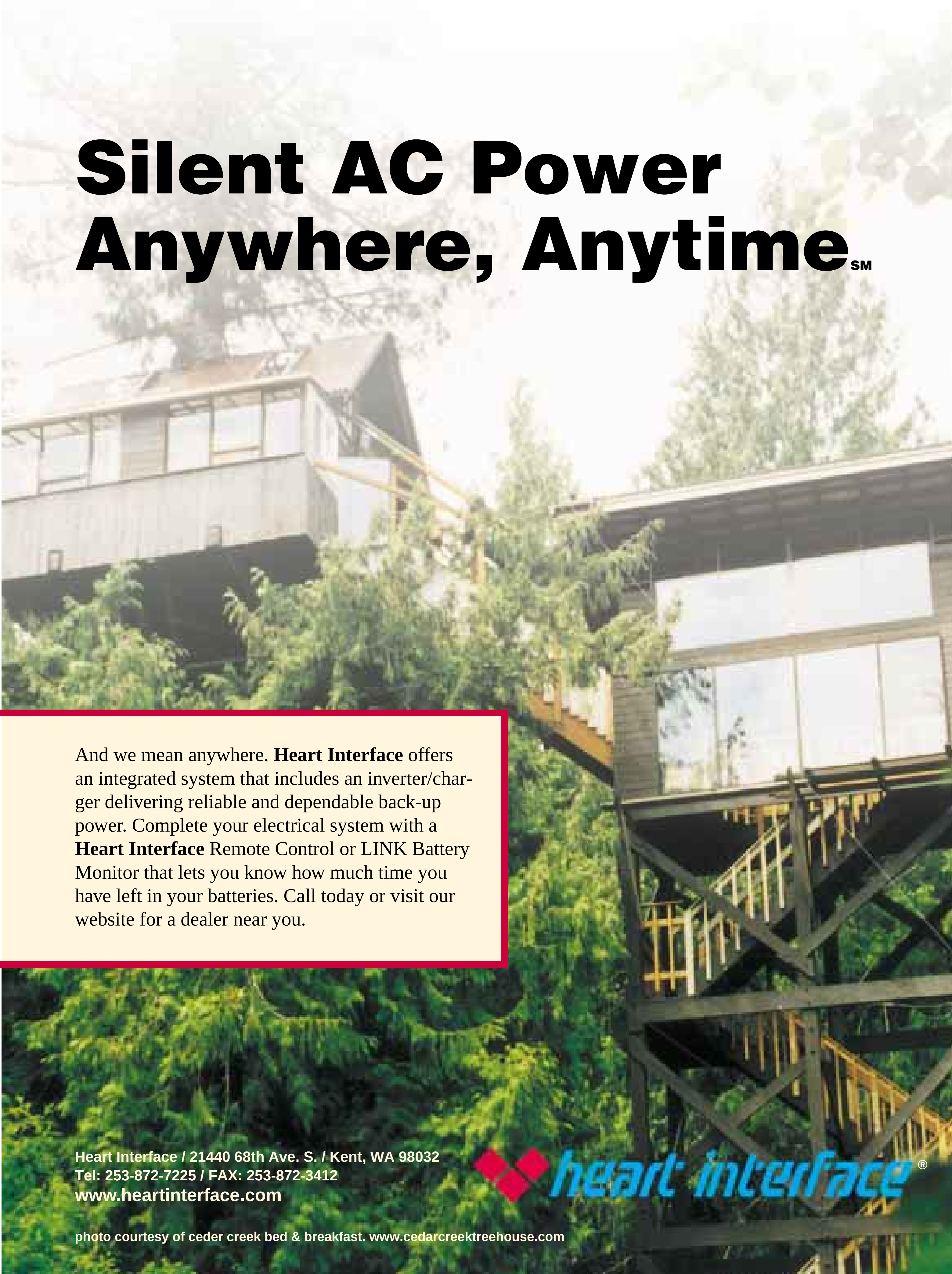
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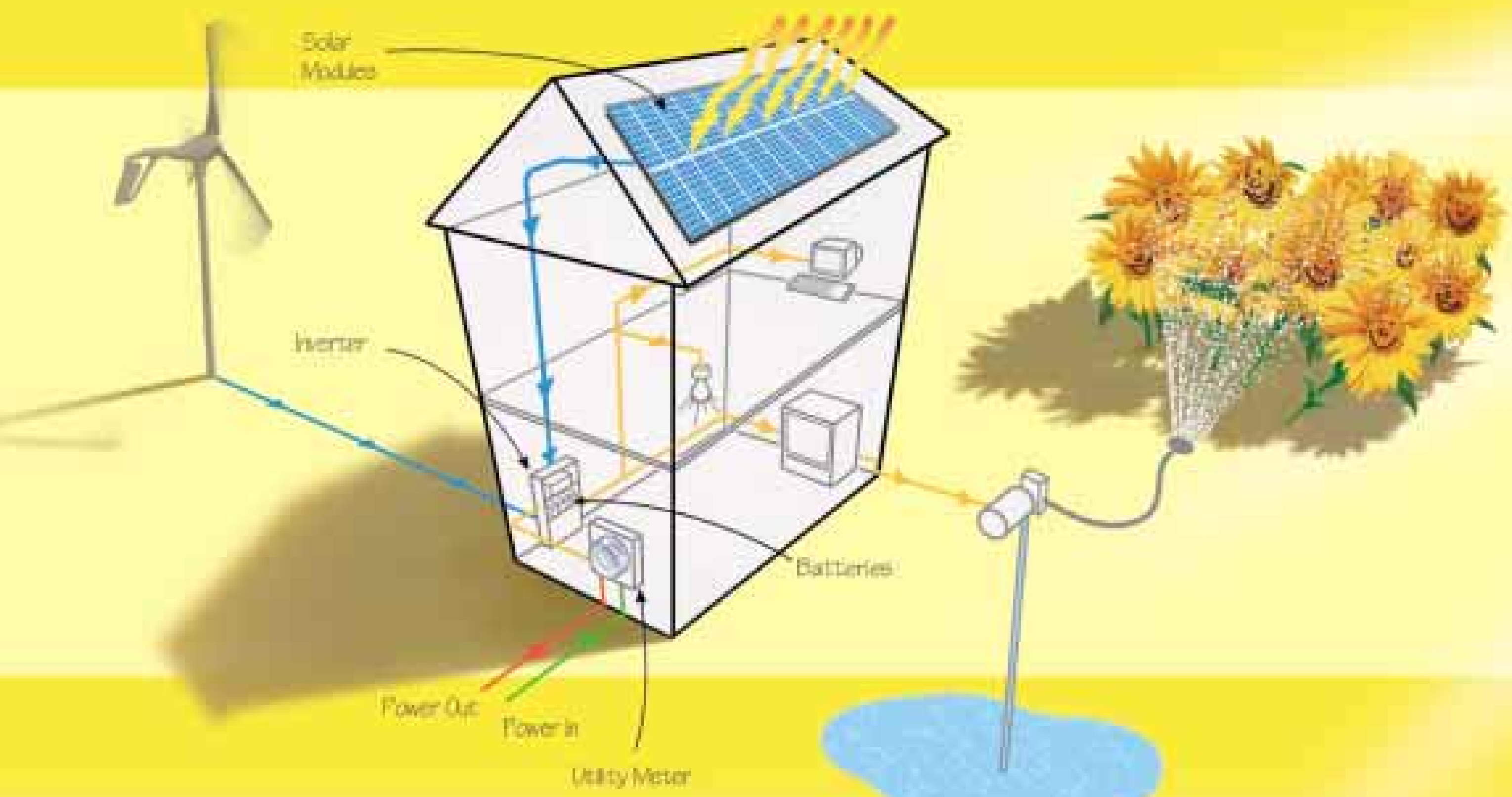


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# HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #75 February / March 2000

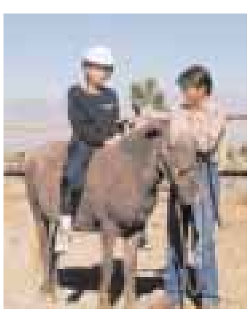
## Features

**8** **20 KW Wind Intertie**

*Tim & Corinne McCorkendale put up a big old Jacobs bird. They cover their power needs, heat their family room, and still sell energy back to the stingy utility.*

**18** **Sometimes DC is All You Need**

*John Surber and Roberta Corrigan power their north woods vacation cabin on a small DC-only system...and it covers all their needs.*



**26** **Home Done, By Hand**

*Melanie Chacon put together her own ranch, her own power system (wind and solar), and keeps her animals, all by feel.*

**34** **PV in the Kenyan Bush**

*Frank Jackson, Mark Hankins, and the Energy Alternatives Africa team provide power for a bush camp at the Centre for Wildlife Management Studies. The project is used as a training ground for future PV techs in Africa.*

**44** **Corporate Model**

*The Kyocera corporation walks its talk by building one of the most efficient office buildings to date. Their corporate headquarters in Kyoto, Japan has 214,000 watts of photovoltaics. And that's just the beginning.*

## More Features

**52** **The Extra Mile**

*A lot of people have big motorhomes, but David Barton added 1,200 watts of PV and now has even more freedom and independence.*

**60** **Powering the Movement**

*A temporary PV system provides the power for the Indigenous Environmental Network's ninth annual Protecting Mother Earth Conference.*

**68** **Himalayan Hydro Makes Hydronic Heat**

*Dennis Ramsey oversees and implements the installation of a hydro-powered hydronic heating system for a dental clinic at 11,500 feet in Namche Bazaar, Nepal.*

## GoPower

**100** **Miracle Battery?**

*Shari Prange explores the new battery technologies, pro and con, and debunks the myth of the miracle battery.*

**108** **Lil' Orphan EV**

*There are a lot of factory EVs left in the world built by companies no longer on the books. Mike Brown gives advice on rehabilitating these orphaned wheels.*

Cover: The desert dawn smiles on Tim & Corinne McCorkendale's 20 KW Jacobs wind generator near the Sandia Mountains in New Mexico.

## Guerrilla Solar


**74** **Guerrilla 0008**
*The Trace MicroSine opens the guerrilla solar movement to most budgets. This guerrilla just plugs 130 watts of PV into any old outlet.*


## Things that Work!


**76** **1,100 Watts Clean**
*Exeltech's XP1100 inverter.*

**84** **Big Red**
*Surrette's 6-CS-25PS, 820 amp-hour, lead-acid battery.*

**88** **Sealed for Your Protection**
*Concorde's Sun Xtender sealed absorbed glass mat battery.*


## Homebrew


**116** **Pulse Width Modulator**
*Dimmer or speed controller, 12 or 24 volt.*


## Book Review


**136** **From Space to Earth**
*John Perlin writes the definitive history of photovoltaics.*


## Columns


**94** **Power Politics**
*The police riot in Seattle. The international mega-corps flex again.*


## More Columns


**114** **Word Power**
*"Photovoltaic cell" defined.*

**122** **IPP**
*IEEE929 drags on; solar guerrilla international; PV market report; bargain hunters seek help; etc.*

**128** **Code Corner**
*2002, a code odyssey. It's time for your two cents.*

**134** **Home & Heart**
*Kathleen is high & dry on her newest appliance.*

**142** **The Wizard**
*Now that we know our enemy...*

**152** **Ozonal Notes**
*A short history of* HP.


## Regulars


**6** **From Us to You**

**80** ***HP*'s Subscription Form**

**81** ***Home Power*'s Biz Page**

**138** **Happenings—RE Events**

**143** **Letters to *Home Power***

**155** **Q&A**

**157** **MicroAds**

**160** **Index to Advertisers**


## Access and Info


**Access Data**

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Recyclable Paper

**Johnny Weiss of Solar Energy International and *HP* Associate Editor Ian Woofenden with Ian's 112 foot tree-mounted Whisper 1000 wind generator.**

Wrapped up in our renewable energy world, it's easy to forget that the technology we love is not well known. One trip to the big city reminds me that almost all of the thousands of people I see have very little idea that our industry even exists. They don't know that we have the tools to harness natural forces to power our homes and businesses. Compared to these "normal" folks, we're part of the fringe.

But is it fringe, or is it cutting edge? At first glance, many people within our industry think it's crazy to put a wind generator in a tree. (Add two RE maniacs hanging on it, and you really have a questionable situation!) But going out on the edge, following something we're excited about and believe in is how we make progress as individuals, as an industry, and as a society.

This is not to say that every wild-eyed scheme we think of is a good idea. I definitely discourage people from trying to reinvent the wheel or do "creative" projects in a reckless way (and that includes tree towers). But the folks who have made major strides in bringing progress to the world haven't let the naysayers stop them.

Even the failures and fizzled products have something to teach us. Finding a way to adapt RE to challenging site conditions is similar to finding a way to present RE to a society that doesn't seem too interested. Both take creativity and "thinking outside the box." The pioneers, with their successes and failures, can lead to established mainstream products.

There's a beautiful middle ground between blindly going after your dream and following the crowd. RE people are delightful to be around because they are passionate about their ideas and plans while (usually!) being open to the constructive contributions of others. We stand to gain the most when we have this combination of passion and open-mindedness.

–Ian Woofenden for the *Home Power* crew

## People


Tor Allen
Joy Anderson
Eva Blake
Mike Brown
Melanie Chacon
Sam Coleman
G. Forrest Cook
Roberta L. Corrigan
Mark Hankins
Steen Hansen
Anne Wallis Haynie
Frank Jackson
Anita Jarmann
Kathleen Jarschke-Schultze
Stan Krute
Don Kulha
Don Loweburg
Harry Martin
Bedah Mize
Tim McCorkendale
Corinne McCorkendale
Karen Perez
Richard Perez
Shari Prange
Dennis Ramsey
Benjamin Root
Connie Said
Joe Schwartz
John R. Surber
James Thompson
Tom Vineski
Michael Welch
John Wiles
Dave Wilmeth
Myna Wilson
Ian Woofenden


## "Think about it…"

***I'd put my money on the sun and solar energy. What a source of power! I hope we don't have to wait 'til oil and coal run out before we tackle that.***

**–Thomas Edison**

# Power Now

# Electric Bills…

# Gone With The Wind

Tim & Corinne McCorkendale



Picture how you would use electricity in your home if you weren't worried about cost, despite the fact that your neighbors pay 13.9 cents per kilowatt hour—one of the highest residential electricity rates in the nation. Now picture a luxurious home with no monthly electric bills because a wind generator supplies all the needs of the home, with extra to sell back to the local utility.

Lifting the 100 foot (30 m) wind generator tower at its center of gravity.

### High Desert Home

We live at an elevation of 6,970 feet (2,124 m) in Sandia Park, New Mexico, on a flat, furrowed two and a half acres that was once a pinto bean field. We live seven miles (11 km) from a mountain range called the Sandias, which is Spanish for watermelon. At sunset the mountains take on a strange deep green and hot pink glow—one of the reasons our state is called The Land of Enchantment.

There are challenges to living in our high desert area. Temperatures swing 50 degrees Fahrenheit (28°C) almost every day of the year, so heating costs are important to a household budget. There are also dust devils, lightning strikes, cactus, and tumbleweeds that make the outdoors inhospitable.

We do, however, have some of the best winds in the nation. These are canyon-effect winds, funneled between the Sandia Mountains and the Manzano mountains, and down through the Tijeras canyon. After observing the weather conditions in our area for about ten years, we were confident that a wind generator would be profitable.

### We Purchase a Used Jacobs

In 1994, we purchased a used gear-driven Jacobs Wind Energy Systems turbine through the want ads in our local electrical co-op's newsletter. The system came with two sets of 23 foot (7 m) spruce blades, an oversized 25 KVA alternator with inductive field winding (no brushes), and a 100 foot (30 m) free-standing Rohn tower. The Jacobs uses an oversized alternator to provide a longer alternator life.

The stub tower consists of a custom eight foot (2.4 m) tower segment which houses the 25 KVA alternator and has the 90 degree hypoid gear drive mounted on top of it. Altogether, the stub tower weighs about 1,200 pounds (544 kg). Most of that weight is in the hypoid gear drive. The stub tower assembly bolts to the three flange plates on the top of the Rohn tower.

As part of the purchase agreement, we promised not to divulge our cost, but a good price for a system like ours would be US$7,000 to $13,000. The man who sold us this system was getting out of the wind generator business altogether, due to his age. He had professionally sold and installed many systems identical to ours for thousands more than we paid. If all runs smoothly, it should pay for itself in about nine years, with a cost of about a dollar per installed, rated watt.

All the hard work comes to fruition
as the wind generator is tipped up on two hinges.

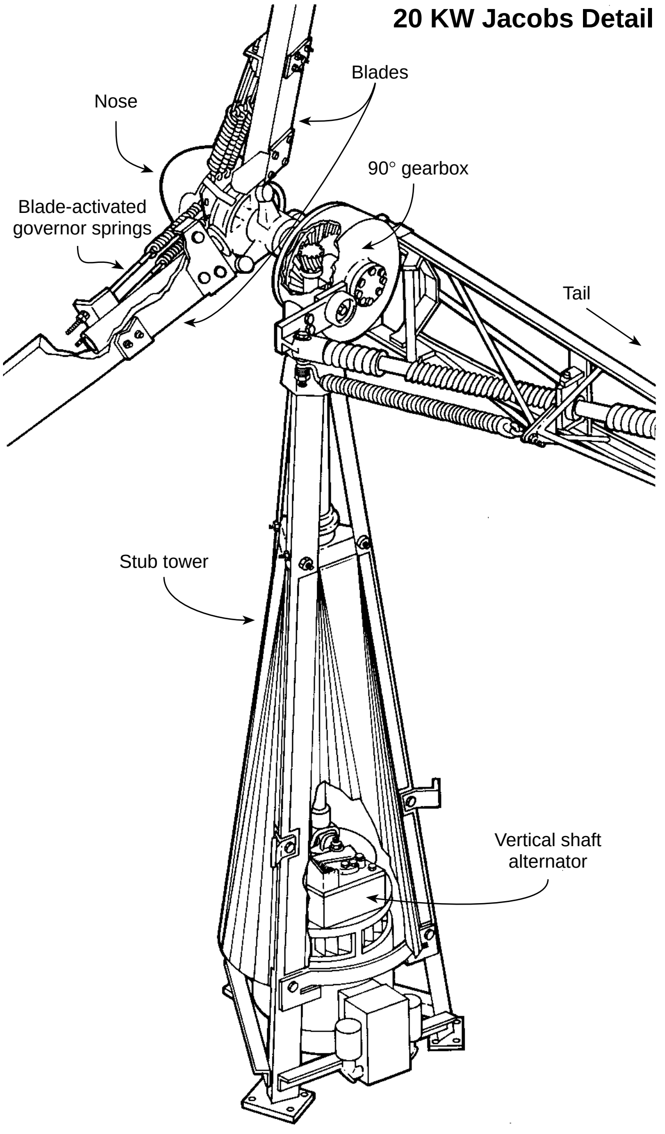
Our back yard with the addition of a wind generator.

### To Guerrilla or Not To Guerrilla
We made the decision to follow all rules and regulations at every government level. We even made sure we had the neighborhood's blessing. This paid off gloriously about two years into system operation. We were working in the yard and a van-load of Bernalillo County building inspectors demanded to see our paperwork on the spot. Our ducks were all in a row, so the inspectors drove away. Since our permit was approved, cell phone towers have sprouted like mushrooms (some would say toadstools) in our area, giving towers a bad name.

### Tim Builds the Tower
Tim assembled the tower in the back yard in his free time. Getting everything ready took about seven months, working weekends and evenings. The tower went together like a giant's erector set. It lay there on its side until the day of the tower raising.

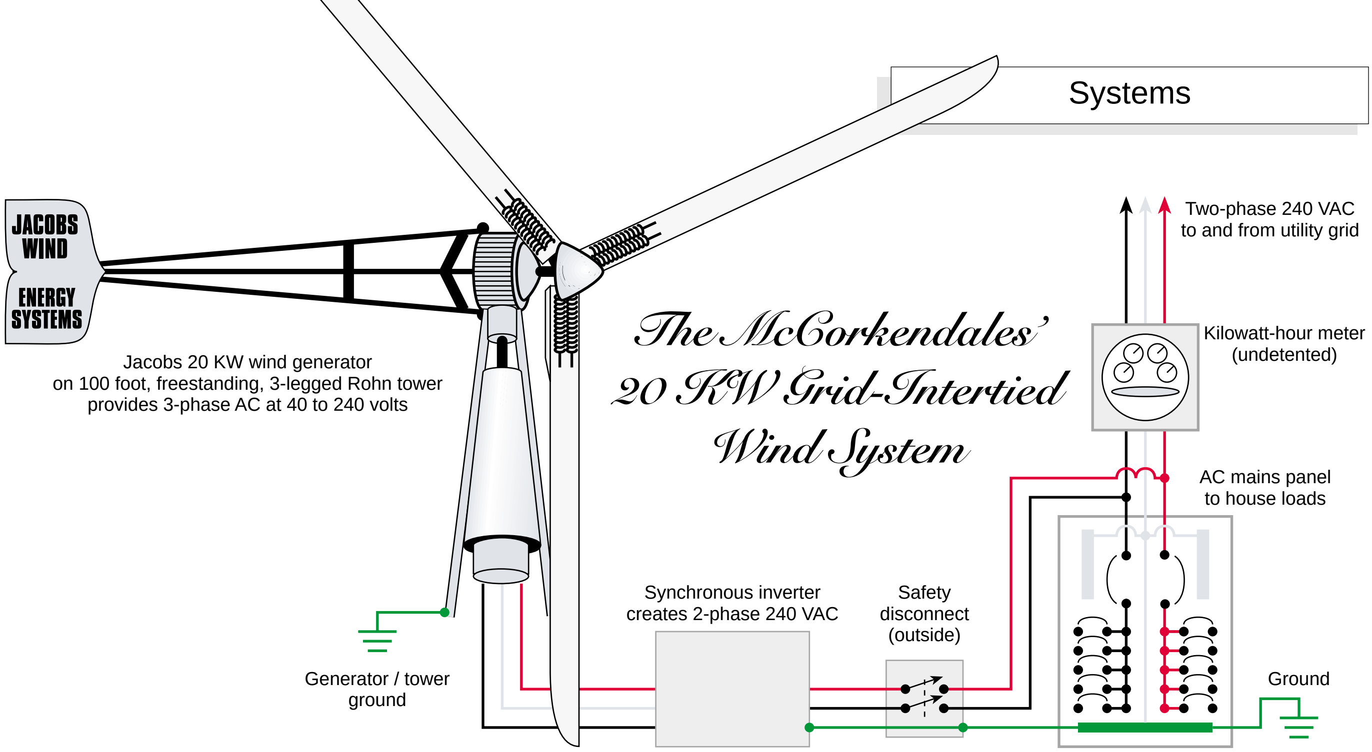
We put the Jacobs stub tower on the end of the Rohn tower and then used a front-end loader to prop up the stub-tower end of the assembly on a 55 gallon barrel. With the top of the tower propped up, we were all ready to mount the blades on tower raising day.

20 KW Jacobs Detail




### Engineering Work
Each trench contained 252 feet (77 m) of 5/8 inch (16 mm) rebar, and wood forms to create a 2 by 2 foot (0.6 x 0.6 m) L-shaped structure. After six yards of concrete had been poured into the forms of each trench, the triangular form joining the three legs was filled. The

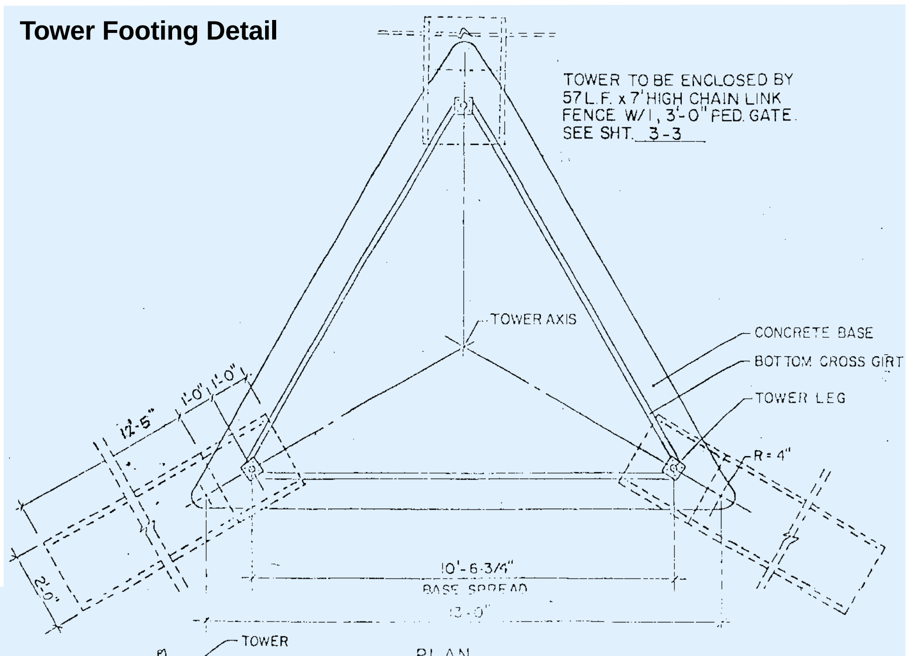
20 KVA alternator rotor, weighing 80 pounds (36 kg).

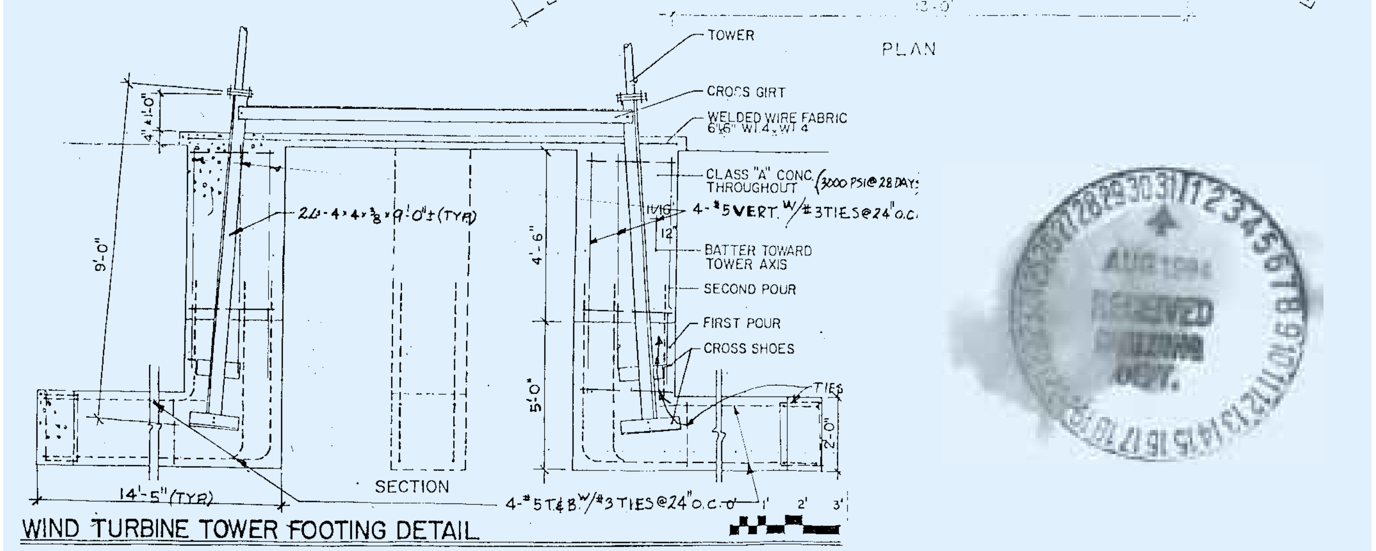



integrity of the triangular pad is insured by remesh (welded wire fabric). The whole foundation has about 20 yards of concrete.

When we were all finished, the only things visible were three flange plates protruding from a triangle-shaped concrete pad. These three flange plates were precisely located to mate with the three flange plates on the bottom of the assembled Rohn tower. This fit was critically important because the entire assembled tower and wind generator were to be lifted by a crane and bolted to these flange plates after the concrete set.

**Tower Footing Detail**



**Jacobs Wind Genny Installation Costs**

| *Item* | *Cost (US$)* | *% of Total* |
|---|---|---|
| 20 yards concrete | 1,157 | 25.3 |
| Architectural approval | 685 | 15.0 |
| Wire | 500 | 10.9 |
| Front-end loader rental | 450 | 9.8 |
| About 4 hours crane rental | 400 | 8.7 |
| Miscellaneous welding | 375 | 8.2 |
| Trencher rental | 354 | 7.7 |
| PUC administration fees | 280 | 6.1 |
| Machining work | 250 | 5.5 |
| Building permit for tower | 127 | 2.8 |
| *Total* | $4,578 | 100.0% |

**Just Enough Wire**

We bought 1,000 feet (305 m) of #6 (13 $mm^2$) wire, which in theory meant three runs of about 333 feet (100 m), at least on paper. When we actually dug the trench and laid the wire from the tower to our house, Tim pulled the wire, and there was only about six inches (15 cm) to spare! We felt fortunate that it turned out six inches too long, instead of six inches too short.

**Tower Raising Day**

Tapping the years of experience of the former owner, we decided to use a crane to raise the tower. We followed his recommendation to assemble the tower on the ground, where we could take all the time we needed. In fact, we hired him on tower raising day to insure that everything would go smoothly. This was well worth it, since the most expensive part of the installation was the hours of crane time involved.

First we installed the blades on the governor and adjusted the governing spring tension to properly set the blade feathering rpm. The next step was to lift the windplant and tower, still parallel to the ground, and bolt on hinges between the footings and tower leg flange plates. The crane then slowly tipped up the entire assembly—blades, turbine, stub tower, tower and all. The whole thing went up perfectly, and rested on the footings. If the measurements had been even one-sixteenth of an inch (1.6 mm) off, the tower would not have mounted on the bolts. Once the tower was upright, we removed the hinges and bolted all three flange plates together.

Tim then did his first tower climb to disconnect the rigging. As he climbed, rain threatened to fall, and there was lightning in the distance. We had heard a story of a rainstorm resulting in a stuck crane and US$3,000 of rental time before a D-8 Caterpillar was used to tow the crane out. But as an old adage says, “He that observeth the wind shall not sow; and he that regardeth the clouds shall not reap.” So Tim climbed to the top, unhooked the crane rigging, added oil to the gearbox, and climbed back down. Rotten weather has slowed us down, but never stopped us!

**History & Service**

We purchased the system in July of 1994. We were officially hooked up to the grid on March 20, 1995. Over the past four and a half years, we have only had a few problems. The lower alternator bearing needed to be replaced once. And the electronics have needed minor adjustments.

The yearly maintenance on our machine consists of greasing the zerk fittings (two on the drive shaft, two on the roller plate that the hypoid gear sits on, and one on each blade), and draining and replacing the 1.5 gallons (5.7 l) of gear lube in the hypoid gear drive. If we hired someone to do the work, we believe it would cost about US$150 per year, but since Tim does all the maintenance, the only cost is grease, gear lube, and Tim’s time.

**Noisy?**

Most people are surprised at how quiet the wind generator is. It’s very quiet in winds up to 30 mph (13 m/s). At this speed, the centrifugally actuated governor begins to feather the blades, making them less aerodynamic and much noisier. When the winds are above 30 mph, we’re not usually outside anyway. Our neighbors to the north have their home about 500 feet (150 m) from our wind generator and say they usually don’t even hear it. The neighbor on the other side has told us that when he can’t sleep, he likes to go outside to listen to the soothing hum of the wind generator.

We live in an area of independent people. In our neighborhood, one man restores Model A Fords. One woman raises exotic birds, and another breeds shar-pei dogs, so we all have an attitude of live and let live. In fact, hot air balloonists and hang gliders have used our wind generator as a landmark to navigate by. They often land in the 80 vacant acres behind our property.

**Paperwork & Contracts**

It took about nine months to receive the legal permission from the federal government and the Public Utilities Commission to hook our system into the grid to sell back power. This meant a back and forth letter exchange, with us filling out many forms and exercising the authority given us by New Mexico Public Service Commission Rule 570. We then were given a five year contract with our local utility, Plains Generation and Transmission (Plains G&T). We are paid a low of 1.620 cents per kilowatt-hour to a high of 3.706 cents per kilowatt-hour for the electricity we generate. We joke

### Local Payback Rates

| *Month* | *$ per KWH* |
|---|---|
| January | 0.0174 |
| February | 0.02586 |
| March | 0.01716 |
| April | 0.02043 |
| May | 0.02022 |
| June | 0.01807 |
| July | 0.0162 |
| August | 0.01725 |
| September | 0.03706 |
| October | 0.0342 |
| November | 0.0326 |
| December | 0.02989 |

that the monthly payback rate seems to be inversely proportional to the winds. If there were not so much truth in it, we could laugh more.

We pay a US$10 monthly fee to the Central New Mexico Electric Co-operative (CNMEC). For this fee, they are supposed to read our meter monthly, and report these readings to Plains G&T. Plains G&T is a separate business from which CNMEC purchases all its power. When we buy electricity, we purchase it secondhand from CNMEC. When we sell it back, our electricity goes to Plains G&T at wholesale rates. This reporting process of our meter readings is important because it determines the amount we are paid for what we generate. The Co-op is also supposed to report the meter readings in an efficient, timely manner. Although we pay our $10 monthly, their part of the agreement has never been fulfilled.

**Wendy and Ruth play on the heated slate floor. We all like it even better than the carpeted areas of the house.**

### April 1999 Data Summary

*Monthly Data*

| *Description* | *Data* |
|---|---|
| Outside meter reading (start KWH ) | 95,945 |
| Outside meter reading (end KWH) | 95,577 |
| Inside meter reading (start KWH) | 38,460 |
| Inside meter reading (end KWH) | 40,500 |
| Plains energy purchase rate (per KWH) | $0.02043 |
| CNMEC rate (per KWH) | $0.13900 |
| Tax rebate (per KWH) | $0.01500 |

*Analysis*

| *Description* | *Data* |
|---|---|
| Total generated (KWH) | 2,040 |
| Total sold to Plains G&T (KWH) | 368 |
| Total consumed (KWH) | 1,672 |
| Utility savings from wind genny | $ 232.41 |
| Plains G&T owes us | $ 7.52 |
| Tax rebate | $ 5.52 |
| Personal use of business product | $ 34.16 |
| *Total Benefit* | $ 245.45 |

For this reason, and also because of the deplorable payback rate, we quickly came to the conclusion that the best use of our electricity was to use it up entirely. The contract forbids us from selling extra electricity to our neighbors, but many months we produce enough to supply about four households. We still pay the fee because we believe they would disconnect us if we didn't uphold our end of the contract.

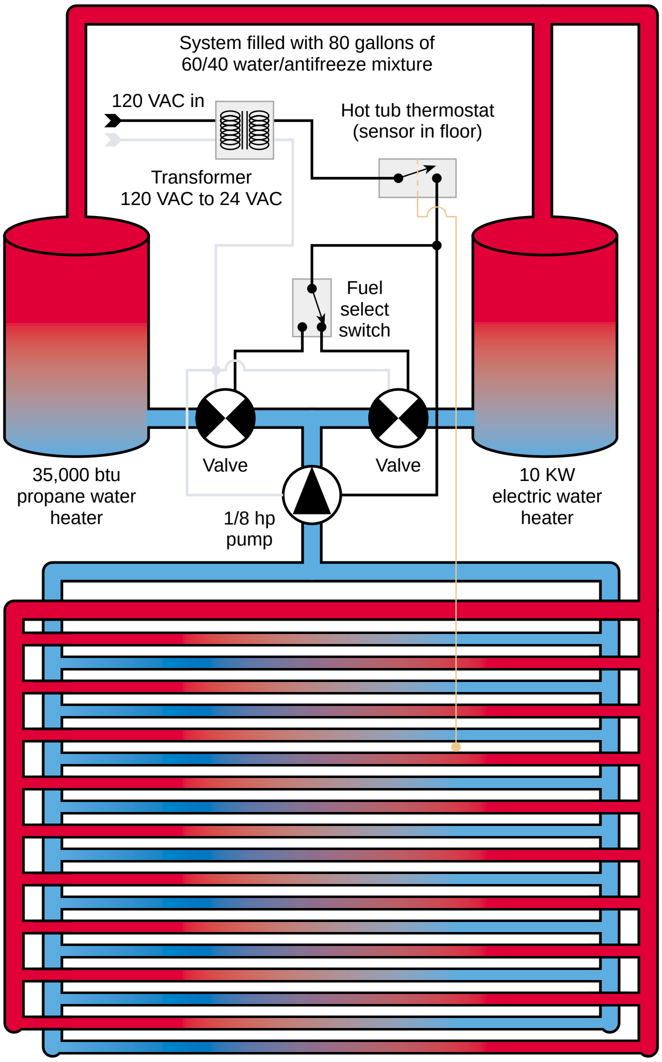
**Warm Floor**

Tim designed and installed a radiant heated floor. It heats our entire house using wind-generated electricity. It warms up to 90°F (32°C) in about twenty-five minutes. And, best of all, it can use up 100 kilowatt-hours per day.

With our heated floor, we only used our woodstove once or twice throughout the entire winter of 1998. We also have a forced air heating system powered with propane, but we do not use it much anymore. This radiant floor design is akin to standing on a beach, where the sand has been warmed by the sun—nice!

The floor is Vermont slate. Under it, cemented to the tile with mastic are quarter inch (6 mm) copper pipes set six inches (15 cm) apart and nestled in wood grooves. The foundation of the floor is a concrete slab. The copper pipes are filled with about 80 gallons (300 l) of a

## Hydronic Heating System




Floor area (not to scale): 1/4 inch copper pipes 6 inches apart aranged in an integrated pattern for even heating.

60/40 water/antifreeze mixture. The fluid circulates in an integrated pattern, so there are no cold spots on the floor. Tim buried a hot tub thermostat in the grout of the floor to act as a temperature sensor.

It is a closed system that circulates through either an electric or a propane water heater. With a switch on the wall, we can choose between heating the floor with electricity or propane. The propane is a backup that we seldom use.

### No Need to Conserve

We put up a wind generator because Tim got bit by the wind energy bug. We hope to be an encouragement to anyone who has a similar ambition. We like the freedom that the wind generator represents. We're not millionaires, but we sure feel like we are. If you visit us, we'll never tell you to turn off the lights or turn the heat down.

## Heated Floor Costs

| *Item* | *Cost (US$)* |
|---|---|
| 100 square feet of Vermont slate | 1,000 |
| Copper pipe and fittings | 500 |
| Sub-flooring (plywood & 2 by 6 lumber) | 500 |
| Propane water heater | 200 |
| Electric water heater | 150 |
| 70 gallons deionized water | 70 |
| Water heater safety tank | 60 |
| 70 gallons antifreeze | 45 |
| Hot tub temperature sensor | 35 |
| *Total* | $2,560 |

### Access

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612-447-6064 • Fax: 612-447-6050
wtic@windturbine.net • www.windturbine.net
Steve answered many questions about our system. WTIC sells new Jacobs Wind Energy System turbines, and can also completely rebuild the mechanical and electrical parts of the system.

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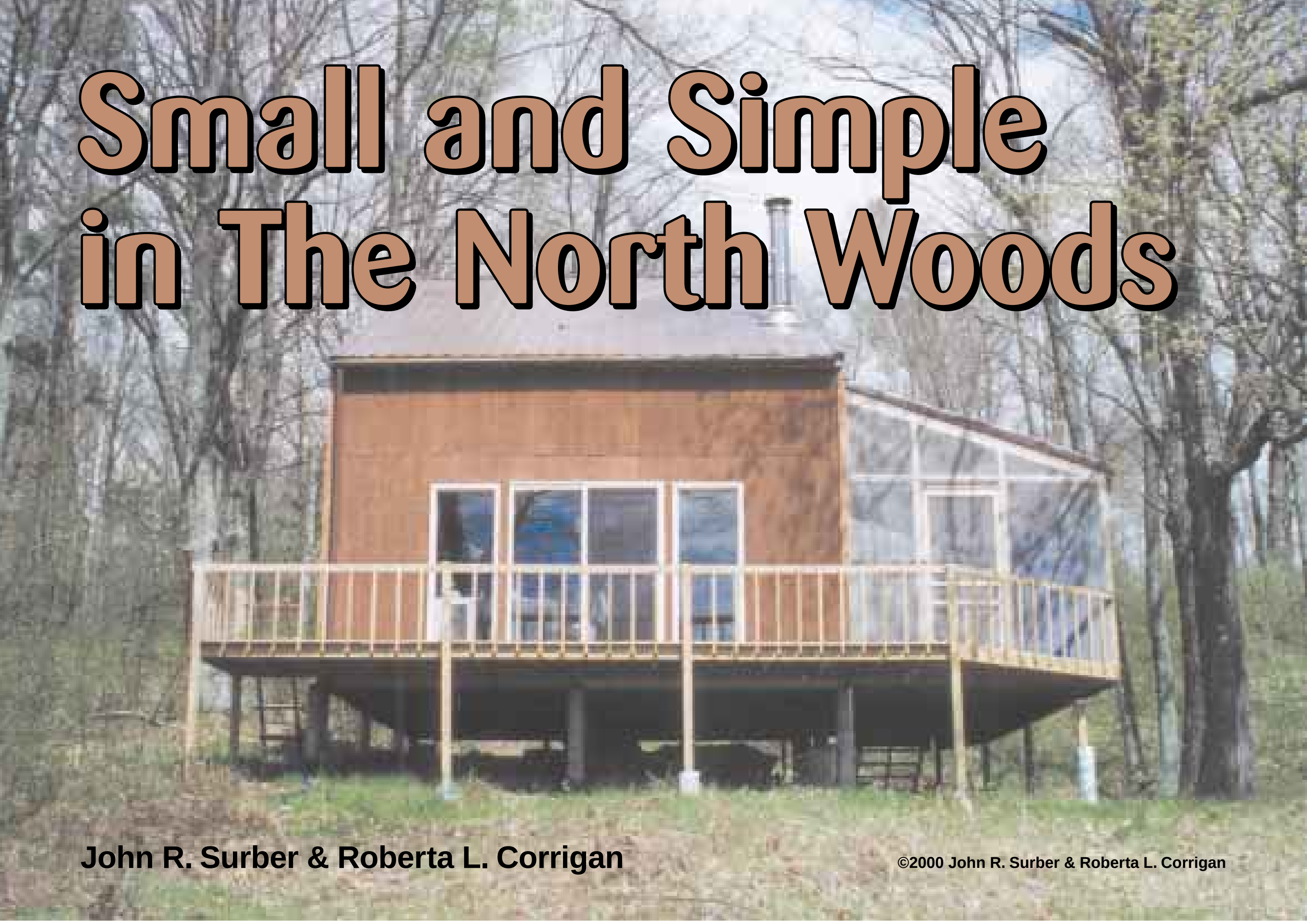
DYNO BATTERY

full page

four color on negatives

this is page 16

# Small and Simple in The North Woods



**John R. Surber & Roberta L. Corrigan**



**John and Roberta's riverside cabin in the north woods of Wisconsin is powered by a DC-only photovoltaic system.**

We've had a long-time desire to build "a place of our own." I have been interested in solar as a source of heat and electricity since the time of the original *Whole Earth Catalog* in the very early 1970s, and read *Alternative Sources of Energy* magazine in the late 1970s. Our project was shaped by constraints imposed by a limited budget and a remote northern Wisconsin site without grid power.

The project was also shaped by several years of reading *Home Power.* The result is a cabin with a DC power system supplemented by propane for the refrigerator, oven/range, hot water, and bathroom heater. The cabin serves as a summer vacation home and a frequent weekend retreat in the spring and fall.

### River Frontage

The site is heavily wooded and has a moderately steep, south-facing slope down to the Menomonee River, which separates northern Wisconsin from the Upper Peninsula of Michigan. Frequent commercial hydro dams along the river produce a wide flowage, making it more like a lake than a river when viewed from the cabin. The cabin is perched about halfway between the end of the drive at the top of the hill and the river at the bottom.

**The proud building crew—"Bungling Bob," Annette, Bobbi, and John.**

There are other cabins in the area with grid power. But when we asked for an estimate from the local power company, they told us we would have to clear brush and saplings from the shoulder of the dirt lane leading to the property, and cut a swath through heavy woods from the lane to the cabin site. All of this clearing, along with the line extension, was going to cost about US$3,000. I thought I might be able to go solar for that price. In addition, we were not keen on cutting all the trees they wanted us to cut to get their equipment in. I suppose my basic antipathy toward grid power might have had something to do with the decision to go solar as well.

