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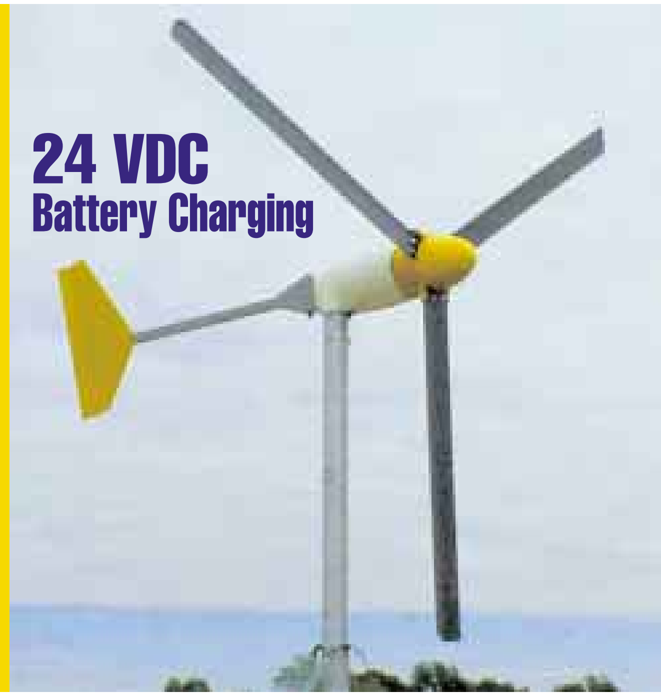

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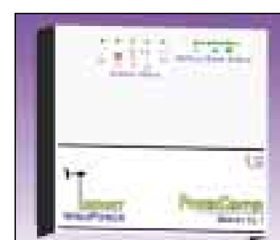

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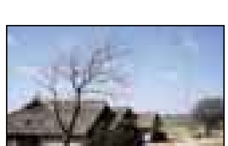
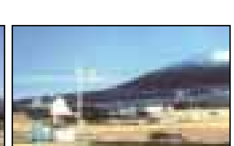
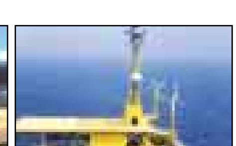
BERGEY WINDPOWER

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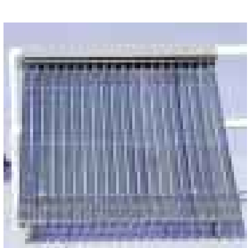
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #84 August / September 2001

Features



More Features

GoPower

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Cover: Blackouts affect thousands, everywhere and every year—how will your house look during the next one?

Guerrilla Solar

Things that Work!

Wrench Realities

They Do It on RE!

Comm Power

Columns

More Columns

Regulars

Access and Info

Access Data

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Star Power

At the Arcata Renewable Energy Fair

The tenth annual Arcata (California) Renewable Energy Fair was held in late April. For the past ten years, we have tried without success to get celebrities to come to the fair, knowing what star power can do to boost interest and attendance.

This year we found out that Woody Harrelson, well-known actor and activist, would be coming through town during the weekend of the fair, and he agreed to speak. Harrelson was on a "Simple Organic Living" (SOL) bike/bus tour that started in Seattle, Washington and ended in Santa Barbara, California. His tour was intended to demonstrate that the planet will not survive unless we all choose to live lightly on the earth. Harrelson walks his talk (or rather rides his talk). He bicycled the entire tour route, and he runs his support bus, called "Mothership," on hemp oil and vegetable oil (biodiesel).

Harrelson buys organically grown hemp clothing, runs all the Mothership appliances on solar electricity, and eats only organically grown foods. He was very pleased with his visit to Arcata, especially when he found out that CCAT would donate 250 gallons of their biodiesel (see *HP82,* page 58) to replenish his fuel supply.

In all the years of the Arcata Renewable Energy Fair, we have never had a larger crowd than the 2,500 who arrived to hear Harrelson's important message. Harrelson fired up the crowd, big time. By the time Woody was done, it felt like many in the audience were ready to change their ways.

You and I can make a difference, but celebrities like Harrelson can have a broad ripple effect. The bottom line? If you run an RE fair, it really helps to do whatever it takes to bring in the extra attendance—including attracting a big name to the event.

–Michael Welch

People

Mike Brown
Drake Chamberlin
Sam Coleman
Windy Dankoff
Jeffrey Evans
Liz Gillette-Ford
Eric Grisen
Kathleen Jarschke-Schultze
Peter Jones
Todd King
Stan Krute
Don Kulha
Tom Lane
Herb Levitin
Don Loweburg
Ken Olson
Karen Perez
Richard Perez
Jason Powell
Shari Prange
Benjamin Root
Connie Said
Joe Schwartz
Linda Tozer
Wightman Weese
Michael Welch
John Wiles
Dave Wilmeth
Ian Woofenden
Rue Wright
William Zeitler
Solar Guerrilla 0015

"Think about it…"

Desert and tundra are ecosystems, but without PV, your rooftop is a wasteland.

–Eric Grisen

Nomad 600 with a 32 watt panel

An Earthship

Jeffrey Evans

The Evans earthship in Colorado is powered by renewable energy and built with recycled and earth-friendly materials.

Living with renewable energy puts a smile on my face every time I think about it—even more today than it did in 1995 when we first built the PV system for our earthship (see *HP59,* page 6). We've gone through some adjustments in six years of living off-grid, and we are now sailing comfortably on the high solar desert of the Colorado Plateau.

South-facing windows facilitate passive solar heating.

The newly discovered "energy crisis" masks the real crisis that motivated us to live on solar and wind in the first place—pollution. Moving off coal-fired, nuclear, and centralized hydro power is about ending massive contamination of our air, water, and soils. Conservation is easy once you understand the real issue. As legendary British bluesman John Mayall says, "Nature's disappearing. It's goin' down—do you care?"

The Earthship

An earthship is an independent home built on principles of

RE System Grows

It is a beautiful, comfortable, energy efficient, and low impact home.

sustainability. It is made of materials readily available anywhere in the world. It functions as a passive solar house, with sunlight heating thermal mass walls made of rammed earth, tires, and adobe. It supplies its own power from the sun and wind, and collects its own water from the sky with a rooftop rainwater collection system. The design represents an effort to change our methods of living, our ways of thinking, and our understanding of the environment.

While enthusiasm is critical, practical knowledge of how to design and build a home and an energy system to meet your specific needs is not so common. We have, through a combination of diligence, necessity, and trial and error, finally reached solid ground with our renewable energy (RE) system.

We started out with a 1,500 square foot (140 m^2) structure and a very modest power system. Over the years we increased the size of the house to 3,000 square feet (280 m^2), and gradually rebuilt and upgraded many of our solar-electric system components. Expanding the size of the earthship was in the original plan. The additional size really didn't impact our solar needs, because we continued to follow a "lights on in the space you're in" conservation policy. We have more lights and outlets, but our consumption hasn't changed much.

Water is collected from the Colorado sky by roof catchment.

Recycled tires with rammed earth fill make cheap and energy efficient walls.

Earthen stucco creates energy-storing thermal mass.

How We Started

Our original system was of modest proportions: eight Kyocera 51 watt panels, an Air 303 wind genny, and a Trace 2,500 watt modified square-wave U-series inverter in a 12 volt nominal system.

The first big problem from our original installation came with the batteries. The first set, ten T-105s, were used not only in the construction phase to run tools, but during our learning phase, when we made most of our mistakes. I didn't know what "equalization" meant until several years of system use had passed, and we didn't have an engine-generator.

Equalization is a periodic, controlled overcharge to bring all the battery cells to the same level of charge or voltage. This reduces sulfation, mixes the electrolyte, and extends battery life. Equalization of flooded lead-acid batteries requires overcharging the battery until the individual cells reach 2.6 volts per cell. That means 15.6 volts for a 12 VDC nominal system.

Check with the manufacturer for equalizing specifics for your particular batteries. And never attempt to equalize sealed batteries. Overcharging sealed batteries will seriously damage them! In our system, when the batteries began to perform poorly, we added a Generac 4000 engine-generator to the system, and started to maintain the batteries properly.

A Closer Look

The next concern, which then became my primary target, was the charging system itself. The original system was built with an on/off switching device that broke the panel charge off at about 14.2 volts. This meant that we could never equalize with the panels alone, no matter how much sunlight was available.

After numerous discussions with installers, dealers, and various experts in the field, I found an installer (Leif Jewel of Ridgway, Colorado really knows his stuff) who could remove the switch system and replace it with a Trace C40 charge controller. This little wonder brought my PV system back to life. One fully automated, solid-state, pulse-width modulated charge controller allowed me, for the first time, to manage my system with the sun. And my batteries were so happy.

A solar hallway along the south wall connects all rooms.

Every room receives solar gain.

More Problems

While the system was given new life after this, our loads continued to make their demands, and take their toll on our batteries. One of the culprits an RE system will encounter is the conventional 1/2 HP AC pressurizing water pump. This energy bandit has a significant motor surge.

I literally ran to the voltage meter every time this monster kicked on, like a frightened deer bolting from oncoming headlights. The voltage would get as low as 11.5 V, and under load in the best of times would be 12.2 V. With each passing month, the meter would dip farther into the white zone as the pump began its sluggish mantra.

Natural building materials lend themselves to artistic creativity.

I was desperate for an alternative. One day I discovered Backwoods Solar. The good folks there told me that this was not such a difficult problem to solve after all. With great trepidation and after intense discussions, I ordered a Shurflo AC pressurizing pump (model #2088-594-154, 115 VAC; 0.94 amps maximum. Actual running amps will depend on gpm flow rate). I was so freaked out that I bought two. (One is still in the box.)

Earthship Loads

Load	*Total Watts*	*Hours per Day*	*Watt-hours per Day*	*Days per Week*	*Watt-hours per Week*	*Avg. WH per Day*	*Percent of Total*
Sun Frost RF-12	60	7.00	420	7	2,940	420	35.0%
3 CF lights	39	3.00	117	7	819	117	10.0%
2 Surge protectors	25	4.00	100	7	700	100	8.5%
Gas oven	600	0.25	150	4	600	86	7.0%
Electric piano	90	1.00	90	5	450	64	5.5%
Washing machine	110	1.00	110	4	440	63	5.0%
TV	60	1.00	60	7	420	60	5.0%
Computer CPU	55	1.00	55	7	385	55	4.5%
Water pump	108	0.50	54	7	378	54	4.5%
Iron	1,500	0.25	375	1	375	54	4.5%
Toaster	900	0.25	225	1	225	32	2.5%
Hair curler	750	0.25	188	1	188	27	2.0%
Monitor	14	1.00	14	7	98	14	1.0%
Printer	12	1.00	12	7	84	12	1.0%
Battery charger	8	10.00	80	1	80	11	1.0%
Stereo	30	0.50	15	4	60	9	1.0%
VCR	19	0.50	10	4	38	5	0.5%
CD	10	0.50	5	4	20	3	0.5%
Radio	10	0.50	5	4	20	3	0.5%
Vacuum cleaner	78	0.10	8	2	16	2	0.5%
		Totals	2,093		8,336	1,191	100.0%

888 watts of PV, and a small wind generator cover the electrical loads.

This little baby has a very small surge—just enough to take my inverter out of sleep mode. And it uses a small amount of energy. I installed it in-line, bypassing the 1/2 hp AC pump with a valve, and leaving the old pump installed in case I ever have to use it again.

Is It Over Yet?

That problem solved, things began to look up. No more giant surges and depleting energy moments. Or so I thought. But the batteries continued to decline, charging quickly, but losing strength quickly after sundown. I continued to be on the lookout for low voltage, worrying about use with every flick of the switch. I realized that I had to take a closer look at consumption.

I discovered that my washing machine was nearly as bad as my water pump when it came to energy consumption (and it didn't clean worth a darn either). With a rated draw of about 600 watts and a significant surge (enough to shut down my inverter when combined with the old water pump), this modern beast could only be run on the sunniest days anyway. I couldn't have been happier to see it in the back of a pickup heading for the Salvation Army store. I didn't even wave.

Solutions

If anything could surpass that moment of joy, it would have to be the day I picked up our freshly shipped Staber System 2000 heavy duty washing machine. Its running power draw is under 200 watts, and it consumes about 1/2 the water of a conventional machine. Water usage varies from 16 to 22 gallons (60–80 l) per load depending on the water level setting.

As for drying, it's all solar now. The old gas dryer went bye-bye with the washer. So I no longer clamber desperately over everything in my path to get to the voltage meter. When I do, I find that the meter barely moves when the washer runs. In combination with the low energy water pump, I can take care of laundry needs just about anytime I wish.

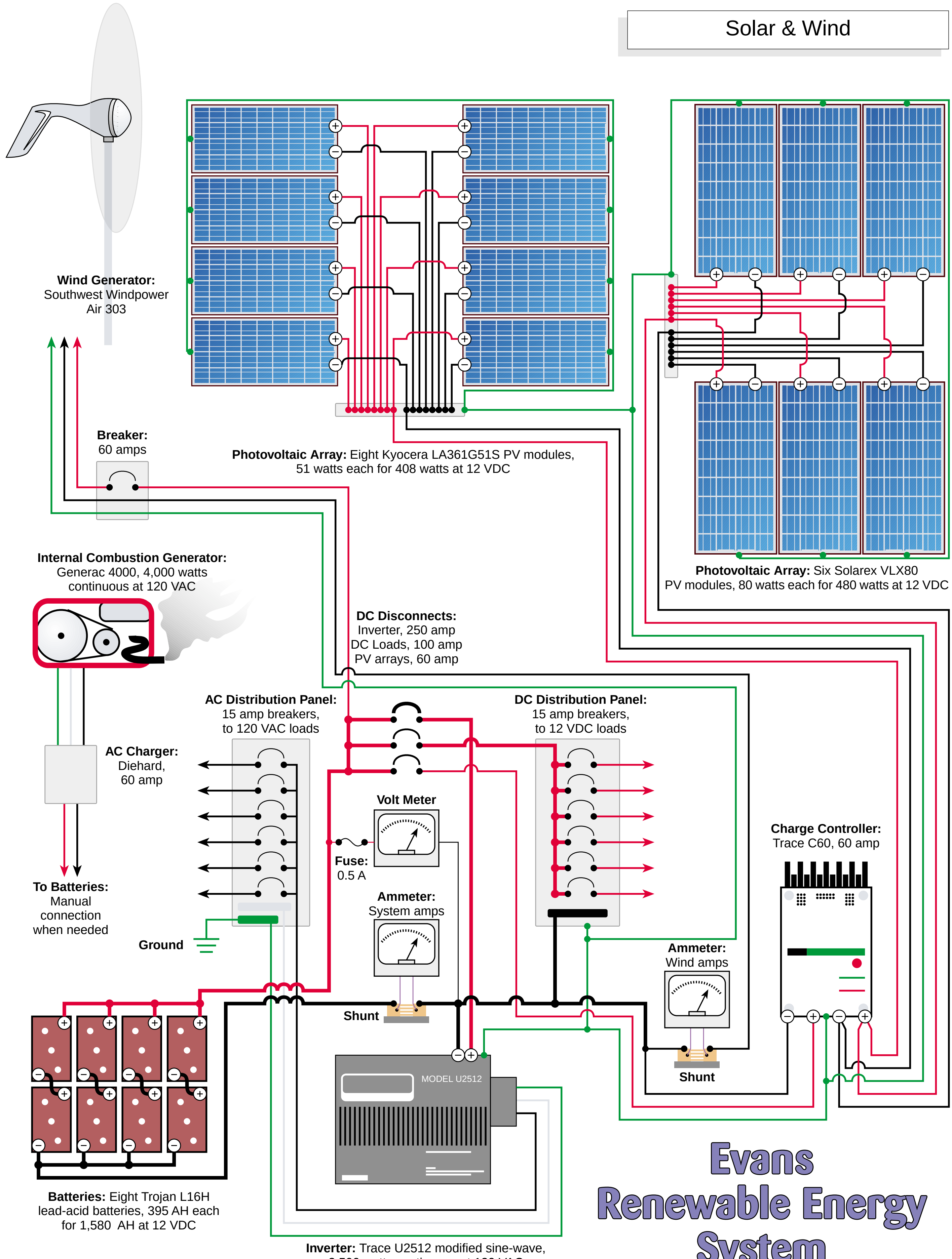
Early in the game, we had replaced our 1950s Servel propane refrigerator with a Sun Frost AC RF-12. At 70°F (21°C), this refrigerator/freezer consumes about 350 watt-hours per day. This is a premiere machine as well, familiar to most RE users. So as we made these upgrades, I was very satisfied with myself. After all, the problems were being eliminated one by one.

Still, there was the storage problem. Even with all the changes, the batteries were losing ground with every passing day. After several years of heavy duty use and abuse, we were seriously short on energy during the winter months, November to March. It was time to replace the batteries, even though there was still some life in the six-year-old T-105s.

New Batteries

Which way to go—another set of T-105s, or move up to the L-16 level? I began yet another furious session of

The power panel includes a modified sine-wave inverter and 60 amp controller.



Evans Renewable Energy System

Eight Trojan L16Hs store 1,580 amp-hours at 12 volts.

research, looking at all the alternatives in the battery world. I assessed cost, weight, availability, and charging factors before buying eight 395 AH high-capacity Trojan L-16s from a local supplier.

These batteries weigh 120 pounds (54 kg) each, which is about what I weigh. Needless to say, it was a vertebral nightmare to get them into the newly expanded battery box. In fact, I had to put the batteries onto the box base, and then build the rest of the box around them.

The actual output of my PV array was around 350 watts, with periodic production from the Air 303. I settled for eight batteries when I really wanted ten. Still, the new pack of eight high-capacity L-16s increased my storage capacity from about 1,100 amp-hours to 1,580 amp-hours.

I figured that with my newly sized loads, I could operate the eight batteries at around 20 percent depth of discharge, where I had been closer to 50 percent before. (Thanks to Kerry Kalarney of Sundance Solar in Montrose, Colorado for advice on battery installation.) We installed the batteries and did some initial equalization charges from the generator. Just before the onset of winter, I began to enjoy my new-found power.

