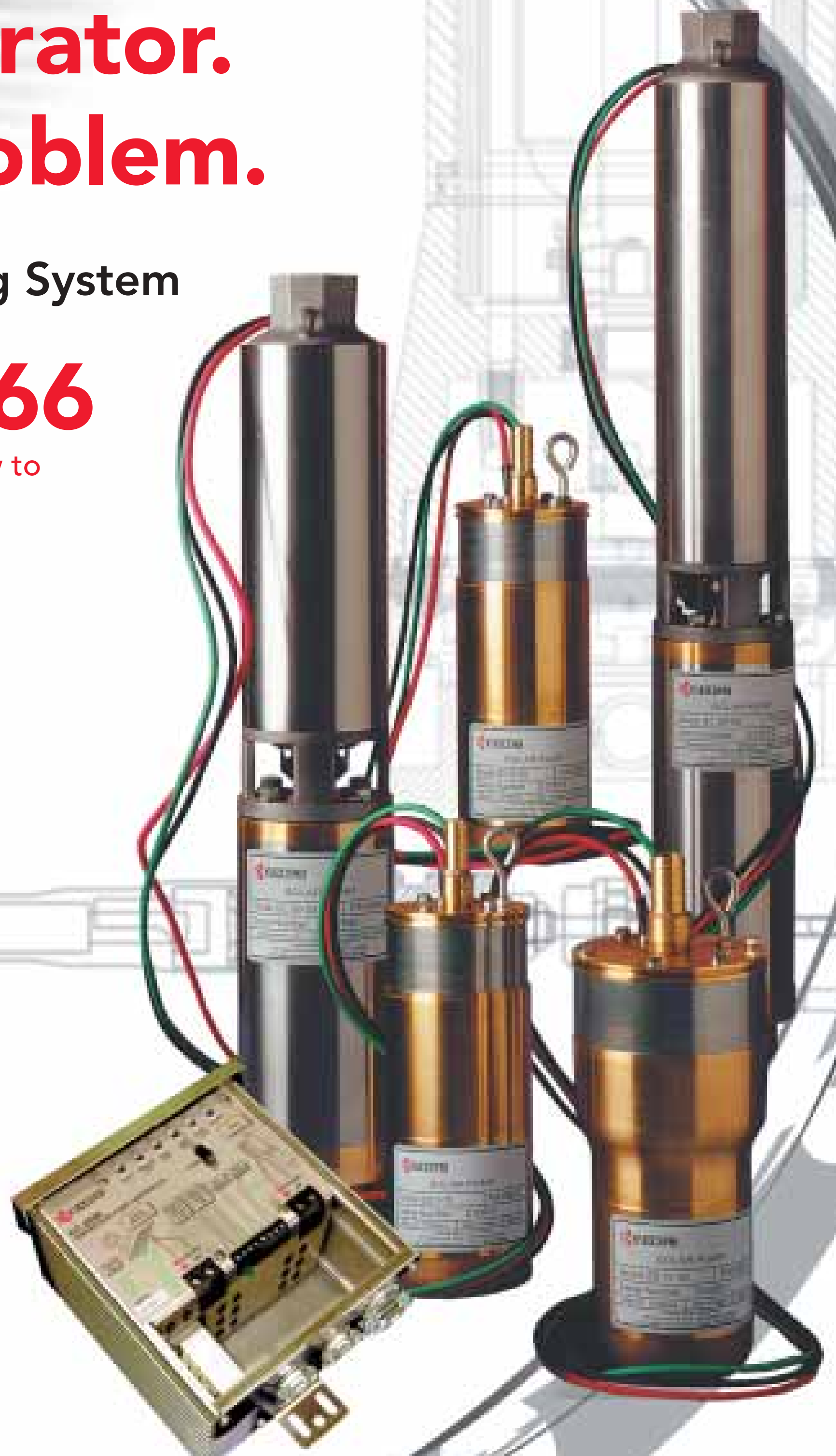

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NOW: I use renewable energy for (check ones that best describe your situation)

- ❑ 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

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ❑ All electricity
- ❑ Most electricity
- ❑ Some electricity
- ❑ Backup electricity
- ❑ Recreational electricity (RVs, boats, camping)
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RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ❑ Solar power
- ❑ Wind power
- ❑ Hydro power
- ❑ Biomass
- ❑ Geothermal power
- ❑ Tidal power
- ❑ Other renewable energy resource (explain)

The GRID: (check all that apply)

❑ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

❑ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

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