**Cabin Design**

The design of the basic structure is a modification of a small house described in detail in the book *The Little House,* written by architect Linda Armstrong. The basic footprint is 20 by 24 feet (6 x 7.3 m) with a 10 by 18 foot (3 x 5.5 m) screen porch on the east wall and a 6 foot (1.8 m) wide deck the length of the south wall. The cabin is supported by concrete pilings poured in place (we mixed the concrete in a wheelbarrow!).

The construction is typical stick-frame, with 2 by 6 studs and T-111 sheathing. The shed-style roof is steeply sloped metal to shed snow, and has survived winters that have destroyed several nearby structures. The interior layout is an open plan, with a 200 square foot (18.6 $m^2$) loft. Most of the south-facing wall is glass, with patio doors in the center. The back 4 feet (1.2 m) of the main floor is under its own (lower) shed roof and accommodates a bathroom and utility room.

The utility room serves as a back (primary) entrance and a storage room. It also houses a 30 gallon (115 l) potable water holding tank, a propane hot water heater, a water pressure pump, and related plumbing. The bathroom contains a stall shower, a Sealand toilet over a SunMar NE composting unit, and a small sink. The front 20 by 20 foot (6 x 6 m) space is a greatroom with a kitchen area against the back wall between the door to the bathroom door and the rear entry door from the utility room. The 10 by 20 foot (3 x 6 m) loft is over the kitchen area, and is used for sleeping. The primary source of heat is a wood stove which gets considerable use in both spring and fall. There is also a small propane heater in the bathroom.

**Cabin Construction**

The cabin was constructed without power tools of any sort. Most construction was done during nesting season, and we were concerned in particular about the eagles and great blue herons. We don't own a generator, and didn't want to rent one for the three weeks it took to build the shell. The decision not to include a generator in the system was based on our distaste for the noise and pollution they produce, as well as the additional cost. In the planning stages, it seemed that we could get along without a generator, and this has been the case. And John just thought it would be cool to do it by hand.

**Two BP Solar 75 watt modules on a homebuilt rack.**

The *process* of building the cabin was more important to us than getting it done in a hurry. Using hand tools forced us to slow it down and savor it. The primary building crew consisted of both of us and Bobbi's parents, "Bungling Bob" and his good wife, Annette. We also had assistance from two friends for brief periods. With that crew, the shell went up in 21 days.

**Solar Electric System**

After several years of reading books and *Home Power,* as well as attending the annual Midwest Renewable

The SolPan power center with lightning arrestor visible.

Energy Fair (MREF) in Amherst, Wisconsin, we decided to go with all DC power. A major factor in this decision was the cost of the inverter, which would have increased the total system cost by about 40 percent. Other factors included our relatively low demand for power; we didn't need large appliances such as a washer, dryer, freezer, or color TV. Furthermore, the RV industry has provided a large range of small DC appliances and lights.

The decision to go with only DC seems to run counter to the current wisdom, but it has been a good decision for us so far. Currently we have five fluorescent lights, one incandescent light, a cell phone, a boombox, a large window fan, a laptop computer, and the water pressure pump. They all run off DC. The boombox runs most of the day. The laptop is an old 486 which we run about two hours a day for fairly pedestrian work. We also use a small 200 watt plug-in inverter on rare occasions.

**Sizing and Design**

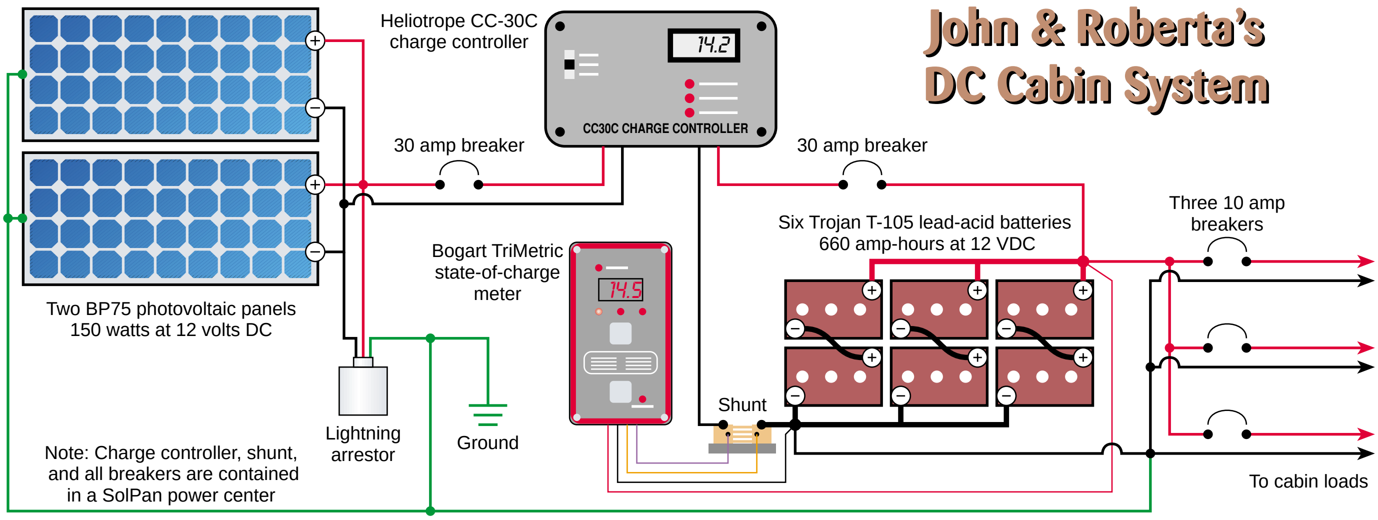
Sizing the system was relatively plug-and-chug. A few years back, worksheets for sizing systems were commonly available in solar catalogs. They began with the computation of anticipated load. This led us to discuss what we wanted and what we could get along without. Our choices may seem a bit odd to some people, but they suit us. So far, a microwave and hair dryer seem to be the most missed items that would be best run off AC.

Our load calculations showed that 150 watts of PV would be adequate, and that 660 amp-hours for the battery bank would handle the anticipated worst case of eleven days without sun in a northern Wisconsin winter. In fact, this would probably not be adequate if we spent two weeks at the cabin in the middle of winter when the days are quite short and the demands for lighting would increase sharply. But extended winter stays were not part of our plans anyway.

The decisions on the panels and battery bank were made after extensive reading. We got an acceptable price on two BP 75 watt panels that fit our needs, and we decided to go with tried-and-true Trojan T-105 batteries. The batteries were available locally in Milwaukee at a reasonable price and their (relatively) light weight made it possible to get them down the hill to the cabin by hand.

The decision on the controls was more difficult. People we talked to at MREF leaned in the direction of home-

A close-up of the TriMetric and the CC-30C.




grown control panels with off the shelf, inexpensive parts such as a Square D service panel and Square D breakers. But we liked the all-in-one power centers like Ananda, partly out of a lack of confidence in our electrical ability. However, the Ananda had features we didn't need, and we felt the price was much too steep. We finally settled on the Heliotrope General SolPan 30 power center.

**Controller**

At the time we bought that unit, it came with the CC-30C charge controller. This was one of the few controllers that had all the features we deemed important for a system that would run unattended for as much as two months at a time. For example, we hoped that the "automatic equalize charge" would keep the batteries healthy without boiling all the water away at a time when we wouldn't be there to top them off.

Also, it came with temperature compensation which is important because our battery bank can vary more than 65°C (115°F) over the course of a year. The SolPan also came with six Weber 12 volt circuit breakers, which are touted as offering overload and short circuit protection as well as functioning as disconnects (see *Code Corner* in *HP52 & 53* for a discussion of these issues). And finally, the unit was intended for a DC system without inverter or generator.

**Wiring the System**

The best location for the solar panels was about 15 feet (4.6 m) from the southeast corner of the cabin. The roof of the cabin does not have the best sun exposure. It is steep, and metal roofing is not very accessible. We built a stand out of pressure treated lumber to get the panels off the ground, and then built a rack of galvanized angle (a modified version of the one in *HP57,* p. 32), to support the panels and permit seasonal tilt adjustments.

The BP panels have weathertight J-boxes on the back that makes wiring them together a snap with anything up to #10 (5 mm$^2$) wire. There is an additional weathertight J-box on the wood frame that supports the panel rack. This connects the #10 wire from the panels to the #6 (13 mm$^2$) cables that run underground, from the panels to the SolPan power center in the cabin. We have a standard ground rod buried near the corner of the cabin, connected to the SolPan ground bar, and also a ground wire from the solar panel rack.

**Six Trojan T-105 lead acid batteries provide 660 amp-hours of storage.**

**Surber/Corrigan System Costs**

*PV System*

| Item | Cost (US$) |
|---|---|
| Two BP75 PV panels | 900 |
| Heliotrope SolPan 30 power center | 600 |
| Six Trojan T-105 batteries | 600 |
| TriMetric with shunt | 153 |
| Wire (#6 from PVs & for ground) | 110 |
| Materials for PV rack | 95 |
| Miscellaneous hardware | 30 |
| *PV System Subtotal* | $2,488 |

*House Wiring & Lights*

| Item | Cost (US$) |
|---|---|
| Five 12 VDC fluorescent lights | 240 |
| Silo (window) fan | 107 |
| 250 feet of #10 wire | 76 |
| Five 240 V receptacles | 20 |
| Five 240 V plugs | 20 |
| 12 VDC incandescent light | 9 |
| *House Wiring & Lights Subtotal* | $472 |

*Water System*

| Item | Cost (US$) |
|---|---|
| Propane water heater | 240 |
| 30 gallon holding tank | 134 |
| Shurflo water pump | 70 |
| Shurflo accumulator | 38 |
| *Water System Subtotal* | $482 |

*Other Appliances*

| Item | Cost (US$) |
|---|---|
| Composting toilet | 875 |
| Propane refrigerator (used) | 280 |
| Propane oven/range (used) | 90 |
| *Other Appliances Subtotal* | $1,245 |
| *Total* | $4,687 |

The logical location for the battery box was in the southeast corner of the cabin, which was the corner closest to the location of the solar panels. However, that would have put the box very close to the wood stove, a potential hazard when the batteries are gassing. So the batteries were placed directly under the cabin. This means that they are exposed to wide temperature swings. But because the cabin isn't heated when we are not there, the batteries were going to experience extreme conditions anyway.

The SolPan power center was mounted inside the cabin, in the southeast corner, directly above the battery box. This arrangement minimized the distances between the battery box and the SolPan (about 8 feet (2.4 m) above) and the solar panels (about 15 feet (4.6 m) from the cabin), yet made access easy.

After installing the battery box, panels, and power center, we started wiring things together. For instructions, we relied on a combination of Jeffrey Fowler's *The Solar Electric Independent Home,* the instructions that came with the SolPan, and "wrench instinct." We ran buried cables from the panels to the cabin and then up into the cabin to the SolPan. We ran a similar line from the battery box up through the floor to the SolPan. For lightning protection, we have a standard Delta (LA-302R) lightning arrestor wired into the main DC leads in the power center.

The cabin itself is wired with #10 (5 mm$^2$) house wire. This wire is pretty stiff, and we found that the easiest way to deal with it is to put short #12 (3 mm$^2$) pigtails in the J-box to make attaching the wire to outlets and switches possible. There are three DC circuits, and no provision made for AC. We used light duty 230 V outlets to avoid having AC appliances plugged in accidentally. The outlets are used for the boombox, window fan, cell phone, laptop, and occasionally a small inverter which is used for chores like recharging the cordless drill (a recent power tool addition).

**Monitoring the System**

The Heliotrope CC-30C charge controller comes with an LCD display that can show battery voltage, array voltage, and array amps. But we also installed a TM-2B TriMetric monitor right above the SolPan. The TriMetric has an LED display that can be switched to read battery voltage, net amperage, and amp-hour usage since the last full charge. Even though it's in a corner of the greatroom, the LED display can be seen from virtually anywhere on the main floor when the display is turned on.

I confess to not being very sophisticated about its use. Initially I would switch it to the amp-hour display each morning and watch, mesmerized, as the battery bank "magically" charged (I am also fascinated by drying paint). Besides this entertainment value, I have also used the meter to track consumption of the various loads. Initially, I thought this would be useful for conservation, but due to ample supply, we have become less concerned about that.

In addition to the three readings available in the display, the TriMetric has nine data registers that store additional information. Throughout the two and a half years (three summers) the system has been in, I have kept written records of values such as minimum voltage, maximum voltage, and amp-hour usage throughout each charge/discharge cycle. This gives me a baseline so I'll notice if anything abnormal happens. So far, the greatest discharge for any one cycle is about 90 amp-hours. In the summer, with long daylight (and consequently less indoor lighting), we may use as little as 20 amp-hours during a cycle.

**Water Supply**

The well is at the end of the drive on top of the hill above the cabin. The pump is currently at 63 feet (19 m), though the head is about 42 feet (12.8 m). We have a Monitor hand pump which can put out about a pint of water per stroke. Originally, we had thought that we could fill a holding tank at the top of the hill and the drop to the cabin would provide enough pressure. Early experiments indicated that this was not going to work well.

The current arrangement uses standard 1 inch water pipe hooked to the hand pump at the top and to a 30 gallon (115 l) tank in the cabin. From there we have an RV-type pressure pump made by Shurflo, and an accumulator. We also have a 6 gallon (23 l) propane RV hot water tank. The rest of the cabin plumbing is off-the-shelf household plastic plumbing and household fixtures. The water pressure is steady and sufficient for a good shower. This system requires ten minutes of hand pumping each day to supply cooking, cleaning, and generous showers for two people with plenty of hot water (though probably insufficient for teenagers).

**How It All Works**

We have been through three summer seasons with the solar electric system, but this is the first season that we have had the water pump hooked up. All seems to be working very well. It appears that the charging system may be oversized. At bedtime, after running lights, boombox, and laptop during the evening, and after pumping water for two showers, dinner, and dinner dishes, we will typically have run less than 35 amp-hours off the battery bank. A little over half a day of sun will completely recharge the batteries while supplying daytime needs.

We still have interior finish work to do on the cabin, but we have no plans for changing the power system. We simply don't feel the lack of anything, and a full-sized inverter isn't worth the cost to us. If it were a full-time home, a "real" inverter would be worth it.

Neighbors who live down the lane have reported several power outages in the last couple of years. I suspect they eventually will learn not to say anything about these outages to us; our smug reply that our power hasn't been out for three years now could get to be galling after a while. Or perhaps we may convert them to homegrown power…

**Access**

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Equipment suppliers:

Backwoods Solar Electric Systems, 1395 Rolling Thunder Ridge, Sandpoint, ID 83864 • 208-263-4290 Fax: 208-265-4788 • info@backwoodssolar.com www.backwoodssolar.com • lights

Northern RV Center, Inc., W7081 Hwy U.S. 2, Quinnesec, MI 49876 • 800-252-1340 or 906-774-1052 Fax: 906-774-3732 • northrv@up.net • propane fridge, stove, heater, and water heater

Solar Spectrum, W4622 Kyes Rd., Tomahawk, WI 54487 • 715-453-2803 • wurlkoth@mail.bfm.org solar-electric panels

Storage Battery Systems, N56 W16665 Ridgeway Dr., Menomonee Falls, WI 53051 • 800-554-2243 or 262-703-5800 • Fax: 262-703-3073 sbs@sbsbattery.com • www.sbsbattery.com • batteries

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# If I Can Do It, You Can Too

**James Thompson**
**Photographs by Kelly Thompson**


It started out as a normal retail phone sale, here at Intermountain Solar. I was talking with a woman from Nevada who wanted to order an AIR 403 wind turbine. But when she asked me to do her a favor by marking the individual wires with tape so she could feel which was the positive, negative, and ground, I knew I was not dealing with a typical customer. The woman then revealed that she was blind, and that she was planning to install the turbine herself!

Ever since I became involved in the renewable energy world, I have come to truly appreciate the sense of independence in so many of our customers. They are individuals who are not looking for a free ride from anyone. But very few encounters will compare to the day I received the order from Melanie Chacon. Intrigued by her fearless independence, I drove several hundred miles with my family to meet this remarkable person. What followed was one of the most inspiring times of my life.

Melanie Chacon, blind due to a continuing battle with diabetes, lost her eyesight in the late '80s, and is now only able to see sharp contrasting images. If a horse is either very dark or very white, she can make out its shape while it's moving; otherwise the color and shape is not clear to her. Yet she has built an incredible horse ranch in the middle of nowhere, with her own hands.

Four Siemens SM75 photovoltaic panels
and an Air 403 make up the main system.

### Ranch Tour

After greeting us at the front gate with her three faithful and jealous golden retrievers, Whetto, Kizzer, and Odie (who is also blind), Melanie took us on a tour of her ranch. I was extremely impressed by the cleanliness and order with which she ran her life and home. Everything had a place and was in its place.

As we walked from corral to corral, being introduced to the horses, goats, and other animals, it was fascinating to watch her operate in her sightless world. She knew exactly which bridle belonged to each horse, which saddle was to be used, and what riding helmet would fit each kid. When I asked for some bug spray, she headed toward another building, felt her way along the back wall to a small shelf where she had a bottle sitting in a spot reserved for it.

Melanie is a well known animal rescuer around her area, and has become known as the person to turn to for help and advice when others are too busy. She inherited most of her animals, including Odie, her blind golden retriever, from abusive situations or neglect from previous owners.

Even though the care for these animals can be expensive, Melanie deals with it using faith and a sense of humor. This was evident when Odie collided with Melanie while he was on a dead run. After regaining her composure and brushing the dust off herself, her only comment was that we should have been there a few weeks earlier when she was taking care of a blind horse. “That was a real treat to see,” she stated with a half smile, “the blind leading the blind; we could put on quite a show!”

Melanie later invited us into her home. She has done most of the remodeling herself, including reupholstering the furniture and sewing the curtains. After a quick tour inside, I was able to spend some time with her one-on-one, recording some of her thoughts and feelings.

### Why Renewable Energy?

“I have always been in love with renewable energy. When I was in college I had a book—I believe it was called *Other Homes & Garbage*—which I read to my dad. That book taught me many things, including how to make a methane digester. And I have the perfect ingredient for it—horse manure. It’s one of my next projects.”

“By having my system, I am able to be out here and not in town. I absolutely hate the city. I was a victim of an assault one night when I was leaving the laundromat, and since then, I refuse to ever use a white cane or let people know that I am not able to see. Out here I know who I can trust and I know who everyone is.”

“One night at about 2 AM, I scared my neighbor to death. His truck had broken down so he had to walk home, but he had been drinking and as he was walking, he kept stumbling. Well, I had no idea who was coming down the lane. Was he ever surprised when I confronted him with a loaded shotgun! He never did that again!”

“Solar power gives me my freedom and security. If you look closely, you’ll see that I have several floodlights with motion detectors attached which are strategically placed around the yard. If anyone tries to trespass at

The author’s son, Ryan, gets a riding lesson from a very capable Melanie.

The Southwest Windpower Air 403 in the evening glow.

ever check them? I would have to stick my finger into acid! I don't think so! These batteries do fine for my needs. On the wall I have an ASC Specialties Concept [12 V, 15 A] controller with an audio alarm."

"All of the lights in the home are 12 volt, which I wired throughout the house [10 light fixtures with DC halogen bulbs, 40 watts each]. I didn't know that they had pretty 12 volt fixtures available or I would have used them instead of what I have now. Also, I have two small 300 watt inverters that I can plug into switchable cigarette lighter plugs around the house. The large inverter [500 watt] I leave in the closet. Then when I need to run the microwave or swamp cooler, I run an extension cord down the hall to them. I would like to have a larger inverter so I can run my washing machine, but that will have to wait. And then finally, I have my new wind generator."

"I love my new wind generator—it's unbelievable. It makes different noises when it's charging, and I can tell when the batteries reach full charge because it starts clutching out. We get 70 mph winds out here sometimes, so I am going to add more wind generators instead of solar panels."

"I am not sure exactly what my load is though. I put my own system together, so I know what it is capable of and what its limits are. Like the TV in the living room—if it's an overcast day and no wind is blowing, right now we can go about two hours and that's it. But if the sun is up, or even at night when the wind is blowing, I don't have to worry about it."

"Outside I have a 10 KW generator which pumps the 700 foot well, and then another 5 KW generator out back which I use for backup. Propane provides me with the rest of my energy needs [including the refrigerator, which uses a 5 watt DC control device]."

night they are not going to get very far. Plus it helps to keep the coyotes out of the goat pen."

### Her System

"My system is very simple. On top of the roof, I have four solar panels that I bought secondhand for $100 each. I'm not sure what brand they are [Siemens SM75]. Then I have 3 Decca [255 AH] gel-cell batteries in the closet. I have friends who have tried to convince me to use flooded lead-acid batteries, but how would I

Wiring done by touch.

### Her Daily Life

"I handle all of the chores myself, but right now my uncle Merl is in need of a place to stay, so he has been helping me with a lot of the tasks. I like the freedom I have though, and I won't give that up. My parents are very concerned about me, but I'm not going to change. And I have had offers from some close friends to invest in my place, but then I would have to give up control of what I do."

"One of the most rewarding things about this place is how it has given me the opportunity to help a lot of kids. Not only do I have the local school children come and learn about renewable energy, I also have parents who bring their handicapped children out to ride my horses."

"There is one child in particular—and I know I'm going to cry telling you this—this five year old boy who had never spoken. He was placed on a pony for the first time in his life. As we were walking him around the corral, his mouth was starting to salivate and you could tell he was struggling to say something. After twenty minutes he looked at his dad and quietly muttered, "Look Dad, I'm a cowboy." Right now I am saving up my money so I can buy some custom saddles for the kids. Riding horses is also one of the best therapies for learning to walk because it stretches and works the walking muscles in your legs and back."

"It has been a lot of work though. And most of it I built myself, including the corral. One day I drove a stake into the ground and with a thirty foot string tied to the stake, I walked till it was tight and then dug a hole. After that hole was done, I took six steps and dug another hole. I repeated the process until I had gone in a complete circle. In order to determine how level the posts were to each other, I placed a board on top of two poles, and put a marble on the board. When the marble would no longer roll to one side or the other, I knew it was fairly level."

**Knowledge from Touch**

"I would like to see products for this industry which are more touchable—safely touchable. The only way I can

**A solar-electric fence is one of several stand-alone renewable energy systems at Melanie's place.**

**Stand-alone solar lighting.**

tell if everything is working or connected properly is to feel it. It would also be nice to have the system communicate to you somehow, like having it speak to you and let you know what the status is."

"You could have braille printed on it, but it would need to be effective, not the way the ATM machines are. They have braille on the keypad, but then the screen will show choices that you need to select… but I can't read the screen because I am blind! That is why I am using the braille! I can see really bright lights, so it would be nice for me to have a small bright light on when my system is charging so I can tell for myself."

"What keeps me going is my faith in God and my desire to help others. I don't blame anyone for my problems and I don't think that this was all by accident. There are times when I could use help, like getting sawdust for the

**Chacon System Costs**

| Item | Cost (US$) | % Total |
|---|---|---|
| AIR 403 (new) | 519 | 24.39 |
| Wiring | 500 | 23.50 |
| Four Siemens SM75, 75 W PV panels (used) | 400 | 18.80 |
| Three Decca 255 AH gel-cell batteries (used) | 300 | 14.10 |
| 500 W Jazz inverter (clearance) | 169 | 7.94 |
| Two 300 W Jazz inverters (clearance) | 120 | 5.64 |
| Pole & guy wire | 80 | 3.76 |
| Charge controller & fuse (clearance) | 40 | 1.88 |
| Labor (self & donated) | 0 | 0.00 |
| *Total* | $2,128 | 100% |

corral, which makes it better for the kids to ride in. But I can manage, and God will usually open the way. I have a good life."

**Who's Handicapped?**

After watching Melanie throughout the afternoon and observing how she interacted with my children, I began to feel like I was the handicapped one. I was so busy with business and everyday activities that I had started to lose focus on what's most important. Watching my kids ride a horse for the very first time, and having them ask to help with the feeding of the animals made me realize how much of life they are missing out on. Here was a woman who asks for nothing, but offers everything to others; a woman who has used a hammer more in the last year than most people ever will; a woman who is not afraid to shovel the manure herself.

Melanie Chacon, blind? Yes. Handicapped? Far from it. If there was only one message she could deliver to the rest of us, it would be this: "If I can do it, you can too."

**Access**

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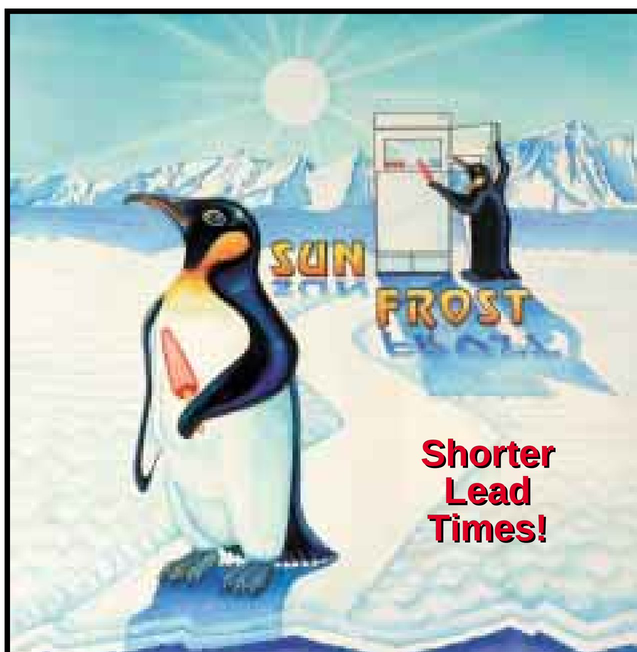

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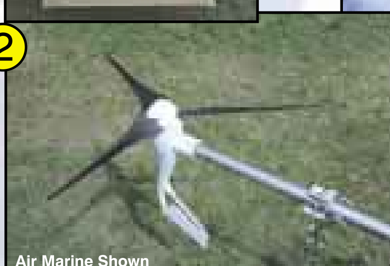
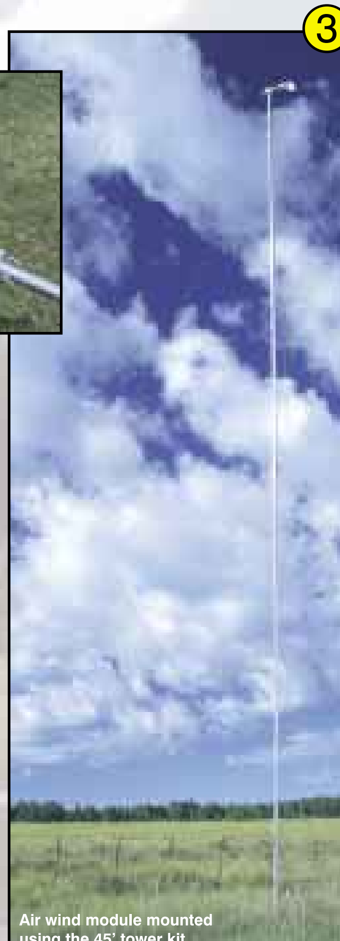


Air Marine Shown



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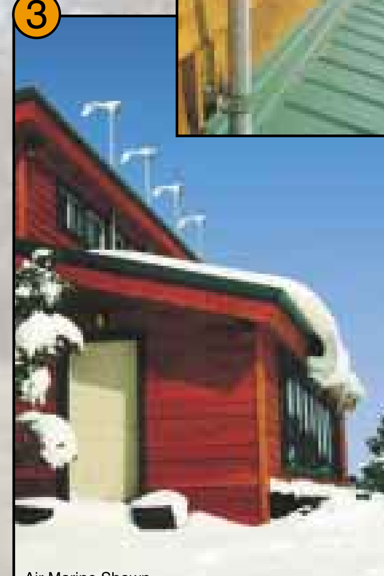

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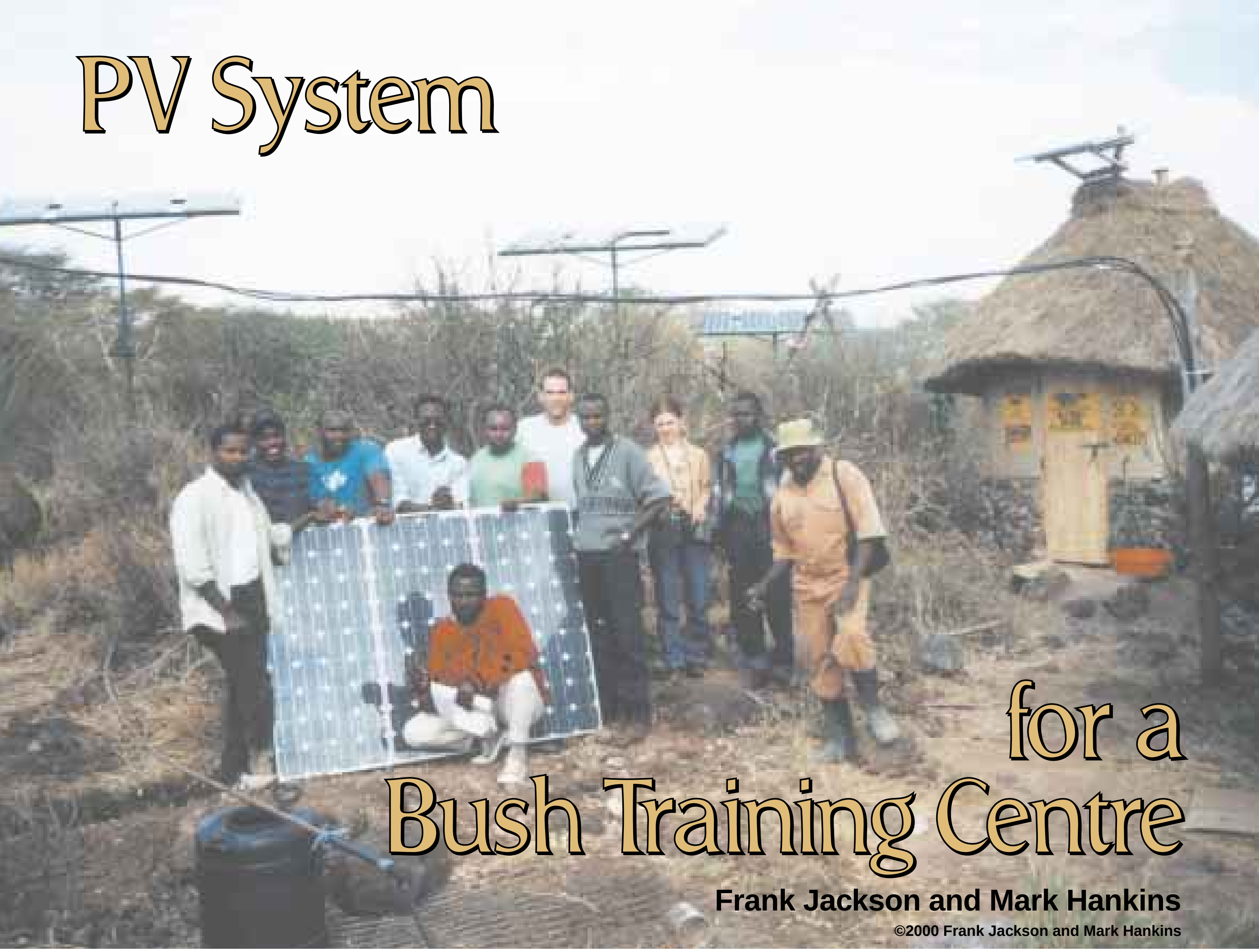
# PV System for a Bush Training Centre



Frank Jackson and Mark Hankins



**Participants at Energy Alternatives Africa's Advanced PV and Off-Grid Energy course at the Centre for Wildlife Management Studies in Kenya.**

When planning their "bush camp" training site near Amboseli Game Park in Kenya, the Centre for Wildlife Management Studies (CWMS) didn't want to go the genset route. They wanted an energy system that would provide a sustainable model for the area. The surrounding communities use the site as a resource, and they are also almost 100 kilometers (60 miles) from the nearest power line. They were excited about solar energy, as it fits within the broad environmental education objectives that their institution promotes.

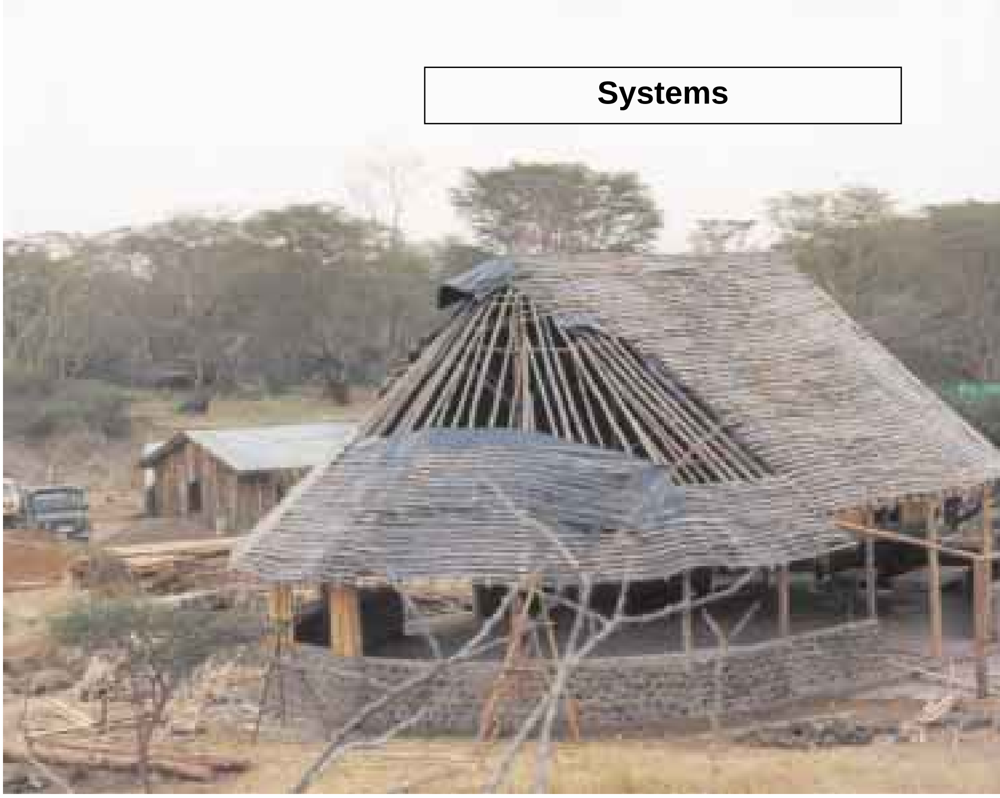
Petroleum generators still have a much larger share of the off-grid power market than PV in East Africa. Even where PV or hybrid PV would be cheaper, a majority of the market still goes for a generator. Why?

Sometimes gensets are the better choice. More often, the prospective customer doesn't have the facts about off-grid PV. Frequently, the "ramshackle" reputation of poorly functioning PV systems (so common in this region) blinds customers who have larger energy needs. Given the lightning-fast development of PV technology, it is understandable that the huge range of stuff available bewilders East African technicians and customers alike. So, despite tens of thousands of well-installed one-panel systems, there is still a lack of manpower to plan and install complex PV systems.

**Making the Plan**

Rodney Swatton was in charge of developing the bush camp training site for CWMS. He approached Energy Alternatives Africa, Ltd. (EAA) to plan an energy system for the camp. EAA is a consultancy specializing in rural energy. Made up of five staff based in Nairobi, we build renewable energy infrastructure in East Africa through training, project management, project planning, energy system design, etc. We do not sell equipment.

Located near Loitokitok, a Kenyan town at the base of Mount Kilimanjaro, the camp's mission is to help international and Kenyan students gain experience in the management and control of flora and fauna in parks, reserves, and ranches. Students live and study in the fenced bush camp, which has twenty permanent tents, several offices, a library, a kitchen, a central thatched lecture hall ("chumba"), staff housing, and a generator house.



**The chumba (main meeting hall) under construction at the CWMS training site near Amboseli Game Park, Kenya.**

While the camp was still under construction, Bernard Osawa of EAA surveyed the site in June 1999, and we parlayed with CWMS to give them an idea of what is possible with PV. As is commonly the case, the customer wanted more power than there was a budget for. We had discussions about how to bridge the gap between the technically and financially possible. In the end, a hybrid system was designed which would get most of its power from PV, but might occasionally have to rely on the genset. CWMS then contracted Solagen, Ltd., the Nairobi BP agent, to supply the equipment.

**Instructor Frank Jackson (right) and students Steven Muthanthi (left) and Peter Anthony (center) test modules.**

**An Educational Opportunity**
Eager to help local technicians get experience with larger PV systems, EAA suggested that the installation be used as a training opportunity, and CWMS quickly agreed to the arrangement, as did Solagen. APSO (Agency for Personal Service Overseas, part of an Irish state aid programme), generously provided Frank Jackson's services as project leader. Frank, who works as a PV electrician in Wales under the name Green Dragon Energy, was eager to apply his ample African experience in another EAA training course. EAA arranged for eight local technicians from Kenya, Uganda, and Tanzania to attend the course.

Between June and August, equipment was ordered, and systems were brought from the drawing board to reality. Solagen finalised system design, and imported PV equipment, lights, and inverters. Frank Jackson handled electric circuits, while EAA oversaw the logistics of making sure things got put in place on time. There were two systems: the hybrid genset/PV system and the smaller "chumba" lighting system.

**PV-Diesel Hybrid System**
This system uses a Trace DR2424 inverter-charger to supply 240 VAC power to the office/library block for fluorescent lights and the students' twenty laptop computers. CWMS had the foresight to choose laptops rather than energy-guzzling desktop computers which would have required five times more power. The two largest loads, a photocopier and a welding machine, are connected directly to the genset.

Large safety signs in English and Kiswahili on the thatch-roofed battery hut.

Goodhope Oscar from the KARADEA Solar Training Facility in Tanzania at work in the battery house.

The PV array is installed on three manually-turned rotating mounts made under EAA co-founder Daniel Kithokoi's supervision in Nairobi. Each holds four 85 Wp (watts peak) BP monocrystalline modules. PV charge is fed to the battery bank through a Trace C-40 charge controller. Energy is stored in twelve BP Powerbloc 2 VDC flooded deep-cycle lead-acid cells. Connected in a 24 V configuration, they provide 580 AH at a C10 discharge rate. The batteries and inverter are installed in a traditional East African thatch-roofed building. It also houses the site's radiotelephone power and control systems.

Both generator and inverter circuits are protected by 30 mA RCDs (residual current devices, known as ground fault interrupters in North America). For the battery and generator house, conspicuous safety signs—in English and Kiswahili—were painted by Frank's partner Clare (who was otherwise busy during the course sketching wildlife and the Kilimanjaro landscape).

All wiring accessories were bought in the local market, which meant we had to do some creative appropriate tech work. Still, we paid particular attention to safety and proper wiring, for two specific reasons. First, all the buildings in this dry area have flammable thatch roofs. Equally important was the fact that we were running a training course and wanted to set a good example.

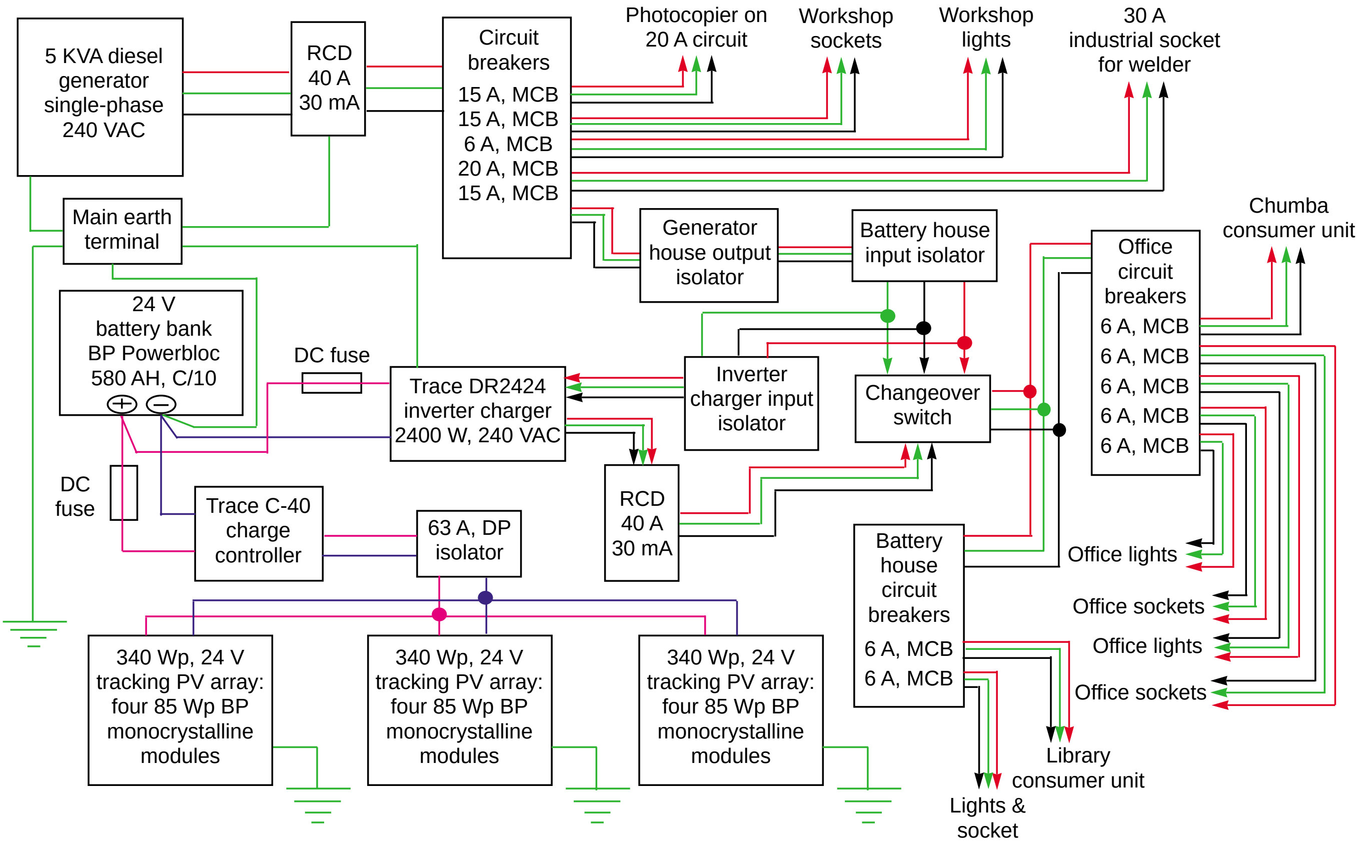
All cables are in PVC conduit, and the ones below ground and between buildings are armoured. While the "armour" is used as an earth (ground), a main earth or "circuit protective conductor" is run separately to every consumer unit. This was done to be absolutely sure of good earthing. East African metal junction boxes are not particularly good, and while we did run earth wires from the tags of the armoured cable, Frank was not sure about their integrity over a longer period of time. So it was decided do to a main earth separately.

The earth loop impedance values were well within those required by UK (and Kenyan) regulations, giving very fast tripping times on the circuit breakers (all AC circuits were protected by local circuit breakers rather than fuses). All system earths were connected to a single earth rod by the generator house. Each PV array was also separately earthed to provide lightning protection.

**The Chumba System**

The chumba is a large thatched hall with tables, audio visual equipment,

## Solar-Diesel Hybrid Electric System
## Centre for Wildlife Management Studies, Kenya, East Africa




white boards, dartboards, and a connected kitchen. It serves as the social centre of the camp, and we felt that it would be wise to provide it with a stand-alone lighting system rather than connect it to the office system. We saw benefit in having two systems so that if one crashed, the other would still be working. This also improves security.

This DC system is powered by three 75 Wp BP monocrystalline modules charging three BP L120 Solarbloc batteries through a BP 20 A charge controller. The chumba and the kitchen have twelve Sollatek PL 12 VDC lights. Light from the Sollatek fixtures is directed into the room by rustic white-painted wooden reflectors, attractively constructed by the site carpenter and students.

**The Course**

EAA, Green Dragon Energy, and eight students installed the two systems in August of 1999. Two of the students were from CWMS. This meant that the organisation would have a full understanding of the system after it was in place. When the course started, the camp was a construction site, with carpenters and masons everywhere. Classes were conducted in a makeshift classroom (which also served as a storage area for thatching material, and housed a bee colony and some black mambas during the course).

Over two intensive weeks, Frank led the course. Mark came down from Nairobi on the third day with last minute equipment from Solagen. Mark is a rural energy trainer and consultant who has been working in Africa since 1983. He is co-founder of EAA. Through training, projects, and promotional work, he has helped develop the PV market in East Africa. His textbook *Solar Electric Systems for Africa* is a well-known trade book. As is usual with EAA courses, mornings were spent in the classroom, while afternoons were spent on the installation, with students rotating from job to job. In the evenings, students worked on personal project assignments.