Until winter actually arrived, that is... Much to my personal aggravation, there was less sun than usual, and production was dismally low—not enough to bring the batteries up to full charge levels. The following few months saw generator charges every three or four days, or so it seemed. Back to the frightened deer look, with long, ritual staring at the meters.

After repeating this experience on a regular basis, I began to see the light. I needed more PV modules! Great sun gods, another project in my long trek toward the unattained vision of energy self sufficiency!

New PVs

So, as soon as the clouds cleared and the ground thawed, I began the installation of six Solarex VLX80 modules. These PVs are rated at 80 watts at 20°C (68°F). To reflect real world PV operating temperatures, the rated output on all modules needs to be derated by about 20 percent.

I planned to put them on a new pole, set in the berm behind the new addition to the earthship. This proved to be the moment of truth. Could I, a classic novice, overcome the massive levels of fright I experienced at the mere thought of doing this myself, and install my own modules?

With a little help from my friends (Glen Harcourt of Solar Works in Placerville, Colorado, I am forever indebted to you), I decided to go forward. Extensive research followed.

Aside from wire runs and laying conduit, the primary problem was how to get power from two arrays into my system without blowing everything to smithereens. The answer? A Trace C60 charge controller. The new array generates 80 watts per panel, rated at 17 volts and 4.71 amps times six panels. That is 480 watts of production, in addition to my original array's rated output of 408

Evans System Costs

Original Installation

Item	*Cost (US$)*
8 Kyocera 51 watt PVs with rack	$3,000
Trace U2512 inverter	2,500
Generac 4000 generator	1,250
Control box, poles, gauges, etc.	1,200
Air 303 wind generator with tower	1,000
10 Trojan T-105 batteries, 6 volt	800
Diehard 60 amp charger	250
Trace C40 charge controller	200
Original Installation Total	$10,200

Upgrades

Item	*Cost (US$)*
6 Solarex VLX80 panels	$2,300
8 Trojan L16H batteries, 6 volt	1,500
Miscellaneous	500
Top-of-pole mount rack	300
Trace C-60 charge controller	200
Upgrades Total	$4,800
Grand Total	$15,000

watts. This gives a total of some 888 rated watts. Derating this number by 20 percent to reflect PV output at real world operating temperatures, I came up with about 710 watts of actual PV production in full sun.

Maximum charging during full sun is about 50 amps. This is confirmed by the actual reading on the meters at the power center. But the joy, the sheer joy, of seeing production on this little home system run up to 40 and 50 amps as soon as the sun lights up is indescribable.

My battery maintenance routine has become adding distilled water to my batteries on a monthly basis and monitoring to make sure that I am getting regular equalization periods. I have not used my generator all winter. Equalization is available regularly from the panels alone.

Time to Enjoy

With the arrival of the new battery pack, I have 1,580 amp-hours to work with (395 AH x 4 = 1,580 AH). At 20 percent depth of discharge, that gives me 316 amp-hours to use (1,580 AH x 20% DOD = 316 AH), or 3,792 watt-hours (316 amp-hours x 12 volts = 3,792).

As the load chart shows, we consume, on average, 1,191 watt-hours of energy per day. At full charge, that leaves us with about three days of stored energy to burn. Of course, at 20 percent DOD, I have a lot of energy to play with if I need to use more.

In addition, with my new PV array, I can produce some 3,550 watt-hours on a sunny winter day (710 watts x 5 hours = 3,550 watt-hours). I am producing nearly three times what I might normally use (1,191 watt-hours x 3 = 3,573 watt-hours, compared to 3,550 watt-hours of production).

My adjustments on the load side over the last four years include removing two energy hogs (washing machine and water pump), and replacing them with energy efficient units. In all this, I increased the number of appliances available, building more capability and versatility into my home use. I also eliminated all serious surges, while at the same time decreasing the overall energy load.

We have invested $15,000 in this system and have used it for six years. At an average cost of $150 per month for utility-powered homes, in another 28 months our system will have paid for itself.

My one remaining fear has yet to be addressed—inverter failure. Somewhere out there, there's a sine-wave inverter waiting for installation in our earthship. But it is an expense that I hope to delay for some years to come. The modified square-wave inverter has its drawbacks, such as noticeable buzzing in my electric piano, but to tell the truth, we don't notice it that much these days.

Sustainable Living, Sustainable Energy

The earthship experience, which has led me into the world of solar energy, continues to be an enlightening encounter. My life, and the life of my family, has been changed forever. I have learned much about the natural world, as well as about our comprehensive disregard as a society and culture for nature itself.

This trek into a new life has taken me into what is rapidly becoming the dominant issue of the twenty-first century—recognizing the massive levels of degradation of our air, water, and soil. I add my voice to the growing chorus of humanity in their call for sustainable living practices, including how we build and where we get our energy.

Access

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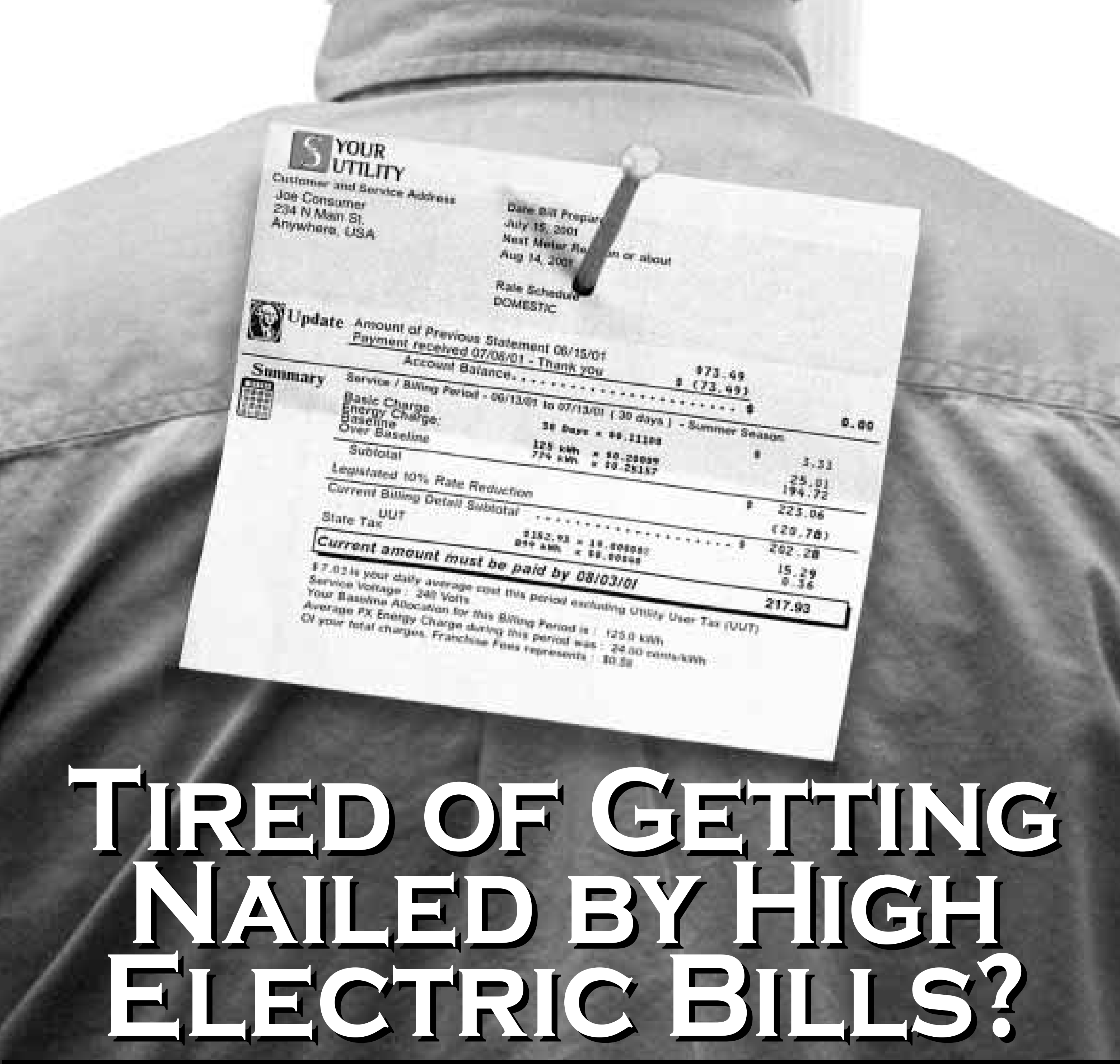
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New Tara in Georgia

A Challenge to the South

Tom Lane, with Linda Tozer

192 Siemens SR-100 photovoltaic modules provide the power for the building and future operation of New Tara.

Scarlett O'Hara's precious Tara in *Gone with the Wind* was a mythical plantation in Georgia that depicted a world-famous image of the southern plantation lifestyle. Steve and Debra Davison's solar-electric plantation in central Georgia—I call it the "New Tara"—has become a legend in the south. And it's only in the beginning stages.

In the spring of 1999, Steve Davison contacted Roger Locke of Hutton Communications in Atlanta, Georgia about his boyhood dream of using solar energy. Because Hutton is the Siemens solar-electric distributor for the southeastern United States, Steve asked Roger to design an initial system for the New Tara.

Our experience with a similar job in Florida *(HP70,* page 15) and with systems around the world since 1977 prompted Roger to include Energy Conservation Services (ECS) in the design team meetings. Within a couple of weeks of the initial contact, Steve, Roger, and I met on a Georgia hillside, setting Steve's solar dream into action.

An avid *Home Power* reader, Steve Davison wanted to use solar energy to power his future home. But he also wanted to build a plantation field of solar modules to feed green power back into the grid and make it available to his neighbors. Before the Davisons built their hillside home, Steve wanted to install a solar-electric system for their temporary home on the property, and for electricity for building their permanent home.

His goal, even in the beginning stages, was to install a solar-electric system that would produce excess power for sale to the rural electric grid. The long-range plan was to make New Tara a showcase of the latest solar and energy efficient technologies, with a goal of encouraging other southerners to "give their sun a job."

All About the System

New Tara's system started with 192 Siemens 100 watt solar-electric modules and eight Trace SW5548 inverters. The storage battery bank contained 36 Deka 1,247 amp-hour 12 volt batteries wired for 11,223 amp-hours at 48 volts. Utility power and a 100 KW Onan Cummins diesel generator were installed for backup should the solar-electric system malfunction, or if the need for backup power arose during inclement weather.

The job started in June of 1999, using a pole-mounted array system with 24 Direct Power and Water (DP&W) racks in three north/south rows. Eight racks were aligned in each row. Each rack holds eight Siemens SR100 modules for an initial array of 192 solar-electric modules. The south-facing hillside pasture provided enough room for the present system and allowed for future expansion.

Sets of three racks, one from each of the rows, were combined at the rack in the middle row with eight custom-made combiner boxes. Each of these custom boxes feeds a Trace C40 controller with a digital voltage meter (DVM) in the power conditioning and distribution building.

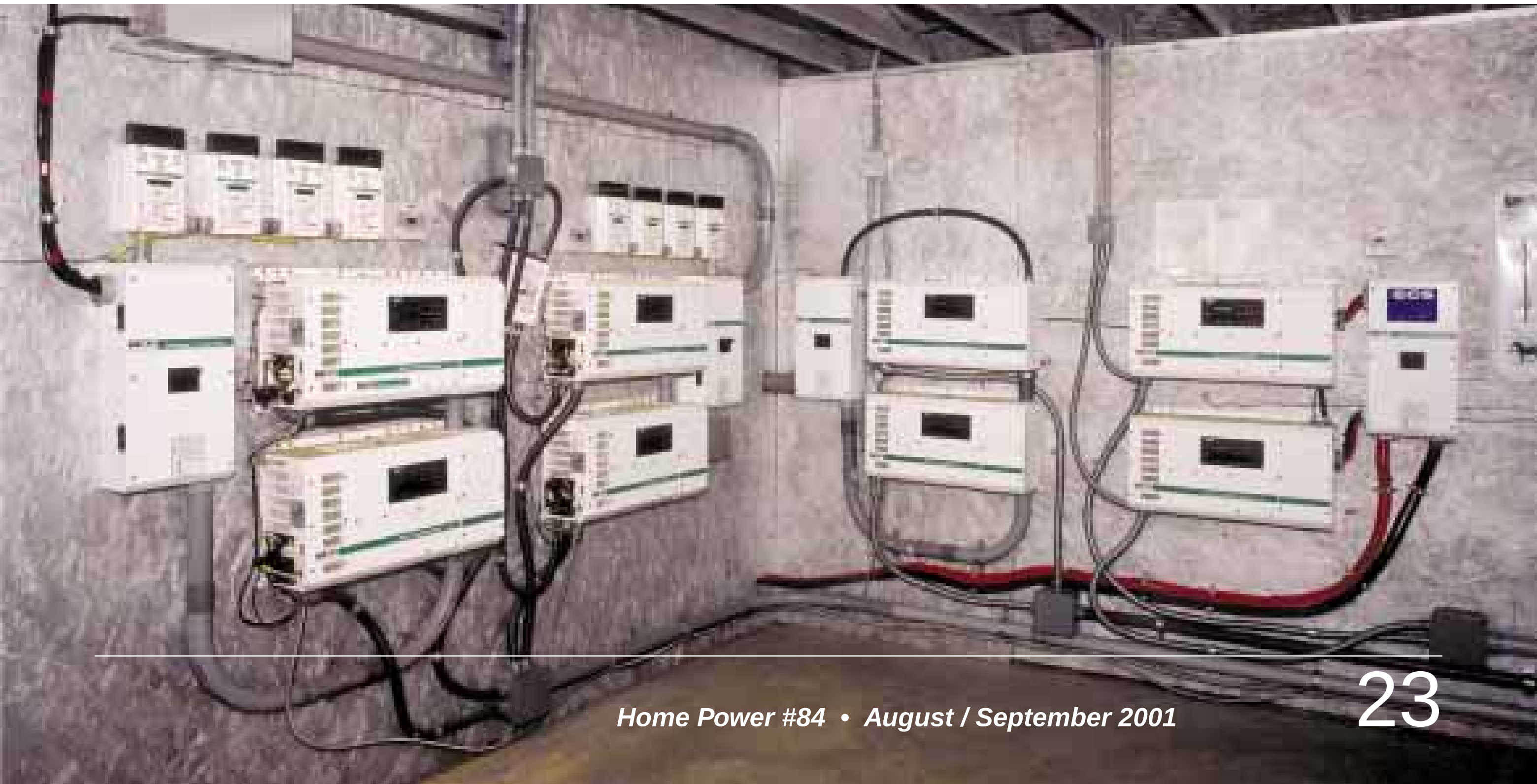
We needed 84 linear feet (26 m) of space on the Davisons' property to install these eight DP&W racks. Each rack was installed 12 feet (3.6 m) from the next one, atop six inch (15 cm) schedule 40 steel poles. Poles were painted with Rust Destroyer rust converting primer, and then painted with an ICC ceramic coating.

The pole racks made for easy east/west alignment on the rolling hillside. Installed this way, the arrays are in full sunlight year-round from 8 AM to 5 PM. Using track racks would have required almost 300 linear feet (91 m) of spacing, instead of the 84 feet (26 m) required with the pole racks, to prevent east/west shading from adjacent racks. Once the poles had been set in concrete, all 24 racks in the array were assembled. Then the 192 modules were attached and wired together in 48 volt subarrays of eight modules each.

Five ECS wrenches took just one day to install the 192 modules on the 24 racks. The DP&W racks have six north/south adjustable positions. Using the solar panel angle guide in *HP36* (page 14) allowed eight north/south adjustments a year. All 24 tilt angle adjustments can be made in less than thirty minutes by one farm hand! Thank you Jeff Randall of Direct Power and Water for this rack design!

Steve and Debra Davison are psyched to set an example by spinning their meter backwards.

The power room includes eight Trace SW5548 inverters capable of 22 KW at 220 VAC.



The twenty-four Direct Power and Water PV racks can be adjusted for seasonal angle in less than one minute each.

Rack Configuration

All eight Siemens SR100 modules on each rack were configured individually as 6 volt modules at 12 amps each. These eight 100 watt modules were wired in series to create a 48 volt subarray at 12 amps. This simple wiring technique only requires one #8 (8 mm^2) wire in series between each module. Two #8 wires were used for the run from each rack to the combiner box, where three racks were combined and grounded.

The positive leg from each rack was wired to a 20 amp RK5 time-delay fuse in a box on the pole. Then it was fed to a combiner box located next to each middle rack row. Eight Trace C40 controllers with DVMs were wired to 60 amp circuit breakers on two of the four Trace DC250 disconnects used with each pair of series-stacked SW5548 inverters. Each Trace C40 was fed from a combiner box by a separate wiring run of #2 (33 mm^2) wire.

Fast-acting polyphaser lightning protection with 50 amp resets for both the positive and negative legs in parallel were used in every box. The original IS-48VDC-30A polyphaser lightning protectors in the combiner box all had to be replaced. They were tripping the positive and negative polyphaser disconnects on hot summer days when the controllers were at open circuit voltage with a full battery bank. IS-60VDC-30A polyphasers were the required upgrade.

In addition to grounding each combiner box, a drip irrigation system was installed for the entire array to produce better grounding during extended hot dry weather and for additional lightning protection. Under full sun, each three-rack subarray produces 36 to 38 amps at 48 to 56 volts from each of the eight combiner boxes. The system delivers a total of 13,824 watts (288 amps at 48 volts) to the battery bank.

Battery Bank

The battery bank, weighing 36,000 pounds (16,330 kg), consists of thirty-six 12 volt, 1,247 amp-hour Deka batteries wired as one large 48 volt battery bank. The eight Trace SW5548 inverters were wired in four groups of two inverters. The Deka batteries had two positive and two negative connectors on each battery terminal. Deka supplied heavy gauge #4/0 (107 mm^2) cable to connect each group of four 12 volt batteries in series at 48 volts.