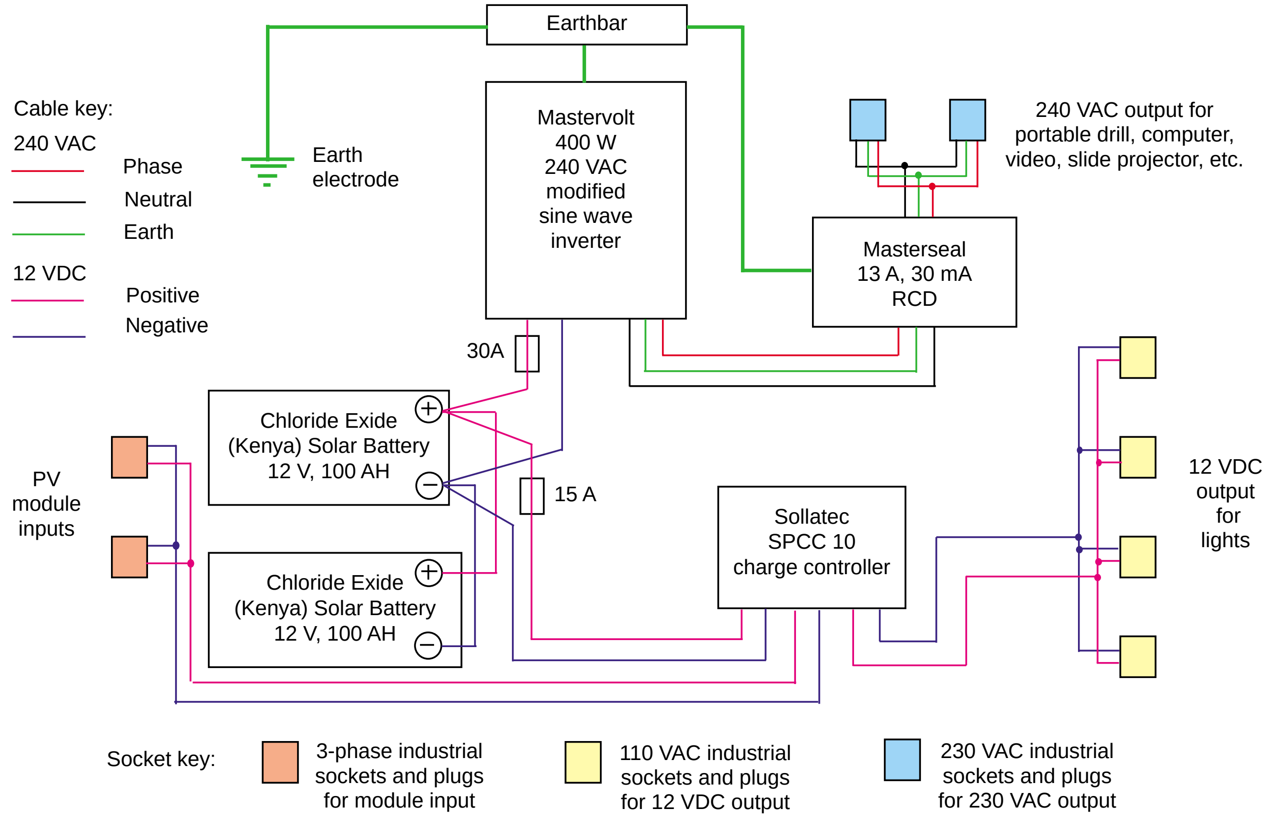
The course covered most aspects of off-grid hybrid PV design and installation: PV arrays, inverters, inverter-chargers, charge controllers, battery banks, diesel generators, circuit design and wiring, loads in off-grid systems, standards and codes, and testing and commissioning of systems. Frank also did one class on small wind turbines which generated considerable

## Mobile Power Supply Unit for Energy Alternatives Africa

As there was no power on site at the beginning of the course, we used EAA's Mobile Power Supply (designed by Frank) to power lights for night classes, laptops, and tools. The unit was designed and assembled to enable EAA to have an electricity supply at hand when carrying out basic solar electricity courses in remote parts of East Africa. It is a self-contained, solar-powered unit providing lights and 240 VAC to power appliances such as computers, printers, VCRs, slide projectors, overhead projectors, small power tools, and other electrical appliances away from the grid.

About the size of a very large suitcase, it is robust, portable, user-friendly, safe, and easy on the environment. Essentially, the unit is a large box with a variety of sockets into which the PV modules, lights, and appliances can be plugged. Extension leads are provided. The electrical energy is stored in locally manufactured deep-cycle batteries.

In the darkness of the savanna night, Frank kick-started our workshop by holding a solar slide show which featured images of what PV can do—grid connected and stand-alone—from East Africa to Wales. The Mobile Power Supply, with non-interchangeable sockets and plugs for modules, AC output and DC output, and generous extension leads, did the job perfectly. When the lights from the Mobile Power Supply were switched off, the site was pitch dark, and the sounds of the African night took over. On several nights, lions were heard roaring at the perimeter of the camp.




interest, since this technology is comparatively unknown in East Africa.

In addition to product information from companies, the *Universal Technical Standard for Solar Home Systems,* and a technical information package, each student got several copies of *Home Power* from the EAA collection in Nairobi. The technical standard is intended to provide a basis for technical quality assurance procedures. The document is available for free download, and ETSI (see *Access)* will also send hard copies free of charge.

Each of the eight students chose a personal design project to complete over the two weeks of the course. These included bush hospitals, rural secondary schools, game park lodges, and a village market centre.


The temporary Trace DR1524 inverter in the battery hut.

Each student had to produce an overall system design for his particular project, including schematics, detailed calculations for the sizing of PV array and battery bank, and a wiring/cabling diagram of essential parts of the complete installation. On the last day, each student gave a thirty minute presentation to the class, and answered questions from peers. This formed one part of the assessment. The second part was a written test which students were given to complete in their own time at home. EAA awarded completion certificates when all of this work was completed.

Students and instructors stayed in tents which were pitched under thatched bays. When the clouds parted, students got an excellent view of the white glaciers on Mount Kilimanjaro's peak, with cool air, fresh sunlight, and bird songs everywhere. We were treated to scrumptious meals cooked "camp-style." The camp cook, Odero, whipped up pancakes, macaroni and cheese, game meat, fruit salads, chapati, and ubiquitous "ugali" (maizemeal) in an improvised temporary outdoor kitchen.

**Complications**

Most of the problems had to do with the logistics of delivering equipment from international sources to the remote site. In Africa, this is always tricky and expensive, and it is never fun. For example, due to Trace backlogs, Solagen/BP had trouble delivering the inverter to the site, and a smaller unit (a Trace DR1524) had to be substituted until the right one arrived.

Local screws are always a problem, but the team persevered. (Why do manufacturers never supply spares for that quarter-inch bolt that always falls off the roof?) The PVC conduit was easy to work with once everyone got the hang of it, but there were some compatibility problems with loop-in, loop-out junctions for the lights, and finding boxes for the sockets. There was also a problem with one of the modules, which Solagen fixed when they came down to inspect the installation with a representative of BP Solar Nairobi.

The other complications had to do with making sure that safety codes were followed. In East Africa, many designers and installers do not see a difference between 40 Wp systems and 2 KWp systems. Too often, they design and install using the same minimal codes.

We find that proper fuses and interconnects between battery and inverter are often not used. Earthing is done as a last minute thing, if done at all. Between inverters, gensets, and PV power sources, there are often no isolators, or the switches used are not properly rated. And, finally, in the generator/battery rooms where proper connections are so crucial, we often find snake-nests of unlabeled wires. Because the same companies that are not safety conscious also tend not to worry about educating end users, some dangerous situations are created in remote sites where large PV systems are installed.

As an example, we were unable to find proper DC fuses for battery-inverter systems in the Kenya market, and no suppliers have them (though many install inverters!). Suppliers in Kenya often leave safety products out of the system, or substitute the wrong products. This has created many potentially hazardous situations, and has given PV an unprofessional and ramshackle reputation. EAA is working with committed local companies to increase awareness of the need for design standards and codes-of-practice, and to increase the supply and use of safety equipment.

**We Visit Later**

Three months after the system was installed and commissioned, Bernard and Mark from EAA went down to see how it was doing. Driving across the savanna under a full moon, we got lost somewhere near the site. Fortunately, we were able to use the system lights to find our way. From a distance, the Sollatek 18 watt security lights seem brighter than kerosene pressure lamps.

**Students David Omgacho and Peter M. Ngalu from CWMS check array voltage.**

We parked, came in through the gates, and found students reading and studying in the chumba under the Sollatek lights. The cooks were making tea in the fully-lit kitchen. In the office, staff were using laptops and printers to produce the next day's class material. Other students were outside playing drums and enjoying lunar energy around a campfire, undisturbed by the noise of a generator!

Site manager Otieno reported that the chumba system had been overused once—the lights had been left on until the LVD cut them off. Afterward they had let the modules give the system a full week's charge before using it again. In short, we found the system in good order, and our measurements showed the batteries and all other parts of the system to be working well. They have not even used the generator yet to top off the batteries. We chalk this success up to good design, careful installation, and—most of all—good user education and discipline.

EAA will be holding occasional two to three week training courses at the bush camp over the next two years. Interested technicians should contact us.

**Appropriate Power**

Perhaps more than anywhere else, rural Africa needs appropriate power systems. Because of the poor reach of the grid, PV and generators will play a crucial role in supplying this power. This bush camp system is a high-quality demonstration of how PV can appropriately meet these needs, and a training system that enables people from the region to learn how PV works. The system shows that when you get both the technical hardware and the human software (training) right, there is no better power source than the sun.

**Access**

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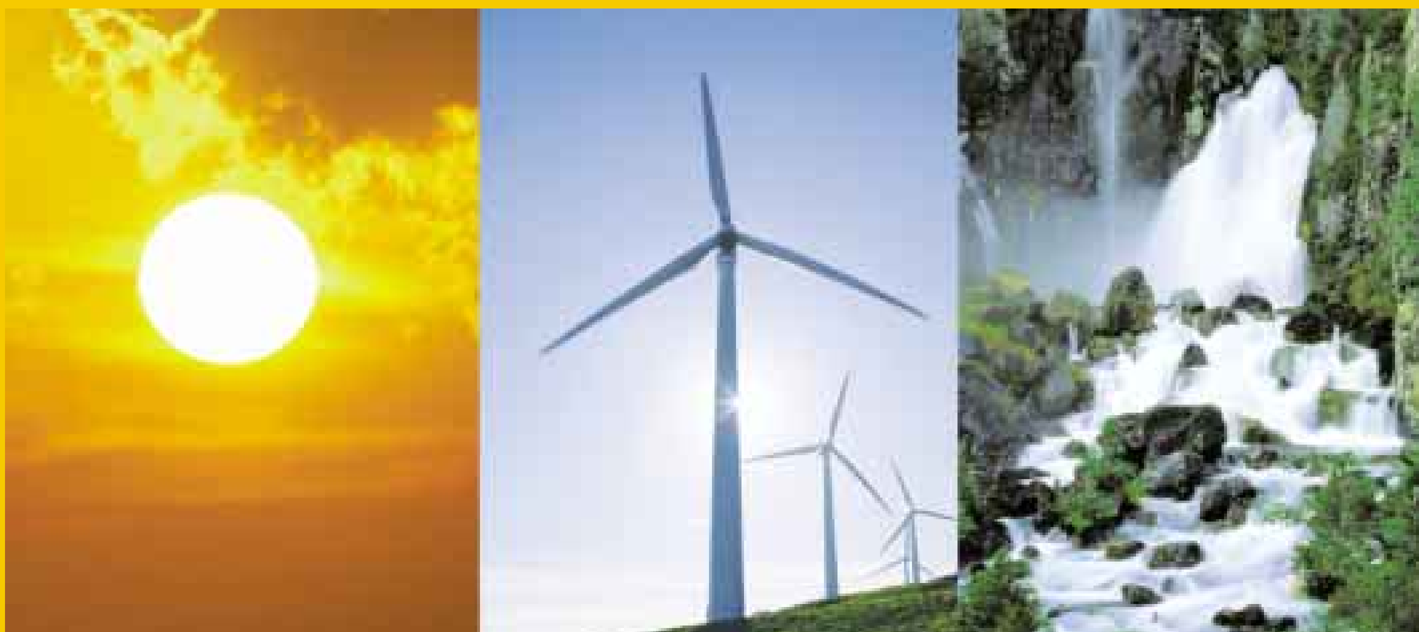

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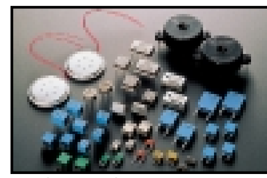

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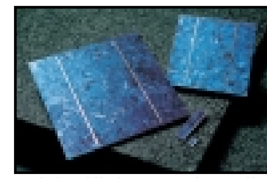

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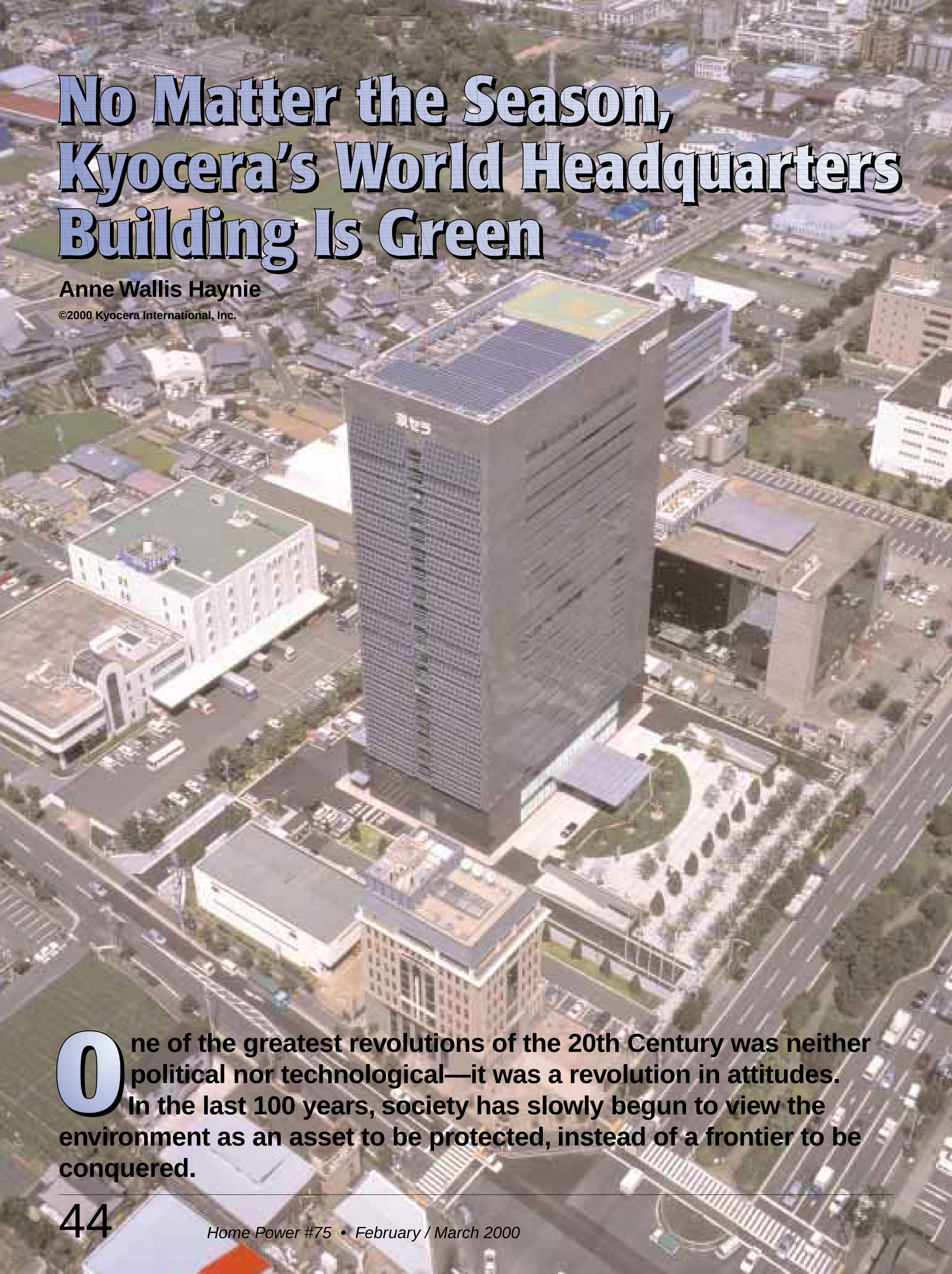


# No Matter the Season, Kyocera's World Headquarters Building Is Green

Anne Wallis Haynie



**One of the greatest revolutions of the 20th Century was neither political nor technological—it was a revolution in attitudes. In the last 100 years, society has slowly begun to view the environment as an asset to be protected, instead of a frontier to be conquered.**

This environmental revolution is growing, led mostly by individuals and small communities who choose to live off the grid—either to satisfy their environmental beliefs, or to fulfill a desire or need to live apart from the grid-connected population. Moreover, these enlightened minds have long wondered when the world's established institutions would join them in their quest to save the Earth.

**Looking up at the south face of the building, the 15 degree tilt of the 1,392 solar panels is apparent.**

**Corporate Green**

If the concept of environmentally-friendly urban office buildings is any indicator, we may be getting closer to winning the support of established interests in our environmental revolution. Kyocera Corporation provided an indication of this with the August 1998 opening of its new world headquarters in Kyoto, Japan. This facility is a 20-story showcase of green technologies designed to be "the world's most environmentally friendly corporate headquarters building."

Kyocera, one of the world's leading producer and supplier of solar energy products, has a history of developing business opportunities by addressing environmental needs. In reflection of this, the company's new headquarters building features the largest vertical solar energy system installed on any urban skyscraper; a co-generation system; perimeter zone ventilation; air conditioners regenerated by ice which the facility freezes at night to diminish afternoon peak electricity consumption; and systems to utilize non-potable rainwater runoff and underground water to promote conservation.

In an unusual twist for a multi-billion-dollar corporation, this building is designed to place the highest priority on environmental issues. Then again, "unusual" has become a recurring theme at Kyocera, where the official corporate motto is "Respect the Divine and Love People."

**Building Concept**

The city of Kyoto is full of urban amenities and rich cultural heritage. Kisho Kurokawa Architects & Associates designed the Kyocera headquarters to harmonize with the local environment and even improve upon it by adding a 3,300 square meter (35,000 square foot) park on the site for the local community to enjoy.

The building is at once aesthetically pleasing and environmentally friendly. No sacrifice was made in space, comfort, or functionality to incorporate the facility's many environmental systems. In fact, the building houses two world-class museums on its lower floors. The Kyocera Museum of Art features Quianlong glassware, modern Japanese paintings, bronze sculptures, Kiwa-yohen pottery, and works by Picasso.

**View of the lobby from the reception desk shows sculptures and wide open space that make the transition from the outdoors to the museums on the first two floors.**

**The clock in front of the building includes a display noting the kilowatts currently being produced by the 1,896 solar panels, as well as the total annual number of kilowatt-hours produced.**

The solar-electric panels have been installed in a unique array, which has been adopted as a joint research theme between Kyocera and Japan's New Energy Development Organization (NEDO). This research project will be used to gather data on various solar energy systems operating long-term to help increase public understanding of solar electricity.

The installation of the solar panels at a 15 degree angle against the vertical south wall optimizes their efficiency and provides space between the wall and the panels for air intake and exhaust vents. The frames of the solar panels and their surface glass were reinforced in consideration of the wind resistance at each installation level. Inconspicuous detailing was added to the lengthwise joint to help it blend in with the other surfaces on the building facade.

The rooftop photovoltaic array (504 panels) faces south at an angle of 5 degrees, and gives a maximum output of 57 KW. The 5 degree tilt optimizes sun exposure to the south without letting the panels shade each other, and without compromising panel space on the roof. Many other systems have been installed on the roof, such as cooling towers for air conditioning facilities, various fans and pumps, and a heliport. The photovoltaic installation has been carefully designed to maximize photovoltaic surface area while allowing for the specific building requirements of an urban office tower.

The Kyocera Museum of Fine Ceramics History displays the development of advanced ceramic technology (the name "Kyocera" is actually a contraction of "Kyoto" and "ceramics").

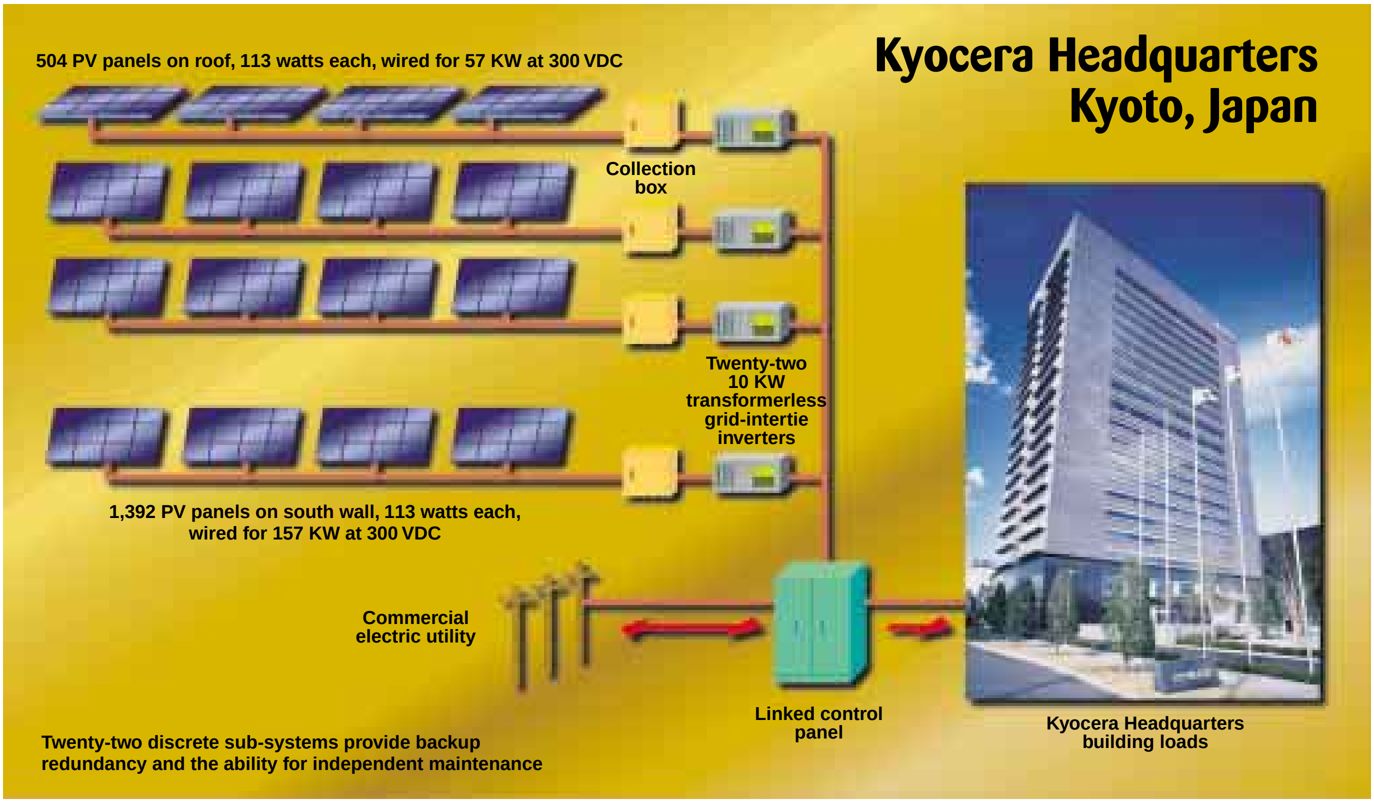
**Solar Power Generation System**

The building features 1,392 solar panels on the south wall, and 504 panels on the rooftop. This creates a total output of 214 KW, or 12.5 percent of the building's electrical requirement. The annual power generation from these solar panels can total up to 182,000 KWH, equivalent to what 45,000 liters (12,000 gallons) of oil would produce at a conventional thermal powerplant. This conservation of petroleum eliminates a significant amount of air pollution—approximately 97.2 metric tons (107 US tons) of carbon dioxide, 133 kg (293 pounds) of sulfur dioxide and 92 kg (203 pounds) of nitrogen oxide per year.

The photovoltaic array is believed to be the first in any large-scale solar generating system in Japan to use a modular design. This modular design combines many small-scale photovoltaic systems into one large system.

There are two different methods for installing large photovoltaic systems. The standard is to have all the modules connect to a single inverter. This causes problems when the inverter needs repair, since the entire system must be shut down to repair a problem with just one of the major components.

Instead, Kyocera chose the modular approach. They have twenty-two separate systems of 10 KW each.




## A Profile of Kyocera Corporation

Kyocera Corporation was founded in Kyoto, Japan in 1959 as a manufacturer of engineered ceramics—a family of advanced materials that includes alumina, beryllia, zirconia, silicon nitride, and many others. These precisely formulated materials have unique physical, electrical, and structural properties not found in metals or plastics.

Unlike the ceramic tea set your grandmother had, these ceramics are second in hardness only to diamond. They are extremely heat resistant, chemically inert, and stable enough to be machined with sub-micron precision. With such desirable characteristics, Kyocera's ceramic products are found in applications ranging from semiconductors to industrial engines to orthopedic joint replacement systems.

Kyocera entered the solar energy industry in 1975, guided by the environmental convictions of its founder, Dr. Kazuo Inamori. Under Inamori's guidance, engineers combined the company's crystalline material technologies with their accumulated expertise in electronics and efficient mass-production. Kyocera has been able to continuously improve all aspects of designing and manufacturing their solar energy products—from processing raw materials to producing photovoltaic cells and assembling finished modules and systems.

By combining their advanced ceramics with metals and plastics, and integrating them with other technologies, Kyocera has become a world leader outside the solar industry as well—in semiconductor packaging, electronic components, optical instruments, and network laser printers. In addition, the Kyocera Group includes affiliate companies like DDI Corporation, Japan's second largest provider of long distance and wireless communication services. In cooperation with DDI, Kyocera has developed an innovative line of telecommunications equipment ranging from network base stations to digital handsets (including the world's first wireless, handheld video telephone).

During the last fiscal year (which ended March 31, 1999), Kyocera achieved sales of US$6.1 billion (725 billion yen), with net income of US$239 million (28 billion yen). The company employs approximately 37,000 people worldwide, including about 20,000 outside Japan. Kyocera has been named by *IndustryWeek* magazine as one of "the world's 100 best-managed companies."

To maximize its future growth potential, Kyocera is now focusing its R&D programs on three general markets: environmental protection, telecommunications/information processing, and "quality of life." This last category includes dental and orthopedic implants; electronic components for hearing aids, heart pacemakers, and other medical devices; wireless communications network equipment; cameras (digital, APS, 35 mm, and 645); created emeralds, rubies, and other gemstones; and solar-powered systems, among other things.

## Kyocera's Solar Division

Since 1975, Kyocera has steadily invested in solar R&D and facilities, including a US$50 million manufacturing plant expansion in the mid 1990s. None of this attracted public attention, however, until 1998, when the company's consolidated PV shipments of 24.5 megawatts made Kyocera the world's number-one producer of solar-electric modules. The company's shipments rose to 29 megawatts, with consolidated solar product sales of approximately US$140 million (17 billion yen), during the last fiscal year.

**World's #1 Solar Producer and Supplier**

In August 1999, Kyocera acquired Golden Genesis Company, North America's leading marketer and distributor of solar electric systems. The company was subsequently renamed Kyocera Solar, Inc. (KSI). This acquisition gave Kyocera approximately US$45 million in additional annual revenue from solar-electric products, as well as two assembly facilities, ten distribution centers, more than 1,000 additional solar product dealers globally, and subsidiaries in Brazil, Argentina, and Australia. With the combined solar product revenue of Kyocera and the former Golden Genesis exceeding US$185 million for the last fiscal year, Kyocera is regarded as the world's number-one vertically-integrated producer and supplier of solar energy products.

**Residential and Commercial Success**

Before acquiring Golden Genesis, Kyocera focused its solar energy business on the Japanese market, where a program of government incentives has led to the installation of approximately 6,000 home solar systems in recent years. Kyocera supplied approximately 43 percent of this market during the last year, and is increasing its support of other markets worldwide through its expanded dealer network.

In addition to residential products, Kyocera's integrated solar energy systems are used in telecommunications; the oil and gas industry; roadway and railway safety and traffic management; village electrification; vacation home power generation; marine and RV applications; residential and agricultural water pumping; agricultural fence electrification; and utility grid support systems for homes and public facilities.

Each 10 KW system is complete in itself, which minimizes output loss by enabling each sub-system to be optimally controlled. In a non-modular system, for example, overall efficiency drops whenever any of the solar panels are in the shade, or if a panel or electrical component needs to be repaired. A modular system eliminates these problems by allowing individual sections of the overall photovoltaic installation to act as independent systems.

There is one potential pitfall to this design: when multiple PV systems exist throughout a building, control and monitoring of the system as a whole can become difficult. Kyocera solved this problem by developing a "local operating network" which provides high-quality monitoring, data collection, and control, with minimal wiring.

The building's local operating network includes 22 separate photovoltaic sub arrays. Each PV module is rated at 113 watts at 16.9 volts, measures 1 meter (3.3 feet) square and 36 mm (1.4 inches) thick, and weighs 21.8 kg (48 pounds). The input voltage of each series string is 300 VDC, feeding into a 10 KW transformerless inverter rated at 200 VAC. Kyocera developed this 10 KW transformerless inverter specifically for the local operating network. It has no fan, so it operates quietly, and boasts a conversion efficiency of 95 percent.

This building is fully grid-connected, since maximum power loads exceed the capacity of the photovoltaic system. Also, any excess electricity generated during weekends or holidays by the photovoltaic system can be sold back to the power company.

**The electrical control room with its twenty-two 10 KW synchronous inverters.**

### Co-Generation System

The building's co-generation system uses reciprocating engines to turn two 520 KW electrical generators. These engines run constantly, and can be used as an emergency backup generation system to supply approximately 60 percent of the building's power capacity needs in the case of a grid power outage. The engines are powered by natural gas to reduce carbon dioxide and sulfur dioxide emissions.

An absorption chiller makes effective use of the engines' waste heat by chilling water for the building's climate control systems. As a result, the energy efficiency of the co-generation system is estimated to be more than twice that of commercially generated electrical power from the local grid. Kyocera is the first company in Japan to combine a natural-gas-powered co-generation system, a photovoltaic system, and standard grid-connected electric power in an urban office tower.

A view of the machine room for the co-generation heat source.

**AC Regenerated by Ice**

The building's air conditioning system takes advantage of the utility company's relatively abundant off-peak energy to produce ice at night (between 10 PM and 8 AM). The ice provides refrigeration during the day to reduce energy consumption during peak energy usage hours. In addition to reducing costs, this type of system can help diminish the large gap between daytime and nighttime energy loads. This can help reduce the likelihood of brownouts on the utility grid.

**Perimeter Zone Ventilation System**

In non-winter months, sunlight hitting an office building creates a "hot zone" indoors near the windows, where indoor temperatures can be much higher than the air outside. In conventional buildings, this area is cooled by additional air conditioning, which consumes a significant amount of energy. In the new Kyocera headquarters, a perimeter zone ventilation system senses indoor/outdoor temperature differentials. During the spring and fall, it automatically brings cooler outdoor air in to help cool the air conditioning fan coils in this hot zone. This provides a natural, environmentally-friendly boost to the building's air conditioning system.

**Air Conditioner Airflow Controls**

Two airflow control systems use sophisticated

## Kyocera's Environmental Commitment

Led by Dr. Kazuo Inamori, founder and chairman emeritus, Kyocera has a long history of emphasizing environmental preservation. More than 95 percent of the company's wholly-owned facilities worldwide are registered to the ISO 14000 standards for environmental management. In addition, Kyocera's "green" initiative includes developing products and technologies—such as solar energy, among many others—that can reduce or eradicate environmental problems at their source.

**Ceramic Engine Components**

Kyocera's ceramics hold tremendous promise for reducing exhaust pollution by allowing engines to operate at higher temperatures and burn fuel more efficiently. Kyocera engineers have created prototype diesel engines made almost entirely of ceramic to demonstrate the material's viability. Today, Kyocera is employing these technologies in Vancouver, Washington to mass produce ceramic parts for heavy-duty diesel truck engines, and in Japan, where it produces ceramic turbocharger rotors, ceramic fuel pump components, ceramic-based components for oxygen sensors, and related automotive pollution-control devices.

**Ceramic Gas Turbine Components**

Kyocera is designing structural ceramic components for gas-turbine powered electrical generators, where higher operating temperatures offer significant improvements in fuel efficiency and emissions. Where solar power remains unfeasible, the potential for "microturbines" in low-volume power generation could be vastly enhanced through the use of these materials.

**Cartridge-Free Laser Printers**

The world's computer users consume an estimated 100 million disposable laser printer cartridges each year. Most go directly into landfills. Kyocera's patented network laser printers eliminate this disposable cartridge through the use of a silicon-coated print drum that prints up to 300,000 pages without replacement.

**Filmless Digital Cameras**

Kyocera's Samurai 2100DG is the world's first 2-megapixel digital camera with a 4X optical zoom. Utilizing no photographic chemicals or film, this camera produces images that are comparable to 35 mm photos at enlargements up to 8 by 10 inches (20 x 25 cm).

temperature sensing to give the building's air conditioning another efficiency boost. One system incorporates blowers with variable-speed motors to automatically adjust airflow to each floor of the building, which reduces unnecessary airflow. In concert with this, a second system provides local airflow control within individual offices by adjusting airflow as needed from each ceiling duct automatically. These systems create significant energy savings in comparison with conventional office buildings by reducing loads on the AC system.

**Use of Underground Water and Rainwater**

This system helps make efficient use of natural resources by using non-potable underground water and collected rainwater as an agent for the air conditioners, to flush toilets, and to irrigate the landscaping.

**Other Environmental Systems**

Kyocera's new headquarters building includes energy measuring systems for each floor, high-efficiency zoned lighting, heat reflecting glass, and even "smart" escalators, which run only when they sense the approach of a passenger.

From any angle, this building's basic concept of combining ecological systems with world-class comfort and style is a milestone in urban design. We believe it represents a new model for the modern office tower, which could serve as an example of environmental awareness in many regions of the world.

In the words of architect Noriaki Kurokawa: "I regard this building as more than just a new corporate headquarters. I believe it embodies a true spirit of challenge—a spirit which initiates new ventures and opens new doors."

**Access**

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CHINA DIESEL

full page

four color on negatives

this is page 51

# A Big Motorhome That Could

**Tom Vineski**



**The Barton Safari motorhome in travel mode, with David Barton at the door.**

As a full-time RVing nomad, I'm always looking for innovative solar applications that push the levels of technological sophistication. When I first saw David and Pat Barton's 40 foot (12 m) 1998 Serengeti motorcoach, I wanted to take a closer look. What the Bartons had done to the standard Safari battery system was totally unconventional. They had added, in effect, their own completely separate AC power generating system!

The regular factory-equipped energy package for that year's model included a 400 amp-hour battery bank, one 75 watt PV panel, a 12 amp ASC regulator, a Heart Freedom 20D 2,000 watt inverter/charger, and a 6.3 KW propane-fueled Onan genset. In many cases, a motorcoach owner will add several panels, upgrade the regulator/controller and add a more sophisticated type of battery monitoring device such as an E-Meter. The Bartons had taken a giant step beyond this more typical upgrade.

**Energy Self-Sufficiency**

The transformation began with the goal of energy self-sufficiency for long-term emergency situations. The Bartons wanted to be comfortable in areas supplied by grid power—in any place that would have been inadequate to provide the 50 amp service necessary for operating all of their loads simultaneously. Their substantial load profile includes two roof-mounted air conditioning units, a 1,500 watt convection microwave, a Combomatic washer/dryer, a satellite TV and home theater system, a computer and printer, lights, and miscellaneous tools and equipment.

The Bartons are long-time supporters of renewable energy in both their personal and business lives. In 1994, David attempted to establish an environmentally-oriented business park that would have used all renewables and promoted other "green" business practices. He is an active inventor and entrepreneur who holds numerous patents in the oil service and studwelding (a method of attaching fasteners used in many manufacturing processes) industries.

The challenge of creating a self-sufficient, solarized motorhome was a wonderful marriage of personal beliefs and the latest in solar technology. *Home Power* magazine provided technical background in solar applications and commercial resources necessary to the undertaking. The technical design and installation were coordinated with Lynn Haynes and Lad Pragay of Southern Stud Weld (David Barton's first business), under the supervision of David Barton, and Tim Vaughn of Solar Utility Network (a Texas RE company).

**Panel installation was made more secure by mounting them to structural aluminum running along the entire roof structure, attached to the rafters.**

**PV Array**

The original calculations showed a need for a system of thirty 50 watt panels. In order to maximize PV output, the entire roof was dedicated as a collector area. For the flat fixed racks, extruded aluminum rails were cut and installed to support the twelve Solarex VLX-80s and six VLX-53s (1,278 watts total). The PVs were configured in two arrays at 24 volts, and cabled with #6 (13 mm$^2$) stranded wire to the two ProStar 30 amp regulators.

The Concorde Lifeline absorbed glass mat (AGM) gel-cell batteries (model GPL-8P, 255 AH) were selected for their high charge current acceptance capacity, safety, and low internal resistance. A Balmar 24 volt, 7 KW brushless alternator and equalizer unit was also added to the 300 hp Caterpillar diesel engine that powers the motorhome. This charges both the primary battery bank at 24 VDC via a Balmar three-stage regulator, and the factory-standard battery bank dedicated to the coach DC loads at 12 VDC.

The Bartons want the freedom to travel, camp, and live with no shore power or very limited power, as is often the case in remote forest service campgrounds or in friends' driveways. They want to be able to operate the two Dometic roof-mounted air conditioning units separately or simultaneously (13,500 btu per hour, drawing approximately 14 amps when running). These and the other AC loads in the motorhome mean they need access to 50 amp service or a 6 KW generator, at a minimum.

**Stacked Inverters**

For stand-alone solar operation, an inverter would need to produce adequate power from the battery bank, or be able to "smartly" supplement the available shore power. After much discussion and consultation with various suppliers and engineers, the Bartons chose two Trace SW4024 inverters. These would be used in stacked mode to produce 50 amp service at 220 VAC from the battery bank, or from 15, 20, or 30 amp shore power.

Each inverter has its own full-function remote for operations and system monitoring. Fused disconnects were installed between the charge controllers and battery bank, and a DC-rated 225 amp circuit breaker was installed between the bank and each inverter (see schematic). The inverter output is then routed to the standard AC breaker panel in the motorhome, where all AC loads are connected. A Todd Engineering PS-250 transfer switch is used to direct AC input from either shore power or the 6.3 KW generator.

**Remote camping is no problem with the extensive power system.**

DC disconnect with two ProStar 30 charge controllers.

**Original RV System**
The DC side of the motorcoach powers the lights, water pump, furnace blower fan, and the various detectors and circuit board controls for the refrigerator, hot water heater, and furnace. This is the factory-installed system mentioned earlier. It uses one Siemens 75 watt panel, a Heart 20D 2,000 watt inverter/charger, an ASC 12/12 (12 volt, 12 amp) regulator, and a battery bank.

The original 400 amp-hour lead-acid batteries were replaced by the Concorde Lifeline AGM batteries, due to maintenance issues and problems with corrosion. This system also has multiple charging sources: the 7 KW Balmar alternator, the 75 watt panel, and when necessary, the Heart inverter/charger operating from any of the AC sources available. An added benefit of this original factory system is that it provides a backup source for a number of the coach AC loads if the main system is down for any reason.

**Roadworthy**
There was a concern that once all this additional equipment was added, the vehicle might have weight and handling problems. With some trepidation, a trial run was made and a weigh-in scheduled. To everyone's delight, no problems were noted. Even after the water and fuel tanks were filled and personal gear was added, the total coach was still within the manufacturers GVWR (gross vehicle weight rating).

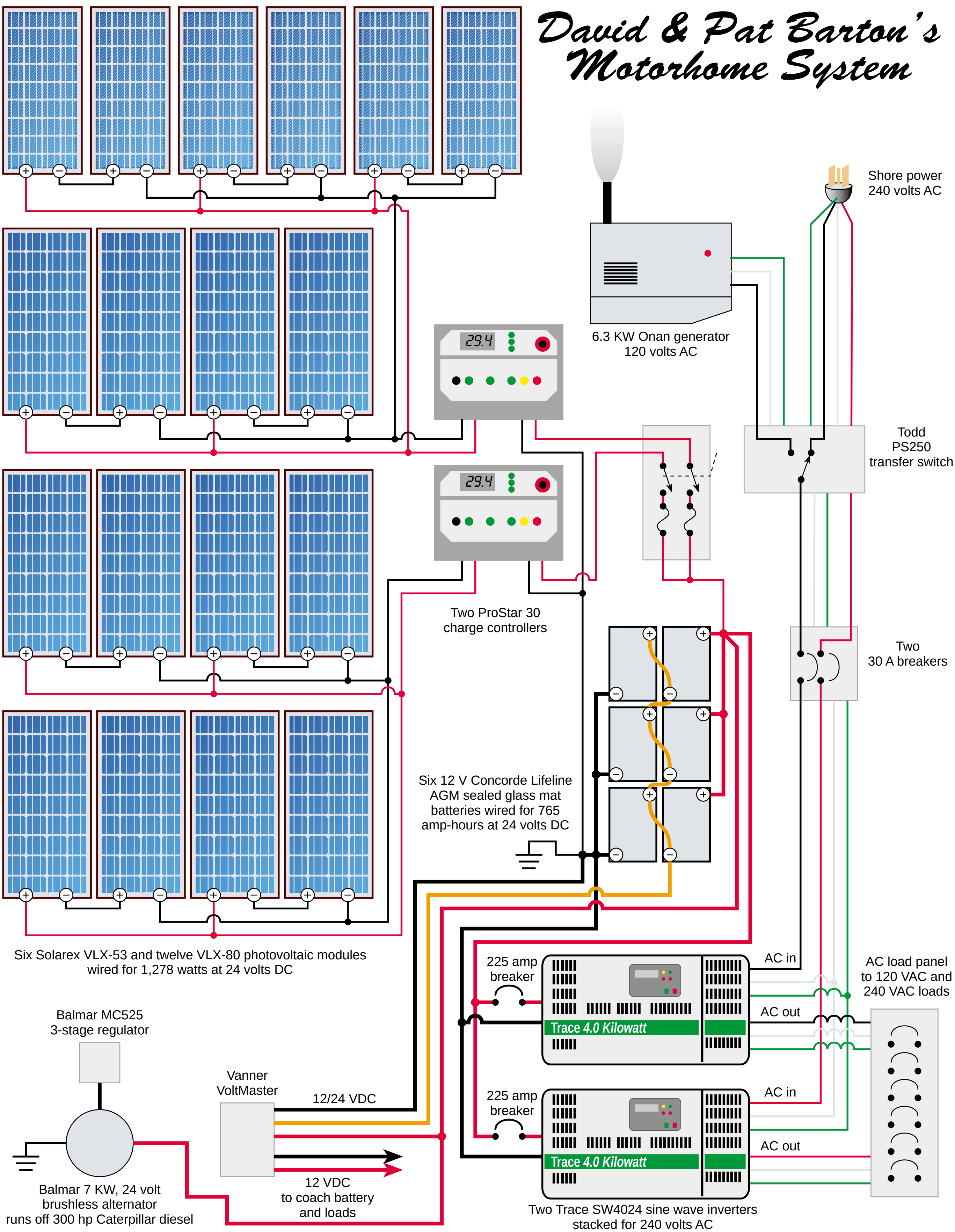
Safari motorhomes are noted for exceptional payload capability, a far cry from most manufactured RVs. However, modifications were made to the steering system. Larger diameter sway bars and mounts were added, and a D. Howard guidance steering centering system was installed for overall safety and control.

David is now in the development and demonstration stage of a trailer-based "Portable Power Source" which contains the same power systems that are in their RV, along with an ultra-efficient Fischer Panda diesel generator, and a colloidal silver water purification and storage system. The new independent system is designed to provide power and water for extended periods, for emergencies, or as a turn-key portable utility. Stay tuned for more information.

Four of the six Concorde Lifeline batteries in the insulated center bay.

**Deluxe Demo**
The Bartons have discovered that their new power system makes getting set up in any new location much easier. Connecting the shore power line is one of the last things they have to think about. And if a 15 amp service is all that is available, not to worry. The Trace inverters are smart enough to adjust the output, making up the difference from the battery storage system, allowing full 50 amp operation of the coach.