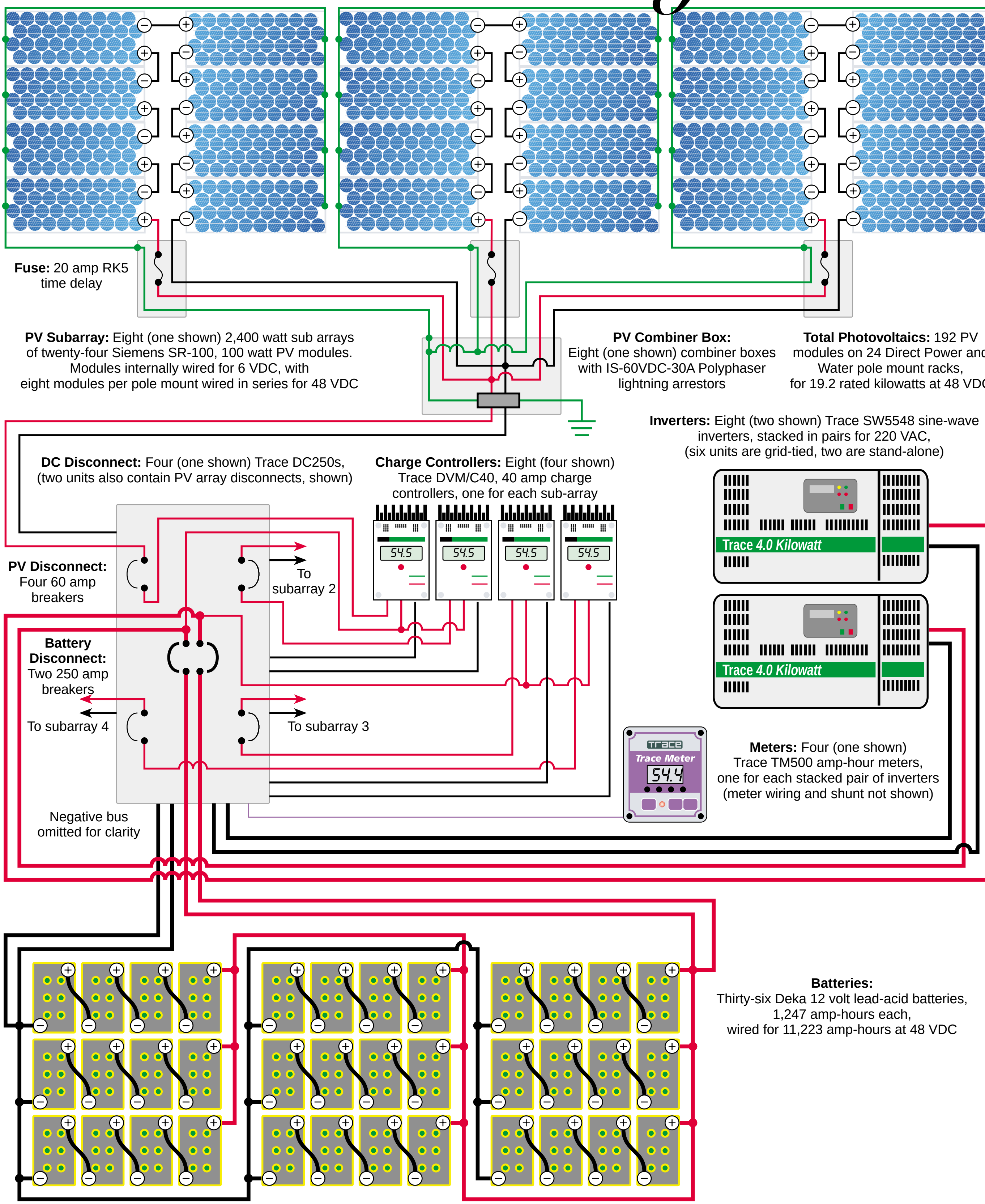
All parallel connections in the huge battery bank were wired with two positive runs and two negative runs of #4/0 cable. Great effort was made to create equal distance wire runs from each of the eight Trace SW5548 inverters to the battery bank. However, having the extra #4/0 cable on all parallel battery connections helped create an even draw from the eight positive and eight negative inverter cable connections on the battery bank's terminals.

Four Trace TM500 battery monitors with 48 VDC pre-scalers were used with each pair of series-stacked SW5548 inverters. This provides a second digital meter reading confirmation on the inverters and the C40 DVMs. They were all wired to separate shunts to give independent information on battery bank voltage.

The output from three pairs of inverters goes to an auto transfer switch. The fourth pair's output goes to a manual transfer switch. From there, it is sent to its own AC subpanel. One pair of inverters powers the main house. The second pair powers the pool house. The third and fourth pairs are split up to power the air conditioning units and pool pumps. The inverters are now in LBX (Low Battery Transfer) mode, which transfers loads to the grid when battery voltage reaches a low set point. We will be using "sell" mode in the future

Recycled rubber pool mats were placed under the battery bank to separate the steel cases from the

Davison Photovoltaic System



Eighteen tons of Deka lead-acid batteries provide 11,223 amp-hours of storage.

concrete. Water Miser vent caps replaced all of the 108 original battery caps. These flip-top caps make the bimonthly inspection and watering of the batteries easier, help reduce hydrogen fumes, extend watering intervals, and prevent an externally created spark from causing an internal battery cell explosion.

All battery terminals were lightly covered with petroleum jelly before wiring, and with lithium automotive grease after wiring to prevent corrosion. Sixteen battery temperature sensors were also used—one for each controller and one for each inverter. These adjust the charge setpoints for different battery temperatures, and insure full charge in all temperature conditions.

Power Room

In this installation, the battery room was separated from the power conditioning room by an insulated wall. The ceiling, walls, and both of the vented roll-up garage doors were coated with LO/MIT-1 radiant barrier aluminum and fire retardant coating. This reduces heat gain inside the building and provides a shield against outside electromagnetic pulses or interference. Because of its spectral reflectivity (95%), the radiant barrier also helps illuminate the room.

The outside walls were insulated, and a continuous ridge vent was installed in the roof to vent the battery room and to keep the room as cool as possible during extremely hot weather. During the day, a solar-powered roof-mounted fan with its own PV module is used to exhaust heat and fumes from the battery room.

A second solar-powered rooftop fan exhausts the intense daytime heat from the eight Trace C40s and the eight inverters in the power conditioning room. The summer temperatures of central Georgia days added a great deal of heat to the power conditioning room, in spite of our best efforts to minimize temperatures.

Magic Materials

It's always been amazing to me that we capture light from a star with silicon crystals made from sand, one of the most common materials on the planet. Then we store the power in lead. These common materials create the magic for carbon-base life forms.

I normally try to size 0.85 to 1 watt of rated PV capacity per pound of storage lead for large arrays (for remote homes with large generators). I invented this formula myself as a relationship of lead to sunlight—it's swamp hillbilly PV system sizing. The Davison system, before expansion, was just over 0.5 watts per pound of lead. We are now adding 120 more SR100 modules to 15 more DP&W racks. This will bring the PV to lead ratio to 0.86 watts per pound of lead.

New Tara Load Considerations

Steve Davison's ultimate goal is to sell power to the local utility. During hot summer days, the temporary home site uses all the power the array creates in a day. For Steve to achieve future goals in his new home (to be finished in 2001), he needed to employ a systems approach for selecting materials and systems. To facilitate this, I introduced Ken Fonorow to the project. Ken is president of Florida Home Energy and Resources Organization (Florida HERO), and a nationally recognized building science specialist and Energy Star expert.

After reviewing the new house plans and completing a structural heat gain and loss analysis, Ken

108 Water Miser cell caps recombine gases created during charging, minimizing the need for watering.

recommended a range of measures to make the new home more energy efficient. Clearly, there is a relationship between the efficiency of a home and its energy requirements. Among the recommended energy efficiency measures were:

- An unvented crawlspace with a vapor barrier installed on the ground and air-sealed to the stem walls.
- Wall-sprayed R-20 cellulose insulation installed in 2 by 6 inch wall stud cavities.
- Double-pane, spectrally selective wood-frame windows with a solar heat gain coefficient (SHGC) of 0.4 or less.
- An unvented cathedral attic with R-36 Icynene insulation installed directly to the underside of the radiant barrier metal roof (to insure that the heating and cooling equipment and distribution ductwork would be within the thermal envelope of the home).
- An open loop geothermal or ground-coupled heat pump system, zoned to minimize the startup draw.
- An advanced load control system, to ensure that multiple systems don't start up at the same time and that they are rotated operationally.
- An LP gas clothes dryer, stove, oven, and a combination of LP gas and solar thermal pre-heater for domestic hot water.
- Compact fluorescent bulbs and other low wattage lighting systems.

Besides building his new home and creating a power source to feed back to the local utility, Steve Davison had another important goal for developing New Tara. He wanted to prove to his friends and Atlanta business and social colleagues that it was possible to power any appliance in a conventional southern home with solar electricity.

I was quite stunned to realize what the loads will include in a typical southern summer day. During the afternoon, operating this southern home meant operating two air conditioning systems, a dishwasher, clothes washer, clothes dryer, electric range, and oven. Since hot water was used for laundry, this meant that a 4,500 watt electric element in the water heater could be operating at the same time as all four electric burners on the stove and the oven—approximately 10,000 watts!

The Davisons' future home would have a solar hot water system as backup to an LP gas water heater. LP gas for the dryer or for cooking was not feasible in the present home. Intermittent water use also meant that a 1-1/2 HP well pump repeatedly started and stopped. The heat from midday cooking and cleaning also added to the household's tremendous radiant heat gain. With routine outside humidity over 80 percent and temperatures in the upper 90s, both air conditioning systems ran at full speed, exploding the home load requirements.

ECS's project supervisor James Dempsey, electrical wizard John Ault, and I had to face a rapid load management learning curve. Managing this inordinately large load was further complicated by the addition of three 1 to 1-1/2 HP pool and spa pumps that operated 24 hours a day. Because the recently built pool and cabana house would one day also be part of New Tara, we added sixteen 4 by 12 foot (1.2 by 3.6 m) Aquatherm Industries solar collectors to provide enough heat to allow the pool to be used most of the year.

Original New Tara design specifications called for six Trace SW5548 inverters. With the additional household load parameters, eight actually were required. James Dempsey worked on all the household loads with local electrician, Joe Rainey. Joe put in automated transfer switches for all eight dual inverter groups, and an 80 amp AC circuit for each inverter's battery charger.

We balanced all transfer switch loads to the home for each dual inverter group. We also automated backup power for battery charging with both the 100 KW Onan diesel generator and the local rural utility grid. This was in case the solar-electric system malfunctioned, or if it needed backup power for battery charging.

A huge 100 kilowatt Onan Cummins diesel generator provides backup.

Efficiency, load shedding, and solar like this pool heater, were all important for the PV system to meet the projected loads.

Solving Problems
Special credit goes to Jim Jackson of On-Site Power. The local rural utility was notorious for having short-term blackouts that resulted in the 100 KW generator starting unnecessarily. Jim designed a relay package that prevented the generator from starting in the event that grid power from the utility was not available, as long as the Trace inverters were operating correctly.

Two SW5548 inverters that are dedicated to the air conditioning and heating system kept tripping their internal breakers when the main air conditioner turned on during the hot summer days. The tripping continued even with no other load and an added start capacitor relay. The air conditioning distributor, technical literature, and factory engineers reiterated that the maximum AC starting surge at locked rotor amps was 65 amps at 240 volts.

Trace specifications indicated that the dual SW5548s could handle that load. We found that it often could not. We didn't know if the Trace system wasn't actually able to handle the 65 amps, or whether the startup load was greater than initially specified.

Geoff Levin at Trace was great. He helped us balance the inverter loads, and started us on the road to solving the inverter tripping problem. Though Trace sent their Power Tracer line logger to document AC running loads, we still failed to locate the problem. However, ECS wrenches with the Fluke 87 series III multimeter saved the day.

Two Fluke 87s set at micro surge time for the AC amp meters both agreed that the compressor sometimes drew 132 amps on startup—way above factory specifications. Problem solved—the AC contractor changed the compressor to two dual-stage systems, and the tripping problem ended.

As a matter of caution, wrenches should be extremely careful to compare any inverter manufacturer's stated continuous and surge ratings to "real situations." Many inverter manufactures, including Trace, often list both continuous and surge ratings in kilowatts (KW) instead of volt-amps (VA).

An inverter's continuous power and surge power ratings might be listed as "5,500 watts continuous; 9,300 watts surge." More accurate ratings are not in watts but in volt-amps. This recognizes that the 5,500 watt rating is, at best, only for 5,500 watts of resistance load (such as fifty-five 100 watt light bulbs).

The inverter may be required to deliver 6,850 watts to power inductive loads for a motor requiring 5,500 watts. Motors put an electromotive force or resistance back into the line, which reduces available wattage and requires additional power at the front end. Meters on the Trace SW5548 only accurately read AC resistance loads. The motor power factor typically requires 25 percent more power from the inverter to meet the load needs.

Net Metering
Georgia's new net metering law passed on April 28, 2001, and links customer-generated power with green pricing. This paves the way for a new relationship between the utility and customer-generated power.

At peak periods, a customer with up to 10 KW of renewable energy capacity for residential applications can get 15 to 20 cents per KWH or more until capacity reaches 0.2 percent of the utility system's peak. This means that Steve Davison can sell at 15 to 20 cents during the day, and purchase the power back at night at 8 cents per KWH if needed.

The Davisons are using power from this system to build their new home. The entire home is being built using solar-electric power, with any surplus going to the grid. Steve and his wife Debra are some of the first residential homeowners in Georgia to enjoy watching their meter run backwards.

Solar Philosophy
There is great diversity of people who support solar

equipment with their wallets rather than rhetoric. Their common belief is that money is given value by how responsibly it is used. The docks along the southern coastal states are filled with yachts owned by people with different philosophies. Many southern estates also have two or three expensive status cars that cost as much as or more than the Davison PV system.

Steve, who made his money with a variety of inventions and businesses, chose to spend his earnings as a solar pioneer, creating New Tara as an example and a challenge to upscale estate and plantation owners of the south. Steve's solar-electric system is much larger and more complex than most. But his beliefs about green and renewable energy are the same as those of people with smaller systems we all read about in *Home Power.*

His challenge with New Tara was to break the southern culture of consumerism that places emphasis on spending money for status rather than for responsible societal value. Making "real value" purchasing the new responsible status symbol of the wealthy could go a long way toward protecting the earth and its resources. This is especially relevant for others in financial positions like the Davisons, who can easily afford systems like this.

We need enthusiastic supporters of solar energy from every walk of life, willing to be examples to their friends and neighbors. In my twenty-three years of solar contracting experience, I have learned one thing: politicians and utility companies don't dictate social values—people do.

Only a change in the majority mindset can reduce the acceleration of global climate change overtaking us. What takes place in the next thirty years could have irrevocable implications for us all. Time is running out—the earth's ecosystems and climate are rapidly changing.

We all know that the end of the oil age is in sight. If you are less than twenty years old, you will probably live to see the last oil wells go dry—sometime between 2040 and 2080.

The renewable energy age is beginning out of necessity. We are starting our upward, renewable acceleration just as the oil industry plunges downward to the end of its ride. Steve Davison's single crystal solar modules may last into the next century—many years after the end of the oil age.

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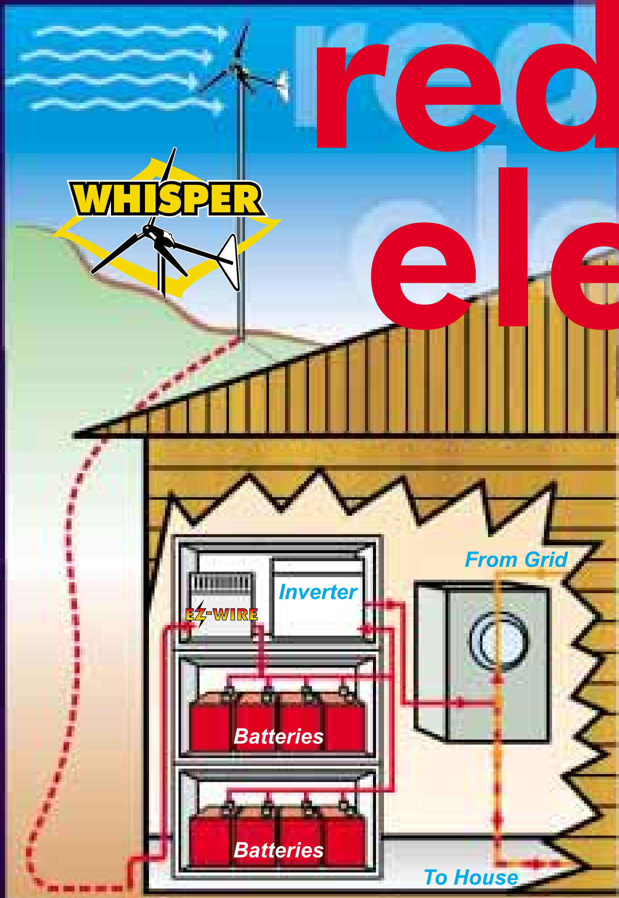

The Wind Electric System supplies power to a personal power station, which directs electricity into your home before drawing power from the power company.

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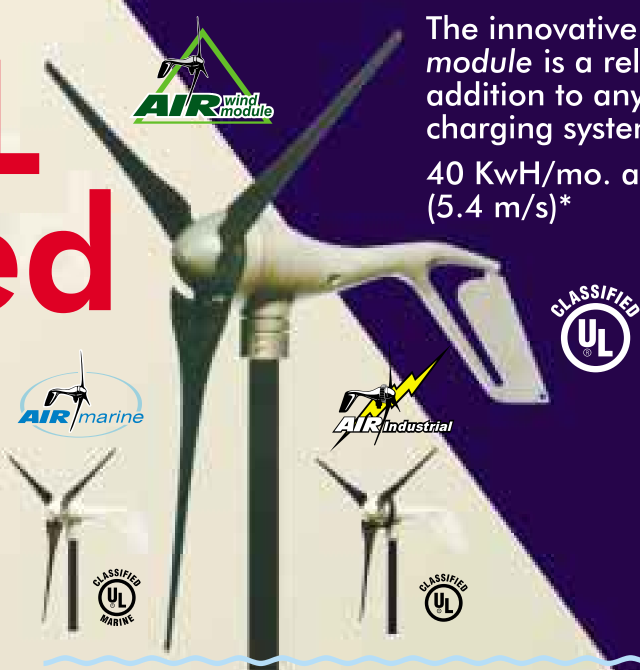

Southwest Windpower is proud to announce that Models Air 403 Land, Marine and Industrial Wind Turbine Generating Systems now comply with all safety and design requirements as outlined in IEC 61400-2 and have earned the right to bear the Underwriters Laboratories Inc. (UL) Classification Mark. For more information on UL, its services, or UL product certification, visit their Web site at www.ul.com.

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Blackout Protection for Your On-Grid Home

Joe Schwartz
& Richard Perez

Which one of these houses is yours? Blackout protection lets you decide when the lights go out.

Rolling blackouts have become a regular occurrence for many electric utility customers in California. Drought conditions in much of the Pacific Northwest have radically reduced hydroelectric generation utilized up and down the West Coast. As a result, the states of Oregon and Washington face a steadily increasing probability of being dragged into California's energy debacle. Lack of both transmission and generation capacity in Illinois, Michigan, Delaware, and New York may plague the residents of these states with blackouts in the near future.

An inverter/battery-based uninterruptible power supply (UPS) will provide blackout-proof power to your home. This system will keep your electric appliances up and running during utility blackouts caused by acts of nature such as storms, or by acts of man such as utility irresponsibility. This article provides all the specifics for a basic UPS system. We call this blackout buster the "Midnight Special."

The system is both modular and expandable—a larger capacity battery bank or renewable energy inputs can easily be added to the system. The basic Midnight Special costs about US$6,000, and that includes professional installation.

System Overview

We chose a Trace SW series inverter as the central component of this UPS system. An inverter-based grid backup system uses utility power, when it's available, to charge a battery bank. When a blackout occurs, selected loads are automatically transferred to the inverter. The inverter's main job is to take a battery's linear DC waveform and create a digital representation of an AC sine wave. This is the waveform that your household appliances are designed to run on.

During a power outage, the inverter uses the energy stored in the batteries to power household loads. When the grid comes back online, the loads are automatically transferred back to grid power. Then the inverter's battery charger goes to work and recharges the batteries, so the system is ready to go when the next blackout rolls around.




The Midnight Special's system components—sealed Concorde 6 volt, 220 amp-hour, absorbed glass mat (AGM) batteries (left); TriMetric amp-hour meter (center); and Trace SW4024 sine-wave inverter with AC disconnect/bypass box (right) and DC disconnect box (far right).

The Loads

The load table (page 36) lists the appliances we selected to be powered by this UPS system. Both essential and desirable loads have been included. The system is designed to support up to a 4 KW continuous load. It will supply about 6,500 watt-hours of energy per day in a normal appliance usage scenario. This system will keep the lights on, the fridge/freezer operating, the communication gear running, and still have power left over to vacuum the floors and do the wash.

The system is designed to power these loads for a period of 24 hours—far longer than the average utility blackout. For power outages lasting several days, an engine-generator or photovoltaics (PVs) can be added to the system to recharge the batteries and energize the system.

This system is not compatible with large thermal loads powered by electricity. It is not designed to run electric stoves, electric water heaters, electric space heating, heat pumps, or central air conditioning. All these loads are very big energy consumers, and beyond the capabilities of this system.

The Parts

This system uses standard off-the-shelf renewable energy equipment—the same inverter, batteries, instrumentation, and safety gear found in many off-grid homes. The renewable energy equipment selected for this system has been proven to be efficient and reliable over years of use in thousands of off-grid homes in the U.S.

The specified components are UL listed for fire safety—just like the rest of the appliances in your home. The cost table (page 38) gives a list of the equipment used in this UPS system. Estimated prices for the equipment and professional installation are included.

Inverter/Battery Charger

A Trace SW4024 inverter creates standard 120 VAC, 60 Hz electricity from the energy stored in the battery bank. Trace SW series inverters are the most commonly used inverters in off-grid and grid backup systems. The model specified for this system is the SW4024. It has a 24 VDC input and a 4,000 VA AC output.

Two other 60 Hz Trace SW series inverters are available—the SW4048 and the SW5548. These inverters have a 48 VDC input voltage and 4,000 VA and 5,500 VA output respectively. The surge capacity of all three models is 78 amps at 120 VAC. Export models are also available with 230 VAC, 50 Hz outputs.

Trace SW series inverters have an onboard, 60 amp AC transfer switch. When grid electricity is present, the transfer switch routes utility power directly to household loads. When a power outage occurs, the loads are automatically transferred to the inverter/battery system. Depending on the nature of the grid failure, this transfer may be noticeable—the lights may momentarily dim. But the transfer time is typically fast enough to keep computers running during most grid failures.

A Trace SW4024 inverter uses three transformers to create an AC waveform to run your appliances. The SW4024 is also designed to run these transformers backwards to charge your batteries. In this mode, the transformers are capable of producing 120 amps at 24 VDC for charging your batteries. The charge rate is user programmable, and the inverter automatically reduces the charge rate as the batteries become full.

This inverter interfaces gracefully with grid power, and is equally at home on the grid or off. And best of all, renewable energy sources can be added to this system. PVs, a wind generator, or a microhydro turbine can supply all the power your home needs. The SW series

Typical Load Table (From Energy Master Spreadsheet)

INVERTER SUPPLIED 120 VAC APPLIANCE POWER CONSUMPTION ESTIMATE

Midnight Special	Date: 08/01/01
Your House	
Sunny, California USA	

AC Watt-hrs. Used Daily 6512

Please note: this is an estimate and is only as good as the information supplied.

All Appliances on the list below are powered by 120 VAC from the inverter

No.	Inverter Powered Appliance	P?	Run Watts	Start Watts	Hours /Day	Days /Week	W-hrs/day	%
1	19 cu ft refrigerator/freezer	1	140	240	10.00	7.00	1400.0	21.11%
1	Computer monitor	1	90	200	8.00	7.00	720.0	10.86%
1	Solar DHW system	1	75	75	8.00	7.00	600.0	9.05%
1	Computer	1	60	120	8.00	7.00	480.0	7.24%
6	Fluorescent lights	1	15	15	5.00	7.00	450.0	6.79%
1	Laser printer	1	700	1200	0.50	7.00	350.0	5.28%
1	Television set	1	75	200	4.00	7.00	300.0	4.52%
1	Stereo	1	25	25	9.00	7.00	225.0	3.39%
1	Washing machine	1	250	500	1.25	5.00	223.2	3.37%
1	Microwave oven	1	800	1200	0.25	7.00	200.0	3.02%
1	Vacuum cleaner	1	1350	2700	0.50	2.00	192.9	2.91%
1	Video cassette recorders	1	40	40	4.00	7.00	160.0	2.41%
1	Fax standby	1	5	5	24.00	7.00	120.0	1.81%
1	Cordless telephone	1	4	4	24.00	7.00	96.0	1.45%
1	Ni-Cd battery recharger	1	20	20	6.00	3.00	51.4	0.78%
1	Fax/Copier	1	40	40	1.00	5.00	28.6	0.43%
1	Sewing machine	0	80	160	4.00	1.00	45.7	0.69%
1	Blender	0	350	700	0.05	7.00	17.5	0.26%
1	Coffee grinder	0	50	150	0.05	7.00	2.5	0.04%

****

Inverter AC W-hrs Consumed Daily	5663	w15% Invert Ineffic.= 6512.2
Largest Appliance Wattage	1350	
Largest Appliance Surge Wattage	2700	
Inverter Priority Wattage	3764	

inverter is even designed to spin your utility meter backwards and place your surplus renewable energy (RE) on the utility grid for your neighbors to use.

Trace SW series inverters require programming once they're installed. The settings table shows recommended set points for the 440 AH battery bank specified for the Midnight Special. Regulation set points for both sealed AGM and flooded lead acid batteries are included.

Batteries

We selected 6 volt, 220 amp-hour, sealed Concorde absorbed glass mat (AGM) batteries for this UPS system. Sealed batteries are becoming more and more popular, especially in on-grid systems where the batteries are typically kept at a full state of charge.

Sealed batteries are very user friendly compared to standard flooded lead-acid cells. They are maintenance free, so you never need to add water. All batteries experience self-discharge, a gradual loss of energy within the battery. But different battery types experience different rates of self-discharge. New sealed batteries have about one tenth the rate of self-discharge (between 1 and 3 percent a month, depending on temperature) of flooded lead-acid batteries.

Sealed batteries are safer. They do not produce large quantities of hydrogen gas like flooded lead-acid cells. So they don't need to be vented to the outside. But they should still be located in a containment. You never want to leave battery terminals exposed to kids, dropped wrenches, etc.

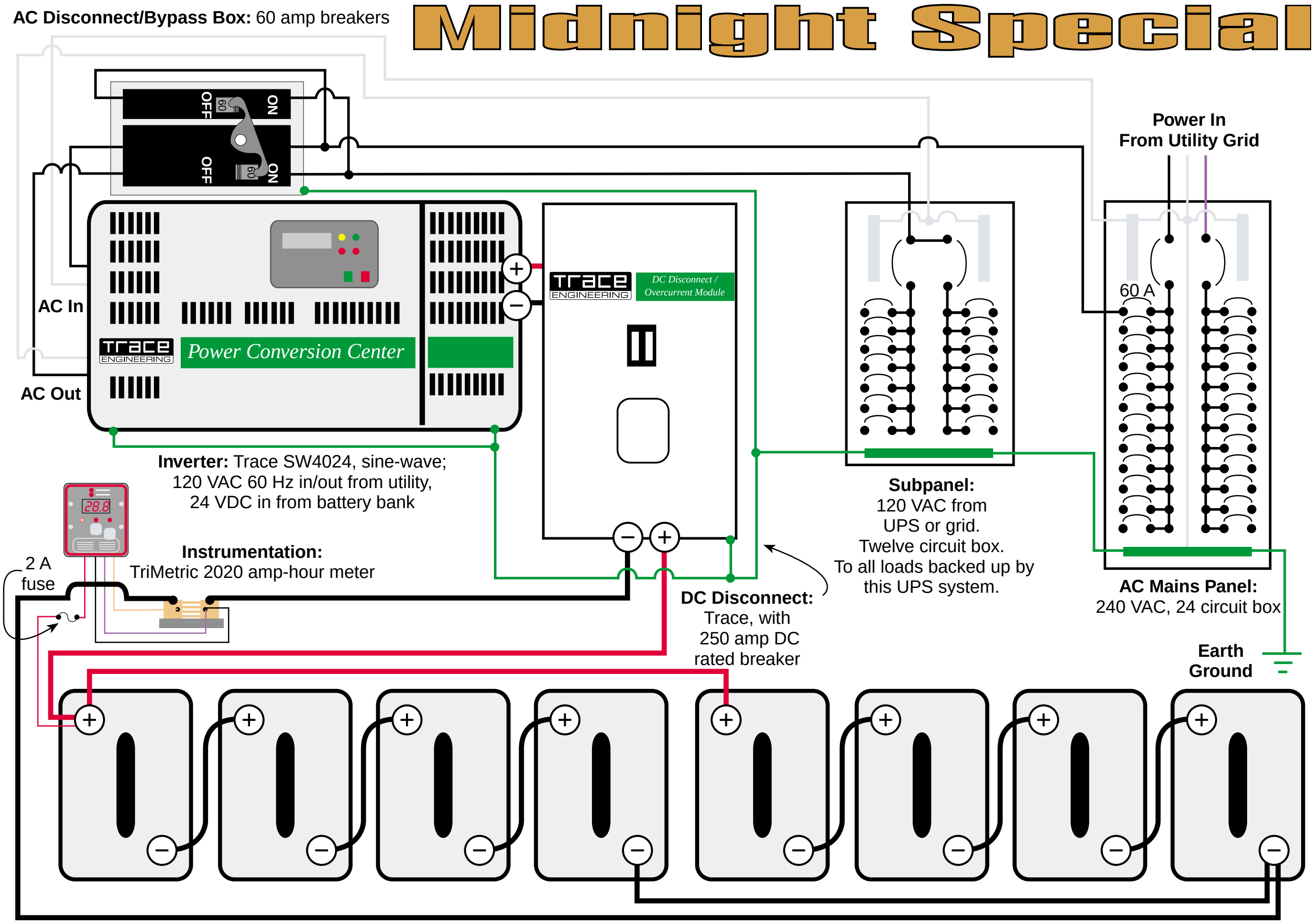
No maintenance, no gassing, low self-discharge—why use anything else? Well, Concorde AGMs cost roughly 40 percent more than flooded lead-acid cells. But if you have the cash, Concorde AGMs are a great way to go.

It's important to note that sealed batteries may be permanently damaged by battery voltages higher than manufacturer specifications. Concorde specifies voltages no higher than 14.4 VDC for a 12 VDC nominal system. So the batteries in our 24 VDC UPS system should never be charged higher than 28.8 VDC. The SW4024 inverter allows you to set both bulk and float voltages, so you can maintain the batteries at the proper regulation voltage.

The 440 amp-hour battery bank for this system is sized for the intermittent use of the appliances listed in the load table. This is a minimal battery bank compared to the full output capabilities of the SW4024 inverter. As the inverter powers these selected loads, battery voltage will sag. This will happen when loads with a large startup surge (like the vacuum cleaner) are turned on.

Most modified square-wave inverters are not voltage regulated. So as the battery voltage drops, so does the AC output voltage. This isn't the case with SW series

Midnight Special



Battery Bank: Eight sealed Concorde 6 volt, 220 amp-hour, absorbed glass mat (AGM) batteries. Wired series/ parallel for 24 volts, 440 amp-hours.

inverters, which regulate AC output voltage (120 VAC +/- 3%). SW series inverters have a user programmable low battery voltage cut-out. They also have an adjustable low battery cut-out delay. This keeps the inverter online when battery voltage dips with the startup of motors with a large surge.

The smaller the battery bank, the greater the voltage depression, and the harder the batteries are worked. A small battery bank also means deeper discharges when the grid fails and the batteries are cycled. But in UPS systems, small battery banks are common. The batteries spend most of their lives at a full state of charge, and are only cycled intermittently.

In an off-grid system, the batteries are cycled on a daily basis. A 700 to 900 amp-hour battery at 24 VDC is a good minimum off-grid battery capacity in relation to the output of an SW4024 inverter. The standard battery bank supporting an SW4024 in an off-grid system is 1,000 to 1,200 amp-hours at 24 VDC. A larger battery bank means higher voltage under load. And because of the increased capacity, the batteries are cycled less deeply, increasing battery longevity.

Battery longevity is directly related to how well the batteries are maintained. The major causes of early battery death are chronically undercharging or overcharging them, deeply discharging them, and not adding water if you're running flooded lead-acid cells. A set of properly maintained batteries, adequately sized for a given system, can be expected to last ten years in a grid backup application. Depending on how often the batteries are cycled, a significantly longer battery lifespan can be expected.

Instrumentation

A critical piece of equipment for any battery-based system is an amp-hour meter. This meter compares the amps coming into the battery from the charging sources to the amps going out to the loads. An amp-hour meter is the only accurate way to monitor the state of charge (SOC) of your batteries. It is also very convenient, and accessible to non-technical users. The meter displays battery SOC as a percentage of total capacity. Just like the fuel gauge in your car, a quick glance at the meter tells you your batteries' SOC.

Typical Midnight Special Costs (From Energy Master Spreadsheet)

RENEWABLE ENERGY SYSTEM HARDWARE COST ESTIMATE

Midnight Special	Date:	08/01/01
Your house		
Sunny, California USA		

Initial Cost Estimate $5760.00

Power Consumption 6632.204 Watt-hours/day

No.	Item Description	Type	Unit Price	Item Total	% of Cost
1	Trace inverter	SW4024	$3,495.00	$3,495.00	54.69%
8	Concorde batteries	B-PVX6220	$179.00	$1,432.00	22.41%
8	Installation labor per hour	estimate	$50.00	$400.00	6.25%
1	Inverter/battery disconnect	DC250	$329.00	$329.00	5.14%
1	Battery amp-hour meter	TriMetric	$200.00	$200.00	3.12%
10	Battery/inverter cables		$180.00	$180.00	2.81%
1	Misc. wire and fittings	estimate	$100.00	$100.00	1.56%
1	Trace SW conduit box	SWCB	$94.00	$94.00	1.47%
1	AC subpanel	8 circuit	$80.00	$80.00	1.25%
1	Inverter bypass switch	Sq. D	$80.00	$80.00	1.25%

Total Initial Hardware Cost Estimate $6,390.00

Three different brands of amp-hour meter are available: Bogart Engineering's TriMetric, Xantrex's Link 10, and the Trace TM500. All three of these meters display battery SOC and other system information.

In this intermittent, grid backup application, an 80 percent depth of discharge (DOD) is acceptable. We never recommend discharging your lead-acid batteries by more than 80 percent (20% SOC). Doing so will greatly decrease your battery bank's longevity. Without a battery amp-hour meter, you won't know how deeply you are discharging your batteries.

In an off-grid system, batteries are cycled on a daily basis. In that case, a 25 percent daily depth of discharge is good threshold to shoot for. Remember, batteries like to be at a full state of charge. The less deeply you cycle them, the longer they'll last.

DC Safety Gear

Your battery bank has the potential to deliver tens of thousands of amps if a direct short ever occurred. This is a fire hazard and a potentially life-threatening situation. So just like the circuits in your house, you want to make sure to have a fused disconnect or breaker between the battery bank and the inverter. Since this breaker is on the low voltage DC side of the system, a high current DC-rated breaker is required.

Trace manufacturers a DC250 enclosure that houses a 250 amp DC-rated breaker. This provides overcurrent protection between the inverter and batteries. It also makes it possible to electrically isolate the inverter from the batteries if inverter servicing is ever required.