David and Pat have taken the coach all over the country, sharing their


David & Pat Barton's
Motorhome System
Shore power
240 volts AC
6.3 KW Onan generator
120 volts AC
29.4
29.4
Todd
PS250
transfer switch
Two ProStar 30
charge controllers
Two
30 A breakers
Six 12 V Concorde Lifeline
AGM sealed glass mat
batteries wired for 765
amp-hours at 24 volts DC
Six Solarex VLX-53 and twelve VLX-80 photovoltaic modules
wired for 1,278 watts at 24 volts DC
225 amp
breaker
AC in
AC out
AC load panel
to 120 VAC and
240 VAC loads
Trace 4.0 Kilowatt
Balmar MC525
3-stage regulator
Vanner
VoltMaster
12/24 VDC
225 amp
breaker
AC in
AC out
Trace 4.0 Kilowatt
12 VDC
to coach battery
and loads
Balmar 7 KW, 24 volt
brushless alternator
runs off 300 hp Caterpillar diesel
Two Trace SW4024 sine wave inverters
stacked for 240 volts AC

**One of the Trace SW4024 inverters and the AC load center breaker inside the center bay.**

experiences and the technology with others at campgrounds and rallies. Even though the level of sophistication and expense may put this system out of the reach of most RVers, it's a great demonstration of the strengths and limitations of a residential-sized solar-electric installation on a motorhome chassis.

**Barton RV System Costs**

| Qty | Description | Cost (US$) |
|---|---|---|
| 2 | Trace SW4024 inverters | 5,216 |
| 12 | Solarex VLX-80 solar panels | 4,657 |
| 6 | Concorde Lifeline 255 AH batteries | 3,090 |
| 6 | Solarex VLX-53 solar panels | 1,572 |
| | Cables, connectors, & cable wrap | 1,541 |
| 1 | Vanner VoltMaster, model 60-100 | 800 |
| 1 | Balmar alternator/regulator | 600 |
| 2 | Trace remote controls | 530 |
| 1 | 220 amp DC circuit breaker | 450 |
| 2 | ProStar 30 PV controllers | 286 |
| | Aluminum for mounting solar panels | 267 |
| | Steel for battery cages | 190 |
| 1 | Square D AC load center & breakers | 85 |
| 1 | 30 amp 3-pole disconnect | 85 |
| | Miscellaneous hardware | 75 |
| | *Total Hardware* | $19,444 |

*Labor*

| Hrs | Description | Cost (US$) |
|---|---|---|
| 120 | Lynn (Electrician) | 3,000 |
| 120 | Lad (Machinist) | 3,000 |
| 40 | Atilla (Labor) | 500 |
| 40 | Darrel (Labor) | 500 |
| | *Total Labor* | $7,000 |
| | *Total System Cost* | $26,444 |

**Access**

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Tim Vaughn, Solar Utility Network, PO Box 154008, Waco, TX 76715 • 254-576-3030 • Fax: 254-576-1009 sunhub@hot1.net

Balmar, Brad Johnson, 19009 64th Ave. NE #4, Arlington, WA 98223 • 360-435-6100 Fax: 360-435-3210 • balmar@balmar.net www.balmar.net • alternators & equalizer

Concorde Lifeline Batteries, Dave Godber, 7702 South Greenleaf Ave., Whittier, CA 90602 • 800-527-3224 or 562-696-6232 • Fax: 562-696-7415 webmaster@lifelinebatteries.com www.lifelinebatteries.com

River City Products, 199 W. Rhapsody, San Antonio, TX 78216 • 800-879-4277 or 210-377-0853 Fax: 210-377-1089 • river@dcci.com D. Howard steering guidance system

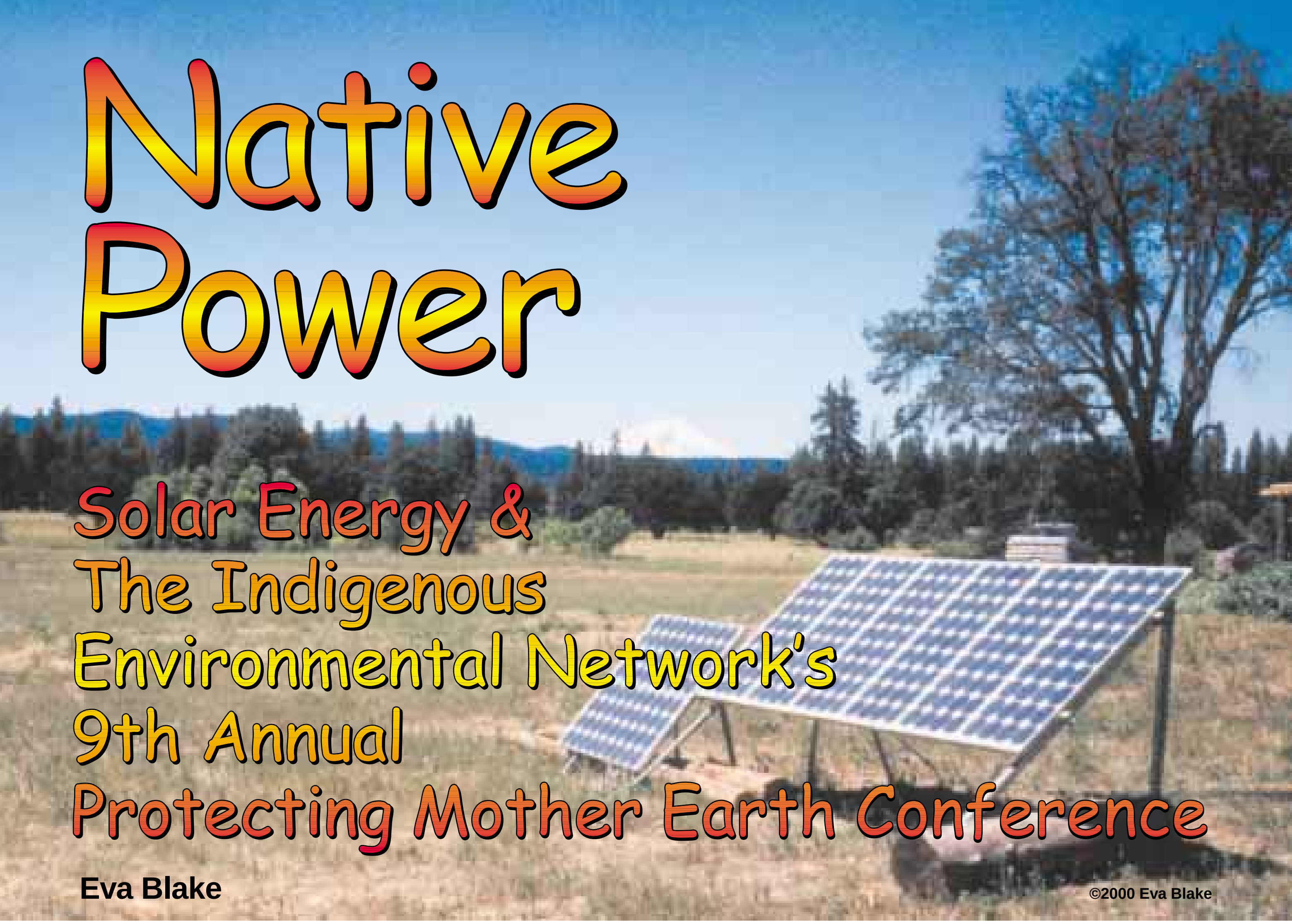
ADDCO,1596 Linville Falls Hwy, Linville, NC 28646 800-621-8916 or 828-733-1560 • Fax: 828-733-1562 dosborne@addco.net • www.addco.net modified sway bars

The Vanner Power Group, 4282 Reynolds Drive, Hillard, OH 43026 • 800 227-6937 • Fax 614 771-2718 Technical: Greg Woeste, Ext. 201 pwrsales@vanner.com • www.vanner.com

# Native Power

## Solar Energy & The Indigenous Environmental Network's 9th Annual Protecting Mother Earth Conference

Eva Blake





**Natural energy powers the fight for nature at the Indigenous Environmental Network conference.**

Clear turquoise skies arched above the Buckskin family camp where close to 1,000 people would soon gather to share stories and strategies of the indigenous experience protecting Mother Earth. Traditional reverence and respect for life guided our decision to use the power of the sun to strengthen our voices. Solar electricity is our ally in the effort to end desecration caused by the use of conventional energy resources.

Swinging off Shasta County road 19 onto a red dusty road, I breathed a sigh of relief. My day's journey from Sebastopol came to an end at the camp in Fall River Mills, California. I had arrived three days before the official start of the conference. I planned to help Bob-0 Schultze of Electron Connection install the photovoltaic system for the conference. The system would power the public address system, the main arbor gathering area, the radio microtransmitter, and lights.

**Native Network**

The Indigenous Environmental Network (IEN) is a national alliance of grassroots indigenous organizations governed by a national council of indigenous individuals from a variety of native nations. IEN fulfills its goals as a non-profit organization dedicated to protecting the sacredness of Mother Earth and her indigenous children in a variety of ways. These include resource and referral networking; providing an information clearinghouse; supporting grassroots endeavors with strategic development; pro bono technical and legal referral; media access and campaign development; hosting an annual conference; participating in national, regional, and local advocacy; writing a newsletter; and assisting with direct action.

The annual conference is one of many effective things IEN does in its pursuit of environmental and social justice (which we believe to be one and the same). Five hundred years of colonial rule have left Turtle Island (an Iroquois name for North America) with a serious environmental crisis. It threatens the survival of all life if we continue to release toxins, dump radioactive waste, clearcut our forests, etc. IEN teaches the indigenous concept that we as humans are not separate from our environment—in fact we are our environment.

What I came to do this year was provide the power—the electrical energy—to project IEN's voice out to the hundreds of people who came to listen and learn. This energy was created from the intense golden rays streaming down upon our camp. Without one lone cloud in the sky, the sun successfully provided us with four days of photovoltaic fuel, as well as a few burned noses, heat strokes, and some dehydrated children.

**The System**

We were lucky to have Bob-0 Schultze of Electron Connection lend us the gear for the duration of the conference. He arrived Saturday with a truckload of solar equipment, wires, tools, and nuts and bolts. Shortly thereafter, Bill Battagin from Feather River Solar Electric came rolling in to help. We spent the next three to four hours making connections and attaching wires and screws to build a 24 volt PV/inverter system.

**Bill Battagin of Feather River Solar Electric and author Eva Blake with the PV system.**

**Modern technologies and traditional values must meld for a positive future.**

The energy, captured by the cells of eight 75 watt Siemens photovoltaic panels, traveled first through a Trace C-40 charge controller to regulate battery charging. It then entered the battery bank after passing through a safety disconnect switch. The battery bank consisted of four Trojan L-16s wired in series with a total capacity of 350 amp-hours.

Leaving the battery, direct current was sent to a Trace SW4024 inverter where it was converted into sine waves at 120 volts, a current that jives with our electronic equipment. Two 20 amp circuit breakers were installed between the inverter output and the plug-in receptacles.

An E-Meter was installed for easy verification of the system's status, giving us readings of amp-hours used, incoming amps, operating volts, and percentage of battery capacity. This little contraption and I became good friends over the next four days as Bob-0 left me in charge of overseeing the system's usage. Maintaining the batteries meant getting a grip on the energy entering and leaving the system.

**The Load**

We were able to power the complete sound and lighting system at the main arbor as well as a microtransmitter which put the conference on air on our homebrew radio station, KIEN. The sound system ran at a maximum 1,320 watts, and actually drew on average about 960 watts of power. The microtransmitter was measured at about 152 watts, and the four lights were each rated at 13 watts.

Tom Goldtooth, Dine/Dakota, the national coordinator of the Indigenous Environmental Network, with Joseph Leon, the soundman.

The schedule of the day's events coincided perfectly with the needs of the system, and allowed three to four hours in the afternoon of no-load time to recharge the battery while workshops were taking place. The first night we consumed very little energy while enjoying a traditional ceremony, a bear dance. The amplifier was only used for about ten minutes, and the lights were not needed, since there was a fire.

The following nights were much more demanding. Talent shows ran their course of Indian jokers, drummers, singers, and poets who filled the arbor with entertainment past midnight. I wired four compact fluorescent floodlights to the arbor for this purpose. They were each rated at 13 watts, providing the same amount of light as a 60 watt incandescent.

**More With Less**

Energy efficiency is a crucial companion to renewable energy systems. The feasibility of RE systems, especially photovoltaic systems, is drastically reduced without conservation, and without reducing energy demand. The principles are the same—reduce consuming fossil fuels and other conventional energy sources to a minimum by practicing the laws of do with less, do without, or do it some other way.

According to the manufacturers, each of the lights we were using would save, in their 10,000 hour lifetime, over 6 barrels of oil, or one ton of coal. This means 7,332 pounds of carbon dioxide (the main culprit in global warming); 67 pounds of sulfur dioxide (responsible for acid rain); and 28 pounds of nitrogen oxides (which produce acid rain and smog) would be prevented from entering our atmosphere by choosing energy efficient lights.

On the first day, an extra 17 watt panel and DC fan left by Bob-0 found a unique niche in the system. The radio transmitter was having problems operating because of the intense heat (over 100°F; 38°C), and had to be shut down. The small PV panel was used to directly power the DC fan, cooling the transmitter perfectly. With the fan we were able to stay on the air, while saving the main system from having another load.

PVs produce good amounts of electrical energy, but the capacity of the batteries is a limitation. Batteries are like a bucket; no more will come out than was put in, and unfortunately solar panels generate electricity slowly. We had a battery capacity of 350 amp-hours, and eight panels rated at 4.4 amps apiece, at 12 volts. So in our 24 volt system, it would take about 20 hours of full sun to completely charge the batteries from zero (and you never want to let your batteries get down there!). Our average total load was about 10 amps. And only between the hours of 9 and 5 were we actually running the loads and charging the battery at the same time. This is why an energy budget with conservation practices had to be established.

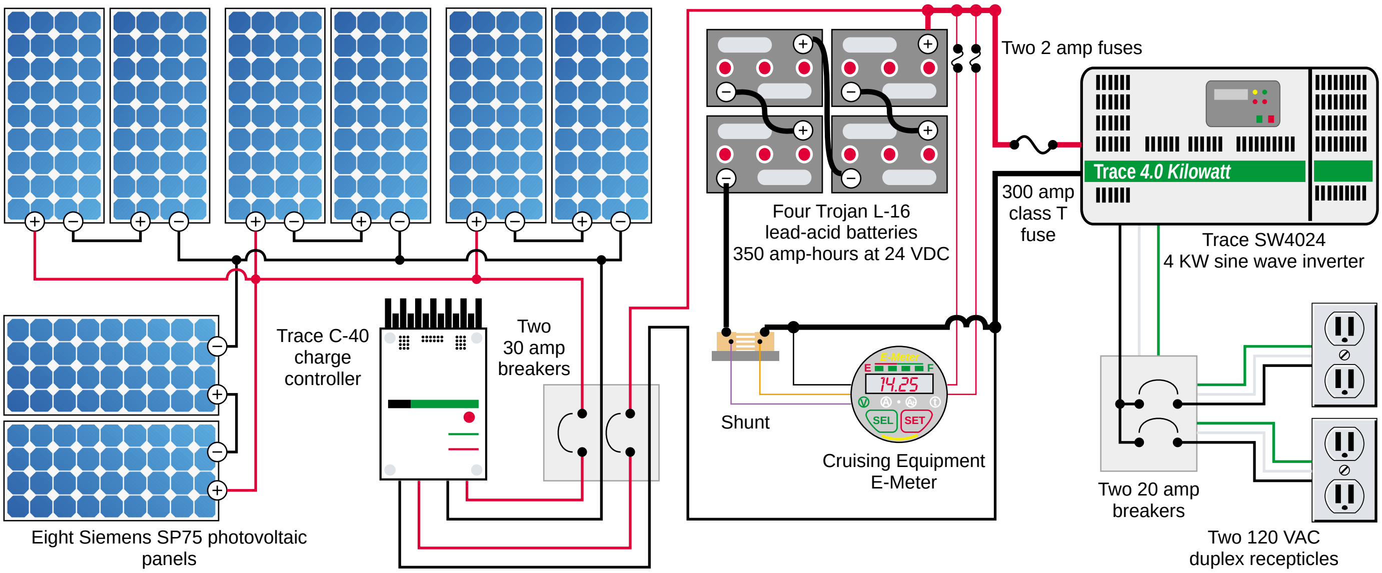
**Solar Education**

Those four days, with the sun blazing down from a bright blue sky, taught many people valuable lessons in solar energy. On the third day, there was an afternoon workshop entitled *Building Sustainable and Healthy Communities,* which was facilitated by Tia Oros of the Seventh Generation Fund. The presenters included Andrew Laahty of Zuni Organic Farmers Association, New Mexico; Paul "Sugar Bear" Smith of Tsyuhekwa Program, Oneida Nation, Wisconsin; and Kevin Begay of NativeSUN/Hopi Solar.

Kevin Begay spoke about the history of their work, which began in Hopi villages and then reached out to some Navajo homes. He led everyone through the system as it trickled power into the batteries, explaining each component and its function. It was excellent to have someone represent a successful, native-run, native-serviced solar business on the rez. NativeSUN is an encouraging and motivating force with firsthand knowledge about how solar can enrich indigenous peoples and their communities.

Other people besides those in the workshop were touched by the solar system, which stood out by the

## The Protecting Mother Earth Conference PV System




main arbor like a glowing candle. Children who stopped to make shadow puppets on the panels got a lesson in the basics of collecting solar energy. Curious adults were drawn over to ask questions about how it worked, how feasible it would be in Guyana, South America, and why renewable energy is so important in the indigenous quest for a sustainable future. In this way, I led small informal "workshops" on the system and networked with many people interested in working with solar energy. It strengthened connections I had with organizations opposing nuclear energy and planning to use solar in their work and at their offices. It was a focal point and highlight of the event.

### Indigenous Energy

Indigenous communities experience some of the most horrible dangers resulting from the production and use of conventional energy sources. According to the stories shared by speakers at the conference, much damage has already been done. Uranium mining exposed Navajo miners to radon gas at between one hundred and one thousand times the limit later considered safe.

Close to one thousand abandoned mines riddle the Navajo Nation. Near these mines lie 99 percent of the product dug from the "dog holes," cast aside in tailing piles, and later built upon by unknowing families. The Navajo Nation also experienced the largest spill of radioactive material in U.S. history when 1,100 tons of waste gushed through a dam into the Rio Puerco river in 1979.

There is organized resistance growing from within affected communities. The five-tribe alliance at Ward Valley has recently halted US Ecology's plans to dump radioactive waste from nuclear reactors in the sacred Mojave desert by the Colorado River.

Indigenous activists know that renewable energy use is also a supporting force in the struggle against these dangers. People are attracted to it because it creates clean, reliable energy by the people, for the people. It enhances tribal sovereignty and self-sufficiency. Supporters of solar energy also know it must be affordable and effective for it to gain enough ground to displace nuclear and fossil fuel energy. Indian people are experimenting with it and have had mixed success. One place where it is successful is at Zuni, where PV pumps water, and is cost effective compared to hauling two tons of water sixty miles (100 km) over rough roads.

A valuable lesson taught by these gatherings of indigenous people is that knowledge is powerful. Access to information is the road to change. Without it, people make ignorant decisions and are more easily exploited. Without knowing the extreme health hazards of uranium, Navajo people have in the past built homes on tailing piles, their children playing in radioactive dust. The exchange of information here gives people the power to make responsible decisions, fight exploitation, and seek healing where damage has already been done. This way, we can fulfill the sacred duty of working for clean air, water, and soil, and a healthy circle of life.

### Access

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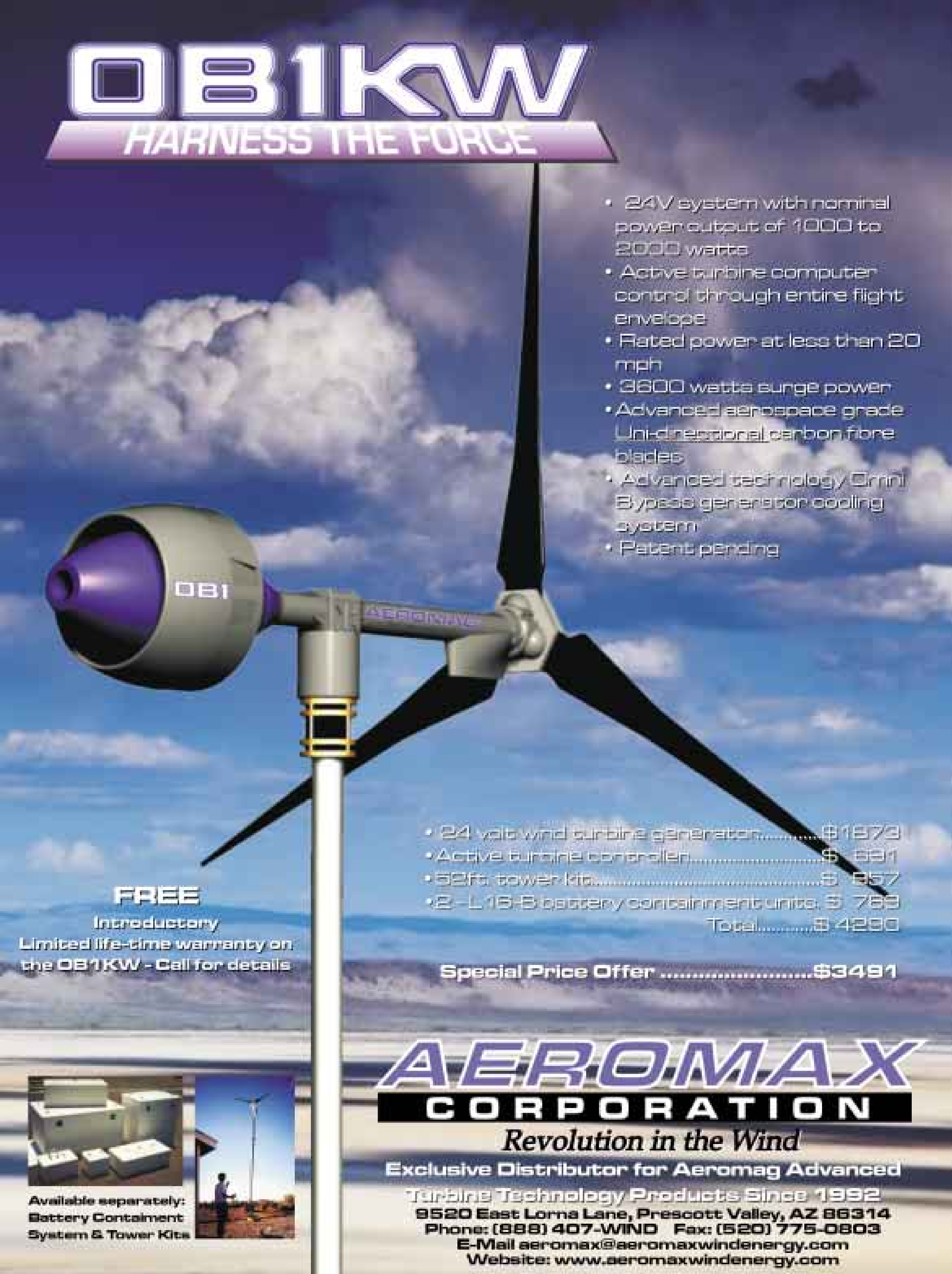
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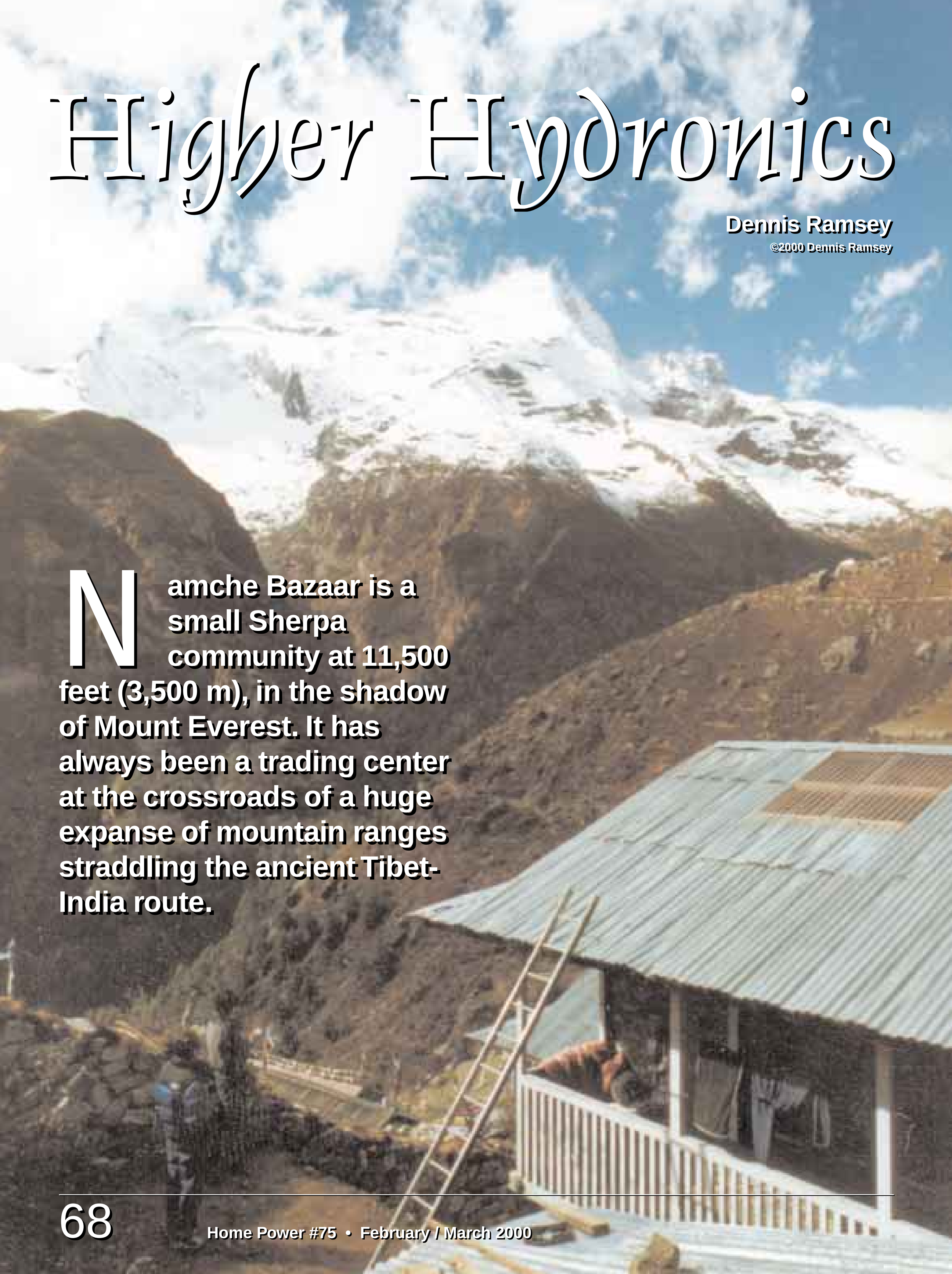


# Higher Hydronics

Dennis Ramsey



**Namche Bazaar is a small Sherpa community at 11,500 feet (3,500 m), in the shadow of Mount Everest. It has always been a trading center at the crossroads of a huge expanse of mountain ranges straddling the ancient Tibet-India route.**

Nowadays, Namche reaps enormous profits from the mountaineering and tourism industries of Nepal. Besides the usual trekkers' lodges, Namche sports two European bakeries, a cybercafe, several pubs and pool halls, a disco and cinema, and pizza parlors complete with real pizza ovens which were helicoptered in.

Porters on the long road to Namche.

### Namche Dental Clinic

In 1994, a bit before these modernizations, Namche got a dental clinic. An unusual group from the UK called the Everest Marathon, which does a high altitude marathon around Everest every other year, decided they would sponsor a dental clinic in this crossroads community. They partnered with the American Himalayan Foundation, and established the Namche Dental Clinic.

Two young adults from the community were sent abroad for two years of training in Canada, and a large building was constructed of stone and timbers. Dental chairs and a range of modern equipment were brought in from the U.S. This clinic now provides services such as fillings, extractions, and cleanings, as well as tooth brushing and flossing lessons to villagers from all over the region. Namche was the perfect choice of location, since it is the main market center in the highlands, and many people travel to town for the Saturday market. Saturday is the clinic's busiest day.

### Cold Dentists

The only thing the clinic lacked was relief from the bitter winter cold. It's so cold, in fact, that the clinic is closed for the month of January each year, since no one would brave the weather to visit the clinic anyway. But during November and February, it's cold enough that the dentists have trouble with their manual dexterity.

The Everest Marathon decided to put some effort into upgrading several features of the clinic, to improve the solar absorption in general, and to install some form of heating system. The Everest Marathon paid for all equipment and in-country expenses, while the Jean-Pierre Michaud Fund of Geneva, Switzerland provided renumeration for the labor.

Diana Penny Sherpa, who is the head of the Everest Marathon, contacted me in Kathmandu about two years ago to talk about the possibilities. We decided that the first thing to do was vault and skylight the space from ceiling to roof, and double-pane the windows. This changed the ambience entirely, by allowing in much more sunlight and warmth. We also talked about solar hydronic heating of the inside operating rooms. A few months later, I was able to visit Namche to do a survey of the clinic's situation.

### Dedication

I flew into Shyangboche, an hour above Namche Bazaar, in a small four passenger Pilatus Porter. Four Japanese tourists sat in the back, and I was in the co-

A Saturday market crowd at the crossroads of the Himalayas.
Some travel from as far as Tibet to trade here.

The Namche Bazaar dental clinic, overlooking town. New skylights add natural light and solar gain.

pilot seat. The weather was so dismal and dangerous that we nearly got lost. We only made it after the pilot ducked under a cloud bank so he could see up the thin valley to the tiny airstrip. Sadly, this veteran pilot, Ang Gyalzen Sherpa, died two hours later trying to repeat the flight with a load of cargo. He was from the village of Thame, just near Namche. I dedicate this project to him.

## Solar Gain

When I saw the clinic, I realized that they had made great strides in the last year. They moved the operating rooms from the cold and damp downstairs to the beautifully vaulted and varnished upstairs. It changed their requirements for supplemental heat entirely. I decided against a solar-based heating system for several reasons.

The much-improved solar gain of the building due to vaulting and double-paning was already sufficient to provide adequate heat except during the coldest or rainiest winter weather. And during such weather, a solar-based system would provide nothing. Since Namche has a very good electrical supply from the Austrian-sponsored 600 KW hydro-electric turbines nearby at Thami, there was another option.

## Hydro-Powered Hydronics

I chose to use the available hydroelectricity to run a hydronic system that would provide a high efficiency heat transfer. (Falling water is driven through the hydrologic cycle by the energy of the sun, so hydroelectricity is renewable—a secondary form of solar energy.)

Hydronics basically means heating a fluid and then pumping it to the areas where it is needed. The fluid dumps its heat into the rooms via radiators. The traditional method of heating in this region is to place embers from the hearth into a metal brazier, which is then put into a specific room. The clinic needed a moderate amount of radiant heat in all of its rooms, which could be based on the renewable energy of hydro. It would be controlled by thermostat, so that they only used enough energy to keep the operating rooms at about 68°F (20°C) in winter. And it had to be automatic, maintenance-free, and user-friendly.

I designed a hydronic circulating system that uses a standard 220 volt, 1,500 watt water heater element and a Taco circulating pump. It moves 9 liters (2.4 gal) of antifreeze through 80 feet (24 m) of 3/4 inch (19 mm) copper tubing which is flush-mounted to the baseboards of every room. The copper tubing is soldered into four 4 foot (1.2 m) baseboard radiators so that the hot antifreeze moves through the building in a continuous loop.

The dental team: Mingma, Doka, and Tek (in the chair). Warm rooms make the fingers work better.

Antifreeze was necessary because the clinic closes during the month of January, when it is bitterly cold. Since the heating system would not be used during this time, plain water would freeze and burst the pipes.

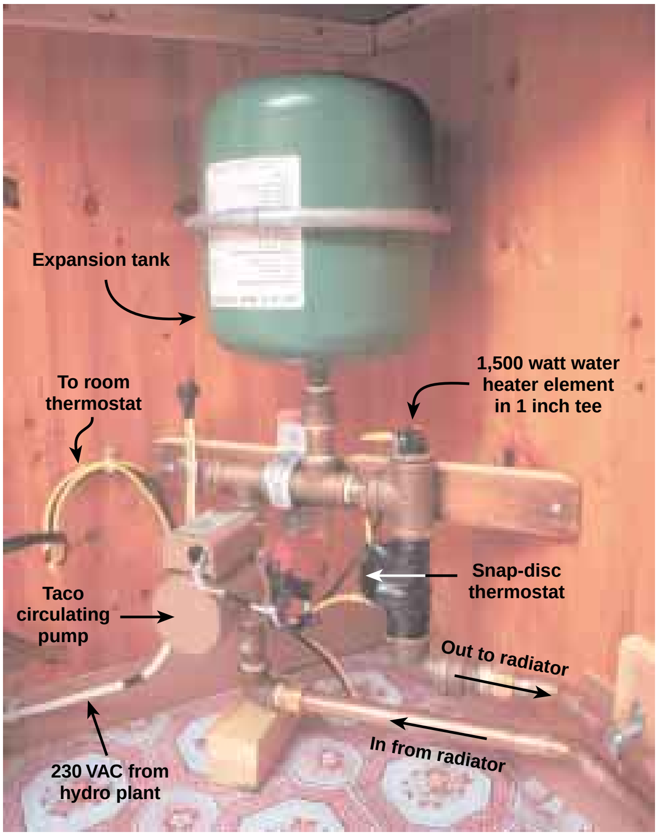
**Thermostatic Control**

There are two thermostats. One is mounted on the wall of the main operating room, and controls the ambient temperature in the building. The other is a snap-disc, wrapped with fiberglass insulation on the outside of the brass T-junction that holds the heating element. A snap-disc is a small diaphragm thermostat which is intended to be surface mounted at a heat source. In this instance it is used at the heating element to prevent burn-out, and to keep the antifreeze from ever boiling.

Besides being noisy, boiling would wreck a closed system with a small expansion tank by creating high pressure. Although the 2 gallon (7.6 l) expansion tank is intended to absorb the increase in both pressure and volume of the fluid as it becomes hot, there is a limit to its ability to do this. Even a small stress leak would be ruinous.

This small hydronic system is intended to pump a moderate amount of heat around the building, and to do so continuously. The thermostats ensure that the system cycles on and off until the building reaches temperature, and then holds it there. Any solar gain through the skylight during the day augments the total heat requirement.

**The hydronic system sends hot water to baseboard radiators throughout the clinic.**




**A Sherpa carpenter builds the corner cabinet to house the hydronic system. System parts are in the foreground.**

There must be a relative balance between the size of the building (800 square feet (75 $m^2$) in this case), and the minimum wattage needed to bring the building to a reasonable ambient temperature. The 1,500 watt heating element was chosen so that the current draw-down would not interfere with the operation of the dental equipment and lighting, while also being adequate to maintain the building at a very comfortable level once the ambient temperature is reached.

I assembled this small system from standard brass pipe fittings from a local hardware store in Oregon. I also shipped the 80 feet (24 m) of Type M 3/4 inch (19 mm) copper tubing and assorted couplings. Three porters walked for eight days to deliver this equipment to the clinic. Air freight is rather expensive in this part of the world.

**Installation**

I was able to return to the clinic in June of 1999 to begin the work. The installation was a bit tricky since the copper tubing had to be sweat-soldered in place. The tiniest leak would have caused me to take much of the tubing apart, and wouldn't be seen until the system was filled with antifreeze. I took meticulous care with my soldering, and was relieved to get it right the first time.

**Author Dennis Ramsey with plumbing in progress.**

We had a Sherpa carpenter with us for a day who made a corner cabinet to enclose the pump/heater. I varnished it the next day to blend with the paneling.

After six days of work, I was able to fill the system with antifreeze, burp out the air, and let the heater operate for a few hours. The slow and gentle heat rising from the radiators warms the whole upstairs of the clinic.

### Welcome Warmth

I spoke with Mingma, one of the dentists at the clinic, by phone from Kathmandu in mid-November, 1999. The clinic also has its own phone now. He informed me that they had been using the system for about three weeks, and that the building is very comfortable. The dentists can now work without fighting the cold in their shoulders and arms, and the patients who walk for miles through the cold to reach the clinic are relieved of their pains by resting in the only fully heated building in Namche Bazaar.

I feel confident that the system will last quite a few years. All of the components are rated for this use, all of the tubing is protected from strain and abuse, and the heating element is thermostatically protected from burn-out. I also provided a kit of spare parts such as replacement heating elements (with wrench), a spare cartridge insert for the Taco pump, and spare snap-disc thermostats.

The loop containing the heater and pump is designed so that the heating element can be changed with the system full of antifreeze, so there is no spillage. Should the pump need maintenance, the cartridge can be changed with minimal loss of fluid. The loop is refilled through the nipple under the expansion tank.

### High Hydronics

The Namche Dental Clinic at 11,500 feet (3,500 m) is probably not the world's highest dental clinic, since both Lima, Peru and Lhasa, Tibet are at higher elevations, and they certainly must have dental clinics. But this may be the world's highest hydronic heating system, or at least the highest one in a dental clinic.

Cheers from Nepal!

### Hydronic System Costs

| *Item* | *Cost (US$)* |
|---|---|
| Motor transport | 486.00 |
| Assorted tools and supplies | 243.75 |
| Taco pump | 183.39 |
| Porterage | 150.00 |
| Four hydronic radiators (4 foot; 1.2 m) | 142.18 |
| Food and lodging | 130.00 |
| Copper tubing | 82.95 |
| Thermostats | 76.83 |
| Brass pipe fittings | 70.00 |
| 2 gallon (7.6 l) expansion tank | 38.90 |
| Heating elements | 30.00 |
| *Total* | $1,634.00 |

### Access

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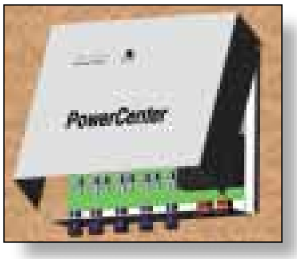


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# TOP SECRET

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

## PROFILE: 0008

**DATE: December, 1999**

**Location: Somewhere in the USA**

**Installer Name: Classified**

**Owner Name: Yeah, right!**

**Intertied Utility: Classified**

**System Size: 130 watts of PV**

**Percent of Annual Load: 3%**

**Time in Service: 3 months**

We've always been into energy conservation. We run compact fluorescent lighting, and turn lights off when we leave the room. We've eliminated most of our home's phantom loads. We dry our clothes on a clothesline, and we're slowly replacing our older appliances with newer, more efficient ones.

Three months ago, we took the next step and got involved in what we like to think of as active conservation. By using PV to produce clean electricity, we offset part of the polluting, coal-fired electricity our reckless, profit-blinded utility sells us.

We purchased and installed a Trace MicroSine inverter and a used 130 watt Sanyo PV. The entire system cost less than a thousand bucks. We installed the MicroSine inside the building rather than on the back of the module, to keep the inverter at a lower operating temperature. The length of the DC wiring between the PV and the inverter is only 48 inches, so voltage drop isn't a problem.

To check out the performance of the system, we did a little plug-and-play with a Brand Electronics watt-hour meter (originally purchased to evaluate our household appliances). On a sunny day, the system produces about 500 watt-hours of clean electricity--enough to offset our daily lighting load.

Why guerrilla? Three reasons. Technically we live in a net metering state. But local RE system owners who have attempted to get utility approval to intertie their systems have been held up by red tape for years. This, by the way, didn't stop any of them from pressing the sell button on their inverters. Technically we also live in a democracy. By going guerrilla, we're casting our vote for a sane energy future. And there's no way the utility can lock this ballot box.

The last reason we went guerrilla has to do with our site. The best solar location is on the roof of an outbuilding several hundred feet from the utility meter. To intertie our MicroSine system, all we had to do is plug the inverter into an AC receptacle inside the building. To meet the standards the utility dreamed up, a separate, lockable disconnect would need to be installed between our MicroSine inverter and the meter. To do this, we'd have to purchase the disconnect and 300 feet of wire and conduit, and dig a 300 foot trench. By the time it was done, this would add at least 50 percent to the cost of the system. All this for a 100 watt inverter that's UL listed to be safe, just like the toaster in our kitchen? Gimme a break.

If the utilities were smart, they'd be pushing RE instead of making it tough for us to install it. They could install dedicated meters on customers' RE systems. As an incentive, the utility would pay customers more than the retail rate for privately produced green electricity. Then they could sell this power at a premium retail rate through their optional green power billing programs. That way, everybody would win. Most of the green pricing programs are selling KWHs like hotcakes. This represents huge earning potential for the utilities, and less pollution for the rest of us.

In the meantime, while we all wait around for the utilities to get their act together, we'll be putting green electricity on the grid anyway. For us, this system is just the beginning. You never know what goes on out behind the barn…

# Things That Work

Tested by Home Power

# Exeltech's XP1100 Inverter

Tested by Richard Perez and Joe Schwartz



The XP1100 is an inexpensive, 1,100 watt inverter that produces super-pure sine wave power. It's reliable, easy to install, and very simple to operate. With a list price of only US$748 for the 12 VDC model and US$820 for the 24 VDC model, the XP1100 is a real bargain.

The XP1100 is a no-frills inverter. It is designed to do one job and one job only—convert DC power into clean 120 VAC, 60 Hz power. This inverter has no battery charger and no sleep circuit, and it will not intertie with the local utility. It is designed for stand-alone RE systems, and when it comes to doing this one job, the Exeltech is superb.

### Shipping Information and Documentation

Exeltech's XP1100 inverter arrived here in March of 1998 via United Parcel Service. Since it's a tiny thing, it's no wonder that it arrived in fine shape and undamaged.

The documentation provided with this inverter is very rudimentary. But the inverter is so easy to install and operate that more extensive documentation would be a waste of paper.

### The XP1100

This inverter is very small in relation to its 1,100 watt output capacity. It is 7.7 inches wide, by 3.6 inches high, by 13.8 inches deep (19.6 x 9.1 x 35 cm). This is roughly the size of half a loaf of bread cut lengthwise. It weighs a mere 10 pounds (4.5 kg).

The XP1100 comes with two 120 VAC receptacles and an on/off switch on the front. The back of the inverter has a removable cover which allows access for wiring the DC cables to the inverter. The XP1100 is conduit ready, and will accept #00 (67 $mm^2$) wire or smaller on its battery input connectors. There is also access to the 120 VAC output on a barrier strip in the rear of the inverter. The 120 VAC output can be hardwired rather than using the NEMA-15 plugs on the inverter's front.

One drawback of this unit is the limited number and size of conduit knockouts. Also, the battery input terminals on the inverter are very close to one another. You have to be careful not to short the positive and negative battery cables during installation.

### Installing the XP1100

In April of 1998, we installed the XP1100 in *Home Power's* main 12 VDC system. This system is serviced by a 1,640 ampere-hour lead-acid battery, about 3 KW of PVs, and a 1 KW wind generator. We wired the XP1100 to the Ananda power center using #00 (67 $mm^2$) welding cable. These cables are short, each only about 24 inches (60 cm) long. Overcurrent protection is supplied by a Class T fuse built into the Ananda.

The XP1100 is easy to install. Just wire it to the battery, plug in to the 120 VAC receptacles in the front, and switch it on. There is nothing to program. Compared to struggling with the complex setup procedures on other inverters, this Exeltech was a breeze to install.

Operating the XP1100 is as simple as it gets. There is only one control—an on/off switch. The inverter will automatically protect itself against electrical overload, over temperature, and input DC voltage which is either too high or too low.


On the 12 VDC model, high voltage cutout is at 16.5 VDC, making this inverter equally at home in lead-acid and alkaline battery systems. Low voltage disconnect is at 10.5 VDC.