Interfacing with the Grid— The Subpanel

The maximum continuous output current from a Trace SW4024 is 33 amps at 120 VAC. Your home's mains panel is probably a 100 amp, 200 amp, or even larger service. So it's quickly apparent that a single inverter can't handle all the loads in a typical, on-grid household.

Usually, only certain loads are deemed important enough to require a backup power source. You need to survey the appliances in your home and decide which ones you want dedicated to your UPS system. The total appliance load must be within the inverter's output rating. In this case, that limit is 33 amps at 120 VAC (4,000 watts) continuous.

The next step is to identify the circuits that power the appliances requiring backup power. Circuit locations are usually listed on the inside of the cover of your mains panel. Once these circuits have been identified, they are pulled from the AC mains panel and rerouted to a new AC subpanel. Now you have a dedicated breaker panel for loads requiring an uninterruptible power supply.

In our case, the output of the inverter is run through a 60 amp breaker and on to the subpanel. In addition, grid power for battery charging must be run via a 60 amp breaker from your mains panel to the inverter. Both of these 60 amp breakers are included in the inverter bypass switch, which is housed in a separate enclosure, typically mounted above the inverter.

Inverter Bypass Switch

You always want to include an inverter bypass switch in a battery based, utility intertied system. You recall that in this UPS system, when grid power is available, it is routed directly to the dedicated AC loads by way of the inverter's internal transfer switch. Very occasionally, an inverter needs to be removed for service. When the inverter is removed for repair, so is the onboard transfer switch. This isolates the dedicated subpanel from the mains panel. That blacks out all the loads powered via the subpanel, which is definitely not the desired effect.

Without the inverter bypass switch, you would have to temporarily rewire the subpanel directly to the mains panel. Then you would have to switch the wiring back again when the inverter was re-installed. If you're not doing the work yourself, this would mean two trips by a local electrician. A bypass switch eliminates this potentially expensive headache.

A three circuit Square D load center (model number QO403L60NS, with butterfly switch), one single pole 60 amp QO breaker, and one double pole 60 amp QO breaker are the parts that make up the bypass switch. At retail, this setup costs about US$80. The bypass switch allows you to throw one switch and route AC power from the mains panel directly to the subpanel. The breakers in the bypass switch also serve as overcurrent protection between the mains panel and the inverter, and between the inverter and the subpanel.

Non-Grid Power Sources

The local utility isn't the only source of electricity. As many off-grid *HP* readers can testify, there are many ways of making electricity that don't involve the utility. The Midnight Special is designed to handle them all.

AC Generators

If a utility blackout begins to stretch out for days, you need to come up with another power source to recharge the batteries and energize the system. The most common option is an engine-powered generator. Trace SW series inverters are designed to simultaneously manage both utility grid and engine-generator inputs. User programmable setpoints allow the use of most common generators.

Trace SW series inverters can also be programmed to automatically start generators based on either time of day or battery voltage. This sample system does not include a generator, since it's designed to power the specified loads for 24 hours. The majority of grid failures can be weathered by an appropriately sized battery bank.

Off-grid homes powered solely by an engine generator will also benefit greatly from the addition of an inverter/battery system. Generator-to-loads direct systems are extremely inefficient to run. Electricity produced by an engine generator costs about US$0.60 KWH.

More often than not, the generator will be operating at a fraction of its full output. Running a 10 KW generator to power a couple of lights and a TV is a tremendous waste of fuel. And you have to listen to the blasted thing whenever you want to turn on a light! Adding an inverter and batteries to the system will reduce generator run time, noise, and fuel costs by 80 to 90 percent.

Photovoltaics, Wind, & Microhydro

Since the gear used in this system is standard stuff, it can switch from a steady diet of grid power to a pollution-free diet of renewable energy. You can add PVs, wind power, microhydro, or a combination. This will make the system (and your home) energy self sufficient. Of course, RE resources are site specific. Most suburban homeowners don't have a stream cascading down their back yard, and wind turbines are tough to site in town.

If you have any surplus RE generated at your home, it can be placed on the grid for others to use. We

Need a Larger UPS System? Or a Smaller One?

Sometimes backup power demands are higher than the rated output of a single inverter. With the addition of an interface cable, two Trace SW series inverters can be stacked in either a series or parallel configuration for increased output.

For example, two series-stacked SW4024 inverters have a 120/240 VAC split phase output. The waveforms of the two inverters are 180 degrees out of phase—like the utility lines coming into your house. This configuration gives you two 4,000 VA legs, and allows you to run 240 VAC appliances. Two SW inverters can also be stacked in parallel for 8,000 VA of single phase, 120 VAC output.

Larger systems will require a larger battery bank. Always start with a survey of the loads you need to back up, and the number of minutes or hours you need to run them. In a grid backup application, your battery bank should be sized for a maximum discharge of 80 percent.

Just want to back up your computer? Off the shelf computer UPS systems may be your best bet. Want to back up your computer, a couple of lights, and your stereo? Calculate the total load you want to power and how long you want to power it. Then choose an appropriate battery bank capacity based on an 80 percent depth of discharge. Exeltech manufacturers small true sine-wave inverters. Several models are available with AC outputs from 125 watts to 1,100 watts. These inverters supply higher quality power than the utility grid. And you're the one to decide when they get shut down!

Midnight Special Inverter Settings

Menu Heading	Menu Item	Recommended Setting
For 8 Concorde Sealed AGM Batteries, 440 AH at 24 VDC		
Inverter Mode - 1	Set Inverter	SRCH (search)
Time of Day - 6		Set Hr/Min/Sec
Inverter Setup - 9	Set Grid Usage	FLT (float)
	Set High Battery Cut-Out VDC	29 VDC
	Set Search Watts	16 watts
Battery Charging - 10	Set Bulk VDC	28.8 VDC
	Set Absorption Time	1:00 Hr.
	Set Float VDC	26.8 VDC
	Set Max Charge Amps AC	20 Amps AC
	Set Temperature Compensation	Lead-Acid
For 8 Flooded Lead-Acid Batteries, 700 AH at 24 VDC		
Inverter Mode - 1	Set Inverter	SRCH (search)
Time of Day - 6		Set Hr/Min/Sec
Inverter Setup - 9	Set Grid Usage	FLT (float)
	Set High Battery Cut-Out VDC	32 VDC
	Set Search Watts	16 watts
Battery Charging - 10	Set Bulk VDC	29.6 VDC
	Set Absorption Time	1:00 Hr.
	Set Float VDC	26.8 VDC
	Set Max Charge Amps AC	20 Amps AC
	Set Temperature Compensation	Lead-Acid

estimate that about US$8,000 worth of PV and a larger battery will make this system capable of delivering about 6 KWH per day. This will run the loads listed in the table, on a site with 5.3 average sun hours per day.

A System with a Future

Considering the increasingly unreliable nature of utility grids, this system offers you a future where the lights are always on. If a storm brings down the power lines and puts out the lights, this system can bring them back. If the local utility gets irresponsible and shuts off the power because they can't make a profit or supply the demand, your lights will still be on. And then there is the tantalizing possibility of adding solar, wind, or microhydro energy to this system. The Midnight Special is a blackout buster with a clean and green future.

Access

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Richard Perez, *Home Power,* PO Box 520, Ashland, OR 97520 530-475-3179 • Fax: 530-475-0836 richard.perez@homepower.com www.homepower.com

Bogart Engineering, 19020 Two Bar Rd., Boulder Creek, CA 95006 831-338-0616 bogart@bogartengineering.com www.bogartengineering.com TriMetric AH meter

The Energy Master Spreadsheet is available for free from the Download section at www.homepower.com or on the *HP* Solar CD-ROMs

Concorde Battery Corp., 2009 San Bernardino Rd., West Covina, CA 91790 • 800-757-0303 or 626-813-1234 • Fax: 626-813-1235 conbat@earthlink.net www.concordebattery.com Batteries

Exeltech, 2225 East Loop 820 N, Ft. Worth, TX 76118 800-886-4683 or 817-595-4969 Fax: 817-595-1290 info@exeltech.com www.exeltech.com • Inverters

Surrette Battery Company Limited, PO Box 2020, Springhill, NS B0M 1X0 Canada • 800-681-9914 or 902-597-3767 • Fax: 902-597-8447 sales@surrette.com • www.surette.com • Flooded lead-acid batteries

U.S. Battery,1675 Sampson Ave., Corona CA 92879 800-695-0945 or 909-371-8090 • Fax: 909-371-4671 dwallace@usbattery.com • www.usbattery.com

Trojan Battery Company, 12380 Clark St., Santa Fe Springs, CA 90670 • 800-423-6569 or 562-946-8381 Fax: 562-906-4033 • applications@trojanbattery.com www.trojanbattery.com • Flooded lead-acid batteries

Xantrex Technology Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-2229 inverters@traceengineering.com • www.xantrex.com Trace inverters, E-Meter, Link 10 & TM500 AH meters, and DC250

Vanner

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7.125 wide
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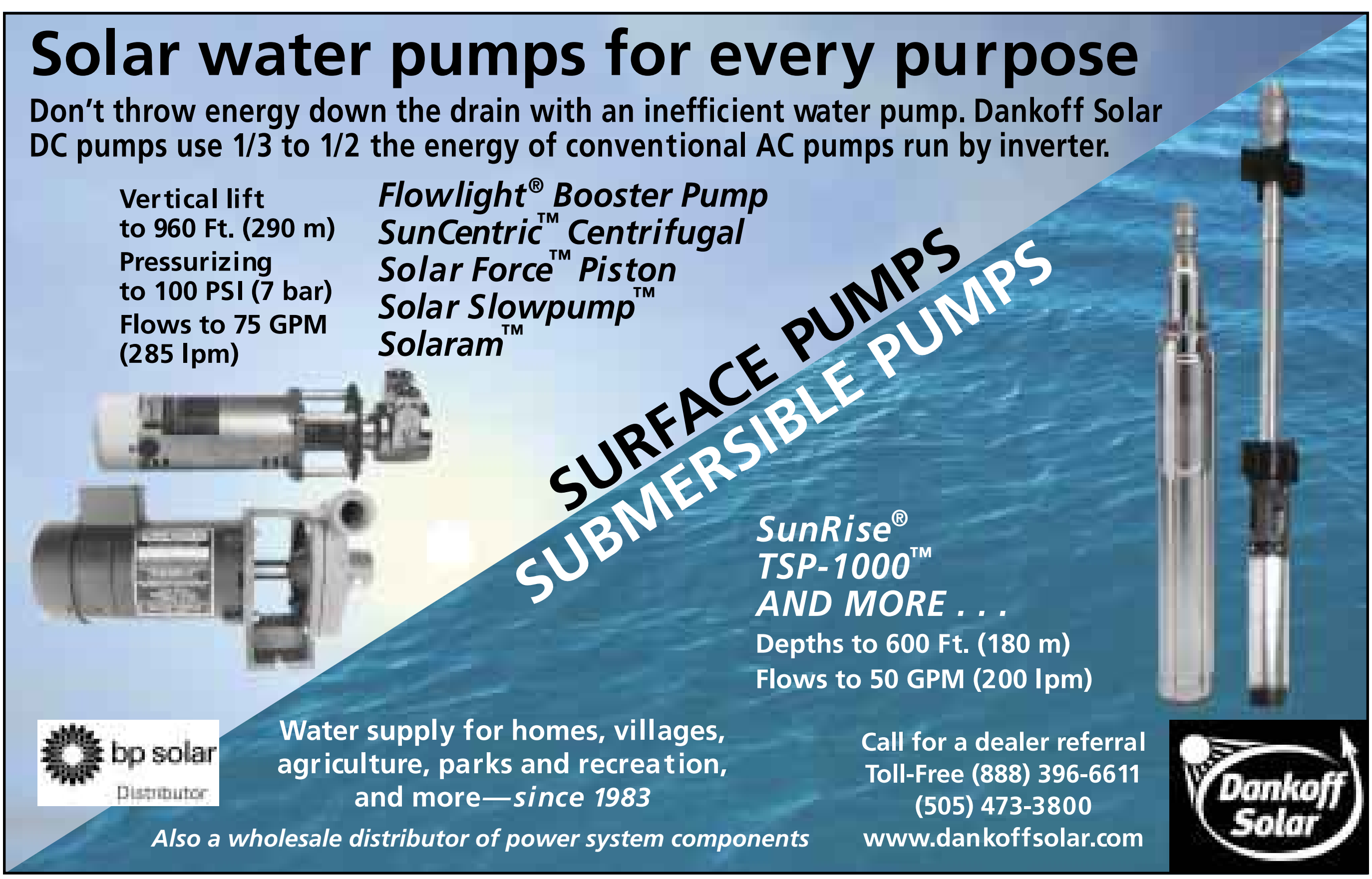
from HP 83 page 48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Don't throw energy down the drain with an inefficient water pump. Dankoff Solar DC pumps use 1/3 to 1/2 the energy of conventional AC pumps run by inverter.
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Pressurizing to 100 PSI (7 bar)
Flows to 75 GPM (285 lpm)
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SunCentric™ Centrifugal
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Solar Slowpump™
Solaram™
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Solar Hot Water: A Primer

Ken Olson

Solar hot water is one of the most immediately cost-effective uses of renewable energy.

Hot water represents the second largest energy consumer in American households. A typical 80 gallon (300 l) electric hot water tank serving a family of four will consume approximately 150 million BTUs in its seven year lifetime. This will cost approximately US$3,600 (at US$0.08 per KWH), not accounting for fuel cost increases. Then it will be replaced by another one just like it. Hmm. Maybe we should rethink this...

An investment in a solar water heating system will beat the stock market any day, any decade, risk free. Initial return on investment is on the order of 15 percent, tax-free, and goes up as gas and electricity prices climb. Many states have tax credits and other incentives to sweeten those numbers even more. What are we waiting for? Forget the stock market. If you have invested in a house, your next investment should be in solar hot water.

In this article I'm going to cover the most common options for solar water heating, basic principles of operation, and some historical perspective on what has worked and what has not.

A Checkered Past, A Bright Future

Solar thermal's past is a good example of why everyone should be skeptical of government involvement in energy. Lucrative federal and state tax credits for solar energy were initiated under President Jimmy Carter in the '70s, and abruptly eliminated under President Ronald Reagan in 1985. This dealt the solar industry a devastating "one-two punch" from which it still has not recovered.

The intention was to stimulate sales for solar thermal systems. But the tax credits resulted in an aggressive promotion of tax credits rather than solar energy. The infant industry was overwhelmed to meet the demand. The demand vanished when tax credits were eliminated, and a majority of solar thermal companies went out of business. Thousands of orphaned solar thermal systems were left behind looking for a service technician.

The solar thermal industry has been purged of the tax credit telemarketers and overnight experts. Today's solar thermal industry includes reliable, efficient products and well-seasoned professionals who have seen it all. Solar hot water is one of the best investments you can make for your house and for the environment.

First Things First

The best savings in hot water come from no cost or low cost options. Before you tackle solar hot water, take these steps:

- Turn the thermostat down. Many water heaters are set to between 140 and 180°F (60 and 82°C). See how low you can go. Try 125°F (52°C) for starters. A hot tub is 106°F (41°C). How much hotter do you need?
- Wrap the water heater with insulation. Insulated water heater "blankets" are usually available where water heaters are sold. (Be careful with natural gas or propane fired water tanks. They use an open flame to heat the water. You need to provide a space for air at the bottom of the tank, and at the top where the flue exits the tank. Safety comes before efficiency!)
- Fix those drips. They may not look like much, but they are a constant and persistent drain on your water heating load, and they waste water too.
- Use flow restrictors and faucet aerators to reduce your hot water consumption.
- Find other ways to use less hot water. Wash only full loads of clothes and dishes.
- Insulate your hot water pipes.

How Large a Solar Hot Water System Do You Need?

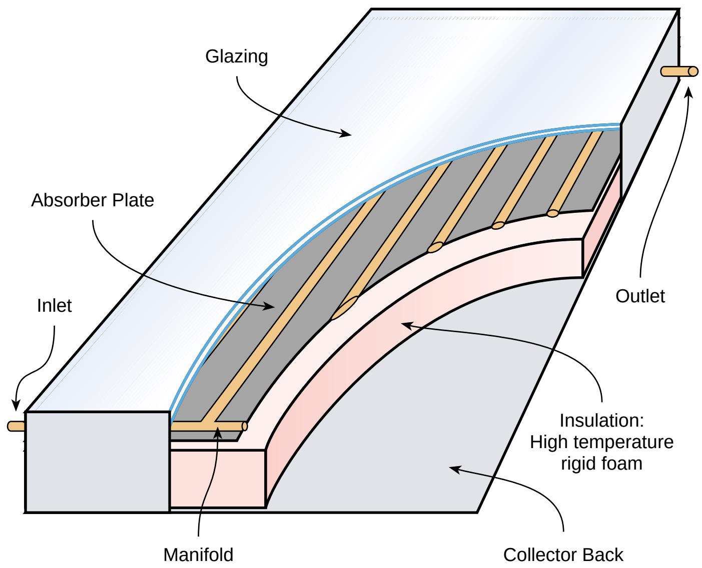
Hot water usage in the U.S. is typically 15 to 30 gallons (55–110 l) per person per day for home use. This includes primarily bathing, clothes washing, and dishwashing. But your commitment to efficiency has a lot to do with your actual usage.

The hot water tank is usually sized to handle one day's worth of consumption. So for a household of four, it would be reasonable to use an 80 gallon (300 l) tank based on daily hot water requirements of 20 gallons (75 l) per person per day.

Smitty and Chuck at AAA Solar in Albuquerque have put forth generally accepted rules of thumb for solar thermal collector sizing based on your climatic region:

- In the Sunbelt, use 1 square foot (0.09 m^2) of collector per 2 gallons (7.6 l) of tank capacity (daily household usage).
- In the Southeast and mountain states, use 1 square foot of collector per 1.5 gallons (5.7 l) of tank capacity.

A Typical Solar Flat Plate Water Heater



- In the Midwest and Atlantic states, use 1 square foot of collector per 1.0 gallon (3.8 l) of tank capacity.
- In New England and the Northwest, use 1 square foot of collector per 0.75 gallon (2.8 l) of tank capacity.

Based on these rules of thumb, a household of four with an 80 gallon (300 l) tank will need approximately 40 square feet (3.7 m^2) of collector in Arizona, 55 square feet (5.1 m^2) of collector in South Carolina, 80 square feet (7.4 m^2) of collector in Iowa, and 106 square feet (9.8 m^2) of collector in Vermont.

Of course, these are big ballpark calculations that will be affected by your incoming water temperature, hot

Key to Plumbing Symbols

- Potable Water: Hotter
- Potable Water: Cooler
- Antifreeze (propylene glycol): Hotter
- Antifreeze (propylene glycol): Cooler
- Valve
- Check Valve: One-way Flow
- Pump
- Temperature Sensor: With wire
- Power Wire: Not always shown

water temperature setpoint, actual usage, and the intensity of the solar resource at your site. You should generally expect that this will give you 100 percent of your hot water in the summer and about 40 percent of your hot water year-round.

Your Choices—An Overview
The type of system you choose will depend mostly on your climate. Freeze-free environments allow for simple, low cost designs. A batch heater uses a storage tank as a collector. A direct pump system circulates water from a collector to a storage tank. A thermosiphon system requires no pump for circulation, just the natural flow of gravity.

Most systems will require some measure of freeze protection. Drainback and closed loop systems with antifreeze and heat exchangers are the best choice for freezing locations. The extra parts increase cost and reduce efficiency, but since one frozen moment can turn into a disaster, it's worth the cost.

Direct pump recirculation systems, which circulate hot water through the collector, are often used where freezing is an infrequent occurrence. That's a risky strategy. Draindown systems, designed to drain water from the collectors to avoid freezing, were the most problematic of system designs. Many were removed or converted. Phase change systems, which in theory could collect heat at night using a refrigerant, never made it into the mainstream of commercial viability. Many of the lessons learned in solar hot water are presented in a publication *Solar Hot Water Systems: Lessons Learned,* by Tom Lane (see Access).

Solar Batch Heaters
The KISS (keep it simple, stupid) rule applies to solar heating. The batch water heater is the simplest of solar hot water systems. Once affectionately referred to as the breadbox water heater by the do-it-yourself (DIY) community, it has become known as the ICS (integrated collector and storage) water heater in the commercial industry. Its simple design consists of a tank of water within a glass-covered insulated enclosure carefully aimed at the sun.

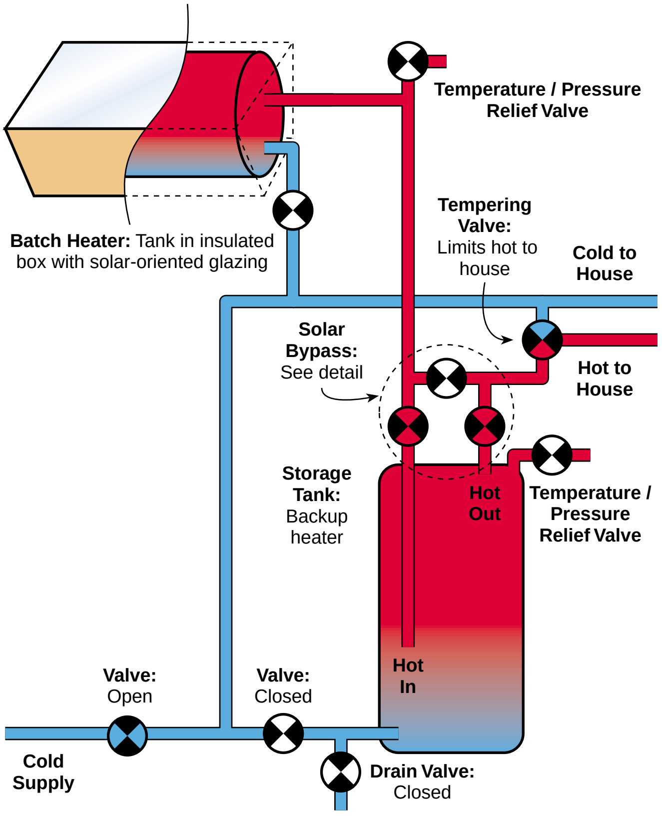
Cold water, which normally goes to the bottom of your conventional water heater, is detoured to the batch heater first. There it bakes in the sun all day long, and is preheated to whatever temperature the sun is able to provide. Water only flows when used. House water pressure causes the supply of new cold water to flow to the inlet of the batch heater, the lower of the two ports.

Simultaneously, the hottest water exits from the higher port. It flows to the input of the existing water heater, which now serves as a backup to finish the heating job as required. Solar preheated water has become the cold water input to the existing water heater. You save whatever the sun is able to provide. And you still get all the hot water you ask for—it's that simple.

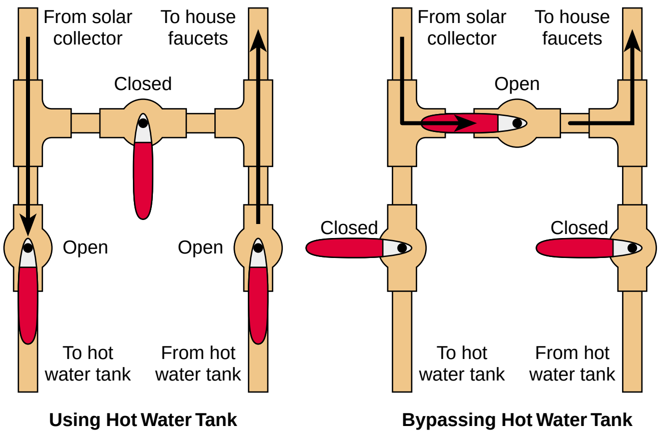
A 40 gallon batch heater.

Bypass Valves
A solar bypass is a series of three valves that allow you to bypass the existing water heater. You can shut it down when the solar collector will do the job alone, such as during summer months or utility blackouts. This is a manually operated configuration; just close off the inlet and outlet valve to the existing tank and open the center valve. This allows hot water to pass directly from the solar batch heater to the house.

Batch Heater System



Solar Bypass Valve Configurations



Caution! These systems produce very hot water! A tempering valve is your protection from being scalded at the tap. You will regularly see temperatures in excess of 160°F (71°C) in summer months, which is much hotter than you are accustomed to getting from your conventional thermostatically controlled water heater. The tempering valve limits the temperature delivered to the tap by mixing in cold water as necessary.

A pressure temperature relief valve (PTRV) must be installed at the hot water outlet of the batch heater in case temperatures or pressures become excessive. You will find one of these valves installed on every conventional hot water tank too. It is a safety measure required by code. This valve only operates in an emergency, and is often replaced if it opens.

Who Can Use a Batch Heater?

Batch heaters are most appropriate for two to four person households (30 to 40 gallon (110–150 l) daily hot water requirement) in climates where freezing is infrequent. Their size is generally limited because the tank is built into the collector.

Multiple collectors can be installed in series for larger capacities. The outlet of the first collector becomes the inlet of the second in order to deliver higher temperatures. Before you put too many on your roof, consider that a 40 gallon (150 l) batch heater will weigh approximately 500 pounds (225 kg).

Some batch heaters have survived the coldest of winters with freeze-free performance because the large mass of the water tank is quite freeze tolerant. But plumbing lines to and from the tank are very vulnerable. You can make it work with a special selective surface on the tank, a well-insulated, double glazed collector, a whole lot of well-sealed pipe insulation (try R-30 or better), heat tape on the pipe, and good karma.

Are you arrogant enough to tempt Mother Nature to turn your water heater into a frozen fountain? Or are you prepared to drain the collector seasonally? If not, this system is not recommended for climates that freeze regularly.

Separate Collector & Storage

The simple design of a batch heater compromises the effectiveness of collector and storage functions. Heating the whole tank of water all at once will take all day to produce useful temperatures. Once hot, you had better use that hot water at the end of the day before the poorly insulated tank loses its precious heat to the cold night sky.

Most solar hot water system designs separate the collector from the storage tank. This can optimize both functions. Why not bring the tank in from the cold, insulate it well, and leave the collectors out in the sun where they belong?

What are the other advantages of separating the collector from the storage tank? Increase the surface area of a collector, compared to the amount of water being heated, and its temperature will rise more quickly. Configure the storage tank to keep the hottest water apart from the coldest water in the tank and you'll have hotter water available sooner. (See sidebar *Maintain Temperature Stratification In Your Tank.*)

There are also advantages in freezing climates. By separating the collector from the tank, you can put your tank and piping indoors out of a freezing environment, and insulate them better for greater efficiency.

Flat Plate Collectors

Flat plate collectors are the most common solar thermal collectors. They are most appropriate for low temperature applications (under 140°F; 60°C), such as domestic hot water and space heating.

Two roof-mounted flat plate collectors.

A flat plate solar thermal collector usually consists of copper tubes fitted to a flat absorber plate. The most common configuration is a series of parallel tubes connected at each end by two pipes, the inlet and outlet manifolds. The flat plate assembly is contained within an insulated box, and covered with low-iron, tempered glass. (See the diagram on page 45.)

The most efficient collector design maximizes solar heat gain, minimizes heat losses, and provides for the most efficient heat transfer from absorber plate to tube. Operating temperatures up to 250°F (121°C) are obtainable, although neither common nor desirable. Remember, you want hot water, not steam.

Selective Surface

A selective surface, often referred to as “black chrome” is far more efficient than a black painted absorber surface. Although a black surface is most efficient at absorbing solar radiation and converting it to heat, it is also highly efficient at re-radiating long wave infrared heat back out. These losses reduce collector efficiency.

A highly polished chrome surface would re-radiate the least infrared heat energy, but of course not being black, it would absorb very little. A selective surface combines the best of both worlds; high absorptance with low emittance. Sound high-tech? It’s been around since the 1950s, and is used on most commercially available flat plate collectors. Its performance is worth the marginal additional cost, particularly in cold climates where radiant heat loss is greatest.

Evacuated Tube Collectors

If you want the highest efficiency solar thermal collector, you’ll be interested in an evacuated tube collector, such as the one manufactured by Thermomax. Although evacuated tube collectors are more efficient than conventional flat plate collectors, they cost approximately twice as much per square foot.

Each tube and fin of the collector is contained within a glass tube from which all the air has been evacuated. Why? Air carries heat from the hot surface of the tube to the cooler surface of the glass to accelerate heat loss by convection. Eliminate the air and you have eliminated convective heat loss.

A Thermomax evacuated tube collector.

To minimize radiant heat loss, the tube is covered with a selective surface. Evacuated tube collectors are most appropriate for high temperature applications (over 140°F; 60°C). They are useful for more common low temperature applications too, such as domestic water and space heating.

Collector to Tank Interface

With the collector and the storage tank separated, the system design must provide a flow of water (or antifreeze) from tank to collector and return. Small circulating pumps provide the necessary flow with very modest energy requirements. Small hot water systems may use a direct current (DC) circulating pump powered by a single PV module (10 to 30 watts depending upon power requirements). You may be able to do without the pump altogether if you design for natural thermosiphon flow.

Maintain Temperature Stratification in Your Tank

Hot water returning from the collector should enter the storage tank about a third of the way down from the top. This water may not be the hottest water you have collected all day, because solar insolation and outside ambient temperatures vary during the day. You don’t want this water to disturb the water at the very top of the storage tank. Draw water for use from the very top of the tank. That is where it’s the hottest.

When hot water is drawn from the tank, it is replaced by new cold water, which should enter at the very bottom. Water circulating to the solar collector should be drawn from the bottom of the tank. Why? Efficiency! Always supply your collector with the coolest water you have available. The cooler a solar collector runs, the less heat it loses to the surrounding environment.

Thermosiphon System: Natural Flow Powered by Gravity

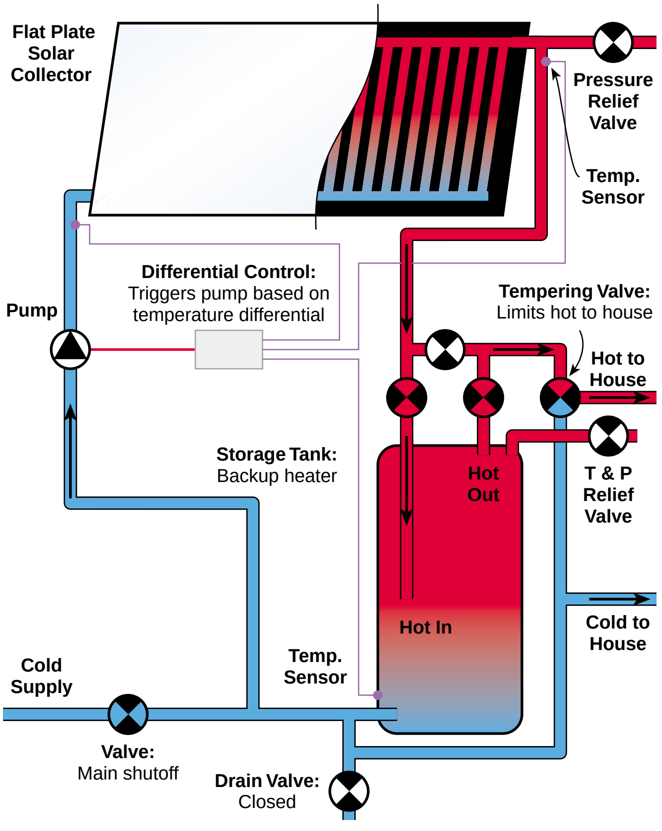
Gravity powers convective flow in a thermosiphon system. Water in the collector becomes buoyant as it is heated, and it rises to an elevated tank. Cooler, heavier water falls from the tank to take its place. For best results, place the top of the collectors at least one foot (30 cm) below the bottom of the tank. Greater height differential will result in greater flow. Larger pipe, shorter runs, and gentle bends will make for an adequate flow rate.

If you require freeze protection, it's not hard to do. The collectors can be filled with an antifreeze solution (propylene glycol is the most common). The heat can be transferred to the domestic water via a heat exchanger.

Direct Pump Recirculation

The direct pump system uses an electric circulating pump to move heat from the collector to the storage tank. This means that you are free from the constraint of placing the collector below the tank, as required for thermosiphon flow. The pump can move heat from the collectors on the roof to a storage tank in the basement. Good sense still calls for minimal length of pipe run for efficiency.

Direct Pump Recirculation System



Rust Never Sleeps:

Open Loop vs. Closed Loop

A "hydronic" system is one that uses a liquid as its heat transfer medium. The most common alternatives to hydronic systems are air systems. Hydronic systems are nearly always categorized as "open loop" or "closed loop"—often referred to as "direct" or "indirect" respectively. If you are not aware of the difference between these, you run the risk of discovering one day that your system has been eaten alive by a slow yet persistent killer—oxygen.

Open Loop

Open loop systems are subject to a periodic fresh supply of oxygen, ready to trash every bit of cast iron, steel, or other corrodible part in your system. Whenever you draw water at the tap or bath, new water simultaneously moves in to replace it. Along with that new water comes a fresh supply of oxygen.

You have two lines of defense against damage by corrosive oxygen. You can prevent oxygen from entering the system, or you can use materials that are resistant to corrosion. Copper, bronze, brass, stainless steel, plastic, and the glass lining of a hot water tank have no problem with oxygen. Use these materials when dealing with fresh water supplies associated with "open" or "direct" systems.

Closed Loop

If your system is a "closed system," you won't have to worry about oxygen. You will be able to use cast iron components (pumps), which can save you money. Closed systems are charged with fluid at the time of installation. As a permanent part of the installed system, new oxygen is not introduced, and corrosion is not a problem. Read on and you will see several examples of open and closed systems.

Another important consideration with open or direct systems is whether or not you have hard water. Over time, calcium deposits from hard water will clog the collectors, ruining them. These deposits can be removed with periodic use of a descaling solution. But if you have hard water, you'll be better off with a closed loop system.

A differential controller turns the circulating pump on or off as required. There are two sensors, one at the outlet of the collectors, and the other at the bottom of the tank. They signal the controller to turn the pump on when the collector outlet is 20°F (11°C) warmer than the bottom of the tank. It shuts off when the temperature differential is reduced to 5°F (2.8°C). Some systems let you adjust this hysteresis.

In climates where freezing occurs infrequently, a recirculation-type differential control will turn the circulating pump on when the collector inlet temperature falls to 40°F (4.4°C). The philosophy behind this design is that the cost of heating your collectors with hot water from your tank is low cost freeze protection if only required occasionally.

These systems were commonly used in the sunbelt, and only where freezing is a rare occasion. Recirculation systems are no longer very commonly used due to vulnerability to freezing as a result of power outages, malfunction of sensor or controller, or damaged sensor wires.

Draindown System (Not Recommended)
A draindown system is an open loop system in which the collectors are filled with domestic water under house pressure when there is no danger of freezing. Once the system is filled, a differential controller operates a pump to move water from the tank through the collectors.

A draindown valve, invented in the 1970s exclusively for these systems, provides the freeze protection function. When the collector inlet temperature falls to 40°F (4.4°C), the draindown valve, activated by the controller, isolates the collector inlet and outlet from the tank. It simultaneously opens a valve that allows water in the collector to drain away. A vacuum breaker is always installed at the top of the collectors to allow air to enter the collectors at the top so water can drain out the bottom. Right next to the vacuum breaker, you'll find an automatic air vent to allow air to escape when the system fills again.