**Exeltech XP1100 Inverter Test — 9 December 1999**

| *Input Data 12 VDC* | | | *Output Data 120 VAC* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Battery Volts* | *Amps In* | *Watts In* | *Vpp Out* | *Vrms Out* | *Amps Out* | *Watts Out* | *Efficiency %* | *Power Factor* | *THD %* |
| 12.63 | 0.8 | 10.1 | 167.6 | 119.2 | 0.00 | 0 | | | |
| 12.57 | 2.5 | 31.2 | 167.6 | 119.2 | 0.13 | 15 | 50% | 1.00 | 0.3% |
| 12.56 | 3.9 | 48.5 | 167.6 | 119.2 | 0.24 | 29 | 59% | 1.00 | 0.3% |
| 12.59 | 5.4 | 68.3 | 167.6 | 119.2 | 0.39 | 46 | 68% | 1.00 | 0.3% |
| 12.59 | 8.4 | 105.4 | 167.6 | 119.2 | 0.66 | 79 | 75% | 1.00 | 0.3% |
| 12.56 | 10.1 | 127.1 | 167.6 | 119.1 | 0.81 | 96 | 76% | 1.00 | 0.3% |
| 12.48 | 12.3 | 153.9 | 167.6 | 119.1 | 1.03 | 123 | 80% | 1.00 | 0.3% |
| 12.51 | 14.4 | 179.5 | 167.6 | 119.1 | 1.23 | 146 | 82% | 1.00 | 0.3% |
| 12.44 | 21.3 | 265.5 | 167.6 | 119.1 | 1.88 | 224 | 84% | 1.00 | 0.3% |
| 12.38 | 26.2 | 324.6 | 167.2 | 119.0 | 2.33 | 277 | 85% | 1.00 | 0.3% |
| 12.36 | 30.7 | 379.8 | 167.2 | 119.0 | 2.74 | 326 | 86% | 1.00 | 0.3% |
| 12.26 | 40.1 | 491.8 | 167.2 | 118.9 | 3.60 | 428 | 87% | 1.00 | 0.3% |
| 12.30 | 45.5 | 560.1 | 167.2 | 118.8 | 4.07 | 484 | 86% | 1.00 | 0.3% |
| 12.10 | 58.4 | 706.9 | 166.8 | 118.7 | 5.13 | 609 | 86% | 1.00 | 0.3% |
| 12.10 | 71.9 | 870.5 | 169.2 | 120.5 | 6.06 | 730 | 84% | 1.00 | 0.3% |
| 11.97 | 86.7 | 1037.4 | 168.8 | 120.2 | 7.13 | 857 | 83% | 1.00 | 0.3% |
| 11.96 | 95.8 | 1145.4 | 168.0 | 119.8 | 7.99 | 957 | 84% | 1.00 | 0.3% |
| 11.88 | 112.1 | 1331.2 | 168.0 | 119.8 | 8.88 | 1064 | 80% | 1.00 | 0.3% |
| *Nonresistive Loads* | | | | | | | | | |
| 12.83 | 8.6 | 111.0 | 167.6 | 119.1 | 0.80 | 95 | 86% | 0.87 | 0.3% |
| 12.12 | 91.6 | 1110.6 | 166.4 | 118.6 | 8.08 | 958 | 86% | 0.94 | 0.3% |

**XP1100 Performance**

We used the Exeltech XP1100 to power a variety of office and household loads—computer systems, TVs, stereos, telephones, faxes, compact fluorescent lighting, and some small motors in our solar DHW system. All the telecommunication equipment operates 24 hours a day, and we really appreciate the Exeltech's constant flow of clean power for these loads.

The XP1100 has remained on from April of 1998 to this day. It has been constantly producing power with nary a hiccup! All the loads powered by the Exeltech have operated flawlessly. There is no annoying buzz on the stereos and telephones, and no noise stripes on any of the video displays. In terms of audio noise, the XP1100 is silent to the human ear. The only time it makes any noise at all is when it is heavily loaded and the thermostatically-controlled cooling fan operates. Temperatures in our power room varied from 42 to 94°F (6–34°C).

After 18 months of flawless operation, Joe Schwartz and I decided it was time to measure the electrical performance of the XP1100 using our test instruments. We used three Fluke 87 DMMs to measure DC input voltage, DC input current via a 500 ampere, 50 mV shunt, and both RMS and peak voltage of the 120 VAC output. We used a Fluke 43 Power Quality Analyzer to measure the XP1100's output current, total harmonic distortion (THD), and the power factor of the loads.

The table shows the data we took during this test. We measured the no load power consumption of the XP1100 at 10.1 watts. We ran a variety of resistive loads over the inverter's operating range of 0 to 1,064 watts. The RMS output voltage was rock solid at an average of 119.3 VAC RMS, with a standard deviation of 0.5 VAC RMS during the entire test.

Peak voltage was right on spec, and averaged 167.7 VAC peak. Standard deviation was 0.6 VAC peak during the entire test. This type of exact voltage regulation is what we have come to expect from Exeltech inverters, and their model XP1100 is no exception. During the test, inverter efficiency was 50 percent when powering a 15 watt load, 87 percent on a 428 watt load, and 80 percent on a 1,064 watt load.

The real news in the data table is the total harmonic distortion (THD). Since the Fluke 43 Power Quality Analyzer is a new instrument to us, this XP1100 was the very first inverter we were able to make THD measurements on. THD was 0.3 percent during the entire test, and it never varied. These measurements tell us that the Exeltech makes power of the highest quality.

To give you an idea of how pure this power is, consider this: A utility feels that if it is delivering power with less than 5 percent THD, it's doing a very good job. The XP1100 produces power that is over ten times purer than any utility can deliver to your wall socket! This means reliable and consistent performance from appliances powered by this inverter. Low quality power has more than 5 percent THD and can cause your appliances, especially computer and electronic equipment, to operate erratically and to have a shorter life span.

We usually do inverter testing only on resistive loads because it yields data with higher accuracy for efficiency computation. Just for fun, we decided to take some data when the Exeltech was powering some nonresistive loads. First we powered up three compact fluorescent lamps and Karen's G3 PowerBook computer. The power factor of these loads was 0.87 and the XP1100 still had only 0.3 percent THD. Next we powered up our ancient Sharp microwave oven (958 watts) with a power factor of 0.94; the THD remained a miniscule 0.3 percent. This is truly amazing inverter performance.

**Applications**

This inverter is ideally suited for use in off-grid systems from homes to recreational vehicles. Its low price makes it an excellent choice for large systems that already have a mod sine inverter and require higher power quality to energize computers, TVs, and stereos. The XP1100's superior power quality and reliability make it a good choice for critical communications equipment that operates 24 hours a day.

**Pure & Reliable**

I have two basic criteria for ranking inverters—power quality and power reliability. If an inverter cannot rate high on those two criteria, it has no place in my system. In our testing, the XP1100 had top scores on both counts, with 0.3 percent THD and 18 months of continuous operation without a single outage or problem. Our previous Exeltech Si1000 ran for six years without shutting down once. The only reason we took it off the wall was to install its newer brother, the XP1100.

The Exeltech XP1100 is an outstanding inverter which is sure to satisfy any system's demand for high quality and reliable power. *Home Power's* computers are spoiled; I will not feed them anything less than the finest power. The fact that the XP1100 costs less than similar-sized modified sine wave inverters is just icing on the cake…

**Access**

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## Home Power's

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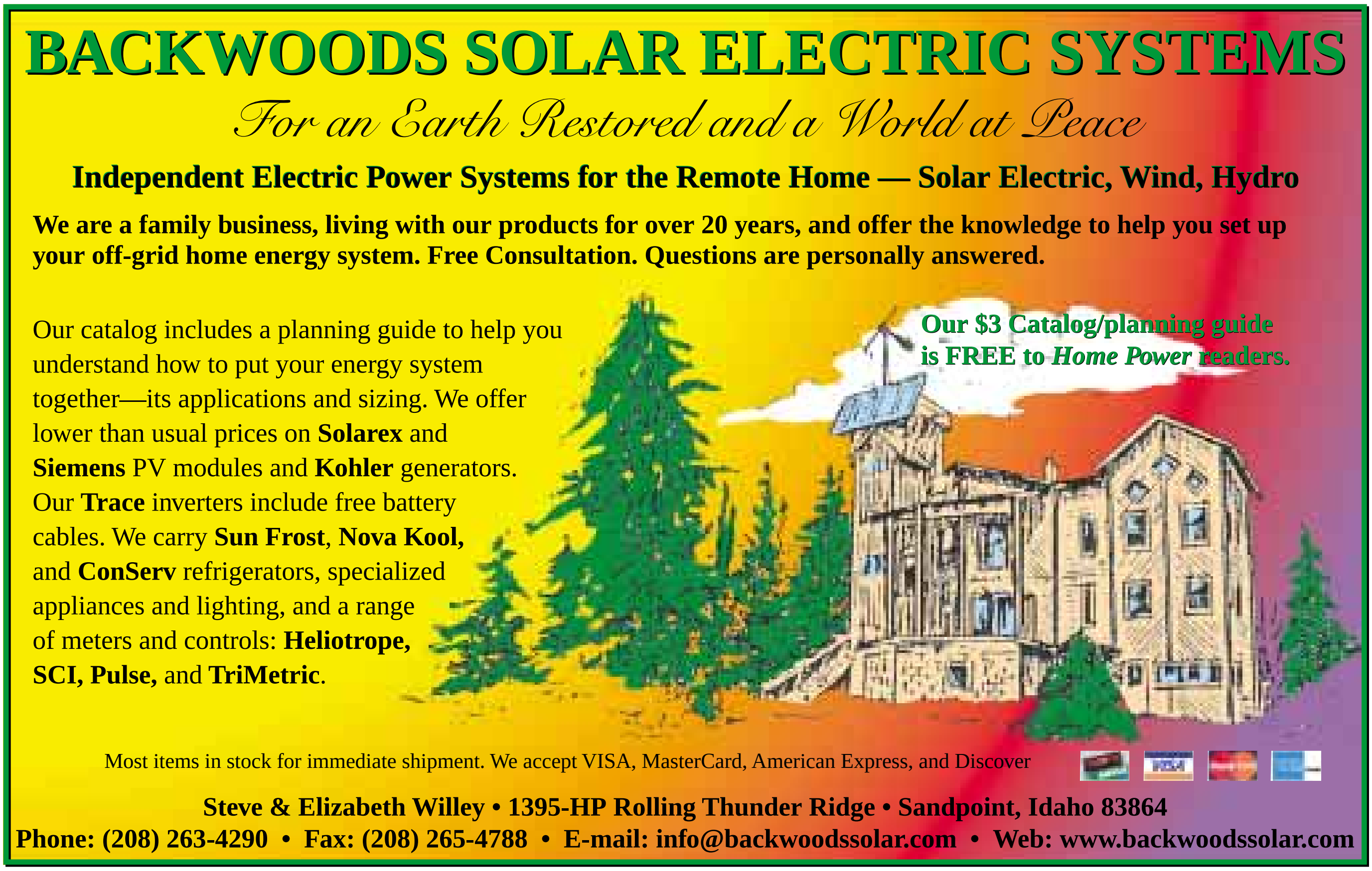

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Things That Work

*Tested by Home Power*

# Surrette 6-CS-25PS Battery

Tested by Richard Perez



This big red Surrette battery is a great choice for energy storage in almost any renewable energy system. Its large size reduces battery interconnections. Its case-in-a-case design reduces battery top cleaning, and increases system safety. The high quality of materials and workmanship make it an excellent long-term battery investment.

### The Surrette 6-CS-25PS

This is a huge brute of a battery. It is 22 inches long, 11 inches wide, and 18 inches high (56 x 28 x 46 cm). This is a six volt battery, and contains three series-connected lead-acid cells. The battery weighs 256 pounds (116 kg) dry, and 318 pounds (144 kg) wet. Each cell contains almost 2 gallons (7.6 l) of sulfuric acid electrolyte, while the whole battery contains about 5.8 gallons (22 l).

With a 1.280 specific gravity sulfuric acid electrolyte, this battery has a capacity of 820 ampere-hours at the C/20 rate, and 1,025 ampere-hours at the C/100 rate. Most PV systems have an average discharge rate of around C/100.

The Surrette 6-CS-25PS uses a case-in-a-case design. In addition to the outer case, each cell each has its own individual case made out of polypropylene plastic. Each cell contains 25 plates, and each plate has a whopping 0.265 inch (6.73 mm) thickness. Each cell has an electrolyte reserve of 3.6 inches (91 cm) above the plates. The three individually-cased cells are placed into the outer case, which is made of high density polyethylene plastic.

The interior cells each have distinct terminals which are bolted together within the exterior case to form the series string. Only two terminals are exposed on the outside of the outer case—the major negative and major positive of the interior six volt series string. On top of the red outer case, each cell has its vent/filler hole with cap.

The manufacturer's suggested retail price of a 6-CS-25PS battery is US$1,358.27. The battery comes with a ten-year warranty against defects in material and workmanship. These batteries are specifically designed to operate in renewable energy systems.

Surrettes are a "Rolls-Royce" battery. They are handcrafted by a small battery company now in its third generation of family management. There are no compromises made in quality or workmanship. This makes them more expensive than other batteries, and best suited for larger, more affluent systems operated by experienced battery users. Due to their long life, I expect them to only be slightly more expensive, in the long run, than the less expensive batteries generally used in RE systems.

**The Test System**

We installed two Surrette 6-CS-25PS batteries on the main system at *Home Power* in March of 1997. After six months of operating this battery, we installed two more of the batteries, for a total capacity of 1,640 ampere-hours at 12 VDC. At the time, the main system was charged by about 2,200 watts of PV modules (about 155 amperes at 14 VDC), a 1,000 watt wind generator, and a 6.5 KW backup generator. System instrumentation is extensive and includes computerized analog to digital data acquisition, an E-Meter, a TriMetric, and an Amp-hour +2 meter.

This system cycles between 10 and 13 KWH daily. The major load on the system is the office, which consumes over 75 percent of the energy. Since the office is normally used during daylight hours, we are able to get by on what is generally considered to be an undersized battery for a system of this size. Nighttime loads usually consume under 2.5 KWH from the battery, so the Surrettes are only cycled about 11 percent of their rated capacity nightly, on average. Most of the energy our system produces is used during the day, as it is produced by the PVs.

**Installation**

I'm not going to say that these huge cells are easy to move. Joe Schwartz and Ben Root did the lugging, and it was tough. When we installed the cells, they were dry, so each battery weighed in at 256 pounds (116 kg). Fortunately there are handles molded into the exterior red case. Without the handles, these cells would have been almost impossible to move.

In our case, dry cells were easier to handle than wet. When one of the cells got knocked over while bouncing up the rough road to our place in the back of Ben's van, there was no mess. The shipping cost is significantly less with dry batteries too. When the manufacturer ships these batteries dry, electrolyte is not included. Once the batteries were in place, we added the sulfuric acid electrolyte, which we obtained from the local battery store (they wondered why we wanted so much of it...).

Wiring the Surrettes into a battery was super simple because the cells are so large. Very few series and parallel interconnects were needed. The terminals on top of the battery are massive—it was easy to bolt on the #4/0 (107 $mm^2$) interconnect and inverter cables. From the battery, we used #4/0 cables to bus the Surrettes into the copper bus bar that encircles the battery room. From there the power is connected via an Ananda power center to the two inverters.

**Using the Surrette 6-CS-25PS Batteries**

I've been using battery-stored power since 1970. There are several characteristics I have come to look for in a battery. Does it hold its voltage high at low states of charge? Does it hold its voltage high during high rates of discharge? Does it recharge efficiently and without undue voltage elevation?

The Surrettes held their voltage over 12.0 VDC when at 50 percent state of discharge and while under moderate loads in the C/50 range. During high rates of discharge (C/5), the battery voltage remained high, well over 12.0 VDC. During our average nightly shallow cycle, the voltage rarely goes below 12.5 VDC. When the Surrettes are recharged, they are almost fully recharged (above 96 percent SOC) before the input voltage reaches 14.8 VDC.

The three battery ampere-hour meters in this system provided much information about how the batteries were used and how they performed. In general, the average nightly depth of discharge was only about 11 percent of the battery's capacity. Deepest depth of discharge was to 64 percent DOD. During the average nightly cycle of 11 percent, these batteries showed recharge efficiencies in the range of 95 to 98 percent, which is very high.

Only during deep discharge cycles to about 50 percent DOD did the battery efficiency drop into the 87 to 88 percent range. We usually have fewer than twenty cycles below 50 percent DOD during a yearly period, all during the winter's cloudy weather. But when the weather here is cloudy, it's usually because a winter storm is moving through, and that means wind power. If all else fails, I start the engine generator so we don't draw the battery down too far.

We currently have over one thousand cycles on these batteries, and they are still performing as they did when they were brand new. According to Surrette's published information, this battery should deliver more than 5,000 cycles, with an average DOD of 20 percent or less. I expect this set of Surrettes to last at least fifteen years before requiring replacement.

Maintenance has been light and easy on these Surrettes, which are equipped with Hydrocaps. The large cells mean that there are fewer cells to water. The increased electrolyte capacity means that watering can be done less often. We check the electrolyte levels every three months and refill the cells—all four batteries use less than a gallon of distilled water.

Keeping the battery tops clean is ultra easy; there is nothing much to do. A combination of the case-in-a-case design and the Hydrocaps (a factory option) keeps all the electrolyte inside the cells. The only other maintenance we do on these Surrettes is routine equalizing charges.

### An Outstanding Battery

The Surrette 6-CS-25PS is a very high quality, deep-cycle battery, ideally suited for use in renewable energy systems. The large cell size reduces battery interconnection and maintenance. The case-in-a-case design increases battery safety while further reducing maintenance. In our almost three-year long test here at Funky Mountain Institute, these batteries have delivered excellent performance. They hold their voltage high during discharge and efficiently accept recharging. All in all, these Surrettes are an outstanding battery.

### Access

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# Things That Work

*Tested by Home Power*

# Concorde Sun Xtender AGM Batteries

Tested by Richard Perez, with help from Sam Coleman



I have always considered sealed batteries to be too delicate for use in renewable energy systems. After a year of testing these Concorde sealed lead-acid batteries, I've changed my mind.

**Concorde Sun Xtender Batteries**

These lead-acid batteries are of the sealed, absorbed glass mat (AGM) type. This means that they never require watering, and can be operated in almost any position, even on their sides. The hydrogen and oxygen gasses, which form when any lead-acid battery is recharged, are recombined within the sealed cells.

These batteries do have safety vents, in case they are grossly overcharged. The plates are separated by a microfibrous silica glass mat. The sulfuric acid electrolyte is absorbed and held captive by capillary action between the mat and the electrolyte. The Concorde AGM batteries have been tested by Underwriters Laboratories (UL) for compliance to UL924 and UL1989 standards. They are UL listed, which means you'll have no problems with the electrical inspector.

We tested two Concorde Sun Xtender batteries, model number PVX-12105. These are 12 volt batteries with a capacity of 105 ampere-hours at a C/20 discharge rate. Each battery is 13 inches (33 cm) long, 6.75 inches (17.15 cm) wide, 9.25 inches (23.5 cm) tall, and weighs 69 pounds (31.3 kg). These batteries cost US$173 each, shipped to Oregon from Northern Arizona Wind & Sun in Flagstaff, Arizona.

**Shipping**

The Concorde batteries arrived here in fine shape via United Parcel Service (UPS). Yes, these batteries can be shipped via UPS, and even transported in an aircraft! Since they are sealed, they meet D.O.T. shipping requirements for a nonspillable wet battery, and are exempted from the hazardous materials category. This can be a major advantage over vented wet cells, which must be shipped via freight. Wet cell batteries are classified as hazardous materials, since the sulfuric acid electrolyte can be spilled.

**The Test System**

In January of 1999, we installed the two batteries in Sam Coleman's cabin system here at Funky Mountain Institute. By wiring the two Concordes in parallel, the resulting 12 VDC battery had a capacity of 210 ampere-hours.

Sam's is a small stand-alone cabin system charged by about 165 watts of photovoltaic (PV) modules. Daily

use on this system averages about 315 watt-hours. In order to assess the performance of the Concorde batteries, we also installed a Cruising Equipment Amp-hour +2 battery ampere-hour meter. We set the RV Power Products Solar Boost 20 PV regulator at 14.2 VDC at 80°F (27°C). This system also has an Exeltech 500 watt sine wave inverter to power 120 VAC appliances.

**Performance**

To say that these batteries worked well would be an understatement. I personally expected them to fail rapidly due to overcharging. In my experiences with sealed lead-acid batteries (mostly of the gelled electrolyte type), even a few hours of moderate overcharging was enough to cause the cells to vent and eventually dry out. Not so with these Concordes. During sunny periods, Sam racked up 15 to 20 overcharge ampere-hours daily, with no damage to these batteries.

Why did the Concordes stand up to this overcharging? They have better electrolyte circulation than gelled cells. The electrolyte in gelled cells is semi-solid (a jelly), whereas in AGMs, the electrolyte is a liquid that wicks around in the absorbed glass mat. This ability to circulate helps get the monatomic (single atom) oxygen and hydrogen together so they can recombine into water.

On one particular occasion, the weather had been cloudy for days. When this happens, I fire up the big engine generator and we recharge all the batteries in all the systems. Well, Sam forgot that the 120 VAC charger was still connected to his system, and the Concordes received a gross overcharge. Their voltage went up to over 15.8 VDC, but they were not damaged by this unintentional abuse. They still work, months later. If a gelled cell vents even once, then it rapidly (within a month) loses a large proportion of its capacity. The Concordes weren't damaged because the oxygen and hydrogen recombined within the cell instead of venting.

At night, when Sam was using the inverter to power the TV and VCR, the Concordes held their voltage high during discharge. Rarely did the battery voltage go lower than 12.45 VDC (battery at 85 percent SOC, with a discharge rate of C/26). Average depth of discharge during this year-long test was about 25 ampere-hours. The greatest depth of discharge was 40 ampere-hours. Sam has a well designed and proportioned PV system, and he manages his loads. During periods of low solar insolation, he reduces his energy consumption.

Sam's cabin can only loosely be called a "conditioned environment." During winter nights, after the wood heater goes out, the temperature routinely hovers around freezing. During hot summer days, the interior temperature of the cabin can reach over 100°F (38°C). The Concordes performed well during these temperature extremes. They hold their voltage well under load even at temperatures around freezing.

The manufacturer rates these batteries to operate from -40°F (-40°C) to 160°F (71°C). The rated capacity of these Concorde AGM batteries is still 80 percent at 32°F (0°C). These batteries perform better in cold temperatures because they have a much lower internal resistance than flooded batteries. The lower resistance allows the electro-chemical reactions of discharging and charging to be more efficient.

One interesting characteristic we noticed was a very low rate of self-discharge. These batteries self discharge only about one-tenth as fast as vented lead-acid cells. The manufacturer rates their self-discharge between one and three percent per month, depending on battery temperature. Regular vented lead-acid cells self discharge about four percent per week.

Here's Sam's comment on these Concorde AGMs: "I've lived on battery-stored energy for seventeen years, and these are the best batteries I've ever used."

**Applications for the Concorde AGM Batteries**

These are truly sealed cells. They are naturals for use in RVs, and in any RE system which has the batteries located inside the living space. There is no need to provide a vented containment. Concorde has had these batteries tested by the U.S. Navy to MIL-B-8565J. This standard allows only 3.5 percent hydrogen concentration during radical overcharges where the battery reaches over 16 VDC and the temperature is at 131°F (55°C). These batteries produced no more than 0.2 to 1.0 percent hydrogen emission—they are safe to use in living spaces.

I'm going to install two Concorde AGMs on our radiotelephone system's base end. This system only gets visited by a human once a year, and the maintenance-free feature of the Concordes will eliminate battery watering.

Folks who are on grid and using inverters in utility intertie situations will appreciate the Concorde AGMs. The batteries can be installed inside, without containments or venting. They are UL listed, which will please the electrical inspectors and insurance companies.

**Thumbs Up!**

The Concorde Sun Xtender AGM batteries changed my mind about sealed lead-acid batteries. No longer do I consider sealed cells to be the "weak siblings" of the battery world. These Concordes are as tough as vented lead-acid cells. They even offer improvements in the areas of low temperature performance and self discharge. And maybe best of all for the experienced battery user, they never require watering. Thumbs up on these Concorde AGMs!

**Access**

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# WTO & Civil Protest

Michael Welch



Just before I headed out for a week at *Home Power's* Agate Flat in December, news reached me about public protests at the World Trade Organization (WTO) talks in Seattle. At the Flat, there is usually a dearth of news. No daily newspapers, no TV, only occasional NPR news, and *Time* magazine arrives several days after most people on the outside have read and recycled it.

While still at home, I had been following major media news, including one of the more progressive daily newspapers, to find out more about people taking to the streets in Seattle. From those early reports, one could assume that every wacko in the U.S. with violent tendencies had descended on that city, wreaking havoc and spreading terror among the citizenry.

I knew something was wrong with that picture. I was aware of several friends and acquaintances who had made the trek. These folks were much different than those portrayed by the media. I knew them as peace-loving individuals, completely committed to the use of non-violent civil disobedience as a tool for change.

### Who Can You Trust?

What could have gone wrong? Could it possibly be that the thousands of peaceful protesters in Seattle were overwhelmed by even greater numbers of their violent counterparts? It turns out that this was not the case. Just as I was leaving town for *Home Power* central, I tuned in to KMUD, the public radio station in Redway,


**Who or what do they protect and serve here?**


**Woman with tear gas protection offers her alternative.**


**Dumpsters ignited by a tear gas grenade were dragged into the streets by protestors to avoid igniting surrounding buildings.**

California. KMUD News is a breath of fresh air in a cloud of mass-media smog.

On the Mud, I heard interviews with people who had been tear-gassed, pepper-sprayed, shot with rubber bullets, and beaten with riot sticks. According to these folks, the real thugs involved were the police! These cops were reacting to nearly all the protesters as if they were committing violence. But there were only very few violent protesters.

In typical KMUD form, the small but venerable news staff had managed to extract the truth. The "major media" was still reporting based on what might sell the most papers. And even worse, they were accepting without question what the WTO and Seattle's police department "public relations" hacks were feeding them. After I got back from *Home Power,* I found that the reporting had changed and was becoming more accurate and fair.

But some damage had already been done. Americans were exposed to the wackiness of the few violent protesters. This helped to sway U.S. opinion against those who were in Seattle to bring attention to the unfair international trade agreements. However, the protesters should have no regrets. This was the first skirmish in the battle. The more direct action and education that takes place, the more public acceptance this fight will have. It is only a matter of time before right prevails, as long as the pressure is kept up.

**Energy Angle**

OK, if I don't talk about renewable energy pretty soon, I may get in trouble with my editors. So far, the WTO has very little to do with energy. But it could have far-reaching consequences for the environment. The WTO has only been in place since 1995, and hasn't had much of a chance to show off its muscle. It is the result of and successor to GATT (General Agreement on Tariffs and Trade), which went into effect in 1948.

WTO may become the tool that multi-national corporations will wield against environmental and labor laws in individual countries. For example, the U.S. may decide to pass a law prohibiting the use of electricity from plants that don't meet certain pollution standards. Then another country, like Mexico (which doesn't have such strict standards), might use the WTO courts to dispute the U.S. laws so that it can sell its cheap, polluting power over the border. A WTO dispute resolution panel might be formed, and the panel may decide that the U.S. environmental laws are acting as a restraint of trade. A party may appeal the resolution of a dispute, but so far, no appeals have been upheld by the "court."

In that case, the U.S. is constrained to uphold the WTO solution to disputes. GATT is a treaty between nations that was ratified by the U.S. Congress. Now we are stuck with it, and bound to the decisions that come out of the WTO panels that hear the complaints. And the worst of it is that these complaints are heard behind closed doors without any public participation at all, flying in the face of what democracy stands for. If the loser of the dispute does not comply, then the winner may be allowed to retaliate by putting in some sort of tariff that favors the winner's trade.

A little bit closer to home, this same scenario could happen with solar modules or batteries. If the U.S. passed laws that placed environmental requirements on manufacturing, and a foreign country that also does manufacturing had no such laws, then they could challenge the U.S. laws based on unfair trade requirements. That might allow them to sell their solar modules or batteries within U.S. borders, even though their manufacturing facilities are horrible polluters.

**WTO versus the Environment**

Not all energy-related WTO interventions are theoretical, however. In the WTO's short life, there have been two far-reaching, energy-related cases that affect environmental quality. Venezuela and Brazil claimed that a U.S. EPA rule aimed at cleaner air quality could affect refineries exporting to the U.S. more than U.S. refineries themselves. This particular case is interesting because first the regulations withstood several challenges available through the U.S. legislative, regulatory, and judicial systems. The Venezuelan government had hired a U.S. lobbying firm to do its bidding. When working within the system failed, the Venezuelan government attacked at the WTO level. The end result was a weakened clean air rule, due to a WTO order.

It is governments, not individuals, that bring complaints to the WTO. Most *Power Politics* readers have a good understanding of what it takes to get government on a particular side—a powerful lobbying force. Do you think that a complaint from an ordinary Venezuelan citizen could make it into a lobbying force and then into the WTO for resolution? No way! Only huge industries have the clout that it takes to line a government up on their side in such disputes.

A second example of the WTO/corporate attack on the environment involves Japanese clean air rules designed to implement the Kyoto Protocol for reducing greenhouse gases. The Japanese government issued new rules for vehicle air standards based on the capabilities of one of the better Japanese auto engines manufactured by Mitsubishi. In 1999, the European Union (EU) complained to Japan and the WTO in a letter that this put an unfair burden on any other country that does not use the Mitsubishi engine. Soon thereafter, the U.S. did the same, on behalf of Daimler-Chrysler and the Ford Motor Company.

These complaints represent several companies that want to make sales in Japan, but don't want to be forced to do it with the environment in mind. They want to sell their polluting vehicles instead of re-designing to meet new environmental rules. At this point, the involved parties are just using the threat of WTO intervention to try to force Japan into complying. There has not yet been any resolution in the case. But there sure is a lot of political weight being thrown around.

**Exercising the Powers We Wish We Had**

If I had my way, I would place a WTO challenge on behalf of the world that would require *all* manufacturers to meet the clean air capabilities of the Mitsubishi engine. But I am just a peon, an individual without power. Most of the WTO cases that we'll see in the coming years will be on behalf of the large and influential multi-national corporations. Expect to see results in favor of the major polluters of the world—the oil companies, car manufacturers, cigarette makers, mining interests, and other large-scale manufacturers.

But without power (the political kind), there is nothing I can do to affect the WTO from the inside; corporations have it all locked up. In fact, none of the WTO dispute resolution methods are open to public viewing, let alone public participation. Only the countries' designated trade officials are allowed to participate. And even though we can hope they do the "official" and non-corporate bidding of their countries, there is no doubt in my mind that our trade "representatives" are there to increase international trade at the expense of labor and the environment.

**Direct Action**

But outside the WTO doors is a different story. Non-violent direct action is making a comeback. People reporting the incidents in Seattle commented that the demonstrations were reminiscent of the Viet Nam War protests of the late '60s and the anti-nuclear protests of the '70s and '80s. Both of those uses of direct action were ultimately successful. I have high hopes that ongoing WTO protests will not only reign in corporate control over international anti-environmental trade concerns, but will serve to empower an entire generation to fix what is broken in many other areas.

My heart goes out to those of you who were injured and abused in Seattle last December. But my thanks and encouragement go out as well, because you are making a difference. Your injuries and inconveniences were not in vain. If history is any indication, the cops and the politicos will take a while, but eventually they will come to understand what we are saying. We can expect to be knocked around until enough people have heard the word, and join in defense of what is right. Keep up the great work. I wish I had been there to lend my voice to yours.

**Access**

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# Exotic EV Batteries:
## *Getting the Lead Out*

Shari Prange 


**Saft brand Lithium-Ion batteries.**

**Question:** What's small and light, safe as distilled water, drives an electric car a thousand miles on a charge, recharges in ten minutes, never needs maintenance, lasts for 10,000 charge cycles, and cures bad breath? Oh, and it's cheap, too.
**Answer: The Miracle Battery.**

Like Elvis, the Miracle Battery is frequently sighted, but never actually touched by human hands. "I saw it on TV…read it in a magazine…heard it on the radio…saw it on the Internet…" and so on. Usually, it's going to be "available in just a few years." Mike Brown, of Electro Automotive, says, "They've been promising me a Miracle Battery within five years for the whole twenty years I've been in the electric vehicle business."

But surely there's something better than plain old lead-acid, isn't there? Well, let's take a look.

### Exotic Chemistry
In simple terms, a battery is a container in which a chemical reaction takes place, releasing electricity. When the battery is recharged, electricity is applied to it, and the chemical reaction inside reverses itself. In the common car batteries we all know so well, the chemical reaction uses primarily lead and sulfuric acid, with a few other elements thrown in for seasoning.

However, there are a vast number of chemicals which could be used to create a similar, electricity-generating reaction. Batteries using chemistry other than lead-acid are known collectively as "exotics."

### Reality Check
When you examine Miracle Battery reports closely, you will find several features in common. Miracle Battery sightings are always exotics. Most of the time, the batteries are not actually in production. Many are at the prototype stage, and often the company is looking for investment capital to begin production.

Or they have a battery suitable for cell phones and laptop computers, and they have made computer projections about what it could do if it were scaled up to run a car. The catch is, when they try to actually scale it up, they discover all kinds of problems that just didn't show up in their projections. For example, sometimes batteries' behavior changes if they are charged and discharged in large groups connected in series instead of as single batteries.

Sometimes the battery will work, but only in carefully handmade test models. In mass production, there is too much variation among units, and it's back to the drawing board. If the batteries do get into successful production, the cost is usually ten, twenty, or even fifty times higher than conventional lead-acid batteries. Often, they are only available to vehicle manufacturers, and are targeted for commercial fleet vehicles.

That said, there *are* some exotic chemistry batteries that are serious possibilities for electric cars. Let's cut through the "vaporware" and look at the most likely candidates that actually exist in the flesh.

### Nickel Cadmium
Nickel cadmium (Ni-Cd) batteries have been around for a long time, with small ones powering consumer electronics, and large ones used in aircraft. The large ones with potential electric car application have been prohibitively expensive for home conversions as new batteries.

However, for safety reasons, aircraft routinely replace a lot of components, including batteries, after a certain

**Comparison of EV Battery Technologies**

| | *Lead-Acid Golf Car* | *Ni-Cd* | *Ni-MH* | *Li-Ion (Three Versions)* |
|---|---|---|---|---|
| Status | Production | Production | Production | Pilot Production |
| Length (inches) | 10.25 | 9.75 | 15.35 | 9.13 |
| Width (inches) | 7.125 | 4.72 | 4.72 | 4.56 |
| Heigth (inches) | 11.125 | 10.23 | 7.67 | 6.88 |
| Weight (lbs) | 67 | 27.55 | 41 | 16.2 |
| Requires maintenance | Yes | Yes | No | No |
| Module voltage | 6 | 6 | 12 | 7 |
| | | | | 10.5 |
| | | | | 21 |
| Capacity (AH at C/3) | 172 | 100 | 96 | 44 |
| | | | | 88 |
| | | | | 132 |
| Specific energy (WH/lb at C/3) | 15.4 | 21.78 | 28.1 | 57.04 |
| Cycle life (hours) | 700 | 2000+ | 1,200+ | 1,000+ |
| Cost each (US$) | 54 | 330 | 2304 | 1848 |
| Cost per KWH (US$)* | 40 | 550 | < 2000 | < 2000 |
| Cost per KWH per cycle (US$)** | 1.23 | 5.28 | 30.72 | 16.63 |

*Based on current production levels.
**Baseline is a home conversion pack of 96V and 172 amp-hours at C/3.
Exotics are compared using multiple battery strings to match voltage and amp-hours as closely as possible.

number of hours in service, well before the end of their useful life. These used aircraft Ni-Cds come onto the consumer market as reconditioned units. Some of these have found their way into electric conversions.

At first glance, it seems that these provide a physically smaller battery pack than lead-acid for the same pack voltage. However, their amp-hour capacity is lower, so it is necessary to run multiple strings in parallel to match lead-acid batteries for range.

They have other drawbacks, too. For one thing, they come in individual cells instead of a multi-cell unit. This means more interconnects, and more potential failure points. Another issue is the highly toxic nature of cadmium. Although more than 99 percent of the cadmium is recycled and used to make new batteries, there are several layers of bureaucratic controls on their handling and disposal, causing some battery distributors to refuse to handle them. Finally, even a pack of reconditioned aircraft Ni-Cds will cost several times as much as a similar capacity pack of lead-acid batteries.

However, there are now Ni-Cd batteries manufactured specifically for use in EVs. Saft makes three “families” of vehicle Ni-Cd batteries. Two of them are heavy-duty units designed for power rather than range. These are intended to be secondary power sources in hybrid

**Saft brand nickel-metal hydride batteries in 12 and 24 volt models.**

vehicles, such as busses, and are the primary vehicle Ni-Cds used in this country.

The third family of Saft Ni-Cds are designed for long range, to be used in pure electric vehicles. These bear a closer physical resemblance to traditional EV lead-acid batteries. They are 6 volt units composed of five 1.2 volt cells. Their white polypropylene cases are slightly smaller than golf car batteries, but have similar automotive or threaded posts. The most immediately apparent difference is weight. The Ni-Cds can save up to 40 percent of the weight of a similar lead-acid pack in some commercial vehicles. A home conversion, however, will need two strings to approximate the capacity of the familiar golf car battery pack, so weight savings will be less.

Although Renault and Peugeot have 10,000 passenger cars on the roads in France using these batteries, they have limited use in the United States. One car that does use them is the Solectria Force. The Ford Th!nk, due to be introduced here in early 2001, will use them also.

Ni-Cds should get periodic equalization charges to 120 percent of “full.” This ensures that the battery pack is balanced, and that all units are at their maximum potential. However, the “memory” problem many of us are familiar with from small, cylindrical Ni-Cds (in which the batteries need to be fully discharged from time to time to maintain full capacity) is not an issue with these batteries. Other maintenance is the same as for golf car batteries: they need to be watered. Although these batteries are well-suited for factory-built EVs, they are still too pricey for most home conversions.

The final question about Ni-Cds is, “How long do they last?” Saft is quoting a cycle life of more than 2,000 cycles for their EV Ni-Cds.

**Nickel Metal Hydride**

Another advanced battery in actual use is the nickel metal hydride (Ni-MH) battery. These are the current favorites of most automobile manufacturers. They were used in the Honda EV Plus, and are in the second generation GM EV1s now available for lease, as well as in the Chrysler Epic van and the Toyota RAV-4 EV.

Compared to Ni-Cds, Ni-MH batteries are lighter, providing even better range. The number that is relevant here is specific energy, which is given in watt-hours per pound or kilogram. The higher the specific energy, the greater the range for the same weight of batteries.

Ni-MHs are sealed batteries. Unlike flooded lead-acid or Ni-Cd batteries, they require no maintenance. There are a couple of variations on the theme of the Ni-MH battery. While the Ovonics batteries from Energy Conversion Devices come in individual cells with metal cases and air cooling, the ones from Saft come in multi-cell plastic monoblock units, with integral liquid cooling.

When GM moved to Ni-MH in the EV1, it was necessary to redesign to accommodate cooling for the batteries. This was extensive enough that it is not possible for the early lead-acid EV1s to be retrofitted with Ni-MH batteries.

Cooling is critical for Ni-MH batteries. Temperature is important to any battery, but more to some than to others. In terms of performance, it is loosely comparable to the common chemical glow sticks used by campers and children. When you snap the stick, a chemical reaction begins inside, and it starts to glow. If it is kept cool, the reaction is slow and the glow is dim, but lasts a long time. If it is warm, the reaction is more vigorous and the stick glows brighter, but burns out faster. With batteries, you can get more power out of them if they are warmer, but you are simply using up the available capacity more quickly.

Another temperature issue has to do with cycle life. At high temperatures, secondary chemical reactions start to take place which degrade the battery’s active material and cause it to “age” prematurely. The goal is to keep them as close to room temperature as possible for maximum life. Temperature is more easily and consistently controlled with liquid cooling. This can be done with a conventional radiator, but it is more effectively accomplished with an air conditioning compressor.

Liquid cooling also opens the possibility of fast charging, recovering as much as 75 percent of charge in thirty minutes. Since this is done using 480 V 3-phase power for input, it is useful for fleets, but not for personal cars charging at home. Ni-MH batteries also require a charge monitoring system, which is separate from the batteries.

The downside of Ni-MH batteries is that they currently cost more than three times as much as Ni-Cds, with only 50 to 60 percent of the cycle life. With volume production, of course, prices will come down, perhaps by a factor of ten, but it is unlikely that Ni-MH will ever approach flooded lead-acid golf car batteries in price. Keep in mind that Ni-MH technology is already in high volume production for small applications, such as laptop computers, where it still exceeds Ni-Cd prices, another mature technology.

**Lithium**

Two types of lithium batteries are commonly mentioned. The most tempting to the imagination is the lithium polymer battery. This is a battery that comes as a moldable flat film. However, at this time it’s in the research and development stage, with production for electric cars still a couple of years in the future.

The other lithium battery is the lithium ion (Li-Ion) battery. This technology is in pilot production and testing now. The Altra EV from Nissan will use Li-Ion batteries from Sony, and Saft has Li-Ion EV batteries in pilot production and vehicle testing as well. The individual cells of these batteries look like AA penlight batteries on steroids. Each is a cylinder a little taller and skinnier than a soda can. For vehicles, Saft bundles these 3.6 volt cells together in a six cell monoblock.

This monoblock is available in three versions, depending on the vehicle's pack voltage needs. With all six cells in series, the battery has a nominal voltage of 21 volts. With two parallel strings of three cells each, the unit voltage is 10.5 volts. Or with three parallel pairs of two cells each, it's 7 volts overall.

The Li-Ion battery has twice the range of the Ni-MH battery, with approximately the same cost, and slightly shorter cycle life. Like Ni-MH, Li-Ion batteries also require an electronic charge management system. In this case, the monitors are built into each monoblock.

**Common Threads**

None of these batteries are available at the retail level. However, Saft indicated that they would sell Ni-Cds and Ni-MH batteries factory direct to anyone interested. All of these batteries use some type of threaded terminal similar to the universal posts commonly found on golf car batteries. These should work better than they do on lead-acid batteries, since they were actually designed for the current draws of a full-sized street car.

Each battery type has its own preferred charging profile. It is critically important to use a charger that is properly matched to the battery pack. All of them take five to six hours to recharge on 240 volts in a home charging situation. This is comparable to lead-acid.

It can be very deceptive to compare batteries based on a single characteristic. For example, cost per battery is meaningless when the batteries have different voltages, amp-hour capacities, and cycle life. Cost per kilowatt-hour compares equal per-charge capacities, but still ignores cycle life. The most balanced comparison would break down the cost of entire battery packs of comparable capacity over each pack's expected cycle life.

**A Perfect Fit**

A flooded lead-acid golf car battery has almost twice the amp-hour capacity at a tiny fraction of the cost of Ni-MH. However, it has half the voltage, half the cycle life, and half again the weight. Which is the "better" battery? It depends on what you need from it.

As Lou Magnarella of Saft succinctly put it, "There is no such thing as the perfect battery." A battery has many characteristics, including range, weight, cost, cycle life, and maintenance. Each battery type has its own areas of strength. The trick is to find the battery that is the best match for your particular situation.

**Access**

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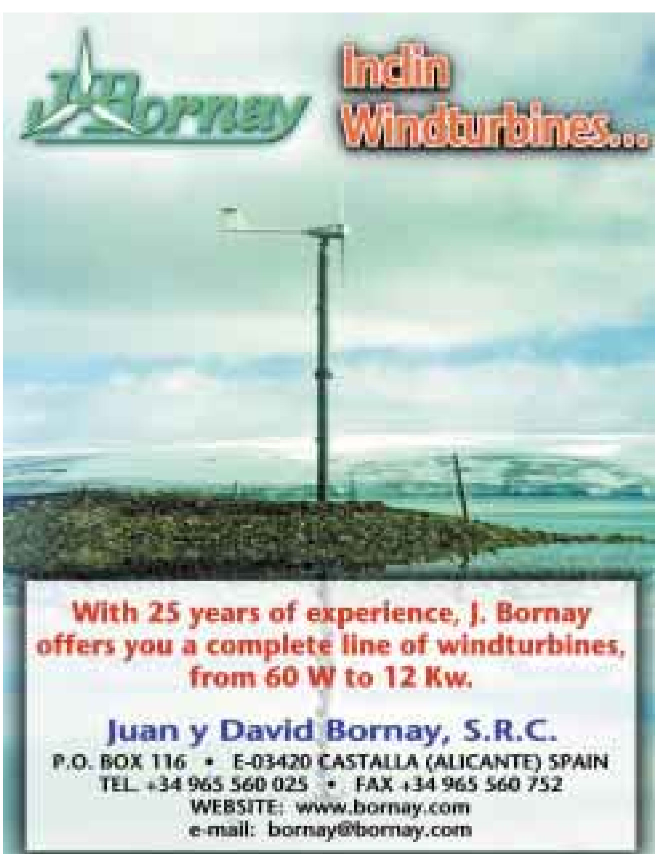

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# EV Tech Talk

**Mike Brown** ©2000 Mike Brown

**I have just bought (been given, inherited) an electric vehicle that doesn't run. How do I get the information I need to get it running?**

This is what I call the Lil' Orphan EV Syndrome. This syndrome has three variations. The first variation is a home-built conversion. The second variation is a product of a "mass conversion" company that has long since gone out of business. In the third variation, the EV is the product of a small company that produced and sold a small number of cars that were built from the ground up as EVs, then went out of business.