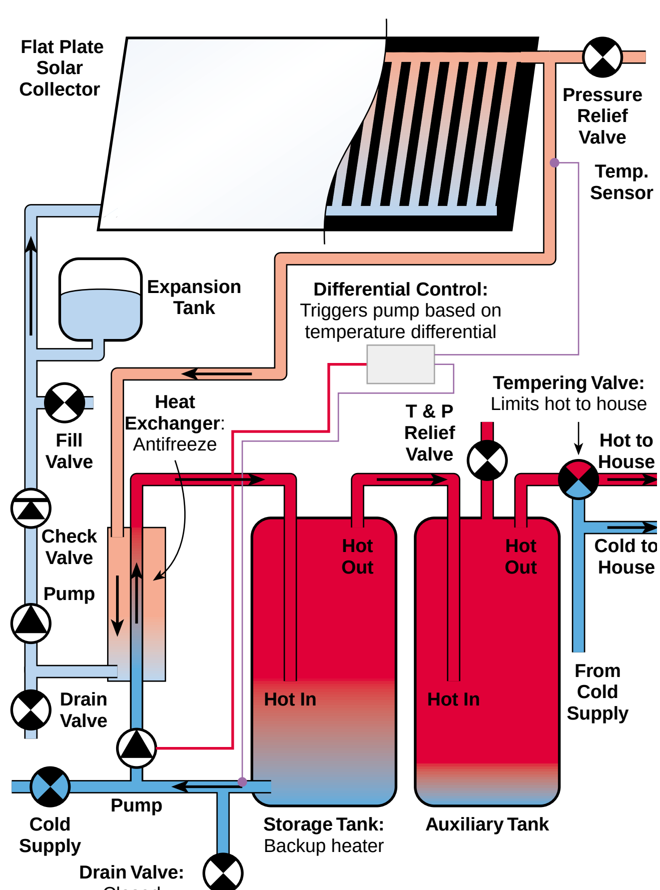
Draindown systems have proven to be the most problematic of all freeze protection systems. They are vulnerable to frozen vacuum breakers and air vents, damaged sensors or wiring, lack of proper pipe drainage, and malfunctions with the draindown valve. This type of system is rarely installed new any more, and is not recommended. Many were converted to drainback or closed-loop antifreeze systems.

Closed Loop Antifreeze Heat Exchanger
Closed loop antifreeze systems provide the most reliable protection from freezing. These systems circulate an antifreeze solution through the collectors and a heat exchanger. Propylene glycol is the most common antifreeze solution. Unlike ethylene glycol (used in automobile radiators), propylene glycol is not toxic.

The closed loop antifreeze systems generally have the most parts. You'll find an expansion tank to allow the antifreeze to expand and contract with temperature change. You'll find a pressure relief valve to protect against excessive pressures in the closed loop; a spring-loaded check valve to prevent reverse flow of the closed loop at night so the collectors won't dissipate the heat from the water heater; an air vent and/or air eliminator to help get the air out of the closed loop (air is your enemy—it can block fluid flow through the system); and a pressure gauge so you can tell if your system is still charged. A couple of temperature gauges are a good idea in any system so you can tell how well your system is operating.

There's also one more assembly of fittings. Two boiler drains with a shutoff valve in between will allow you to charge the system with your charging pump. Once ready to charge the closed loop with your antifreeze

Closed Loop Antifreeze Heat Exchanger System



solution, a charging pump is used to circulate the fluid throughout the loop, expelling all the air in the process.

Closed loop systems like this are quite common, whether they be for solar domestic hot water, radiant floor heating, or hydronic baseboard heating. Despite the many additional parts and fittings, they have a high degree of reliability, and are well understood by heating contractors.

There is a downside to the closed loop antifreeze system design. Once a solar water heating system has satisfied its daily responsibilities, the system stops circulating. Without circulation to remove heat from the collectors, temperatures can climb to as high as 400°F (204°C).

These high stagnation temperatures, as they are called, can cause problems with air pockets and breakdown of glycol antifreeze solutions. Air pockets form because high temperatures drive dissolved gases out of solution. Systems using propylene glycol as the antifreeze may use an inhibitor additive to prolong the life of the glycol. Otherwise, the glycol can break down, resulting in a sludgy deposit. Silicon and hydrocarbon oils have been used to avoid these problems, but they are expensive and are incompatible with seals and gaskets found in most off-the-shelf components.

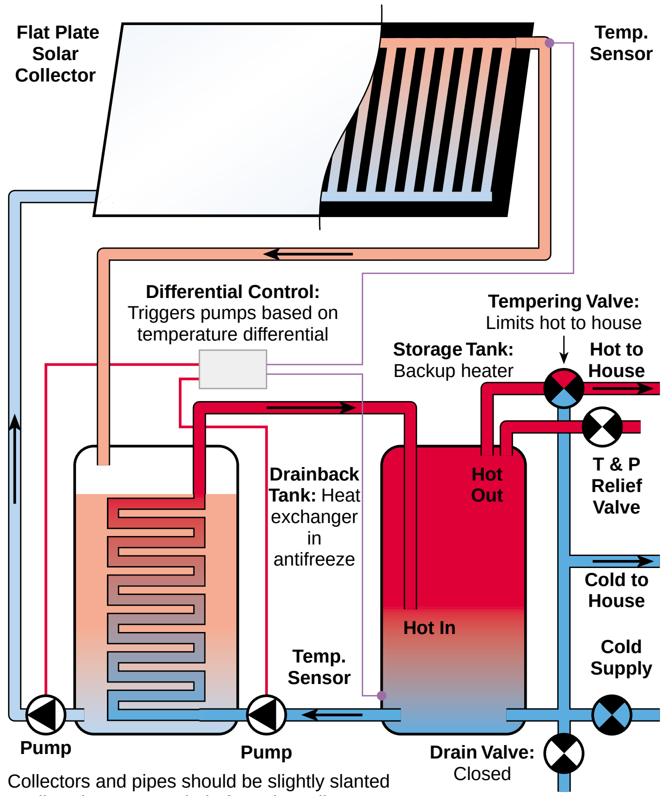
Drainback: A Simpler Closed Loop

Although similar in name to the draindown type system, the drainback system is far different and much more reliable. It also provides some advantages over the closed loop antifreeze system. Drainback systems may use water as the heat transfer fluid, since the collectors drain when not in operation. Antifreeze provides an extra measure of freeze protection from poor drainage and controller or sensor malfunctions.

A circulating pump operated by a differential control is turned on when the collector outlet is at least 20°F (11°C) warmer than the tank outlet. Water or an antifreeze solution is lifted from a small reservoir tank and circulated through the collectors and back to the tank. Heat is transferred to the domestic water via a heat exchanger in the reservoir tank. The circulation loop through the collectors is a closed loop. The water or antifreeze solution is installed at the time of installation, and does not present a recurring supply of oxygen.

A drainback system requires a larger pump than any of the other systems described here. It must have sufficient capacity to lift the fluid to the highest point in the system. When there is no more heat to be collected, the controller turns the pump off, and all the fluid drains back to the reservoir tank. The collectors are empty. They can't freeze, and they can't overheat the

Closed Loop Drainback System



Collectors and pipes should be slightly slanted to allow the water to drain from the collectors.

antifreeze. As a DIY homeowner, you won't need a special charging pump either. When it comes time to change the antifreeze, you can just drain and refill the reservoir tank.

The Choice is Yours

The system you choose will be determined first by whether you need freeze protection. If you live in a freeze-free climate, choose a batch heater or small thermosiphon unit for small systems serving one to three people. Larger needs can be met with an open loop direct pump system circulating water from storage tank to flat plat collector.

If you need freeze protection or have hard water, choose one of the closed loop systems with antifreeze and a heat exchanger. Either one will heat your water without fear of freezing.

Solar hot water is a good investment. Whether you are a do-it-yourselfer with plumbing skills or want hire a professional installer, I suggest you locate a dealer who serves your area. Ask their professional advice. Find out the products and services they have to offer, and which is the best fit for your needs and climate. Contact the American Solar Energy Society or the Solar Energy Industries Association for assistance in locating a contractor or supplier in your area.

Solar Hot Water System Types: Advantages & Disadvantages

System Type	*Characteristic & Use*	*Advantages*	*Disadvantages*
Solar Batch Water Heater	Open loop; Integrated collector & storage; Freeze protection generally limited to infrequent or light freeze climates	Simple; No moving parts	Freeze protection typically poor; Inefficient in cold climates; Small systems only
Thermosiphon	Typically open loop; May be closed loop with heat exchanger & antifreeze	Simple; Requires no electricity for operation	Collector must be located below tank; Inappropriate for use with hard water (open loop system)
Direct Pump System	Open loop; Freeze-free climates	Flexible placement of tank & collector; can be powered by PV	No freeze protection; Inappropriate for use with hard water
Direct Pump Recirculation System	Open loop; Climates where freezing is an unexpected occasion	Simple; can be powered by PV	Freeze protection is limited to infrequent & light freezes; Inappropriate for use with hard water
Draindown	Open loop; Designed to drain water when near freezing	Can be powered by PV	Freeze protection is vulnerable to numerous problems; Collectors & piping must have adequate slope to drain; Inappropriate for use with hard water
Closed Loop Heat Exchanger	Closed loop; Cold climates	Very good freeze protection; Basic principles well understood by conventional plumbing trades; No problems with hard water; can be powered by PV	Most complex of all systems, with many parts; Heat exchanger & antifreeze reduce efficiency; Fluid may break down at high stagnation temperatures
Drainback	Closed loop; Cold climates	Very good freeze protection if used with antifreeze; No problems with hard water; Simplest of reliable freeze protection systems; Fluid not subject to stagnation temperatures; Simple to homebrew; can be powered by PV	Heat exchanger & antifreeze reduce efficiency; Collectors & piping must have adequate slope to drain; Requires larger pump to lift

Access

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AAA Solar Supply Inc., 2021 Zearing NW, Albuquerque, NM 87104 • 800-245-0311 or 505 243-4900 Fax: 505-243-0885 • info@aaasolar.com www.aaasolar.com • For more design and schematic detail click on “Design Guide” then “Hot Water.”

Thermo Technologies, 5560 Sterrett Pl., Suite 115, Columbia, MD 21044 • 800-7SOLAR7 or 410-997-0778 Fax: 410-997-0779 • info@thermomax.com www.thermotechs.com • Thermomax evacuated tube collector

American Solar Energy Society, 2400 Central Ave. G-1, Boulder, CO 80301• 303-443-3130 • Fax: 303-443-3212 ases@ases.org • www.ases.org

Solar Energy Industries Association, 1616 H St. NW, 8th Floor, Washington, DC 20006 • 202-628-7745 Fax: 202-628-7779 • info@seia.org • www.seia.org

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Power to West Africa

Wightman Weese

The crew installing the fourth array. The photovoltaics were set at 15° south.

In September of 1998, I received a letter from a Canadian missionary, Grace Birnie, who is doing language translation for the Feri people of northeastern Benin. Her translation work required her to move to a small village in a rural part of Benin that was not served by utility power. Grace was looking for information about solar-electric systems, and I was happy to provide it.

My wife and I had worked in Niger during the '60s. In the intervening years, I made a number of trips to install solar-electric systems for small Bible schools scattered throughout the "boonies" of Niger, Burkina Faso, and Benin.

Benin, just west of Nigeria, measures about 675 miles (1,090 km) from north to south and about 325 miles (520 km) from east to west, and is shaped much like a large turkey drumstick. Most of its 4.5 million people live near the coast. Some of the larger cities have electricity. But only 6 million kilowatt-hours (KWH) of the 251 million KWH used each year is produced in the country, and it comes from diesel generators. The rest comes from hydroelectric dams in nearby Ghana.

Grace had been working in the town of Kandi, one of the larger towns of Benin. In order to be nearer to the language group she works with, her organization decided to move her to a small village called Pede, several miles north of Kandi. Living in the village was more practical for her language work, but it meant that she would be without the five amps (at 220 VAC, 50 Hz) of electric service she had from Kandi's small diesel generators.

In Pede, she would need power to operate her computer and printer, as well as lights, a well pump, and other household appliances to survive in the sub-Sahara climate. Daytime temperatures soar to 115°F (46°C) or higher in the October to April dry season.

Grace heard that I had been bringing out work teams from the United States to set up small, 12 volt photovoltaic systems for several schools in northern Benin. She asked if I could help her get power for her new house. Grace asked for a solar-powered system that would deliver 220 VAC, 50 Hz power to operate her household appliances. In May 1999, the project began in earnest. We had to make decisions about sizing, funding, and the logistics of getting equipment through customs and into the country.

System Sizing

First we had to determine how much energy she needed for the small house that was being built for her. We developed a usage chart and began negotiating maximum and minimum uses. We needed to determine:

- The amount of usage each day, to determine the battery bank size and the number of solar modules needed.
- The maximum amperage at any given time of day, to ensure that the inverter we chose could produce enough power to keep refrigerator and well-pump motors from stalling due to insufficient inverter output current.

All the numbers, Grace told us, were maximums. She thought she would rarely exceed these, and would most often use considerably less. For instance, the guest room could go for weeks without being occupied. Her water usage, she said, was less than 100 gallons (380 l) a day, which the pump could supply in a matter of minutes.

Modules

To begin the design, we needed to know how many hours of effective sunlight would be available to us at that location, which was 11° North latitude and 3° East longitude. We referred to a valuable study recorded on the Web by NASA (http://eosweb.larc.nasa.gov/sse).

The NASA study shows the "surface solar energy data set," which divides up the globe into rectangular cells. The program can show insolation data for any part of the world. The table (see next page) shows the data for Grace's location, cell #3873. This area of northeast Benin gets an average of six to seven hours per day of effective sunlight. We made our calculations based on six and a half hours per day.

We calculated as follows, based on 3,800 watt-hours per day: 3,590 x 1.1 to compensate for system losses = 3,949 watt-hours per day. For a 12 volt system, this comes to 329 amp-hours per day. We selected 65 watt Solarex modules, which were rated to produce roughly 4 amps.

Using the calculation of 330 AH per day, we divided 330 by 6.5 sun hours per day to arrive at 50.7, which is the amperage required from the solar array. With the modules we'd chosen, this meant we actually needed at least 13 modules (50.7 ÷ 4 = 12.6).

Map: Benin, ca. 1992. Courtesy of The General Libraries, The University of Texas at Austin. Benin's national flag has been added by *HP*.

Unfortunately, we had brought only twelve modules with us, not realizing that the 1/2 HP water pump (Meyers submersible #7GSO5R/SO4942) drew so much. To be safe, we perhaps should have installed fourteen or sixteen modules. We had to hope that Grace would be very frugal and keep her energy usage to a minimum. (When we returned to upgrade the system, we added four more modules, bringing the total to sixteen.)

Grace Birnie's house was built with hand tools and sun-dried bricks.

Benin Monthly Insolation

Month	Average (KWH per m^2 per day)	Minimum	Maximum
January	6.22	5.94	6.42
February	6.75	6.50	6.92
March	6.53	6.00	6.78
April	6.66	6.51	6.80
May	6.84	6.24	7.28
June	6.30	6.23	6.46
July	5.53	4.93	5.94
August	5.31	4.84	5.55
September	5.67	5.44	5.96
October	6.54	6.37	6.75
November	6.42	6.23	6.58
December	5.78	5.63	5.98

Courtesy NASA, http://eosweb.larc.nasa.gov/sse

Inverter
We were designing a 220 volt system, calculating that we would need at least 320 AH per day. We probably should have opted for a 3.3 KW inverter, but we saw from the usage table that rarely would more than 2,000 watts at 220 volts be drawn at any one time. Trying to save some money, we decided on a 2.6 KW Trace inverter (SW2612E), which is rated at 28 amps maximum at 220 VAC. This inverter has a peak conversion efficiency of 90 percent.

Batteries
One major problem of overseas installations of solar-electric systems is the battery issue. Gel-type batteries do not operate well in hot weather. And lead-acid batteries have to be shipped by surface carrier. Customs charges for most African countries also make the price prohibitive. Some people have used regular truck batteries, but the thin plates don't last very long in solar-electric systems.

Local prices were high—more than US$200 apiece. But importing solar batteries from the States or Europe, including overland shipping, would be very expensive. We decided we were better off buying locally.

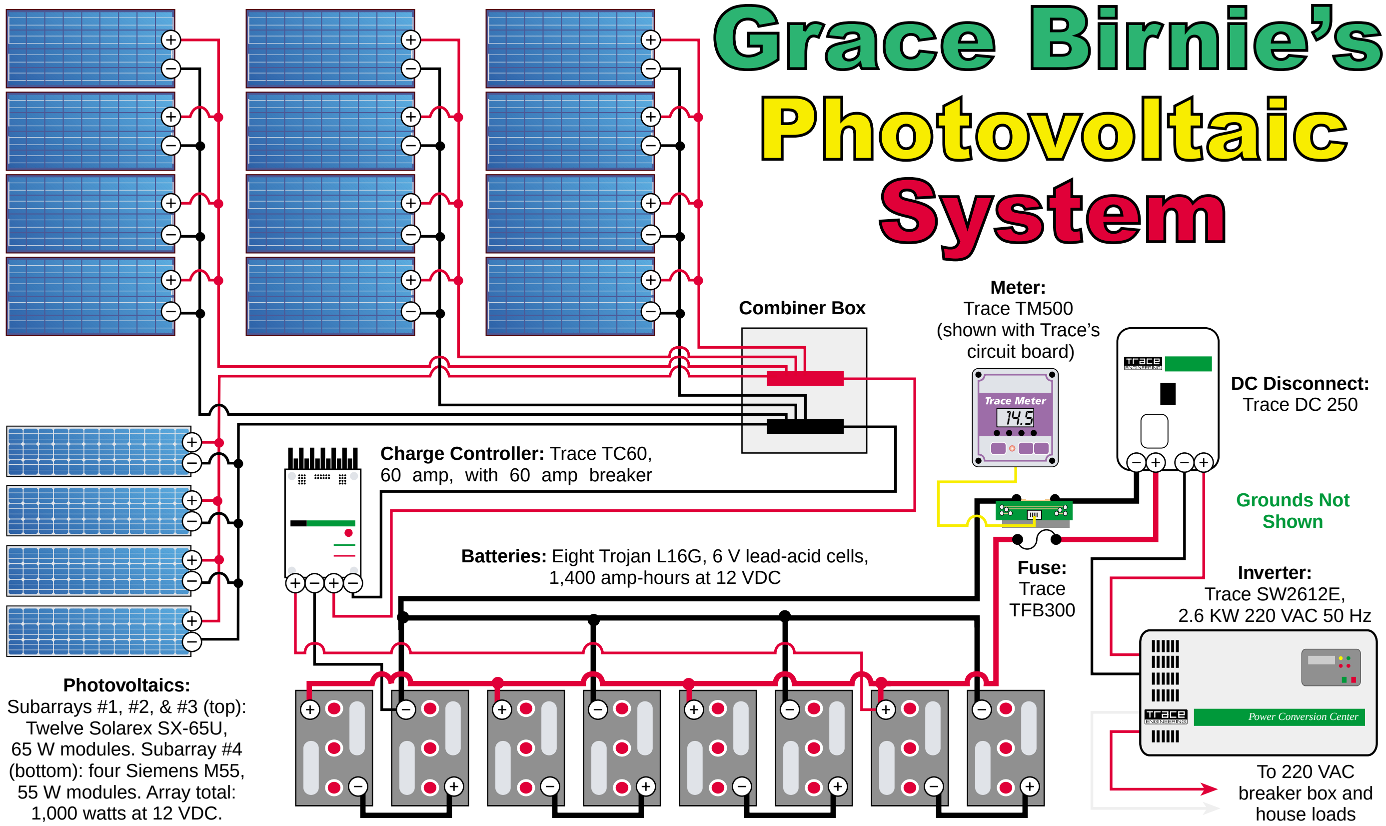
After a long search, we found an African dealer who sold so-called "solar batteries." The label stating that they were made in Germany was a photocopied sheet, lightly pasted on the batteries, which bore no other trademark.