Finding the information and parts for these EVs is part detective work, part networking, and part just brute force brain work, tracing wire and cable circuits by eye and with a volt/ohm meter.

**Home-Built Conversions**

With the home-built conversion, your best hope lies with the person who did the conversion. If the converter is available and able to help, restoring the EV to running condition should be fairly easy.

In the event that the builder of the EV is not able to help, your next source of information is any documentation that came with the EV. I have seen examples of documentation ranging from nothing at all to a full notebook covering every aspect of the conversion, with full color wiring diagrams. One man had even gone so far as to have his wiring diagrams laminated in plastic to protect them from damage.

If all you received with the EV was a tattered envelope with a few receipts for the components, you might be able to get copies of the original instructions (if any) from the component manufacturers. If there's a receipt for a complete conversion kit, and the kit supplier is still in business, contact them to see if they can supply you with their assembly instructions.

Another possible source of information is the Electric Auto Association. If there is an association chapter where the car was converted, somebody there might remember the conversion, or even have helped to do it. Even if this isn't the case, the members of a chapter near you could be a source of much valuable information and help.

If you are still stuck with no documentation or wiring diagrams, brute force reverse-engineering is your only choice. What you will need in order to do this is:

- A copy of my *Convert It* manual to help identify components and get an idea of how a conversion should be done.
- *Home Power* magazine, *61 & 62,* for my articles on troubleshooting a dead EV.
- An auto-ranging digital multimeter.
- A "project notebook" to record your findings, and any notes on changes you might make.
- A box of colored pencils for drawing color-coded wiring diagrams in the project notebook after you have it all figured out and running. Remember, you might not be the last owner of this EV.

Follow the procedure given in the troubleshooting articles. Usually problems in the battery pack are pretty evident, such as a bad battery or batteries, an open interconnect, or a blown fusible link in the series string.

In my experience, the place where home converters seemed to get the most "creative" is where the car's existing 12 volt electrical system and the high voltage/low amperage part of the traction battery pack come together. All manner of relays (most of which are unnecessary) get inserted to control other relays, which in turn control main contactors, voltmeters, and other supporting components. About all you can do in this area is start at the 12 volt auxiliary battery with your multimeter, and work your way through it. Do your testing carefully. It's a jungle under that hood.

Careful methodical testing of the high voltage and low voltage systems and their interface may reveal a simple problem that is easily solved. Or it may point to a failed

**The Trans 2 is a decent little neighborhood EV, now "orphaned."**

component, such as a controller or motor. In addition, the troubleshooting process will give you an understanding of your EV.

**EVs From a Mass Converter**

If you are searching for information on one of these EVs, it helps to know the players. In the late 1970s and early ‘80s, around the time of the second “gasoline crisis,” there was a big increase in interest in EVs. This came from both the general public and the federal government, but there was very little interest on the part of the major manufacturers. Suddenly, there was a demand for EVs, with the majors unable or unwilling to fill it. Several small companies were formed to fill the demand, and some of them produced conversions that are still in use today.

One company in Texas, Jet Industries, converted Ford Courier pickup trucks, Ford Escort sedans, Dodge Omni hatchbacks, and those tiny Subaru “vans,” which were smaller than VW Bugs. These were well designed, well built conversions with state-of-the-art components. The documentation consisted of service manuals comparable to those issued by major manufacturers, with illustrations and wiring diagrams.

These cars and trucks were sold primarily to government and utility company fleets for use in “fleet test demonstrations.” After their fleet time was done, many of these EVs were bought by members of the general public. They were refurbished and upgraded with modern components, and are now part of the biggest EV fleet of all—the civilian fleet.

The large number of these cars still in use and the excellent original documentation provided with them makes information about them easier to come by than it is for some of their contemporaries. Again, the local chapter of the Electric Auto Association would be a good place to look for help. Perhaps the best source of information on Jet Industries EVs is Stan Skokan in Mountain View, California. Stan has been a dealer for Jet EVs for many years, and has refurbished and returned many Jet EVs to daily use. For those of you reading this who don’t yet have an EV but want one, Stan has several like-new Jets for sale.

The Lectric Leopard is another mass conversion EV that is still with us. This EV was a Renault LeCar converted by U.S. Electricar Corporation of Athol, Massachusetts (remember that name, it comes back later). Not as many Leopards were produced as the various Jet models, but a lot of them have been updated and are still in use. Documentation and circuit diagrams are scarce. I have a one-page wiring diagram for the version with an SCR speed controller, and a five-page explanation and test document for the SCR controller. I also have a wiring diagram and instructions for upgrading the car with a Curtis/PMC controller.

There were other mass converters during this period, but their output was so low that finding or recreating documentation and wiring diagrams for any surviving cars would be similar to the process for home-built conversions mentioned above.

**Same Song, Second Verse**

The early 1990s saw another surge of interest In EVs brought on by environmental concerns, the introduction of the Impact EV by General Motors, and worries about gasoline supplies brought on by the Gulf War. This time the demand for EVs came mostly from the general public, with less attention from government and utility fleets.

This change in the market brought about the founding of many custom conversion businesses doing one-off conversions for private owners. Some of these ventured into mass conversion on a smaller scale than previous companies. Levels of standardization and documentation varied widely. Orphan cars from these converters should be approached like home-built conversions, as described above.

One company in California, Solar Electric Engineering, started out in the EV industry refurbishing used EVs. These included several Lectric Leopards it acquired when it bought the assets of U.S. Electricar, along with the rights to the name. In addition to playing the name game (it went from Solar Electric Engineering to Electric Motor Car Corp to U.S. Electricar), the company converted Pontiac Fieros, Ford Escorts, and in the last round of conversions, Geo Prizms and Chevy S-10 trucks.

I have worked on several of these EVs and assisted by phone, email, and snail mail in the troubleshooting and repair of several others. But I have yet to see any wiring diagrams or documentation. They may be out there somewhere, but I couldn’t find them.

Solar Car Corporation in Florida did quite a few one-off conversions for individuals, and toward the end of its existence did a run of S-10 trucks for fleets. I have only seen some early documentation from them, and there wasn’t much to it. Maybe the fleet conversions came with more detailed information.

Eco Electric in Arizona built a run of very nice S-10 pickups with documentation to match. If the information package stayed with the truck, you should have no trouble reviving it.

There is one bright note in all this list of the dear departed EV companies. The most successful of all the mass converters is Solectria in Wilmington, Massachusetts. They have been converting Geo Metros into Solectria Forces for many years for both the civilian and fleet market, and have moved on to other types of vehicles. All their EVs are fully supported in parts, service, and technical information.

The amount of effort involved in reviving a mass-converted EV varies from simply following the book for a well-documented conversion, to tracing one circuit at a time as you would for an undocumented home-built conversion.

**Mass-Produced Purpose-Built EVs**

This section could almost be dedicated to one EV, the Sebring Vanguard Citicar. With over 2,000 Citicars built, it is probably the most recognized EV in existence, with the possible exception of the GM Impact/EV1. Built in Sebring, Florida by Bob Beaumont in the 1970s, it has an almost cult status among EV enthusiasts.

The good news for those true believers is that Bob Beaumont was an experienced new and used car dealer at the time he started building the Citicar. This automotive experience produced a complete documentation package for each of the dealerships that he set up to sell the EV. The package included a parts book, a service manual (complete with job descriptions and the flat rate time allowed for each job), and a complete set of wiring diagrams. This information has survived the years in several hands (mine included), and is copied and distributed as and where needed.

The Citicar became the Comuta-car after the assets of Sebring Vanguard were purchased by Commuter Vehicles, Inc. The Comuta-car and a variation called the Comuta-van, which was aimed at a US Post Office contract, were produced in smaller numbers, and I have never seen any documentation for these vehicles.

There are several other orphan EVs such as the Tropica (another Bob Beaumont project), the Trans 2 neighborhood car, and no doubt others I missed as they went by. Keeping up with the EV world is hard, but help is available on the Internet.

Recently I got a call from a woman who had a dead Trans 2. The dealership that sold it to her would no longer work on it because the Trans 2 company had gone out of business. My first step toward fixing this EV was to post a request for information on the Electric Vehicle Discussion List on the Internet. Within two days, I was told that the assets of the Trans 2 company had been bought by Global Electric Motors, and was given a URL (Web site address) for the company. A trip to the Web site gave me an email address, which led to a phone number and some very helpful people who gave me advice and sent a wiring diagram. The dead Trans 2 will be back on the road soon.

**The Destination Is Worth The Trip**

Reviving a dead orphan EV can be a hard, dirty, and often expensive job. Having the right information can give you a place to start and a path to follow.

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So if you have an orphan EV you need help with, contact me. If it is a Jet Industries car, get in touch with Stan Skokan. If you are online, subscribe to the Electric Vehicle Discussion List (it's free) and post a request for help. If you are not online, contact me and I'll post your request for you.

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Electric Vehicle Discussion List
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# Wŏrd Pow´ẽr

## Renewable Energy Terms

# Photovoltaic Cell— Semiconductor device that converts light into electrical energy

Ian Woofenden



*Derivation: "Photo" is from Greek "phos, photos"—of or produced by light. "Voltaic" is from "volt," named after Alessandro Volta—producing electrical pressure or voltage.*

A photovoltaic (PV) cell directly converts light energy into electrical energy. It is *light* from the sun—not heat—that is used; crystalline cells are actually more effective when cool. Each cell develops about half a volt of DC electrical potential. The maximum amperage of the cell is proportional to its surface area. We most often see series strings of about 36 cells put together to charge a 12 volt system. We call these "modules" or "panels."

The photovoltaic effect was first discovered in the late 1800s. Scientists noticed that light shining on crystalline selenium produced a current. Later, researchers found that silicon was more effective as a base material. In our present day PVs, the silicon is doped with boron, phosphorous, gallium, arsenic, or other materials. This creates loosely bound electrons, easily liberated by incoming photons (energized light particles). It also forms the "p-n junction," a region that naturally pushes those freed electrons through an electrical circuit to do useful work.

The photovoltaic cell is overlaid with a grid of conductive wires which are connected together and eventually go to the battery terminals or the load. When the photons bump the electrons through the p-n junction, the electrons follow the rest of the circuit set up by the wires and battery.

Hugh Piggott says PV is "the energy shortcut—from the source to the ultimate goal in one conversion." There are no moving parts in this beautiful system. Only the photons and electrons move, and there are plenty of them to go around. One of my favorite demonstrations of this technology is the pump in the bucket. Connect a small PV module to a bilge pump that's in the bottom of a five gallon bucket full of water. Put the PV in the sun and watch the pump run. I've enjoyed seeing young children, scientific folk, and even my local backhoe operator become excited about PV's potential after seeing this simple demonstration.

One closing note on the word: While we in the industry are very comfortable saying "photovoltaic" and "PV," the terms seem mysterious to many people. I think it's often better to say "solar-electric" when speaking to the uninitiated. When we say "solar panels," lots of people think of solar thermal panels, an entirely different technology which gathers the sun's energy in the form of heat. "Solar-electric" is a much easier phrase for most people to understand, and it clearly distinguishes the two different technologies.

**Access**

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# Pulse Width Modulator

## *for 12 and 24 Volt Applications*

G. Forrest Cook



A pulse width modulator (PWM) is a device that may be used as an efficient light dimmer or DC motor speed controller. The circuit described here is a general purpose device that can control DC devices which draw up to a few amps.

The circuit may be used in 12 or 24 volt systems with a few minor changes. This device has been used to control the brightness of an automotive tail lamp, and as a motor speed control for small DC fans of the type used in computer power supplies.

**Pulse Width Modulation**
A PWM circuit works by making a pulsating DC square wave with a variable on-to-off ratio. The average on time may be varied from 0 to 100 percent. In this way, a variable amount of power is transferred to the load. The main advantage of a PWM circuit over a resistive power controller is the efficiency.

At a 50 percent level, the PWM will use about 50 percent of full power, almost all of which is transferred to the load. A resistive controller at 50 percent load power would consume about 71 percent of full power; 50 percent of the power goes to the load, and the other 21 percent is wasted heating the dropping resistor. The PWM circuit will typically waste well under 1 percent of the power, depending on the load current. It takes a constant trickle of power to operate, so the efficiency improves with higher power loads.

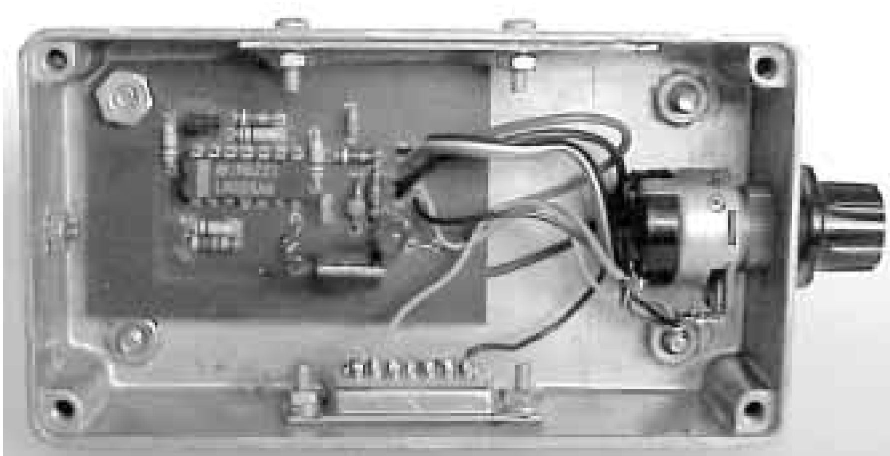
**Advantages**
Load efficiency is almost always a critical factor in renewable energy systems. An additional advantage of pulse width modulation is that the pulses are at the full supply voltage and will produce more torque in a motor by being able to overcome the internal motor resistances more easily. A resistive speed control will present a reduced voltage to the load, which can cause stalling in motor applications. Finally, in a PWM circuit, common small potentiometers may be used to control a wide variety of loads, whereas large and expensive high power variable resistors are needed for resistive controllers.

**Disadvantages**
The main disadvantages of PWM circuits are the added complexity and the possibility of generating radio frequency interference (RFI). RFI may be minimized by locating the controller near the load, using short leads, and in some cases, using additional filtering on the power supply leads.

This circuit has some RFI bypassing in the form of a capacitor (C3) across the load, and produced minimal interference with an AM radio that was located under a foot away. Radio interference was undetected at greater distances. If additional filtering is needed, a car radio line choke may be placed in series with the DC power input. Be sure not to exceed the current rating of the choke.

**Theory**
The PWM circuit requires a steadily running oscillator to operate. U1a and U1d form a square/triangle waveform generator with a frequency of about 400 Hz. U1c is used to generate a 6 volt reference voltage which is used as a virtual ground for the oscillator. This is necessary to allow the oscillator to run off a single supply instead of a +/- voltage dual supply.

U1b is wired in a comparator configuration and is the part of the circuit that generates the variable pulse width. A comparator is a circuit in which the op-amp's output is true or false depending on whether the voltage on the op-amp's plus input is higher than the minus input (true) or vice versa (false). U1b pin 6



**Pulse Width Modulator Specifications**

| *Item* | *Specification* |
|---|---|
| PWM frequency | 400 Hz |
| Maximum current with IRF521 FET | 9 A continuous, 27 A peak |
| Maximum current with IRFZ34N FET | 26 A continuous, 100 A peak |
| PWM circuit current | 1.5 mA at 12 V with no LED and no load |
| Operating voltage | 12 or 24 V, depending on the configuration |

receives a variable voltage from the R6, VR1, R7 voltage ladder. This is compared to the triangle waveform from U1d pin 14. When the waveform is above the pin 6 voltage, U1 produces a high output. Conversely, when the waveform is below the pin 6 voltage, U1 produces a low output. By varying the pin 6 voltage, the on/off points are moved up and down the triangle wave, producing a variable pulse width.

Resistors R6 and R7 are used to set the end points of the VR1 control. The values shown allow the control to have a full on and a full off setting within the travel of the potentiometer. These part values may be varied to change the behavior of the potentiometer.

Q1 is the power switch. It receives the modulated pulse width voltage on the gate terminal and switches the load current on and off through the source-drain current path. When Q1 is on, it provides a ground path for the load. When Q1 is off, the load's ground is floating. Care should be taken to insure that the load terminals are not grounded or a short will occur. The load will have the supply voltage on the positive side at all times.

**The controller with a DC muffin fan.**

LED1 is optional and gives a variable brightness response to the pulse width. Capacitor C3 smooths out the switching waveform and removes some RFI. Diode D1 is a flywheel diode that shorts out the reverse voltage kick from inductive motor loads. In the 24 volt mode, regulator U2 converts the 24 volt supply to 12 volts for running the PWM circuit. Q1 switches the 24 volt load to ground, as it does for the 12 volt load. See the schematic for instructions on wiring the circuit for 12 or 24 volts.

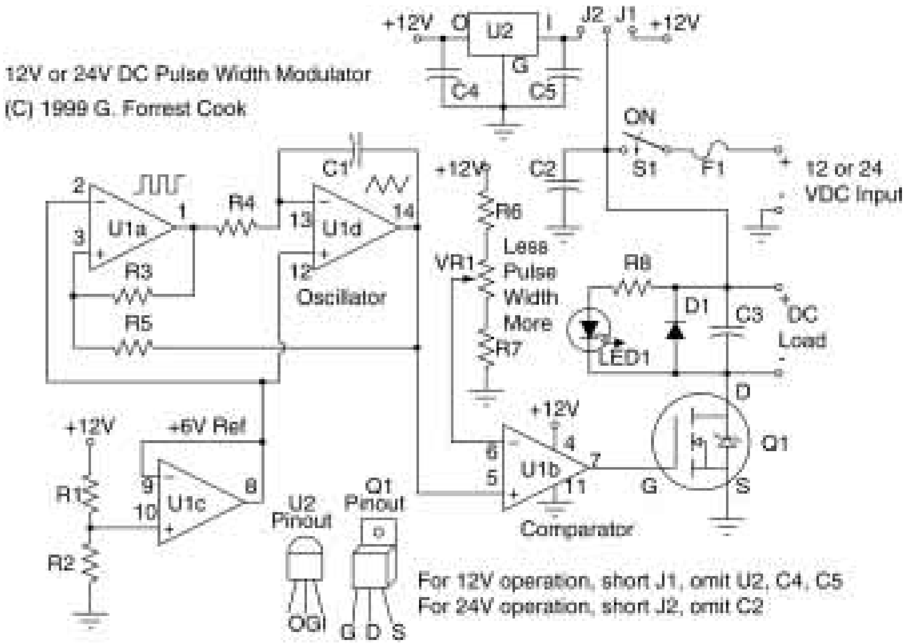
At the 1 amp current level, no heat sink is needed on Q1. However, if you will be switching more current, a *large* heat sink is *mandatory.* Q1 may be replaced with a higher current device such as an IRFZ34N. All of the current handling devices, switch S1, fuse F1, and the wiring between the FET, power supply, and load should be able to handle the maximum load current.

To prevent shortening the life of the FET, it is advisable to run the circuit below the maximum rated current. Eighty percent of maximum is a safe range to work with. Inductive loads such as motors have huge peak current ratings, and exceeding the ratings of the FET will guarantee part failure. Take into account the maximum current for the motor when it is stalled. High power motor controllers require extra clamping circuitry for reducing high voltage spikes. This is usually done with zener diodes across the FET D-S terminals. Information on such circuitry is beyond the scope of this article—consult the data sheets from the FET manufacturer (International Rectifier Corp, www.irf.com).

**PWM Parts List**

| | |
|---|---|
| U1 | LM324N quad op-amp |
| U2 | 78L12 12 V regulator |
| Q1 | IRF521 N channel MOSFET |
| D1 | 1N4004 silicon diode |
| LED1 | Red LED (any kind should work) |
| C1 | 0.01 µF ceramic disc capacitor, 25 V |
| C2–C5 | 0.1 µF ceramic disc capacitor, 50 V |
| R1–R4 | 100 K 1/4 W resistor |
| R5 | 47 K 1/4 W resistor |
| R6–R7 | 3.9 K 1/4 W resistor |
| R8 | 2.7 K 1/4 W resistor |
| VR1 | 10 K linear potentiometer |
| F1 | 3 A, 28 VDC fast-blow fuse |
| S1 | toggle switch, 5 A |

**PWM Schematic**

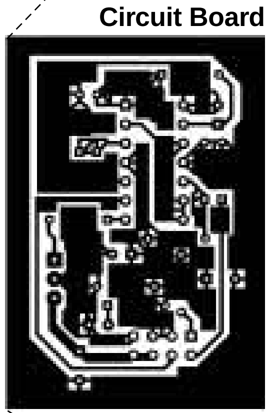



## Construction

The prototype for this circuit was constructed on a regular IC proto board, with parts and wires stuck into the proto board holes. One version of the finished circuit was used to make a variable speed DC fan. The fan was mounted on top of a small metal box and the PWM circuit was contained inside the box.

I built a simple circuit board using a free circuit board CAD program, PCB, which runs on the Linux operating system. The circuit board image was printed with a PostScript laser printer onto a mask transfer product called Techniks Press-n-Peel blue film. The printed film is then ironed on to a cleaned piece of single sided copper-clad board.

**PWM Circuit Board**

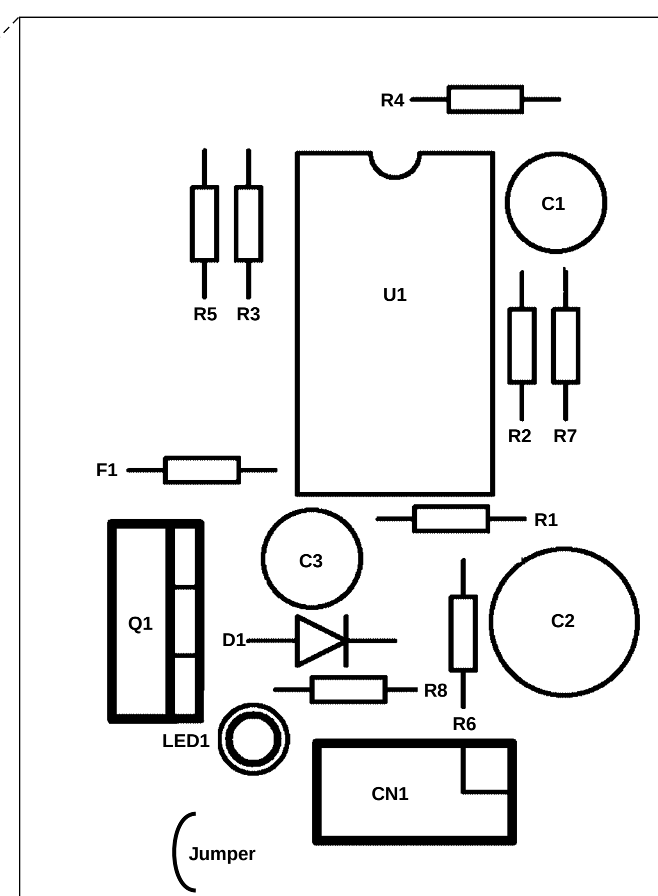


The circuit board is etched with ferric chloride solution. A board pattern is shown at right. This may be photocopied onto a piece of Press-n-Peel blue film. The circuit board and parts layout are available for download from www.homepower.com. Holes are drilled with a fine gauge drill bit, parts are soldered in, and the board is wired to the power and load. This technique is great for producing working boards in a short time, but is not suitable for large numbers of boards.

Alternately, the "dead-bug" construction method may be used. The name "dead-bug" comes from the appearance of the circuit board, with chips and parts strung together at random angles. This involves taking a piece of blank copper PC board, gluing a wire-wrap IC socket to the board with five minute epoxy, then soldering all of the parts to the wire wrap pins. Grounded pins can be soldered directly to the copper board. No alignment should be necessary with this circuit.

The PWM component locations pictorial is shown from the parts side—solder on the other side of the board. The circuit board is for the 12 volt version of the circuit. It may be used for 24 volts by wiring an external 12 V regulator for the +12 V

**PWM Component Locations**



supply, and moving the parts at the DC load + terminal to 24 V power.

Circuit board connections for CN1 (pin 1 is marked with a square):

1 VR1-low
2 VR1-high
3 +12 V power from fused line
4 VR1-center
5 Load +
6 Spare ground
7 Load -
8 Ground return for 12 V power

**Use**

This circuit will work as a DC lamp dimmer, small motor controller, and even as a small heater controller. It would make a great speed control for a solar-powered electric train. I have not tried the circuit with larger motors. In theory, it should work in applications such as a bicycle motor drive system. If you experiment with this, be sure to include an easily accessible emergency power disconnect switch in case the FET shorts on.

Keep in mind that the pulse current through DC motors will be many times the average motor current rating. The FET will be destroyed if its specifications cannot handle the full pulse current. FETs may be wired in parallel to increase their current.

Wire the circuit for 12 volts or 24 volts as per the schematic, connect the battery to the input terminals, and connect the load to the output terminals. Be sure not to ground either of the output terminals, or anything connected to the output terminals, such as a motor case. Turn the potentiometer knob back and forth; the load should show variable speed or light.

**Access**

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www.eklektix.com/gfc/ • PC Board PostScript files: www.eklektix.com/gfc/elect/solarcirc/pwm1/index.html

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Don Loweburg



# Still Waiting

In the last issue, I covered some problems with the proposed IEEE 929 standard, and some related inverter issues that were responsible for frequent grid disconnects in net-metered systems. As that article went to press, sources within the IEEE standards community assured me, and *Home Power,* that the proposed standard would be revised so that inappropriate grid disconnects would not occur.

Well, the standard will be revised as of January, 2000, but that doesn't mean we're out of the woods on this issue. Trace is still shipping the old chip, even though they know it's a dud, and that the IEEE has changed the standard. They are slow to fix the problem, and aren't telling customers what's up. By shipping the old chip, they are setting grid-tied customers up for problems.

PG&E is still requiring the old limits, because the IEEE standard has not actually changed yet. They are jamming Trace with a requirement they can't meet, and creating barriers by demanding performance that is not available.

This entire brouhaha (see *Things That Used to Work, HP74,* page 122) surfaced in late September, 1999 when I attempted to install an "upgrade" chip in a grid-connected inverter. Feeling confident that Trace Engineering had had time to change the chip programming to comply with the newly revised IEEE 929 standard and improve their internal voltage calibration, I ordered another chip. Trace customer service very quickly sent another chip, but the chip had the same programming as the first one, sent two months earlier.

There seems to have been a total disconnect between all the conversations I'd had with the engineering, marketing, and customer service departments at Trace. This astounds me. Though most Trace inverters are installed outside California, the service territory of PG&E (the local utility) includes over one third of all California utility customers. This is not an inconsequential market.

For at least the last four months, none of these customers have been able to legally net meter without the upgrade chip that is being required by the local utility. But that's a chip that still does not work reliably when installed! Customers are being held hostage, caught between PG&E and Trace Engineering. What would you wager on the percentage of these customers who are connecting to the grid anyway? Trace and PG&E, congratulations! You are major drivers of the guerrilla solar movement in California.

### Guerrilla Solar Goes Global

Readers of *Home Power* are aware of the numerous methods that utilities have employed to thwart the growth of independent power. Methods include blocking or limiting the scope of net metering laws, imposing expensive and unreasonable technical interconnection requirements, requiring high priced liability insurance, and bureaucratic stonewalling.

Against this backdrop, we have witnessed the rapid growth of what has become known as the guerrilla solar movement. This movement is fueled by utility behavior. It should be no surprise that utilities in other countries are reacting, predictably, like their U.S. counterparts when faced with independent generation.

The following excerpt from an article in the August-September 1999 issue of *Photon,* a German PV magazine, details the emergence of a global guerrilla solar movement. The article is titled *The Waiting Game—Implementing Spain's New Feed-In Regulation Faces Obstacles.* The author, Michael Schmela, describes how Spanish utilities are obstructing the implementation of Spain's rate-based incentive program, enacted on December 23, 1998.

The program supports up to 50 MW of new PV. Here are some all-too-familiar points made in that article. The author is quoting two Spanish PV project installers: "The law does not define the technical specifications for the grid connection.… And with grid connection being a new issue to grapple with, each of Spain's dozen utilities requires different standards and regulations.…"

"We connected our PV system to the grid without the agreement of the utility…[because] a contract that demands the investor to charge per bill, to fulfill superfluous security needs adapted to big co-generation plants and the installation of four meters—one for the inverter's own consumption, one for electricity consumption, one for production, and a last one to measure the difference—is ridiculous."

And regarding another project; "We are going to install ten systems and see how the utility will react." I believe this assertive attitude is exactly what is needed in order to confront utility barriers. We could use more of this at the institutional level in this country.

**Latest PV Market Statistics**

Strategies Unlimited is a market analysis company that collects data on a number of high tech industries, including PV. Our company, among many others, participated in a recent market survey. In consideration of our participation, Strategies Unlimited shared the results of that survey with us. With their permission, I am sharing those results with *Home Power* readers. Please note that 1999 figures are estimates.

Wholesale module prices declined 5 percent during 1998–99, from US$3.99 (per rated watt) in 1998 to US$3.79 in 1999. During the same period, U.S. market share of global module shipments went up from 13 to 15 percent. More significantly, the total U.S. module market went from 16.6 MW to 24.1 MW. This represents a 45 percent increase in the U.S. market. Global shipments went from 130 MW in 1998 to 164.4 MW in 1999, a 26 percent increase. Relatively, the U.S. market grew at almost twice the global rate.

Another view of the U.S. market is provided by data on product distribution. In 1998, 70 percent of sales occurred through distributors, while the remaining 30 percent was sold directly by manufacturers. In 1999, distributor sales increased 5 percent while direct manufacturer sales declined 5 percent. This trend is consistent with the growth of a PV infrastructure, including companies that design, install, and service systems. Having a competent, trained infrastructure will remain crucial to the continued growth of the PV industry, domestically and globally.

A final view is provided by examining the U.S. market by application type. During 1998–99, industrial applications declined 7 percent, grid-connected increased 5 percent, off-grid increased 1 percent, and consumer applications increased 1 percent. Allowing for the fact that the majority of the grid-connected applications are residential rooftop systems and that the off-grid consists mainly of water pumping and residential, it can be seen that the U.S. market is strongly dominated by end user applications. For 1999, the total percentages by category are: industrial, 26 percent; grid-connected, 41 percent; off-grid, 28 percent; consumer, 5 percent. Almost 75 percent of the market is in end user applications.

**What the ?**

The following is quoted from the same issue of *Photon* mentioned earlier. Headline: "BP Solar and Shell Solar searching for electricians."

"Both BP Solar and Shell Solar began early this summer to get electricians and roofers on board to install PV systems. These small and medium-sized companies [electricians and roofers] are still barely involved in the German PV market because nearly 600 specialized PV installing companies currently cover the market. 'But they won't address new clientele,' states Gerwin Dreesmann of German BP Solar."

If 600 specialized PV installing companies cover the market, why the need to recruit installers? Roofers and electricians are probably "barely involved" because they are not qualified to do the work. Based on my experience in the construction industry, roofers are probably the least qualified to install PV.

The only time I hear this line about roofers installing PV is when a suited corporate type, who most likely knows nothing about construction, is talking about lowering the cost of installed PV! Further, the remark, "But they won't address new clientele," implies that there must be more PV work in Germany than the 600 specialized PV installing companies can handle. I doubt that.

What is really going on here? Are BP and Shell attempting to "restructure" the existing PV industry? Perhaps these corporate giants prefer to work with "partners" over whom they can exert control. I would surmise that the specialized German PV installing companies bear many similarities to U.S. installing companies. We have independent entrepreneurships built on vision, risk-taking, and hard work. These are companies used to doing business in a competitive environment.

Perhaps BP and Shell don't want to work in a truly competitive market. I believe these corporations are committed to reducing competition. If that is so, all of us who have built our companies from the ground up should keep a keen eye on the corporate sector and make sure that we behave and engage in business practices that truly further our best interests.

## I Bought My System On the Internet and I Need Some Help

So began Bob's desperate plea. He may have initially imagined the "system" he bought to be plug and play. But when the boxes and crates began arriving, and he had not a clue as to what they were, Bob knew he was in trouble.

The components weren't bad name brands. But a lot was wrong: The system advertised as capable of running a 240 volt AC water pump turned out to be a single inverter system. The German diesel turned out to be from China. Bob got wimpy 1/0 battery interconnects not adequate for a high power system. The single charge controller supplied was not sufficient for the number of PV modules he bought. In the end, it cost Bob about US$7,000 over and above his original purchase price to upgrade and install the system.

Bob got off easy. Several weeks after Bob's system was installed, I got a call from Keith, Bob's friend in Costa Rica. Bob and Keith had both bought from the same Internet company. Keith wanted me to fly down immediately and repair his system. Keith's bigger problem was that he also had the Internet PV company install the system. I could not help Keith, but here is a summary of his Internet experience. (A US$20,000 lesson).

These were the main problems:

- Undersized array wiring
- Batteries, generator, and inverter housed too close together
- Loose connections
- AC run from inverter to house undersized
- System poorly designed for load
- 240 VAC service never hooked up
- Promised labor not completed
- No combinor box for the four wind generators
- Poor siting of wind generators
- Poor mounting of wind generators that required re-mounting

These problems all came from the fact that the installer-seller was not qualified.

### Everybody Loses

The point here is that the customer is being hurt. Also, the PV industry gets a black eye from experiences like this one. The core of the problem is that the customer is led to believe that PV systems are "units." How many calls have I gotten asking for information on a "solar unit"?

The fact is that these systems are complex, and do not consist of hardware only. The systems must be properly designed for specific tasks. Considerable craft is required to install and interface with the customer's existing electrical system. Proper interfacing may require the installation of sub panels and transfer switches, significant projects in themselves.

Many customers are misled by low component prices either in print or on the Internet. When merchandise is sold at 5 percent over cost, it is difficult for installing companies to match these prices. However, the customer needs to be aware that there is more to a system than boxes of equipment.

Customers need to know the total installed cost, and to value the expertise required to do the job correctly. The cut-rate deal seldom ends up being a good deal overall. In both cases cited above, local installers ended up fixing the problems, but the final cost to the customer was more than if they had had the local installer do the job in the first place.

## Take Off the Blinders

The PV industry has an identity crisis. On the one hand, the average person on the street understands that with solar "you can disconnect from the utility." Intuitively they grasp that independent power and utility power are antithetical. And yet many PV manufacturers think that PV should be deployed within the utility system. This may be due to their belief that utilities represent an easy market for PV.

Many environmental groups share a similar view. For them, using the utility system to deploy PV is the "easy" way to achieve their environmental goals. Out of this unholy alliance of PV manufacturers, utilities, and environmental groups we have inherited mushy thinking. It's thinking that is reflected in mushy words like, "win-win," "collaborative process," and "partnering relationships."

I don't see an easy path. I see a tough road ahead. Why would we expect the entrenched energy monopolies to roll over? Shouldn't we expect them to create barriers at every turn? There is hope though, and it lies with the *users* of energy. The transformation will be from the bottom up. And at that level, PV and independent power is unstoppable—one roof at a time, one happy customer at a time.

### Access

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# Road to the 2002 Code

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

On November 1st, proposals for changes to Article 690 of the 1999 *National Electrical Code* were received at the National Fire Protection Association (NFPA). These proposals represent a coordinated input from more than 30 people in the PV industry (The Photovoltaic Power Industry Forum). If these proposals are accepted in either an "as submitted" or edited form, they will appear in the 2002 *National Electrical Code (NEC).* The proposals and the substantiation for each are presented below.

The actions of the *NEC* Code-Making Panels on these proposals will be available from the NFPA as a Report on Proposals due out in late July 2000. Comments from anyone—including the general public—will be received at NFPA until October 27, 2000. All proposals were submitted by the Photovoltaic Power Industry Forum; Ward Bower, Chairperson; John Wiles, Secretary.

**Figure 690.1(A) Identification of solar photovoltaic system components**
Proposal: In this figure, the Blocking Diodes have been drawn incorrectly as an arrow with a line on top. They need to be redrawn with the correct symbol for an electronic diode. See Figure 690-7 in the *NEC Handbook.*

Substantiation: Corrects drafting error.

**Figure 690.1(B) Identification of solar photovoltaic system components in common system configurations**
Proposal: In the Stand-Alone System figure, label the unmarked box at the bottom of the figure: "Energy Storage."

Substantiation: This label was accidentally left off the submission for the 1999 *NEC.*

**690.2 Definitions**
Proposal: Add the following definition:

Diversion Charge Controller. Equipment that regulates the charging process of a battery by diverting power from energy storage to direct-current or alternating-current loads or to an interconnected utility service.

Substantiation: Required to define devices used in this article.

**690.2 Definitions**
Proposal: Add the following definition:

Bipolar Photovoltaic Array. A photovoltaic array that has two outputs, each having opposite polarity with respect to a common reference point, sometimes called a center tap.

Substantiation: Required to define devices and connections used in this article.

**690.2 Definitions**
Proposal: Delete the definition of System Voltage and replace with the following:

Photovoltaic Systems Voltage. The direct current (dc) voltage of any photovoltaic source or photovoltaic output circuit. For bipolar or multiwire installations including 2-wire circuits connected to bipolar systems, the PV systems voltage shall be the highest voltage between any two dc conductors.

Substantiation: Defines terms used in this article and updates terminology.

**690.4(B) Conductors of Different Systems**
Proposal: Delete the text in this section and replace with the following:

Photovoltaic (PV) source and PV output circuits having disconnects from the PV energy source shall be permitted in the same raceway or junction box with circuits from non-photovoltaic systems. Photovoltaic source and PV output circuits shall be permitted in the same raceway or junction box with other circuits from the same PV system.

Substantiation: The intent of the basic requirement is to prevent PV source and output circuits that may normally be energized during daylight periods from being in the same raceway with circuits of other electrical systems that are unrelated to the PV system. In many cases there are no disconnects in these PV circuits and they are always energized during daylight hours. Repairs and operations on these "other system" circuits might be affected by the always-energized PV circuits. "Other system" circuits include ac grid power conductors, telecomm circuits, or radio frequency cables. The term "other systems" was not clear, and the text has been revised accordingly. The text was also revised from the negative to the positive.

The first sentence of the proposed addition allows same-raceway installations if the PV circuits have an available disconnect provision that can de-energize these PV circuits. These PV source and output circuits then become no different than any other circuit in a multiple circuit raceway.

The second sentence recognizes that persons working on any circuits associated with the PV system (inverter ac outputs, control circuits, etc.) will be aware of the nature of the PV source circuits and take proper precautions. It allows any circuits from the same PV system to be in the same raceway without restriction.

**690.4(C) Module Connection Arrangement**
Proposal: Delete the last two sentences from this paragraph.

They are: Sets of modules interconnected as systems rated at 50 volts or less, with or without blocking diodes, and having a single overcurrent device shall be considered as a single-source circuit. Supplementary overcurrent devices used for the exclusive protection of the photovoltaic modules are not considered as overcurrent devices for the purpose of this section.

Substantiation: These sentences conflict with the requirement established by labels on listed photovoltaic modules for a series module protective fuse on each module or string of modules. The first sentence in this section establishes the safety requirement. The industry is now using source circuit combiners to meet the requirement.

The labeling requirements for modules are being coordinated with Underwriters Laboratories (UL) to indicate on the module label or in the instructions, the maximum number of modules that may be connected in parallel.

**690.5(B) Disconnection of Conductors**
Proposal: Revise the last sentence to read as follows:

Opening the grounded conductor of the array or faulted sections of the array shall be permitted to interrupt the ground-fault current path.

Substantiation: Corrects grammatical error in the 1999 *NEC.*

**690.6(A) Photovoltaic Source Circuits**
Proposal: Correct the spelling of “photovoltaic” in the second sentence

Substantiation: Corrects spelling error in the 1999 *NEC.*

**690.6(D) Ground-Fault Detection**
Proposal: Replace the existing text with the following:

Alternating current (ac)-module systems shall include a ground-fault detection device to reduce fire hazards. A single detection device shall be permitted for each system (one or more modules). That device shall detect ac ground faults, indicate the fault, and disconnect the alternating-current module(s) from the ac source.

Substantiation: Revised text requires the device and clarifies the requirement. The 1999 *NEC* did not require the device, only permitted it.

**690.7(A) Maximum System Voltage**
Proposal: Change the title of the section to:

(A) Maximum Photovoltaic System Voltage

And add the word “photovoltaic” in the first sentence between the words “maximum” and “system.”

Substantiation: Clarifies the section and makes it consistent with new definitions and other sections of this article.

**690.8(B)(1) Devices With Internal Current-Limiting**
Proposal: Overcurrent protection for photovoltaic output circuits that supply devices that internally limit the current drawn from that photovoltaic output circuit shall be permitted to be rated at less than the value computed in 690.8(B). This reduced rating shall be at least 125% of the limited-current value. An overcurrent device in an assembly listed for continuous operation at 100% of its rating shall be permitted to be used at 100% of its rating. Photovoltaic output circuit conductors shall be sized in accordance with Section 690.8(B).

Substantiation: This addition allows the use of a smaller overcurrent device than the calculation in 690.8(B) normally requires. The reduction is allowable because certain listed devices such as charge controllers and inverters can limit the maximum current that can be drawn from a source circuit.

The second sentence ensures that the overcurrent device will not be operated at more than 80% of its rating.

The final sentence ensures that the conductors are properly sized to handle fault currents from the photovoltaic source that could result from faults on the photovoltaic side of the overcurrent device.

**690.9(C) Photovoltaic Source Circuits**
Proposal: Add the following second paragraph:

The standard values of supplementary-type overcurrent devices allowed by this section shall have ratings in one-ampere increments from one to 15 amperes. Higher standard values shall comply with Section 240.6(A).

Substantiation: Article 240.6(A) sets standard values for class-type fuses. This Section allows listed supplementary-type fuses. Module-protection fuse requirements established by UL and the module label require fuses with ratings between 5 and 20 amps. For example, to increase the 8-amp required value of a module-protection fuse to the first standard value of 15 amps would create a safety problem. This proposal defines and requires that the proper fuse value be used.

**690.9(E) Combined Photovoltaic Module and Source Circuit Protection**
Proposal: A single overcurrent device shall be permitted to meet the conductor protection requirements established by Sections 690.8 and 690.9 and the photovoltaic module overcurrent protection requirements established by labels on the module.

Substantiation: UL instructions and labeling require that a series module-protection fuse be used to protect each module from reverse currents. In series-connected strings of two or more modules, only a single overcurrent device is required to protect all of the modules in the string. The rating of this overcurrent device is normally the same as or greater than the rating of the code-required overcurrent device to protect the module interconnection conductors. Frequently, a single overcurrent device can be used to meet both of these requirements.

**690.9(F) Conductor Ampacity When Using Parallel-Connected Modules**
Proposal: Where a single overcurrent device, allowed by Section 690.9(E), is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of (1) and (2).

(1) The rating of the single fuse.

(2) 125% of the short-circuit current from the other parallel-connected modules.

Substantiation: Under fault conditions, the individual module conductors will be required to carry currents through the fuse from batteries or other sources plus 125% of the short-circuit currents from the other modules.

**690.14 Additional Provisions**
Proposal: Delete the existing sentence and replace with: Photovoltaic disconnecting means shall comply with (A) through (C).

Substantiation: Photovoltaic source circuits have unique properties that are different from utility service entrances. The unnecessary reference to Article 230 causes some AHJs to require unnecessary or unsafe equipment. Article 690 contains all necessary requirements for disconnecting means. Section 690-14(C) is added in a separate proposal.

**690.14(C) Grouping**
Proposal: The photovoltaic disconnecting means shall be grouped with other disconnecting means for the system. A photovoltaic disconnecting means shall not be required at the photovoltaic module or array location.

Substantiation: To comply with the code requirements for grouping all disconnects of a power system in a single location, it is necessary to have the photovoltaic disconnecting means grouped with the other disconnecting means. Although photovoltaic modules and arrays may be located some distance away or on the roof, there is no requirement for a disconnect at the source because the source is energized in daylight whether or not the disconnect is opened.

**690.31(B) Single-Conductor Cable**
Proposal: Add USE-2 to the three acceptable cable types in the first sentence.

Substantiation: Many photovoltaic module installations operate at temperatures that require a 90°C, wet-rated, sunlight resistant single-conductor cable. USE-2 meets these requirements, is commonly available, and is the most appropriate cable for this application.

**Table 690-31(C) Correction Factors**
Proposal: Change the last two Fahrenheit (°F) temperatures as follows:

Change 141-149 to 141-158

Change 150-158 to 159-176

Substantiation: Corrects errors in the table

**690.41 System Grounding**
Replace the existing contents with the following:

For a photovoltaic power source, one conductor of a two-wire system with a system voltage over 50 volts and the reference (center tap) conductor of a bipolar system shall be solidly grounded or shall use other methods that accomplish equivalent system protection in accordance with Section 250.2(A).

Substantiation: Updates the terminology to be consistent with new definitions and definitions in the 1999 *NEC.* Moves the exception into the basic requirement. All equipment in the code is required to be listed so that 1999 *NEC* requirement for listed devices is not needed. The proposal also merges the FPN into the requirement to ensure that the device used is fully defined.

**690.45 Size of Equipment Grounding Conductor**
Proposal: Replace the existing paragraph with the following:

Where not protected by the ground-fault protection equipment required by Section 690.5, the equipment-grounding conductor for PV source and PV output circuits shall be sized for 125% of the PV-originated short-circuit currents in that circuit. Where protected by the ground-fault protection equipment required by Section 690.5, the equipment-grounding conductors for PV source and PV output circuits shall be sized in accordance with Section 250.122.

Substantiation: When Underwriters Laboratories (UL) recently listed a PV combiner enclosure, they determined that ground faults in PV source and output circuits can result in continuous currents from the PV array flowing through the equipment-grounding conductor even after all overcurrent devices have tripped. This determination indicates that the equipment-grounding conductor for these circuits should be able to carry the currents from the PV sources. These equipment-grounding conductors should be sized at only 125% of the short-circuit current (Isc) since the additional 125% derating for continuous operation is not required. The equipment-grounding conductor (sized at 125% Isc) might be one size smaller than the circuit conductors (sized at 156% Isc) in a few systems.

If the system has a Section 690.5 ground-fault protection device installed, then the interruption of the fault current will prevent these PV currents from flowing in the equipment-grounding conductor and the increased size is not necessary. In this case, the requirements of Section 250.122 are appropriate.

**690.51 Modules**
Proposal: Delete this section

Substantiation: These requirements duplicate the requirements established by UL Standard 1703 and are required on the labels of all modules. This section is no longer needed.

**690.52 Alternating-Current Photovoltaic Modules**
Proposal: Delete this Section

Substantiation: These requirements duplicate the requirements established by UL Standard 1703 and are required on the labels of all modules. This section is no longer needed.

**690.55 Energy Storage**
Proposal: Photovoltaic power systems employing energy storage shall also be marked with the information in (1) and (2).

(1) Maximum operating voltage including any equalization voltage

(2) Polarity of grounded circuit conductor

Substantiation: These additional markings will facilitate the inspection, maintenance, and operation of the system.

**690.56 Exterior Location**
Proposal: Any structure or building with a photovoltaic power system capable of acting as a Stand-Alone System shall have a permanent plaque or other label placed in a visible location on the exterior of the building or structure with the notice (1) and information (2). For structures with a utility service entrance, the label shall be located adjacent to the service entrance, exterior meter socket, or exterior utility disconnect.

(1) "This structure contains a Stand-Alone Electrical Power System"

(2) Location of system disconnects (PV, battery, and other energy sources).

Substantiation: Facilitates the rapid shut down of all power to a building in an emergency.

**690.64(B)(5) Load Side**
Proposal: Delete this section

Substantiation: With utility-interactive inverters, this section is not needed. Circuit breakers, used to conduct currents from a utility-interactive inverter into a load center, may be subjected to faults on the inverter side of the breaker. While the breaker may carry normal operating current in a reverse direction, any overcurrent tripping in a fault situation is in the normal forward direction.

Other sections of the code (not this one) may require clamping backfed breakers, but this is not necessary since these breakers, if removed while being used, immediately become de-energized or dead due to the de-energizing circuits in the connected inverter.

**690.71(D) Nonconductive Cases**
Proposal: Flooded, vented, lead-acid batteries with more than 24, 2-volt cells connected in series (nominal 48 volts) shall not use or be installed in conductive cases. Conductive racks used to support the nonconductive cases are permitted where no rack material is located within six inches of the tops of the nonconductive cases.

FPN: This requirement does not apply to any type of valve regulated lead-acid battery (VRLA) or any other types of sealed batteries that may require steel cases for proper operation.

Substantiation: Battery cases of flooded, lead-acid batteries made of steel or other conductive materials must be grounded to meet the requirements of this code.

Acid and dirt films on the tops of the cells created during the normal charging and equalizing processes form conductive leakage paths between the circuit conductors and the grounded cases. These leakage paths may lead to higher and higher fault currents that can result in fires and explosions.

Attempts to float or otherwise electrically isolate these conductive cases may result in a shock hazard between the cases and the grounded racks or conductive floor. Paint or other thin insulating films have not proven effective in isolating grounded cases.

Sandia National Laboratories has documented battery fires, explosions, and shocks to qualified service personnel over the last five years on battery systems employing metal cases.

The FPN is added for explanatory reasons. This proposal does not apply to any type of valve regulated lead-acid battery (VRLA) or any other types of sealed batteries that may require steel cases for proper operation.

**690.71(E) Segmented Batteries**
Proposal: Battery circuits, subject to field servicing, where there are more than 24, 2-volt cells connected in series (nominal 48 volts) shall have provisions for qualified persons to disconnect the series-connected strings into segments of 24 cells or less for service. Non-load-break bolted or plug-in disconnects are permitted.

Substantiation: Working on high-voltage strings of batteries is inherently hazardous, even for qualified persons. Breaking the strings into not more than 24-cell segments allows the individual cells or batteries to be serviced at voltages of 48 volts (nominal) or less. While it is optional with the servicing person to break the strings, the provisions for such disconnects should be required. Some battery systems are installed with welded inter-cell connections that cannot be disconnected without cutting cables.

The hazard is significantly reduced for batteries operating below 48 volts nominal. No problems have been documented using metal cased batteries at 48 volts nominal in forklift truck applications.

Some high-voltage sealed (VRLA) battery systems are sealed in a container at the factory and are not serviced in the field. They would not be subject to this requirement.

**690.71(F) Floated Batteries for Maintenance Operations**
Proposal: Battery installations where there are more than 24, 2-volt cells connected in series (nominal 48 volts) shall have a switched disconnect, accessible only to qualified persons, that ungrounds the battery electrical system for maintenance. This switch shall not unground the remainder of the PV electrical system. The use of a non-load break rated switch shall be permitted.

Substantiation: Battery systems, due to the presence of conductive acid films on batteries, are inherently hazardous to service. By allowing the qualified maintenance person to unground the battery, the hazards may be somewhat reduced even when protective clothing, proper tools, and correct procedures are used. Since it is generally acknowledged that a floated, high-voltage battery is safer for servicing, the requirement is mandatory.

The hazard is significantly reduced for batteries operating below 48 volts nominal and is not required for these lower-voltage systems.

**690.71(G) Ungrounded Battery Systems**
Proposal: On photovoltaic systems where the battery system consists of more than 24, 2-volt cells connected in series (nominal 48 volts), the battery system shall be permitted to operate with ungrounded conductors provided that conditions (1) through (4) are met:

(1) The photovoltaic array source and output circuits shall be solidly grounded.

(2) The dc and ac load circuits shall be solidly grounded.

(3) All main ungrounded battery input/output circuit conductors shall be provided with switched disconnects and overcurrent protection.

(4) A ground-fault detector and indicator shall be installed to monitor for ground faults in the battery bank.

Substantiation: This proposal permits high-voltage (above 48-volts nominal) battery systems to be operated in an ungrounded state if the listed conditions are met. Certain types of power processing equipment (inverters) can be designed for this type of operation. This proposal may be most likely applied on higher voltage (above 200 volts) systems. This ungrounded operation may increase long term reliability and fire safety in the system.

**690.72(A) Diversion Charge Controllers–Independent Backup**

Proposal: A photovoltaic power system employing a diversion charge controller as the sole means of regulating the charging of a battery shall be equipped with a second, independent means to prevent overcharging of the battery.

Substantiation: Diversion controllers are connected between the battery and a diversion load. This external circuit will have overcurrent protection. If the controller fails, if the diversion load is sized improperly, or if the overcurrent device opens during a fault or is manually operated, the battery charging process is no longer regulated. In systems using the inverter to divert excess battery current into the utility grid, the inverter may fail or the utility grid may go down.

An independent or backup charge regulating system is needed to improve the safety on those systems having diversion controllers. See related new proposal 690.72(B).

**690.72(B) Diversion Charge Controllers–Overcurrent Protection and Ampacity**

Proposal: Circuits containing a direct-current diversion charge controller and a direct-current diversion load shall comply with (1) and (2).

(1) The current rating of the diversion load shall be rated at least 150% of the current of the diversion charge controller.

(2) The conductor ampacity and the rating of the overcurrent device for this circuit shall be at least 150% of the maximum current of the diversion charge controller.

FPN: This requirement does not apply to ac or dc circuits using inverters that control the battery charging process by feeding power into the utility lines. Such circuits are used in several modes and must be sized and protected in a normal manner as required elsewhere in Article 690.

Substantiation: If the diversion load is undersized or if the overcurrent device in the circuit of a diversion charge controller opens from overloads due to excess diversion currents, the charge control process is lost and the battery may be over charged creating a safety hazard. Requiring the 150% rating on the diversion load, the overcurrent device, and the cable ampacity is consistent with other systems that could create hazardous conditions when overload protection is included. See Section 240.3(A). The 150% rating provides the necessary short-circuit protection.

The FPN is added for explanatory reasons. This requirement does not apply to ac or dc circuits using inverters that control the battery charging process by feeding power into the utility lines. Such circuits are used in several modes and must be sized and protected in a normal manner as required elsewhere in Article 690.

**Code Corner Online**

The Southwest Technology Development Institute Web site (www.nmsu.edu/~tdi) is now online. It has all of my *Code Corner* columns, an index of frequently asked questions, plus an Adobe Acrobat PDF copy of my manual, *Photovoltaic Power Systems and the National Electrical Code: Suggested Practices.*

**Questions or Comments?**

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

**Access**

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# Home & Heart

Kathleen Jarschke-Schultze



I've had several e-queries, asking if I still love my Staber horizontal-axis washing machine. Also, readers have been asking what I know about energy efficient clothes dryers. Since I am not able to test all the different brands of appliances, I will share with you the choices I have made, and why.

**Staber First**

Yes, I still love my Staber washing machine. It was sent to me to test in 1995. The machine I have was already on the west coast, and was being returned because of a dent on the side. Staber rerouted it to me so I could run a real-life, off-grid test. After I used it (see *HP47 TtW!),* I was not willing to let go of it. Rather than ship it back to Ohio, I bought it.

At the time, the Staber was the only super-efficient washer on the market. Since then, other manufacturers have developed and are selling clothes washers just as frugal with electricity and water. The Staber, however, is the only washer that retains its guarantee while being used on an inverter-based power system.

The only problem I have had with my Staber is a broken belt. We called Staber and they immediately sent out a replacement, free. I have heard from other Staber owners, and they are effusive in their praise of the machine and the company.

A caution: Frank at Crystal Pines Renewable Energy says the Frigidaire Gallery washer, a super-efficient front loading washer, will not run on any inverter power but full sine wave. Although the warranty on most appliances do not specify RE systems as grounds for invalidation, it would be a "don't ask, don't tell" situation. Kind of like guerrilla housewife. Hey, I like that.

**Hung Out to Dry**

On the subject of super-efficient clothes dryers, I have to admit that the absolute best for resource use is the sun. The problem is that the sun is not always available to use. Sure you may have a wood stove, so you could string your laundry around your house. I am here to tell you that that gets really old, really fast. Sun drying is a seasonal option at best.

**Frigidare Gallery stackable gas dryer.**

**Dryer History**

When my parents retired to Paradise (California, that is), they gave me their old gas clothes dryer. My dad got me the small orifice which was needed to adapt the dryer from town gas (natural gas) to country gas (propane). Bob-O and I remodeled the basement bathroom into a laundry room. The toilet in there never did flush properly. We were always afraid someone would try to use it, so we removed it. The dryer was a nondescript brand and model. I don't even remember what it was. But it was certainly old—I do remember that.

It did dry the clothes. But you had to run it through two 50 minute cycles to get one load of clothes dry. I was resigned to this. I thought maybe it had something to do with the fact that I was using propane, although I really didn't know why. Then my cousin Denise told me that her old dryer did the exact same thing. She lives in town and uses grid power and natural gas. It wasn't the gas; it was the age of the machine.

After that revelation, I was determined to get a new dryer. Of course I had to shop for one. The dryer I dreamed of was of the stacking variety. It had to fit in the corner of my tiny laundry room. I wanted it to stack on top of a home-built cabinet, which I could use for storage.

You see, three walls of our basement are surrounded by earth. The fourth wall is cinder block up to about waist high, and wood above. Since the dryer exhaust pipe had to go through the wood to the outside, my old dryer had to be away from the wall about six inches to allow room for the vent hose. I was crouching in a doorway of the tiny room to load and retrieve the laundry from the dryer. A stacking dryer could be vented straight through the wall, so it would be six inches farther back from the door. It would also be high enough that I could stand up straight to load and unload it.

**High & Dry**

I began looking at dryers whenever I was even close to an appliance store. If I saw a stacking dryer in an advertisement, I would coax Bob-O into at least looking at it. The problem was that appliance manufacturers seem to think they really have a valuable item in a gas dryer. They are always more expensive than a watt-sucking 220 VAC model. And when you add the attraction of being stackable, they really raise the cost.

Bob-O was quite sly about getting me a dryer for my birthday. I really didn't have a clue that he had ordered one. It is a Frigidaire Gallery model, with its orifice changed for propane. Bob-O made me a cabinet to put it up on, and Joe Schwartz modified the base to my specifications. I couldn't be happier with it.

It has a moisture sensor, and just dries the clothes until they're done. It uses half the electricity of the old one, about 272 watt-hours per load, using our Trace 4024 sine wave inverter. That may seem like a lot of electricity, but like many gas-fired appliances these days, it uses an electric glow bar to heat the thermocouple. In the winter we are on hydro power, and it is not a drain on our system. If we are producing power and not using it, we're wasting it.

An added bonus of using a dryer is the lint trap. The Staber washer does not have a lint trap. By drying the clothes in a dryer, I am able to remove what lint there is.

**How Dry I Am**

If it sounds like I am rationalizing having a really great new clothes dryer, well, I am. I only have to go downstairs once instead of twice. I am not crouching in the doorway. My new cabinet has a shelf that pulls out to hold the laundry basket while I load and unload the dryer. I love it. I am very much into planning and outfitting our home for our old age. With a little care, this dryer will serve us a long time.

**Access**

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

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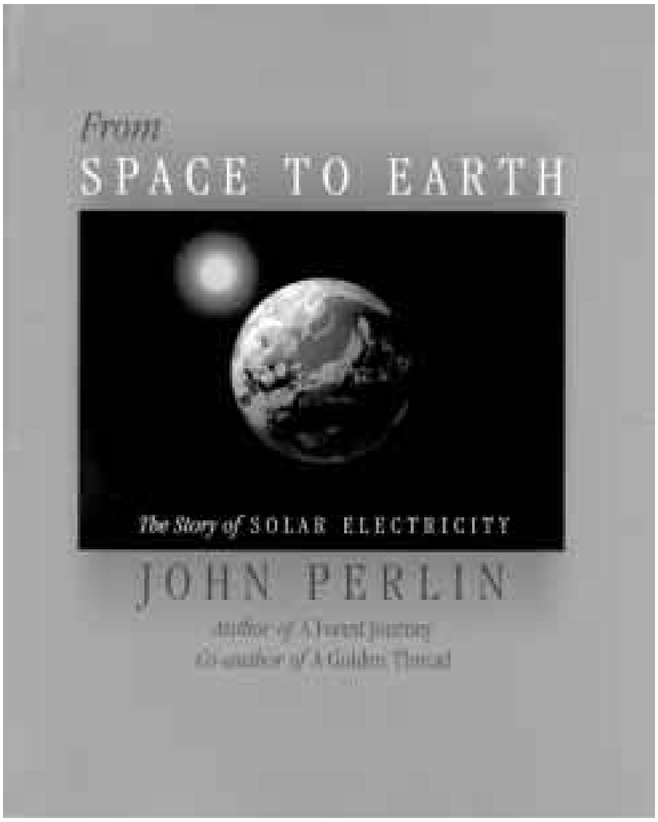



# From Space To Earth: The Story of Solar Electricity

By John Perlin

**Reviewed by Tor Allen**



It was a very pleasant surprise to find John Perlin with his new book at the ASES conference this past summer in Portland, Maine. As a researcher, educator, and advocate of renewable energy, I'm always on the lookout for materials that will increase my own knowledge, and also be useful in helping to educate others. This new book, *From Space To Earth: The Story of Solar Electricity,* is an absolute treasure.

**Solar 101—Required Reading**

The book is a must read for anyone interested in the subject of clean energy, whether you are a newcomer or an old-timer. It's not just another dry presentation of a technology. Perlin does an excellent job of telling the history of solar electricity (photovoltaics, or PV) by focusing on the *people and their needs,* which helped drive the development of PV.

Examples include Hans Zeigler's relentless crusade to put solar cells on America's first satellite, Captain Lomer's fight to power navigational aids, and Father Verspieren's efforts to pump water in the Sahara Desert. The stories of these individuals and others help make this book a fascinating read, and provide a motivational boost, urging us to strive ahead despite adversity.

I was introduced to photovoltaics in the early '90s (my collection of *Home Power* dates back to February, 1991). Over the past nine years, I've watched PV applications gradually and silently become part of our lives, even in my urban area. Emergency highway call boxes, portable construction signs, and solar-powered bus shelters are some examples. The book describes these applications and many others that now rely on photovoltaics as the first choice for power.

**Research**

In a world where the Internet is becoming a growing source of information—much of it without reference to authors or sources—this book exceeds my greatest expectations of accountability. Perlin meticulously documents his sources (and there are many, including numerous previously unpublished papers and unclassified documents), giving the reader complete confidence in the material presented.

**What Lies Ahead?**

Throughout the book, John shows how the photovoltaic industry progressed by meeting the challenges of providing power for stand-alone, wireless applications. It becomes clear why the centralized PG&E 6 MW PV plant no longer exists, while several thousand stand-alone PV systems continue to support critical functions, helping to keep the utility's transmission and distribution grid operating (switches, cathodic protection, meterological towers, water level sensors, microwave repeaters, etc.).

Perlin emphasizes that the demand for solar electricity will continue to be driven by stand-alone applications. Distributed grid-tied applications also are starting to pick up speed, as the role of the grid is redefined in this age of electric utility deregulation.

**Solid History**

In my quest to learn more about the solar industry, and to find material that is useful in educating others, this book is a prize. It is a reference book with personality. Solar electricity is about people and their needs, not just the technology. Perlin has written a history book that anyone can relate to, providing a solid foundation on the subject. It has become a cornerstone in my solar workshops. I hope you enjoy it as much as I do.

**Access**

*From Space To Earth: The Story of Solar Electricity,* John Perlin, 1999 (ISBN 0 93948 14 4), US$32 from aatec publications, PO Box 7119, Ann Arbor, MI 48107 800-995-1470 or 734-995-1470 • Fax: 734-995-1471 aatecpub@mindspring.com

Author: John Perlin,1809 Hillside Rd., Santa Barbara, CA 93101 • 805-687-0160 • Fax: 805-966-1344 solarperlin@aol.com

Reviewer: Tor Allen, President, The Rahus Institute, 1535 Center Ave., Martinez, CA 94553 • 925-370-7262 Fax: 815-461-1465 • tor@rahus.org • www.rahus.org Also at the Pacific Energy Center, 851 Howard St., San Francisco, CA 94103 • 415-972-5925 Fax: 415-896-1290 • eat5@pge.com www.pge.com/pec

# HAPPENINGS

**AFRICA**
Kagera Community Development Trust is looking for a donation of US$12,655 for fabrication and distribution of solar cookers as a pilot to tackle an energy crisis. Also looking for representative in the U.S. for the solar projects. Contact C. Fidelis Mutakyahwa, PO Box 1005, Bukoba, Tanzania • mutta@twiga.com

**AUSTRIA**
Mar 9–10, World Sustainable Energy Day 2000, Wels, Austria. Showcases globe's outstanding projects & initiatives, info on policy developments. O. O. Energiesparverband, Landstrabe 45, A-4020 Linz, Austria • +43-732-6584-4380
Fax: +43-732-6584-4383 • office@esv.or.at
www.esv.or.at

**CANADA**
Oct 15–18, '00, The International EV Symposium, Contact: EVS-17,
650-365-2802 • Fax: 650-365-2687
ElectricEVent17@aol.com

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

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

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

**CHINA**
Apr 18–21, 2000, Int'l Exhibition on New Energy, RE, and Energy Saving 2000, Shanghai. Coastal Int'l Exhibition Co.,
852 2827 6766 • Fax: 852 2827 6870
www.coastal.com.hk
general@coastal.com.hk

**CUBA**
Apr 24–28, 2000: Cubasolar 2000, Sierra Maestros. Learn how Cuba meets energy needs with RE. Includes rural electrification, bioclimatic architecture, ecotourism, culture & energy conscience, and research & production of RE equipment. Contact: Emir Madruga Fax: 24 1732 or 24 2699
sol@colombus.cu

**FRANCE**
Feb 7–9, '00, Global Business & Technical Outlook for Decentralized Power conference, Nice, France. Workshops, industry leader insights, keynote. Contact: Intertech, 19 Northbrook Dr., Portland, ME 04105
207-781-9800 • Fax: 207-781-2150
info@intertechusa.com

**NATIONAL U.S.**
May 12–18, '00, American Tour de Sol, U.S. EV Championships, New York City to Washington, D.C. Contact: NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051
Fax: 413-774-8053 • edu@nsea.org
www.nesea.org

American Hydrogen Association nat'l headquarters: 1739 W. 7th Ave., Mesa, AZ 85202-1906 • 480-827-7915
Fax: 480-967-6601 • aha@getnet.com
www.clean-air.org

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

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

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

Energy Efficiency & Renewable Energy Network (EREN), links to gov't & private internet sites & offers "Ask an Energy Expert" online questions to specialists:
www.eren.doe.gov • 800-363-3732

Mar 13–Apr 24, '00: Photovoltaic Design Course—Online! Six week course teaches how to size and design a complete solar-electric system. $500 includes internet course, textbook, PV design CD-ROM, and *Home Power* CD-ROMs. Contact: SEI, PO Box 715, Carbondale, CO 81623
970-963-8855 • Fax: 970-963-8866
sei@solarenergy.org • www.solarenergy.org

Green Power Web site: includes deregulation, "green" electricity choices, technology, marketing, standards, environmental claims, and national & state policies. Global Environmental Options (GEO), & CREST: www.green-power.com

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

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

Sandia's Web site, "Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices," "Working Safely with PV," & balance-of-system technical briefs, info on battery & inverter testing: www.sandia.gov/pv

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

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

Solar curriculum for upper elementary & intermediate grades-Free! Six week science curriculum or individual sessions. Over 30 classroom presentations & demos using free or low cost materials. Florida Solar Energy Center, Susan Schleith • 321-638-1017
www.fsec.ucf.edu

6th Annual National High School Student Solar Design Contest. Cash prizes for students, and trophies for teachers & schools sponsoring winning entries or having large student participation. Student entries: paper designs of solar powered devices, judged on originality, presentation, & technical application. Entries due Apr 1, '00. Winners announced on the mall at the EarthDay 2000 Celebration. Potomac Region Solar Energy Association, Solar Technology Education Project, 11407 Cam Ct., Kensington, MD 20895 • 301-593-4752

**ALABAMA**
The Self-Reliance Institute of NE Alabama seeks others interested in RE, earth-sheltered construction, & other self-reliant topics. SINA, 6585 Co Rd 22, Centre, AL 35960 • cevans9@tds.com

**ARIZONA**
Feb 21-26, '00: Women's PV Installation Retreat, Tucson. Basics of electricity, PV components, solar site analysis, system sizing, and a field installation. Women instructors. $500 includes lodging.
SEI, PO Box 715, Carbondale, CO 81623
970-963-8855 • Fax: 970-963-8866
sei@solarenergy.org • www.solarenergy.org

Feb 28–Mar 4, '00: PV Design & Installation Workshop, Phoenix. Basics of electricity, PV components, solar site analysis, system sizing, and a field installation. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

March 11–12, '00: Hydrogen Conversion class. March 18–19, '00: Fuel Cell class. $225 per class, plus $50 deposit to register. American Hydrogen Association nat'l headquarters: 1739 W. 7th Ave., Mesa, AZ 85202-1906 • 480-827-7915 Fax: 480-967-6601 • aha@getnet.com www.clean-air.org

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

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

Energy Efficiency Building Standards for CA. Download or hard copy. CA Energy Commission, 800-772-3300 www.energy.ca.gov/title24

**COLORADO**
Solar Energy International, hands-on workshops. 1 & 2 week sessions: PV Design & Installation, Advanced PV, Wind Power, Microhydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Experienced instructors & industry reps. For owner-builders, industry technicians, business owners, career seekers, & international development workers. $500/week. SEI, PO Box 715, Carbondale, CO 81623 970-963-8855 • Fax: 970-963-8866 sei@solarenergy.org • www.solarenergy.org

**CONNECTICUT**
Mar 15–18, Building Energy 2000: Buildings, People and the Planet, 16th Annual QBC Conference, Yale University. A Conference on Renewable Technologies and sustainable design strategies. Contact: NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 Fax: 413-774-6053 • nhazard@nesea.org www.nesea.org

**FLORIDA**
Apr 28–29 & July 14–15, 2000. Solar Electric Home for the South. Learn to design, size, & install a solar electric system. Learn what makes a home comfortable in hot, humid climates. $125 for 2 days. Energy Conservation Services, 6120 SW 13 St., Gainesville, Fl 32608 • 352-377-8866 Fax: 352-338-0056 • tom@ecs-solar.com

**IOWA**
Iowa Renewable Energy Association (IREA) meets 2nd Sat every month at 9 AM, Prariewoods, Cedar Rapids. All welcome. Call for schedule changes. I-Renew, PO Box 466, North Liberty, Iowa 52317 319- 875-8772 • irenew@irenew.org www.irenew.org

**KENTUCKY**
Appalachia-Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, & more. ASPI, 50 Lair St., Mt Vernon, KY 40456 • 606-256-0077 aspi@kih.net • www.kih.net/aspi

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

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

**MONTANA**
Sage Mountain Center; seminars & workshops, one day, inexpensive sustainable home building, straw bale const., log furniture, cordwood const., solar electricity, more. SMC 79 Sage Mountain Trail, Whitehall, MT • Phone/Fax: 406-494 9875

**NEW MEXICO**
Profit From The Sun workshops, Moriarty, NM. RE, energy conservation, sustainable living, & energy independence. PFS, 505-281-1300 days • 505-832-1575 eves & weekends • proffit@flash.net www.proffitfromthesun.com

**NEW YORK**
Apr 24–29, '00: PV Design & Installation Workshop, Woodstock. Basics of electricity, PV components, solar site analysis, system sizing, and a field installation. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

Oct 15–19, '00. Bioenergy 2000: Moving Technology into the Marketplace, the 9th biennial Bioenergy Conference: NRBF, 202-624-8464 • nrbp@sso.org

May 11–12, '00, Heavy-Duty Hybrid-EV Conference, LaGuardia Crowne Plaza, NY City. NESEA, 50 Miles St., Greenfield, MA 01301 • 724-772-7148 • Fax: 413-774-6053

**NORTH CAROLINA**
How To Get Your Solar Power Home: Seminars 1st Sat. each month starting in March. Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 Fax: 336-376-1809 • solarvil@netpath.net

**OHIO**
RE classes, 2nd Sat. each month, 10 AM to 2 PM. Tech info, system design, NEC compliance, efficient appliances. In advance: $70, $90 w/spouse. Also hands-on straw bale post & beam building. Solar Creations, 2189 SR 511 S., Perrysville, OH 44864 419-368-4252 • www.bright.net/~solarcre

**OREGON**
Aprovecho Research Center, non-profit edu. org., 3 ten week internships. Spring, Summer, Fall. Appropriate tech, sustainable forestry & organic gardening. Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198 • apro@efn.org www.efn.org/~apro

SolWest Workshops: Retrofitting an Existing House for Energy Efficiency, by Anthony & Victoria Stoppiello, Mar 10–12, '00. Annual Tour of Homes, hosted by EORenew, May 27, '00. Grid Intertie System Installation, a pre-fair workshop, by Richard Perez & Joe Schwartz, July 25–28, '00. John Day, OR. EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • solwest@eoni.com www.eoni.com/~solwest

**PENNSYLVANIA**
Aug 21–23, '00. Energy 2000 Energy Efficiency Workshop and Exposition: Pittsburgh, PA. Energy mangers conference. By the DOE's FEMA Program, Dept. of Defense, and the General Services Admin. Contact: Florida Solar Energy Center, 1679 Clearlake Rd., Cocoa, FL 32922 800-395-8574 • joann@fsec.ucf.edu

**TENNESSEE**
Apr 10–15 '00: PV Design & Installation Workshop at The Farm, Summertown. Basics of electricity, PV components, solar site analysis, system sizing, and a field installation. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

Kids To The Country; a nature study program for at-risk urban Tennessee children. Sponsorships & volunteers welcome. Contact: 51 The Farm, Summertown, TN 38483 • 931-964-4391 • Fax: 931-964-4394 ktcfarm@usit.net

**TEXAS**
Mar 20–25, '00: PV Design & Installation Workshop, Austin. Basics of electricity, PV components, solar site analysis, system sizing, and a field installation. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

Sep 29–Oct 1, '00: Renewable Energy Roundup, Fredericksburg. RE exhibits, demonstrations, workshops, tours. TX RE Industries Assoc. & Texas Solar Energy Society, 512-345-5446 • R1346@aol.com www.renewableenergyroundup.com

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

**WASHINGTON STATE**
San Juan Islands workshops. Oct 23–28, '00: Wind Power with Mick Sagrillo ($500), Oct 13–15 Microhydro Power ($250), Oct 29 Solar, Wind, & Water Power for the Northwest ($75). Contact: SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 sei@solarenergy.org • www.solarenergy.org

**WISCONSIN**
Midwest Renewable Energy Association (MREA) Workshops. See ad. Call for cost, locations, instructors, & further workshop descriptions. MREA Membership & participation: all welcome. Significant others half price. MREA, PO Box 249, Amherst, WI 54406 715-824-5166 • Fax: 715-824-5399 • mreainfo@wi-net.com

June 16–21, '00: ASES, Solar2000-Solar Powers Life, Share the Energy conference. June 16–18, '00: Midwest Renewable Energy Fair. Both events together in Madison, WI. See ASES ad.

June 12–16, '00, Women's PV Design, $450. Contact: SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 sei@solarenergy.org • www.solarenergy.org

# the Wizard speaks…

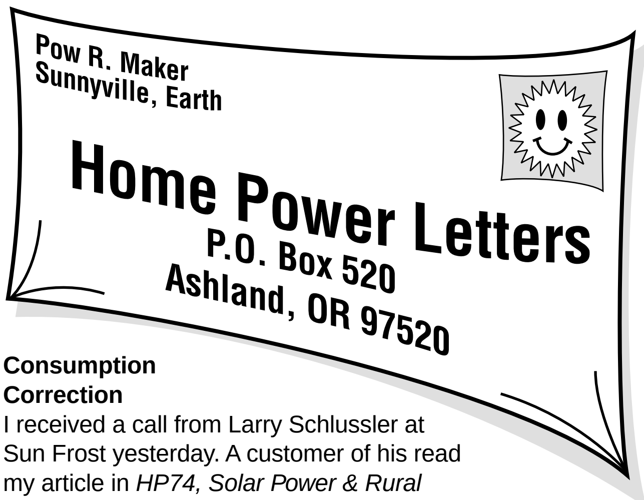
## Problems & Solutions

Planet Earth has some serious problems. They are man-made problems. Many believe we are on the verge of a serious environmental disaster. The problems can be summed up as too many people using too much of the planet's resources, and creating massive amounts of waste and pollution. This is causing accelerated environmental degradation.

We already have the tools to address these problems. We just need to use them. First we must reduce the human population of the Earth. Next we need to become more efficient and less wasteful. Then we must develop the solar/wind/hydrogen fuel and energy economy. Finally, we must develop a system to recycle as close to one hundred percent of our wastes as possible. This means all wastes—industrial, agricultural, human, and others.

The problems can be solved. It just requires the will to do what is necessary. If we do not have the will or inclination, then the natural process will solve the problems in its own way. However, we will not necessarily like nature's solution. The sooner we act, the sooner things will begin to turn around. Waiting until disaster is just around the corner is waiting too long. Act now.






**Consumption Correction**

I received a call from Larry Schlussler at Sun Frost yesterday. A customer of his read my article in *HP74, Solar Power & Rural Development in Nicaragua.* The customer questioned a part in the text (page 37, *Systems Overview)* that said the Sun Frost RFVB vaccine refrigerator draws 156 watts—while there was only one 75 watt panel in the schematic. Larry was glad to hear that his unit functioned well on only one 75 watt panel (after a six month follow-up and five months into the worst season in this particular area, insolation-wise), but would like it clarified that his unit only draws 50 watts. My apologies for the error. Kathy Dickerson, Director, Agency for Environmental Health, Inc., PO Box 850977, New Orleans, LA 70185 504-894-1411 • aehngo@earthlink.net • www.aehngo.org

**Sown Seeds**

Dear Richard, Thank you for the generous supply of *HP74* that contained our article about the class project, *PV on Wheels.* I have carefully distributed these copies to students, school board, administration, guidance counselors, and project supporters. The seeds have been sown! I look forward to a future of educational growth on renewable energy at Scales Mound High School. I see a forest of mighty oaks and many acorns of knowledge ahead. This is a good thing!

Also I can tell you about the look of pride and self confidence I saw in one of the project students when I gave him his copy. He beamed with pride as other students looked over his shoulder and quizzed him about the article and project. For a moment (a very important moment), it was as if this kid had thrown the pass that won the game. It really made his day. Thanks.

I'll follow up with an end of the first year report on the project in June '00.

What's next? A Harley Davidson electric motorcycle. I'm looking forward to how the school board and administration react to the EV project proposal. I plan to sail it by them this coming budget year.

Thanks again for the help and support—as a teacher it really made my day! Oh, and thanks for the *HP* subscription for the school. The librarian put it right on the shelf where more students can read about RE. And now they can have some serious fun learning about it at their school—good ol' Scales Mound High School. Learning is fun—serious fun! Dick Anderson, Industrial Technology Instructor, Scales Mound High School, 210 Main St., Scales Mound, IL 61075 815-845-2215 • Fax: 815-845-2238 • rca@scalesmound.net www.scalesmound.net

**Student Project?**

Dear folks at *HP,* Some of your readers are aware of what I'm working on; most of course are not. I showed up in John Day, Oregon at EORenew's 1st annual SolWest renewable energy fair last summer with an idea for converting some of the energy in a stream of moving (but essentially flat) water into mechanical energy. Not all that novel an idea, except this system isn't rotational like a waterwheel or turbine. This system's prime moving mechanism reciprocates.

Oversimplified a little, it incorporates a single vane or blade attached to a swing arm that is supported over a moving stream. It moves back and forth in a pendulum-like motion, by changing the angle of the blade relative to the water at the end of each stroke. A connecting rod runs horizontally to a counterbalanced crank that rotates at about 30 rpm in a streamflow moving about 3 fps.

This was my first experience at a renewable energy event, and the debut of my machine, which really wasn't complete. I expected a considerable number of naysayers and a lack of comprehension. Instead, from the opening networking dinner, where I happened to sit down with Ian Woofenden of *HP* and Kelly Larson of Alternative Energy Engineering, I was met with sincere interest and enthusiasm. Fairgrounds staff, vendors, demonstrations, participants, and observers were all really neat people, and I'm semi-reclusive by nature.

Since then I've connected the machine to a small AC generator, and produced about 300 watts. The unit powered some light bulbs and a circular saw with no load against it, and also direct-powered a roller pump similar to the one in *HP72,* only larger. I'm not an engineer, so my development so far has been instinctive and "bend to fit."

What I would like to do is find a mechanical/electrical engineering student with an interest in RE who would be interested in helping develop this system, maybe as a class project. I have several ideas, but it's going to take a while using my methods. Among the problems is converting a push-pull motion with high energy midstroke and dead spots on the ends, to mechanical power suitable for readily available components that rotate at relatively high speeds—generators, pumps, compressors, etc.

The advantages of the system are very low head requirement, no diversion, free passage of fish, and it sheds debris. So it's not necessary to alter the stream, just capture a little gravity-induced power where appropriate. Thanks for the forum and the access. Lawrence, 26600 Gail Ln., Middleton, ID 83644 208-585-6000 • lawrencehydro@yahoo.com

*Hi Brant, It was a pleasure to meet you at Solwest, and I hope you find help from our readers for your research project. I frequently run into people who would like to tap the energy in flatwater rivers and streams on their properties. Many hydro experts say that it can't be done economically. I would love to see someone prove them wrong. Ian Woofenden*

**Louisiana Solar Group**
I am interested in forming a solar/RE users group in the Baton Rouge, Louisiana area. My name is Jeff Shaw and I can be reached at jrs@rpmengbr.com or 225-767-0715.

**Sustainable Farm**
Dear Richard and the crew at *Home Power:* As I try to rock our kid to sleep, I want to take a moment to thank you for your terrific publication. After reading the first Tickell article on the Veggie Van *(HP65,* p. 46), we were sold on biodiesel! We did our vehicle research, and located a source of biodiesel. The photo shows our 1980 diesel Mercedes Wagon. After spending 14 days in Iraq, pumping up with gas was a painful experience!

Keep up the absolutely terrific work. I've enclosed a couple of articles on our work so you know what we are up to out here in Massachusetts. Take care, Ricky Baruk and Deb Habib, Seeds of Solidarity Farm, 165 Chestnut Hill Rd., Orange, MA 01364 • solidar@shaysnet.com

*Right on, Ricky and Deb! We love getting feedback about folks who are part of the solution. I read the two articles you enclosed (*Nurturing Seeds of Solidarity, Telegram & Gazette, *Worcester Mass, August, 1999; and* Seeking Liberation from the Cycle of Ecological Oppression, People's Voice of Franklin County, *Summer 1989).*

*I'm impressed by the work on your organic farm. Reclaiming old pastureland to grow locally-distributed organic food is noble. I'm also a great fan of mulching and using worms. Extensive recycling, growing organic food, a 26 by 44 foot solar compost-heated greenhouse, PV system, solar hot water, composting toilet, constructed wetland to filter your greywater—sounds like you've got it covered.*

*A biodiesel-fueled wagon seems like the perfect transportation for your homegrown organic produce deliveries, returning with barrels of restaurant compost scraps for your hungry worms. Excellent! May others follow in your footsteps. Joy Anderson*

**Incompatible Utilities**
Richard: Thank you for not backing down on your critique of utilities *(Letters, HP74).* They are simply incompatible with a democratic and environmentally stable society. For example, suppose a utility like PG&E sends out 5 million bills each month. They need only add a $1 charge per month, a sum so small it will escape attention, and in a year they have a fund of $60 million for political mischief. In a 1905 issue of *Arena* magazine I found this quote: "No influence in political, business or general life has proved so corrupting to government, so demoralizing to the press and other public opinion-forming organs, or so vicious in lowering the moral ideals and integrity of the people as private companies operating public utilities."

The PUC is just an elaborate, expensive, and useless pretension. If the utility wants a 0.5 billion increase, they ask for 1.0 billion and the PUC grants 0.5 billion. It is all part of a corrupt system, of which publicly-owned grids are about as equally destructive of the environment as privately-owned grids.

And thank you for pointing the way. J.B. Neilands, Professor, Emeritus, Department of Biochemistry, UC Berkeley Iron@UClink4.berkeley.edu

**UPS Safety Concerns**
I have read with great interest several articles in *HP* regarding utility workers' concerns with grid-intertied inverter safety. They regularly target these products as potential threats to utility worker safety, citing equipment failure as a remote possibility.

In the meantime, many homes and businesses have installed UPS equipment to protect their computers and sensitive electronics from utility power "irregularities"—brownouts, outages, and reconnect surges. These entry-level UPS products, often obtainable for around US$100, are far less sophisticated than synchronized, sine wave inverters which are listed for utility interconnection. Yet there seems to be little vocal concern by utilities that UPS products could jeopardize utility worker safety in the event of malfunction, component failure, or accident. Moreover, UPS products are typically installed by the end user without the assistance of a licensed electrical contractor or the watchful scrutiny of the local electrical inspector.

How can utility companies cringe about the safety of grid-intertied synchronous inverters listed for this purpose while ignoring UPS products? I would feel safe speculating that there are far more UPS products installed on the grid than there are grid-intertied synchronous inverters. If safety was really the issue, then utilities would worry about the remote possibility of a UPS failure backfeeding the grid. I suspect revenue loss from grid-intertied renewable energy customers is their chief complaint—not safety. Erich Deters erichtd@commons.aim-smart.com

*Hi Erich, I share your feelings that potential loss of revenue and, even more so, control of generation sources, are the utilities' main concerns with intertied RE systems. Unfortunately, lineman safety has become the red herring in* *denying RE system owners access to the grid. Utilities have a responsibility to insure the safety of their line workers. So step one is to educate all uninformed utilities about the safety features of modern utility interactive (UI) inverters.*

*Unlike UI inverters, UPS systems do not have the circuitry required to backfeed the grid. This is why utilities typically don't require notification of UPS systems installed on the grid. Joe Schwartz*

**Sending a Signal to the Utilities**
Hi. I don't know if everyone is aware, but Trace Engineering has now made it possible for all solar guerrillas to unite and literally send a signal across the utility lines directly to the utilities that they are no longer in control of their grid!

The advent of the remote communications adapter that plugs into the serial port on the Trace SW inverter has made it possible to program the inverter from a PC via a modem. What if all Trace SW inverters (currently programed as utility backup with PV) were suddenly put into sell mode at the same time?

Here is how I propose a message be sent to the utilities over their own grid: First we need to equip all previously installed Trace SW inverter systems that are now using the grid for backup instead of "sell mode" with remote communications adapters and modems. Then announce via email to the regulatory committees and the utilities that on a certain date all solar-powered systems across the country will be feeding the grid for the period of one week. We should give them about a week's notice, maybe two (to be nice). Then at the selected hour we signal all SW inverters to switch to sell mode by reprogramming them remotely from a central location.

I hope we will have enough inverters, PV panels, and enough sun to create a big enough signal in the form of excess power on the grid that the utilities can't account for, that they will now longer be able to deny our existence! We can say, "Guerilla solar was here." David M. Austin • DaveNRGman@ascent.net

*Hi David, Great idea! Unfortunately, even if every grid-tied Trace inverter in the U.S. was backfeeding all of its PV power to the grid at once, the utilities would be hard pressed to even notice. There just aren't enough of us yet. The growth of grid-intertied PV systems is stunted by the myth of payback, and the hurdles of utility authorization. Until people (and governments) compare the cost of renewables with the true costs of utility power, the movement will suffer. And until the monopolies are usurped and green power producers at all levels are allowed to freely share their resources with society, the movement will suffer.*

*Yes, there is a long fight in front of us before we will have a measurable effect on the utilities meters, their bottom line (contrary to their whinings), and their pollution. But that is our raison d'etre. I can't wait until the day when our pressing the "sell" buttons in unison not only awakens the utilities, but the unpressing of them leaves society in want. Ben Root*

**Hypocrisy of Independent Living**
Dear Richard, I saw you at the Southwest Renewable Energy Fair at Flagstaff. It was a fine educational experience for me, as is every issue of *Home Power.* A lot of the technical information is over my head. By reading and by talking to knowledgeable folks, I'm slowly learning about RE. I certainly support your efforts and those of most of your readers. I'd like to point out, however, a contradiction I see over and over.

A major theme in *HP* is "good" (such as RE advocates) vs "bad" (such as power companies). The "good" love the earth, and the "bad" are destroying it. What I see in every issue of your magazine, though, are pictures of single-family homes on clearcut hillsides, festooned with solar panels and wind generator towers. While owning a large lot to keep neighbors at bay is probably more satisfying than sharing a wall in an apartment or a lot in the typical suburbs, it is hardly "good" for the earth. What about the loss of flora and fauna, not to mention pristine views? In South Texas, the Hill Country is turning into a gigantic new suburb with 2 1/2, 5, or 10 acre lots of "nature lovers." I've seen the same process in Colorado and New Mexico. It's suburbia on a big scale.

If we truly loved the earth, we could use other cultures as models. First, the Old Order Amish seem to have a handle on taking care of the earth. They are true stewards of this land. Second, Germans tend to cluster in high-density living units with each town owning and maintaining their own surrounding forest. While living with them for two years, I learned about reducing my daily consumption and to recycle instead of dumping my trash.

Any traveler to Germany outside the city can witness people enjoying the benefits of technology in a tremendously congested area, and still enjoy nature. In the U.S., the most earth-friendly lifestyle consists of living in the city, using public transportation, and cutting back on consuming.

I believe RE is *the* answer to the world's energy needs. Many third world countries would benefit tremendously if they used some of the devices in your magazine. But, as an American, I propose we who are RE enthusiasts be more forthright and less sanctimonious. If I (we) wanted to save air quality, I wouldn't have driven all the way to Arizona to park next to RVs for the Southwest RE Fair in Flagstaff—I would have read about it. If I (we) truly placed the earth's needs before my own, I probably wouldn't plan to build a passive solar house on 5 1/2 acres in the beautiful Texas Hill Country. I would move back into an apartment.

People like the Amish, many Germans, and city dwellers can live more efficiently in terms of resources by living in groups. Let's knock off the hypocrisy of independent living being better for the earth. Keep up the good work, Paul Bauml, San Antonio, TX

*Hey Paul, Your letter brings to mind Ernest Callenbach's novel,* Ecotopia. *In Callenbach's utopian vision, American suburbs are eliminated, and densely populated, but comfortable urban centers are created. Trees are planted and stream courses are allowed to flow freely above ground. In your suggested European fashion, commercial and residential zoning are no longer separated, allowing for efficient mass transit.*

*The question of "Where to put all the people?" points to public enemy number one—overpopulation. Over 6 billion served. What we can all do is minimize our impact on the planet's ecology. Using RE to generate clean electricity is something tangible and immediate. On-grid RE systems offer both the independence of uninterruptible power, and when we place green energy on the grid, interdependence, as we share clean energy with our neighbors. The best of both worlds, perhaps. Joe Schwartz*

*Hi Paul, You make many good points, none of which I can really disagree with. But the one I like the most is about not being sanctimonious. Many of us are in this movement for "green" reasons. But I think the dirty little RE secret is that we're also in it 'cause we* like the neat technology. *I certainly count myself in that number, and I'm not ashamed. I think going after what we believe in and are interested in is the most important thing. Trying to convince others to live or believe as we do is a distraction at best, and counterproductive at worst. We have to walk the walk, and our talk should be about our walk and our choices, not telling others what to do. St. Francis of Assisi said, "It is no use walking anywhere to preach unless our walking is our preaching." If I weren't in the middle of preaching at you, I might go farther and say "why preach at all if our walking is our preaching"…*

*I think some people like living in the country and some people like living in the city. We should encourage everyone to find ways to live that are light on the planet and sustainable. We would love to see more articles submitted to* HP *about individual and community use of renewables in the city. The subsidized grid makes it harder for people to make the choice for renewables there, but it is happening, and we encourage readers to share their successes. Thanks again for your thought-provoking letter. Ian Woofenden*

**Inverter Homebrew**

*Home Power,* Can you get me something on how to build or fix inverters? The inverter is the heart of a solar electric system. I can make a square wave inverter, but I don't like them! Is there a book on inverters? I'd like to read more on inverters in *HP.* Your friend in solar electric, Kenny Runner, Galloway, WV

*Hi Kenny. There are no books on homebrewing sine wave inverters. Unfortunately, we can't even get schematics for them either. Good luck in your search, and please let us know if you find anything useful. Richard Perez*

***HP* in Spanish**

Dear Richard Perez: ¡Saludos desde las Antillas! I am writing on behalf of Pablo Díaz Cuadrado, a farmer, builder, and inventor of Puerto Rico's mountainous Toro Negro Forest. Pablo is committed to stepping lightly on the Earth, and would very much like to begin working with solar, wind, and/or hydroelectric energy. However, he does not read English, and has no access to technical information on harnessing these energy sources in tropical ecosystems.

Part of being colonized is about consuming the products and energy resources provided by the colonizer. In the public school system, one text actually goes so far as to say that the Puerto Rican archipelago, one of the largest of the Antilles, and certainly blessed with steady wind currents, solar, tidal, and hydroelectric potential is a "small *island* bereft of resources."

After calling American Solar and the DOE about the possibility of getting information on renewable energy systems in Spanish and having no luck, one of those synchronicities that mark our lives put *Home Power* magazine in my hands! *¡Felicitaciones!* Such great work! I was very impressed and when I saw your last name, I said to myself: Maybe Richard Perez can help!

So I'm writing to you to find out if you know of any information published in South or Central America or throughout the Caribbean or in Spain that you could connect us to (we do not have access to the internet). Maybe you would be interested in getting a professional translator to work on an average of one article per magazine in Spanish. At the end of a year, you'd have an entire magazine in Spanish!

Please forgive my presumption at making such a suggestion. I am moved to suggest it because we desperately need something like your magazine out here in Puerto Rico, throughout the Caribbean, and throughout the Spanish-speaking Americas. I know you get the gist. Can you help? Thank you! We look forward to hearing from you. Green blessings, María Bendetti, HC-1 Buzón 6361, Orocovis, Puerto Rico 00720-9706 • 787-867-5561

*Hello María, we'd love to see this information presented in other languages as well. Unfortunately, we can barely keep a handle on publishing* Home Power *in English, let alone in other languages. Translating is the easiest step—it's the cost of republishing and printing the magazine that's the problem. We have already given permission to two different individuals, one in Spain, to translate and reprint* Home Power *material. We will be happy to grant permission to translate and reprint* Home Power *to serious and responsible people if it means getting the technology to those who would otherwise miss out.*

*Three people who are doing work in the renewable energy field in Spanish are Richard Komp, Susan Kinne, and Hector Gasquet. Ken Olson at SEI also may be able to help you out. Here's their access information. Richard Perez*

*Richard J. Komp, President, Maine Solar Energy Association, RR 1 Box 7751, Jonesport, ME 04649 • 207-497-2204 sunwatt@juno.com*

*Susan Kinne, Electrical Engineering Department, National Engineering University, Telcor Central Box #5595, Managua, Nicaragua • 505-267-0275 ext. 335 • Fax: 505-278-1461 skinne@unicom.uni.edu.ni*

*Hector Gasquet, 10909 Bill Collins Ct., El Paso, TX 79936*

*Ken Olson, SEI, PO Box 715, Carbondale, CO 81623 970-963-8855 • Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org*

**Mixing Batteries**

Dear *Home Power:* I'm a Canadian residing here in the Dominican Republic. I came here to build microwave systems for the telephone company, then opened a small business in electronics. After many attempts in different areas, we decided to hone in on alternative energy. We do, on a large scale, sales of large UPS systems to big companies; and on a smaller scale, backup power for homes, generally made up of charging sources, batteries, and inverters.

With our 40-plus large customers and dozens of smaller ones, we often get used batteries given to us. With my test equipment, it is easy to determine if a battery is still good. We are aware of the rule against mixing battery types or units of different ages. But with different types of batteries, some in near-new condition, we have been breaking all the rules and doing some experimenting.

At this moment we are using a 12 VDC bank made up of two Power Batt PRC-1265 (65 AH @ 8 hr), two Best BATA-0483 (100 AH @ 20 hr), and three Yuasa NP12-38 (38 AH @ 8 hr) batteries. The Power and Best units were practically brand new, and the Yuasas about one year old.

We have been experimenting using a variety of connections and have come up with an arrangement which seems to be working. The three Yuasas are paralleled with #8 wire, the two Bests are paralleled with bus bars equal to #00, and the two Powers are paralleled with bus bars equal to #0000 cable. The Yuasas are farthest away from the load and are jumpered to the Bests with #8 wire, then the Bests go up to the Powers with #0 cable, and the jumpers from the Powers to the main inverter bus bar are #0000.

This setup wasn't given much in-depth thought or calculation except that we wanted the batteries to share the load partly based on each one's percentage capacity of the whole group.

The other day we had a ten-hour power failure (not uncommon) and we were pulling about 28 amps DC from the bank. We watched the voltages and it seems that the different gauges of inter-battery connections have a balancing effect. After ten hours, the bank voltage was 12.04 V. The Yuasas were around 12.06, the Bests around 12.05, and the Powers about 12.04.

We realize that this isn't a very scientific analysis of the situation, but we are very curious to know if anyone else has experimented with battery mixing. My future plans are to build two very heavy gauge, flat copper bus bars along the wall above the battery bank and then connect the different types and sizes to the bars using different gauges of cable to balance the different capacities and be able to monitor exactly how much power is being drawn from each battery. We want to come up with some sort of theoretical connection guide for people with situations like us. I'll bet lots of people are missing batteries right now, and may be doing it detrimentally.

My theory is that if I add non-standard batteries to my string in such a way as to lessen the depth of discharge for all of them, I'm doing the right thing regardless of the guidelines. However, if by adding strangers to the group, the discharge is deeper, then the idea should be discontinued. Hope you found this interesting. John H. Van Allen, Republica Dominicana, West Indies

*Dear John, Rock and roll. Let me know how it turns out. Richard Perez*

**Dishwasher Search**
Dear *Home Power,* We really appreciate the information in the magazine. We have a small system now, but we're planning to upgrade when we build a better house over the next couple of years.

My question is this: What type of dishwasher is the best for an RE system? I know that most will say "manual," but I have a progressive neuromuscular disorder and foresee needing an automatic dishwasher. Asko is one brand that is supposed to be super-efficient, and I hope to get to Atlanta this winter to see one. They're not available here.

A friend said there are countertop models, but I've never heard of them and don't want something that is more trouble than convenience. She also said an RV model might be good for me because my countertops are extra low, to fit my height. I didn't know RVs *had* dishwashers.

What ideas do you folks have on this subject? Thanks for any help you can give. Georgia Pomphrey, Rockford, TN

*Hi Georgia, After I get an appliance I don't keep up on what's out there, so really everything I know about dishwashers is in* HP52, Home & Heart, *page 94, where I wrote about getting my Asko. Cautions about full sine wave inverters and invalidating warranties apply to all appliances. Kathleen Jarschke-Schultze*

**Small 12 Volt PV System**
Dear *Home Power.* You guys are so lucky living in Ashland. I used to live there from 69 to 71 playing in a rock band. I miss Lithia Park and the Shakespeare Festival.

Could you please steer me right on some PV? I am trying to outfit my 82 Ford 4WD van with a 12 volt system. I have space for two PV panels on the roof and a custom box that would hold four Trojan T-105 batteries. All I will be running is a 12 volt AC/DC TV (70 watts), a stereo (60 watts), and a small 12 volt light, for about six hours a day if possible. Roughly 200 watts total.

What type of controller would you recommend? I have been looking at a Trace C-40, an SCI, and a Morningstar. Are the UniSolar panels superior in low light? (There really isn't that much sunshine here in Seattle. That's why I thought UniSolar might be good.) Are two 64 watt panels enough? Are four T-105s enough? Would I need circuit breakers?

I've been trying to gather ideas from your most recent issues. Any advice you could give me would really be appreciated as you guys are the foremost experts on the subject, in my opinion. Thank you very much, Scott Stilwell, Lynnwood, WA

*Hello Scott. First, I'd like steer you to Ben Root's great article on load analysis, in* HP58, *page 38. The first step in sizing a system is figuring out your loads. You can download this article and a loads spreadsheet from www.homepower.com.*

*If you want to draw 200 watts for 6 hours every day, that's a total of 1,200 watt-hours per day. Using the equation of volts times amps equals watts: 1,200 watt-hours divided by 12 volts* *equals 100 amp-hours. Four Trojan T-105 batteries wired in series-parallel for 12 volts has a capacity of 220 amp-hours. If you use 100 amp-hours, you're drawing your battery down a little less than 50 percent.*

*The batteries can handle that depth of discharge that frequently if you're kind to them and make sure they get filled back up daily. If you only had two 64 watt PV panels to do the job (not counting your car alternator that you can use to charge your batteries while driving), that's a total of 128 watts peak. If you're using a total of 1,200 watt-hours daily (from the above calculation), divide 1,200 WH by 128 W—you'll need about 10 hours of sun at peak wattage to top those batteries off.*

*Ten hours of sun year-round, especially in Seattle, is totally unrealistic. You either need to reduce your loads or increase your charging sources. Perhaps you could use LED lighting? I'd also recommend installing some instrumentation so you can monitor your system. I have an E-Meter that tells me how many amp-hours I have in my battery bank, but there are other good meters out there. And yes, you will definitely need all the appropriate fusing. We have lots of examples of small systems in our back issues.*

*I just hooked up a small 12 volt PV system on my full-time 18 foot RV. There are many good products out there, but here's a quick run-down on some of my system components and why I chose them.*

*I installed two 100 watt Siemens SR100 panels on a Direct Power adjustable tilt-up rack. The rack is made for RVs, and tilts 45° either fore or aft. It's also easily adjustable with thumbscrews, and is fairly lightweight. When I was researching panels for my system, I measured the available space on my roof, then checked out dimensions of different panels. The Direct Power rack is made to fit two SR100s, and was exactly the right size for my roof, so I went with that setup.*

*Before I bought the Siemens modules, I also looked at UniSolar. UniSolar makes flexible, unbreakable, lightweight panels without the glass. The UniSolars looked really attractive, but I was trying to maximize my surface area since my rig is mostly in the cloudy Northwest. Because I was really tight on roof space, the fact that the UniSolar modules don't put out as many watts per square foot as some other panels was the deciding factor against them. I hear that UniSolars have a good reputation in high heat and in partially-shaded conditions, though I don't know about low light. Ian Woofenden tells me that the BP590s are considered to be the most space-efficient panel on the market now, as far as he knows, and that they get high marks for low light and partial shading.*

*My charge controller is a Heliotrope RV-30, made especially for RVs and applications where there are two battery banks. Keeping my engine battery topped off with solar energy is a definite plus—the RV-30 regulates both my engine battery and the four Trojan T-105s in the coach.*

*I selected the four Trojan T-105s because they were inexpensive and had a proven track record. Lead-acid batteries were no problem in my application because the space I planned to put them in is vented to the outside, and because I planned to use Hydrocaps. Since then, however, I've become very interested in some of the newer sealed gel-cell batteries.*

*Good luck with your system, and above all, have fun! Joy Anderson*

**Can't Skim *HP***

Hey, *Home Power* is getting too big! In this info age we are bombarded with volumes of printed material. One mag I subscribe to is the *CEE News,* covering the electrical construction industry. A quick read, so I pick it up first. (By the way, *Code Corner* in *CEE* is a must-read for all renewable energy installers.) Another mag I read is *Wired.* Too much, too jarring, cutting edge computer culture info, but the last thing I read, and since it went by way of corporate takeover, I may drop it.

Take as many ads as you can, police the price and claims. We can make intelligent decisions whether to read them or not.

But each article from your staff has so much credibility that I can not skim them. I need less basics—that's what the *Solar2&3* CD-ROMS are for. We need news, politics, code, installation articles, and new products news.

And thanks for the renewal notice—just don't abuse it. State the notice as your one and only and last 30, 60, or 90 day notice. We are all conditioned by the mainstream publishers by getting 6 and 8 month renewal notices. How many million times have I been told not to exaggerate… Reese K.

*Thanks for the flowers, Reese, and your comments. My brother-in-law calls those cheap western novels "grapes," 'cause you read them quickly for pleasure, just like popping grapes into your mouth. I'm glad that* HP *is on the other end of the reading spectrum—with serious mental nourishment instead of just snack food. We try to make each article full and solid. Sorry to torment you, but we're aiming to keep you from skimming!*

*We also try to keep our ad to article ratio well below normal magazine standards, though our advertisers perform a valuable service, keeping you up to date on new products. And speaking of products, you'll be happy to see three* Things that Work! *reviews in this issue. Thanks for the encouragement. Ian Woofenden*

**Community vs Corporate Wind Development**

As the debate over a proposed wind farm in Washington County, Wisconsin heats up, I offer a viewpoint overlooked thus far in the statewide debate. Does Wisconsin want community or corporate wind development?

Community wind is locally owned, produced, and consumed wind-generated energy scattered widely across a county or state in "micro-clusters" of 1 to 3 turbines per site.

Corporate wind is investor-owned and consists of dozens (or hundreds) of wind turbines concentrated over a small area (a "wind farm") with the energy usually transmitted out of the area or state.

If given a choice, I'd assume that most Wisconsinites would favor community wind. Yet, two recently signed state laws favor corporate wind over community wind. In 1998, Governor Thompson signed a so-called "Electric Reliability Act" (Act 204). This year, a so-called "Public Benefits" bill passed, which further hinders Wisconsin's small business' efforts to gain a foothold and grow with Wisconsin's emerging wind generating market.

Act 204 mandates that 50 MW (about 25,000 homes) of new renewable energy be constructed in Wisconsin by December 2000. This mandate favors corporate wind because only a large-scale wind farm can meet the arbitrary deadline. Smaller-scale community wind needs time to build a business plan, locate sites, negotiate contracts, and erect towers. Act 204 punishes Wisconsin's emerging green independent power producers (IPPs) because only the investor owned utility "big boys" can meet this mandate's deadline.

Likewise, the recently enacted so-called "Public Benefits" bill also favors corporate wind. This bill mandates that Wisconsin get about 2 percent of its energy demand from renewable sources by 2010. This legislation doesn't require that the supply be generated in Wisconsin. Corporate wind from Iowa or Minnesota can meet that requirement. Once again, corporate wind wins and community wind loses.

It appears that both Act 204 and the Public Benefits bills signed by the Governor are badly flawed and anti-small business. Both bills badly hurt Wisconsin's emerging green IPPs. I encourage all who favor community wind to contact the PSC in Madison and ask why corporate wind is being heavily favored in Wisconsin. Michael Mangan, Emerald Energy, LLC, 1102 N. Breens Bay Rd., Oconomowoc, WI 53066 • 262-646-4664

**RE Museum Proposal**

Hi Richard, I'm in the process of putting together a museum. The site is off I-70 in Illinois, at Martinsville. I would like the buildings powered by a renewable energy source—underground pipe with antifreeze, and solar for lights, heat, etc.

1) This would be Illinois' first renewable energy museum. 2) I would like to hold a renewable energy fair with the Midwest Renewable Energy Fair from Wisconsin. 3) Manufacturers would have permanent displays in a future wing of the museum (Earth's Future). 4) I'm working to obtain grants from Illinois Department of Commerce, and federal grants as well.

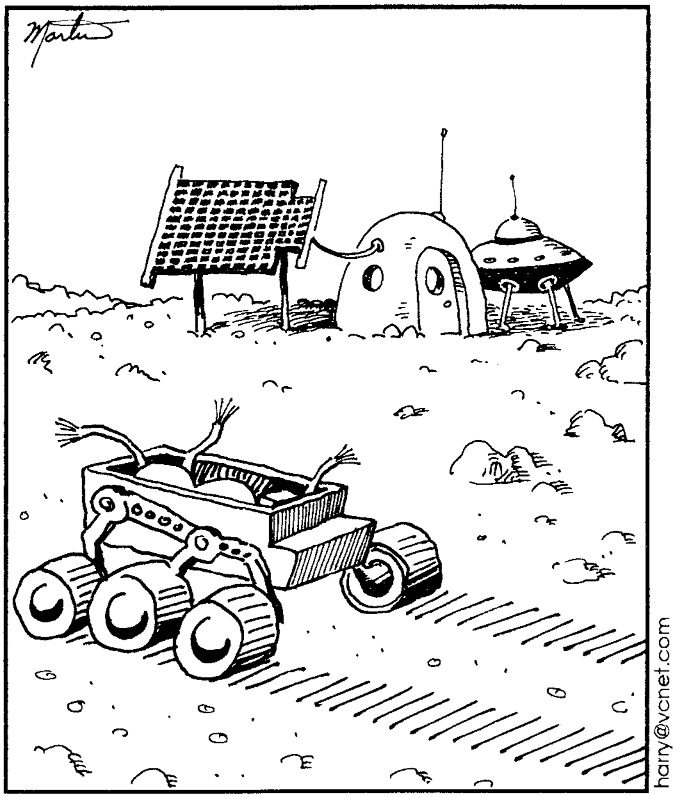
I would love to hear from people and businesses. I want to study all possible plans before construction. Do you have any ideas how I could pursue this project? Hope to hear from lots of people! Sincerely, Cindy Connor, 604 E. Union St., West Union, IL 62477 • Fax/Phone: 217-279-3463

**Getting Started**

It started with Hurricane Floyd, as it was bearing down on North Carolina. I had run out and gotten water and food supplies for my elderly in-laws and myself. I was looking for C-cell batteries. None were to be found, so I adapted a portable radio with a set of jumper wires to a 6 volt lantern battery. However I was still in need of batteries. So I went to a discount store and bought a 12 volt truck battery, went to Radio Shack and bought two 3-outlet 12 volt power strips and fuses, and wire. I came home and adapted all I needed for the three of us. We survived the storm and the power outage.

I have been reading *Home Power* magazine for about three years now. I plan to use all of this information once I retired to our 40 acres in southwest Utah. Well to make a long story shorter, I bought a 60 watt solar panel and a charge controller from a dealer on the Internet, and now keep the truck battery I bought topped off. I know the truck battery is not the right battery for real use and storage. But I'll use it until it dies, and then buy the correct type. I bought a 20 watt, twin-tube, 12 volt fluorescent light, and mounted it over the kitchen sink. I use it daily. I am building two 12 V white LED lights (like in *HP73)* for use in the stairwell of our home.

I am sorry that I waited so long to get started with solar power, but at least I have started. Even though I am a small user of the power of the sun, at least I have begun. I thank you and your staff for all the very good work you all do in getting out each issue. By the way, *HP73 & 74* are—in my mind—the best two issues so far. All the best, Terry Smith bnme@carolina.net




What really happened to the Sojourner Mars Rover


## *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 twelve years ago was to give a subscription to our local public library.*

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

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

*To Adopt a Library write or call*

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Ozonal Notes

# A Short History of *Home Power*

Richard Perez



As we enter the year 2000 and *Home Power's* thirteenth year of publication, I thought you might enjoy a short history of how this publication began and developed.

**Back to the Land**

It all began when Karen and I joined the "back to the land" rush in 1970. After four years of city living, we became Haight-Ashbury refugees. We joined the flow of folks leaving the cities and seeking a better life in the country. After seven months of traveling, which spanned the U.S. from coast to coast, we finally found our home on Agate Flat, Oregon. Oddly enough, after all of our determined and highly planned searching, we found our homestead by getting lost. We went looking for property miles from here. We got lost. It rained, and we could only go downhill. We ran into a local sourdough old timer named George Wright who mentioned that he had property for sale. We bought it.

We found, as many back-to-the-landers do, that the only land we wanted and could afford was off-grid. In our case, it was six miles from the nearest commercial electric power outlet or telephone. This didn't bother us at all. We'd had enough of city conveniences, and we were willing to rough it if it meant that we got to live in a beautiful and serene place. We bought our homestead and moved in. With the help of two friends, we built a 26 foot diameter geodesic dome in thirteen days, using only hand tools. This dome taught me that I was not a carpenter. It leaked badly, but we survived our first winter in the Siskiyou Mountains.

We used kerosene lamps for lighting. We hauled our water in five gallon jerry cans from our spring, about 300 yards from the dome. We heated the uninsulated dome with a wood stove. We were total greenhorns when it came to country living. Our heads were full of the romantic nonsense that comes from living in the city and dreaming of a country life. For just one example, we attempted to gather an entire winter's firewood without using a chain saw. Fortunately, we had old Sourdough George for a neighbor. Without him and his chain saw, I suspect that we might have frozen out during our first winter.

When we moved to the country, we immediately went into economic catharsis. All our skills were city skills—skills which we could find no market for in our country environment. Over the years we adapted. Karen punched cows for neighboring ranchers. I built barbed-wire fences, made custom hunting knives, and did odd jobs around the neighborhood. We did whatever we could to survive in our new home.

It was pretty grim financially. There were three years in a row when our entire household income was under US$600. Karen developed at least a hundred ways to fix beans and rice. For four years we made do without a truck, and hauled all our supplies in via backpack and horse.

Our only electrical appliance was a small Sony cassette player powered by C-sized dry cells. Most of the time, we were too broke to buy batteries, and we had to do without the Grateful Dead's music. The Dead are our muses. We listened to them live at the Panhandle, Avalon, and Filmore. Their music was just about the only thing we wanted to export from the city.

**Our First Electric Power System**

Around 1977, I decided it was time to electrify our homestead. We were tired of kerosene lighting. It was smelly, dim, and dangerous. We also wanted more music, without the expense and hassle of buying fleets of dry-cell batteries. Since my background was in physics and electronics, I decided to build a power system.

I went to the junkyard and got an alternator from an old truck. I hooked this alternator to a castoff one-lung gas engine. We saved up and bought a car battery. I combed auto junkyards for taillights, which I turned into lights for our house. Everything was scrounged and recycled from dead cars and trucks—right down to the wire and switches. This early system worked. It wasn't very powerful, but it brought electricity to our homestead for very little money. We ran lights, radios, and the cassette player. Over the years we added to this system.

By 1983, our neighbors noticed what we were doing and asked me to do it for them too. We went into the off-grid power system business. We bought our first PV module in the spring of 1985—it took us a year to save the money for it. It was soon followed by two more modules as our RE business grew.

**Selling RE Systems to Others**

By 1987, I had electrified over a dozen homesteads in our immediate neighborhood. Our RE business had grown to the point where Karen and I actually regained the privilege of paying taxes. I had written a book on batteries which was published by TAB Books in 1983. I was also churning out pamphlets for my RE system customers to help them learn how to run their systems and how to care for their batteries.

Since we had already electrified our neighborhood, I went searching for new customers. What I discovered was that there was no effective place for us to advertise our business. I also discovered that each new customer had to be educated about the possibilities of living off-grid with solar power. We decided that we needed a publication specifically devoted to small-scale RE systems—a place where we could both educate and advertise. We needed *Home Power.*

***Home Power* is Born**

In November of 1987, we mailed 7,000 copies of *Home Power #1* to folks who had purchased a PV module or other RE gear within the last few years. Many RE businesses were kind enough to donate their mailing lists to help us get started. Some of these businesses believed enough in what we were doing to actually advertise in the first issue. We mailed the issue and held our breath. Within a month, we had over 4,000 subscribers.

In those days, we mailed *Home Power* free to anyone who requested it. Our original concept was that *Home Power* would provide hands-on technical information about RE systems, and support itself by selling advertising within its pages. This concept worked well until around *HP13,* when printing, paper, and mailing costs began to exceed our advertising revenue. With *HP15,* and after more than two years of giving subscriptions away for free, we began charging for *Home Power.* At this point, the magazine was barely supporting Karen and me. We were publishing the magazine from a single Mac computer at our homestead on Agate Flat. We needed help, and the only way to get it was to hire folks to work with us. Karen and I were working twelve hour days, seven days a week. We couldn't begin to keep up with the flow of info and sales on our own.

Over the next few years, the magazine really began to grow—more subscribers, more advertisers, and more pages of RE info. More and more folks wanted to use RE to power their homesteads. *Home Power* became the place to learn the technology and to access the required hardware via our advertisers.

**Getting Colorful and Slick**

In 1993 we took a big risk. We'd had trouble getting *Home Power* on newsstands. While the info in *HP* was real enough, its physical appearance wasn't up to newsstand standards. Newsstand distributors were put off by our funky black and white print job on recycled newsprint paper. If we were going to spread *HP's* message via newsstands, then we were going to have to make some changes. So change we did.

With *HP35,* we changed printers and revamped our production. We went from paste-ups (art board masters) to a total digital production; Instead of sending paste-ups to our printer, we sent computer disks. We also moved into a higher quality, full color print job, but still on high quality recycled paper. We couldn't have accomplished this without the aid of our new printer, St. Croix Press in New Richmond, Wisconsin. St. Croix was invaluable—they taught us digital publishing technology and helped us with the many mistakes we made. With this change, newsstands began selling *Home Power,* and the mutant spore began to spread even farther.

**Getting *Home Power* Online**

We began putting *Home Power* online for computer users in the early 1990s. We ran our own computer BBS and gave our information to anyone who cared to download it. We still continue this, only on the Internet rather than on a BBS. We really like getting back to our roots by giving away the information in *Home Power.* While we can't afford to do this with the paper edition because of printing, paper, and postage costs, we can do this on the Internet.

**Home Power Today**

We still have the same mission statement—to provide technical information and hardware access for small-scale RE systems.

For each of the last four issues, we've printed 26,500 copies of *Home Power.* About half of these copies go out to newsstands worldwide, and the remainder are mailed to subscribers worldwide, or sold as back issues. About 45,000 people download our current issue for free from our Web site. About 125 RE companies advertise their products and services in each issue. We've also branched out into publishing books and CD-ROMs.

Our editorial office is still on Agate Flat, and still six miles off-grid. Our RE systems here have grown over the years to meet the electric power demands of this office. We now have about 3.3 KW of PV modules and a 1 KW wind generator. All these computers can really suck up the electricity. We call our establishment on Agate Flat, "Funky Mountain Institute." While funky it is, it works and it grows. We no longer have to haul our water in jerry cans. We now have such downtown luxuries as solar-heated showers and a washing machine.

Today we are a crew of over a dozen folks. The *Home Power* crew members work their butts off for their wages, but also for the satisfaction of working on something they love. It's great to be part of a crew that is so high on their work. All of us could make more money in other endeavors, but we're driven by our commitment to spreading the word about renewables.

This commitment, and the conscientious, hard-working spirit of the crew members lets us work with a looser structure than many companies our size. Our editorial and layout staff are scattered up and down the west coast, telecommuting from their home offices much of the time. Email is the glue that holds this scene together, as we work with each other, and with authors around the globe.

In contrast, over the last few years we have centralized our ordering and shipping department, which used to be managed out of several homes. The office crew at our new downtown business office and warehouse efficiently takes your calls and gets the goods out the door and on their way to you. So on many fronts, we, like the small-scale RE industry, are continually growing and changing. And indeed, what a long strange trip it's been.

As we go into the year 2000, I want to thank you, our readers, on behalf of the whole *HP* crew. You are the folks who have made *Home Power* a success. Without your support, we'd be out of a job. Without your support, the RE industry would still be where it was ten years ago—a dream for the future. It's all of you who have made small-scale RE evolve from a dream into a reality. I salute you!

**Access**

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richard.perez@homepower.com
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# Q&A

### LED Homebrew Confusion

Dear *Home Power,* I enjoy reading your magazine. Recently, I read Jonathan Scherch's article on LED lighting *(HP73,* page 88). I too would like to make some of these lights. However, I have a few questions before I start.

First, what is a candela, and how does it relate to lumens? How does one know if the amount is appropriate for the lighting task?

Second, the LED schematic on page 90 is a bit confusing. There's a 220 Ω resistor between the 12 V, 1 A regulator and the battery written, but not drawn in the schematic. Is it there, or not?

I plan to use 7,000 mcd, 10 mm, 3.4–4 VDC, white LEDs on a 12 volt circuit. Will this schematic work for my situation? Thanks, Leon Birstein, Black Mountain, NC

*Hello Leon. "Candela" is a newer term than "candle," but they mean approximately the same thing. They are both units of luminous intensity, which is a measurement of light received, not transmitted.*

*A candle, abbreviated as the letter "l," is the "intensity of light emitted through an opening 1/60 of a square centimeter in area from a hollow platinum enclosure, maintained at a temperature of 1,773°C." That may be more than you wanted to know, but practically speaking, a 40 watt incandescent bulb has a luminous intensity of about 35 candles, while a 100 watt bulb puts out about 130 candles.*

*Each of your 7,000 mcd (millicandle) LEDs will put out about 7 candles. If you follow Jonathan's schematic and wire every two LEDs in series, each of these parallel strings will put out about 14 candles. Two parallel strings (four LEDs), at about 28 candles, will give you somewhat less light than an equivalent 40 watt incandescent bulb. If you want to read or do any detail work under the light, you'll need at least a dozen LEDs per light.*

*On the schematic, the resistor under the regulator isn't necessary. That text denoting that extra resistor slipped through during our production process. And you won't need that schottky diode, either—just scratch it out of the schematic, and cross it off your shopping list. The LEDs you're planning to use should work just fine. Happy homebrewing! Joy Anderson*

### Battery Connector Sizing

Aloha Friends at *Home Power,* Love your magazine! I have a technical question: What stranded copper cable gauge does the *NEC* require for battery connectors in a bank consisting of twelve 2 volt lead-acid chloride cells (submarine batteries) to make a 24 volt battery bank? Each cell is rated for 87 amps maximum discharge. The length of the cables is about 7 inches. Can I use this to run a Trace DR2424 inverter if I keep the AC output below 1,900 watts? Is soldering better than swaging? Thank you. Sincerely, Erik Frye • digfreely@maui.net

*Hello Erik, Please double check the discharge figures on your batteries. Is there an amp-hour capacity figure? I'd be interested in physical dimensions of the cells as well.*

*The 87 amp discharge figure on your batteries may relate to the capacity of the cell at a 20 hour discharge rate. It may not be an instantaneous amperage limit but rather a cell capacity specification. If the capacity of each 2 VDC cell is 87 amp-hours, multiply this by 12 and you have an 87 amp-hour battery at 24 VDC. The 7 inch cable length leads me to believe that this is not the case. If it is, the battery capacity is very marginal in relation to the output of the inverter.*

*The minimum battery capacity Trace recommends for their 24 VDC DR inverters is 100 AH. And this is only for utility backup systems with small, short duration loads. An 87 AH battery will not be able to maintain voltage when a sizable load is placed on the inverter. The default low voltage disconnect setting on the DR2424 is 22 VDC. The inverter will shut down when the battery reaches this voltage and needs to be restarted manually. Voltage depression gets worse when batteries are at a low state of charge or operating at low ambient air temperatures.*

*Article 480 in the* NEC *deals with batteries. There are no* NEC *requirements that specifically address battery interconnect sizing. Interconnect size is based on ampacity and conductor temperature ratings listed in* NEC *article 310.*

*In your case, you have a single series string of cells. Because only one current path exists, the interconnects will be subject to the total amount of current being drawn from the batteries. In larger battery banks with multiple series strings, more than one path exists. Assuming equal conductor size and length, total current is divided equally among each series string of cells. #2/0 copper cables are the standard interconnects used in battery-based RE systems. In open air, #2/0 copper cables are good for 225 to 300 amps, depending on the temperature rating of the conductor's insulation. Your DR2424 has a rated input current of*

*140 VDC. The lugs on the cables should always be soldered. Joe Schwartz*

**Todd Chargers**

Help! I suggested that an off-grid friend get a Todd 75 amp charger to supplement his Trace DR2412 modified sine wave inverter's charger. He has a 3 KW Honda genny running at 60 Hz, 120 VAC according to the metering built into the Trace. The cable feeding the chargers is not very long and is 12 gauge.

With his battery voltage around 14.1 V under charge (he is 350 AH down with twelve L-16s), he sees about 50 amps with the Todd feeding the batteries alone. If he turns on the Trace's charger, this goes up to about 60 amps. He was hoping for around 125 amps or so with both of them running. I can't figure out why the Todd doesn't put out more. He has the adjustable one and the set point is at max. The Trace is set to charge to 14.7. Alone, the best it has ever done is around 50 to 60 amps, dropping off to around 40 or so as the cells charge. The batteries have #00 cables, so they should be big enough.

Do you have any ideas why this combo would not crank out better charging amps when working together? I would imagine as the battery voltage rises, the current is going to drop off somewhat, but these batteries are not fully charged and the combined charging current is not much better than one alone. Todd Cory, KE6SXS toddcory@jps.net

*Hello Todd. Your friend's experiences with the Todd charger are normal. I have three here, and only one will deliver above 50 amps at over 14 VDC. The Todds are rated at 75 amps at 12 VDC. Current rolls off rapidly as voltage rises.*

*Your friend should have bigger wire between the genny and the chargers—at least #8, but #6 would be better. Both chargers work mostly off of the peaks of the 120 VAC waveform. Even a slight voltage brownout can greatly reduce charger performance. Check it out with a Fluke 87 in 1 ms peak mode. You should see at least 158 VAC peak at the chargers when they are operating. Those Hondas have great peak voltage on their AC waveform.*

*The only battery chargers I've used which do not roll off in current as voltage rises are the switchers made by Statpower. They are much more expensive than the Todds. The Todds are inexpensive for a 75 amp charger, and you get what you pay for.*

*I'd suggest that he just run the Todd when the battery is over 14 VDC. Even though it's not great, it's still more efficient than the charger built into the Trace. By the way, tell him to start the genny and* then *plug in the Todd, and to unplug the Todd* before *he stops the genny. Many folks have had Todd failures if they leave it plugged in while starting and stopping the generator. It's not a very well designed or well made switching power supply. Richard Perez*

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# Index to Advertisers


aatec publications — 111
Abraham Solar Equipment — 127
Adopt a Library — 151
Advanced Composting Systems — 30
Aeromax Corporation — 67
Alternative Energy Store — 40
Alternative Energy Systems Co — 32
Alternative Solar Products — 75
Amazon Power company — 151
Applied Power Corporation — 41
AriStar Solar Electric — 151
ASE Americas — 58
AstroPower — 25
Atlantic Solar Products — 42
BackHome — 125
Backwards to the Future — 133
Backwoods Solar Electric Systems — 83
BargainSolar.com — 133
Bell Solar International Inc — 141
Bergey Windpower — 17 & 73
Bogart Engineering — 120
Bornay Windturbines — 104
BP Solar — 2
Brand Electronics — 112
BZ Products — 137 & 141
C. Crane Company — 141
C.C. Solar Technologies — 141
China Diesel — 51
Circuit Cellar — 64
Creative Energy Technologies — 137
Dankoff Solar Products — 82
Delivered Solutions — 79 & IBC
Dyno Battery — 16
Eagle-Picher Technologies LLC — 103
Eklektix — 140
Electro Automotive — 111 & 140
Electron Connection — 91
Energy Conservation Services — 93
Energy Outfitters — 126
Energy Systems & Design — 127
EPOWER — 107
ETA Engineering Inc — 114
Exeltech — 83
FireWind&Rain — 57
GennyDeeCee — 79
GenSun Integrated Solar Electric Systems — 105
Global Power Systems — 97
Great Northern Solar — 107
Greenshelf — 150
Guerrilla Solar T-shirts — 98
H-Ion solar — 154
Harris Hydroelectric — 141
Heart Interface — 1
Heaven's Flame — 79
Heliotrope General — 107
Hitney Solar Products — 127
Home Power Back Issues — 150
Home Power Biz Page — 81
Home Power CD-ROMs — 80
Home Power Sub Form — 80
Home Power T-shirts — 98
Horizon Industries — 151
Hot Products Inc — 72
Hydrocap — 120
Innovative Energy Systems Inc — 127
Intermountain Solar Technologies — 66
International Carbon Bank & Exchange — 110
Invertrix Inc — 86
Jack Rabbit Energy Systems — 78
KTA Services Inc — 112
Kyocera Solar Inc — 43 & OBC
Lake Superior Renewable Energy — 142
Maple State Battery — 132
Morningstar — 23
MREA Workshops — 98
MREF/ASES — 99
Natural Energy Systems — 133
NESEA — 140
New Electric Vehicles — 106
New England Solar Electric Inc — 135
Newinli International Inc — 82
Northern Arizona Wind & Sun — 121
Northwest Energy Storage — 59
Offline — 140
PicoTurbine — 156
Planetary Systems — 96
Pony Enterprises — 142
Quick Start REading Special — 150
RAE Storage Battery Company — 137
RCH Fan Works — 120
Read Your Mailing Label — 106
Refrigeration Parts Solution — 151
Renewable Energy Videos — 90
Rolls Battery Engineering — 93
RV Power Products — 115
Siemens Solar Industries — 15
Simmons Handcrafts — 142
Snorkel Stove Company — 80
Solar 4 U Inc — 104
Solar Converters Inc — 137
Solar Depot — IFC
Solar Electric Inc — 133
Solar Energy International — 87
Solar On Sale — 113
Solar Pathfinder — 107
Solar Plexus — 30
Solar Village Institute — 107
Solar Webb Inc — 126
Solar Works Inc — 119
Solarex — 33
SolarRoofs.com — 150
SolarSense.com — 7
Soltek — 112
SOLutions — 115
SolWest Renewable Energy Fair— 104
Southwest Windpower — 31 & 121
Staber Industries — 113
Sun Frost — 30
SunAmp Power Company — 126
Sunlight Energy Corp — 64
SunLine Solar — 115
Sunsense — 154
Sunweaver — 14
SunWize — 111
Surrette Battery Company Ltd — 105
Temiskaming Independent Energy — 126
Texas Renewable Energy Roundup — 92
Trace Engineering — 90
Trojan — 50
Two Seas Metalworks — 65
U.S. Battery — 24
Vanner Power Systems — 97
Veggie Van — 156
Vermont Solar Engineering — 125
Wattsun (Array Tech Inc) — 127
Windstream Power Systems Inc — 119
World Power Technologies — 64
Zomeworks — 121

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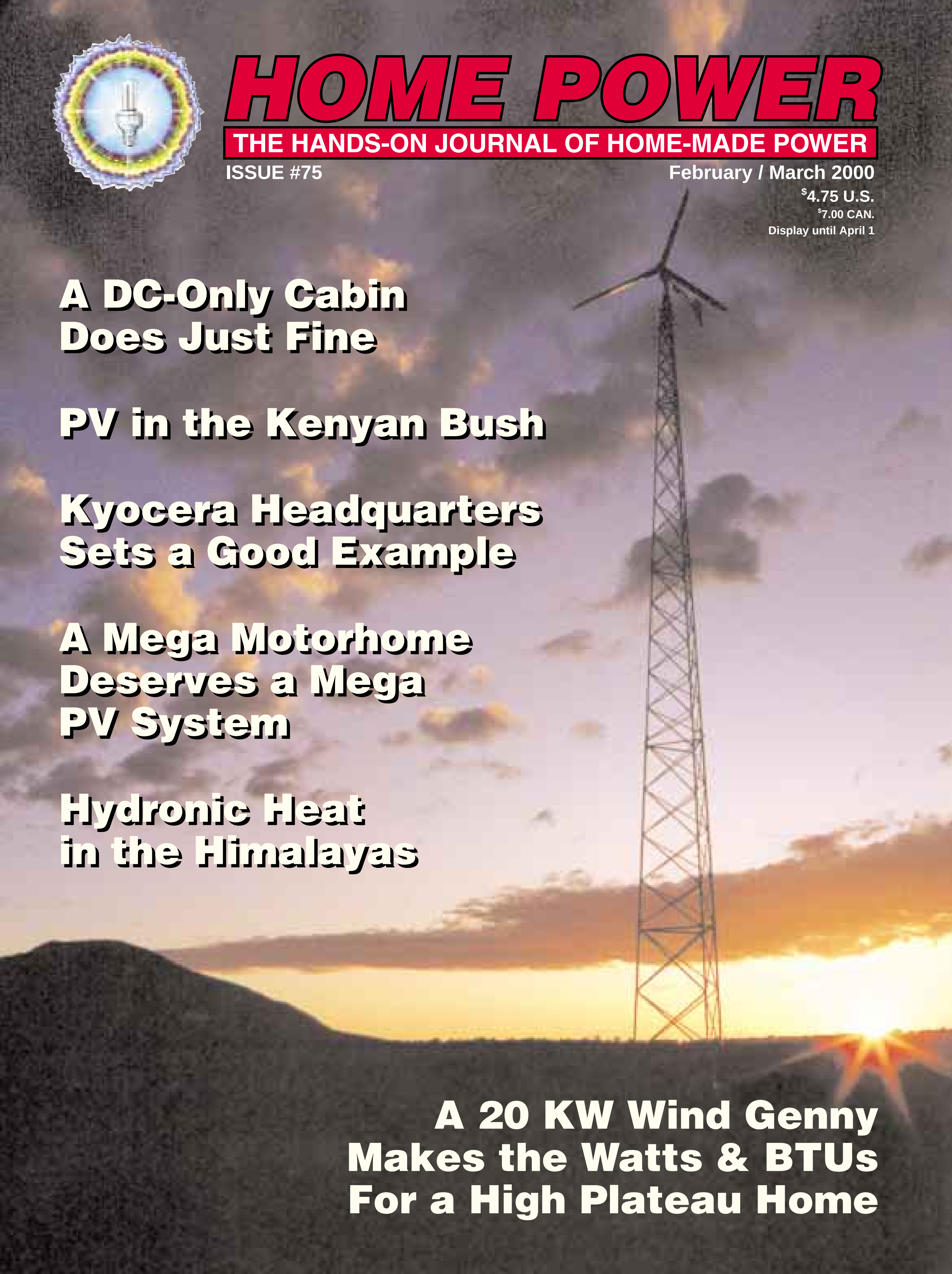

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*(continued on reverse)*

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