They were 12 volt batteries rated at 105 AH, with an unusual cell arrangement. Rather than six cells in a row, there were two rows of three cells. The terminals

Birnie Loads

Item	Watts	Hrs/day	Avg WH/day	Hours of Typical Power Usage: 6-8 AM	8 AM-Noon	12-2 PM	2-6 PM	6-8 PM	8-11 PM	11 PM-6:00 AM
Outside security lights	40	10.0	400					40	40	40
Kitchen lights	40	3.0	240	80		80		80		
Pump, 1/2 hp	400	0.5	200	400	400	400	400	400	400	400
Master bedroom lights	40	2.0	160	40		40		80	80	
Livingroom lights	40	3.0	120					80	80	
Dining area lights	40	3.0	120	40				80		
Guest room lights	40	1.0	40					40	40	
Bath lights	20	2.0	40	40		40		40	40	
Hallway lights	20	1.0	20					20	20	
Porch lights	20	1.0	20					20	20	
Storage lights	20	0.5	10	20		20		20		
Appliances										
Refrigerator	145	8.0	1,160	145	145	145	145	145	145	145
Computer	300	3.0	900	300	300	300	300	300	300	
Blow dryer	1,000	0.1	70	1000						
Microwave	500	0.1	35			500		500		
Hand mixer	200	0.2	30				200			
Printer	30	0.5	25		50	50	50	50	50	
		Totals	*3,590*	*2,065*	*895*	*1,575*	*1,095*	*1,895*	*1,215*	*585*

Grace Birnie's Photovoltaic System



were mounted very close together on the same end of the battery, making them very tedious to hook up without short circuiting.

Cloudy periods can last for two or three days, and there are seasonal Harmattan winds, bearing dust clouds that slightly obscure the sun. We wanted to have enough battery capacity to give some leeway. To be on the safe side, we purchased twelve of the batteries from a dealer in Cotonou.

We wired the batteries in parallel, which theoretically gave us 1,260 AH at 12 VDC. We had to consider an allowable level of battery discharge to insure reasonable battery life. We weren't sure how carefully the system would be monitored, or whether the batteries would be discharged too deeply. So we allowed for a 25 percent discharge limit. Drawing an average of 320 AH per day, the batteries would not be discharged below 75 percent state of charge, except on very cloudy days.

Temperatures affect battery effectiveness. 78°F (26°C) is the ideal temperature for optimum battery performance. Since ambient temperatures in that region average from 75 to 110°F (24–43°C), we didn't think the batteries, stored on a shady porch area, would be greatly affected.

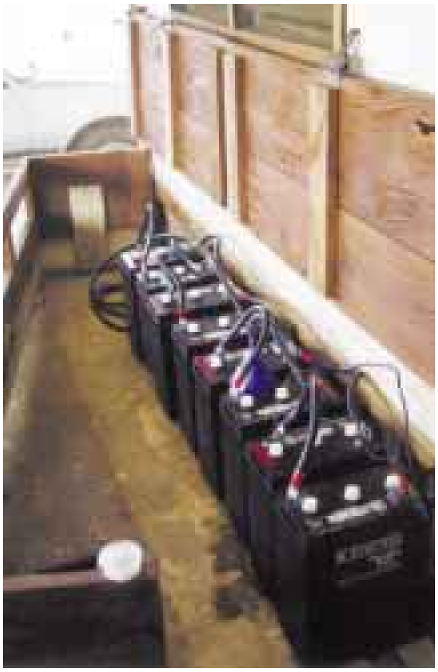
It didn't take us long to realize that purchasing the local batteries was a mistake. They began to fail very quickly, resulting in another quick trip to Benin from the U.S. with eight 350 amp-hour Trojan batteries. That gave us 1,400 amp-hours of battery power to replace the 1,260 amp-hour bank that failed.

Other Equipment

The 12 PV modules were parallel wired into four subarrays of four modules each. The modules were mounted on the roof, and eight #6 (13 mm^2) stranded copper conductors (a major positive and a major negative for each four module subarray) were run to a combiner box located in the kitchen. The #6 copper wire gave us an acceptable voltage drop of under 2 percent.

From the combiner box, we ran the PV output to a Trace TC60 charge

The lead-acid batteries live outside in West Africa's temperate climate.



Birnie System Costs

Item	Cost (US$)
12 Solarex modules SX-65U	3,492.00
Trace SW2612E inverter, 2.6 KVA	2,026.50
4 Siemens modules SM55	1,560.00
8 Trojan L16G 6 volt batteries	600.00
TC60 charge controller, 60 amp	230.30
Trace DC250 disconnect	217.00
Well pump	185.21
Trace TM500 power meter	171.50
Pump motor	149.00
Cable, battery interconnects, etc.	120.00
Trace TFB300 inverter fuse and holder	52.50
Spare fuse	26.60
Total	$8,830.61

controller, which is rated to handle 60 continuous amps. The TC60 has a built-in 60 amp, DC rated breaker that provides overcurrent protection for the PV array output.

The charge controller has a battery level indicator, but to be safe, we decided to also use a Trace TM500 amp-hour meter. This meter operates much like a fuel gauge keeping track of state of battery charge, as well as other useful information. The user can tell at a glance whether the system is in good working order and not overcharging or undercharging the batteries.

We needed a DC disconnect and a substantial fuse between the batteries and the Trace inverter (SW2612E). We installed a Trace TFB300 fuse block and a Trace DC250 DC disconnect.

Installation

We installed the batteries, controller, meters, disconnects, and inverter on the same wall. The batteries are outside on the screened-in patio, on the other side of the wall. Four of our team members and some casual laborers did the installation. From start to finish, it took us from Wednesday afternoon to Saturday afternoon—a total of about 24 working hours for the crew.

We had one disappointment. The local electrician, who was to install all the lighting fixtures and other appliances, hadn't finished his work by the time we had to leave. So we weren't able to see the house lit up and appliances running. We did see 220 volts AC on the voltmeter, which is what we came to Africa to deliver.

Solar Alternative

What was the alternative to a solar-electric system? Perhaps Grace could have used a generator, which would cost more than US$5,000 in Benin. Fuel cost in that part of the country ranges from US$3-5 per gallon. It would not have taken long to eat up the US$9,000 that Grace spent on this system. And with Harmattan dust storms, which play havoc with machinery, a generator might need to be replaced within eight to ten years. We believe that this solar-electric installation was well designed, and should deliver adequate power for years to come.

Access

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Grace Birnie, SIM, B.P. 16, Kandi, Republic of Benin grace@birnie.parakou.sim.org

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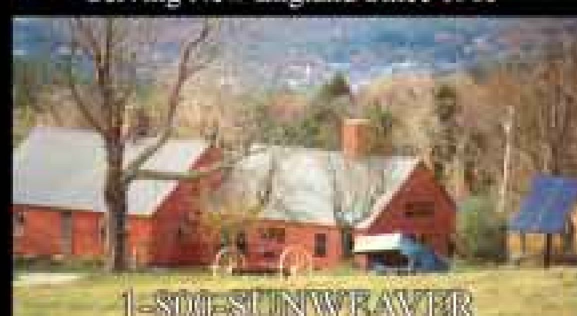

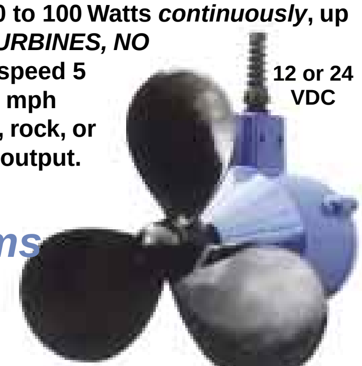

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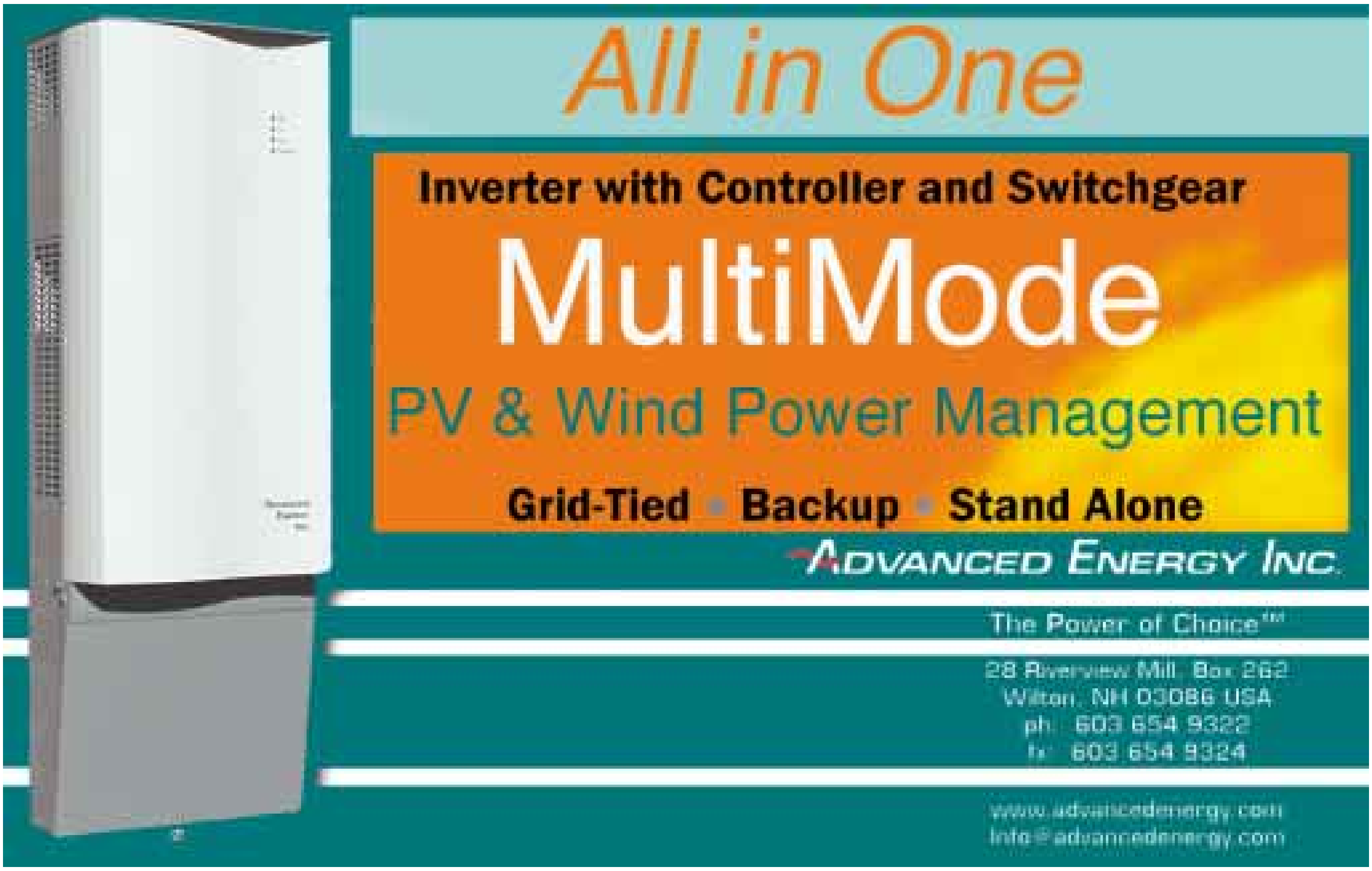
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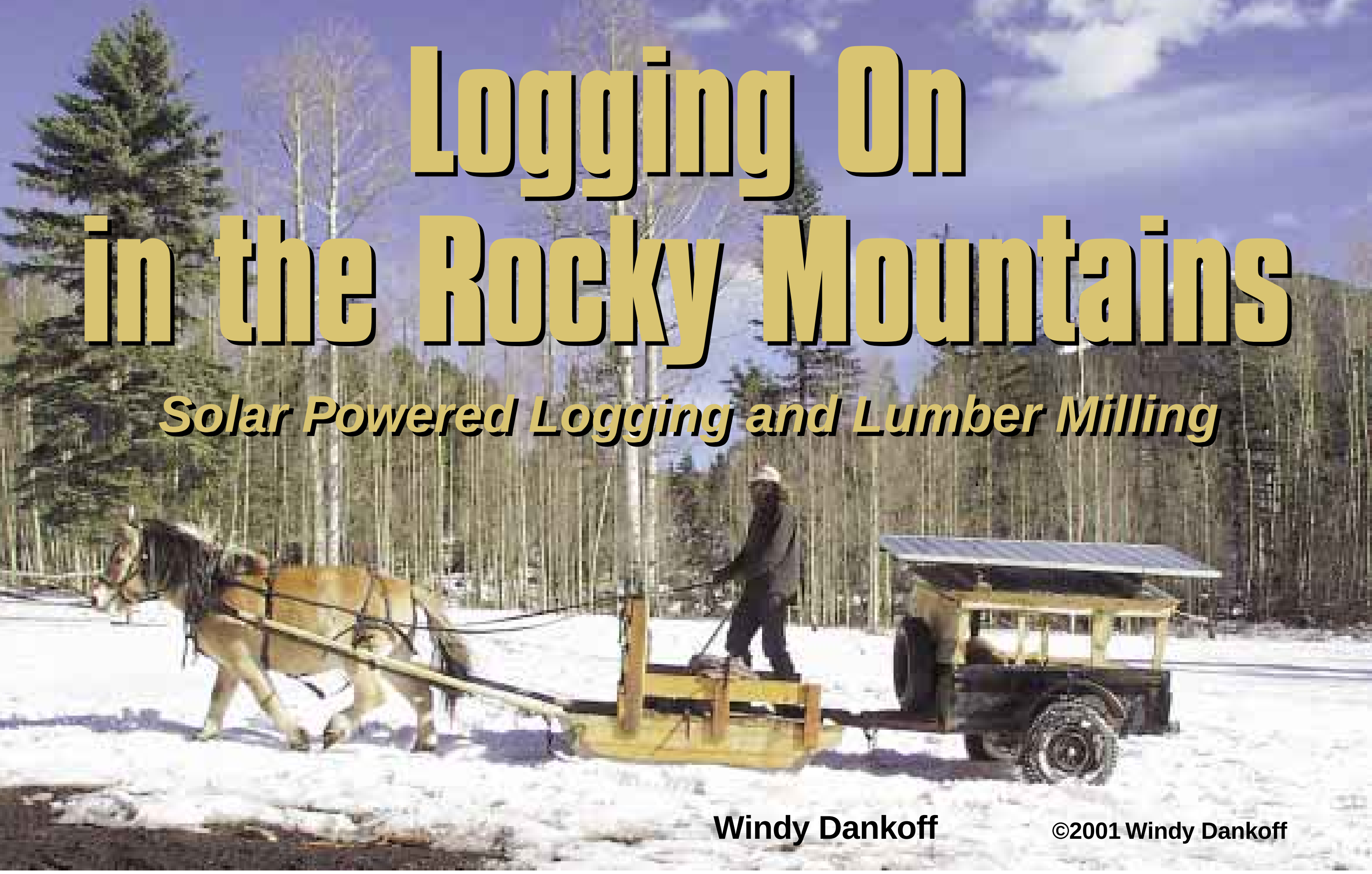

Ingot the horse pulls Rico and the solar power trailer that runs the chain saws.

Can logging be an ecological activity? Can we use modern felling and milling equipment without noise, fumes, or fossil fuels? Can solar logging be part of a viable way of life? Rico, Mary, and Brad say, *"Yes!"*

Rico and Mary Meleski are homesteaders. They have spent twenty-five years learning the skills of backwoods living. They live at an elevation of 9,400 feet (2,865 m) in the southern Rocky Mountains, 10 miles (16 km) from a paved road and about that far from the nearest power line.

They are part of a loose-knit community of back-to-the-landers that has inhabited northern New Mexico since the late 1960s. Photovoltaic (solar-electric) power systems have been common there since the early 1980s, largely due to the efforts of Brad Rose, the local "solar gizmologist."

In August 1996, Rico and Mary took a job as caretakers of a piece of private land surrounded by national forest. They formed Edge Habitat Associates, a non-profit organization, to offer wilderness experience through guided excursions, and to demonstrate traditional homestead living. They believe it's easier to spend less, without all the trappings of modern America, than to struggle to earn more.

Rico and Mary's 12-year-old daughter Aspen thrives on the adventures of backwoods living, learning about life directly, as well reading and studying. During the isolation of winter, Brad sometimes skis in with his daughter Sophia, who is Aspen's best friend. During warmer weather, Sophia occasionally comes up with her school class on a field trip.

Rico and Mary built their cabin from logs and rock, insulated it with straw, and plastered it with clay. During the winter, their only way in and out is on skis. They buy bulk food from a cooperative twice a year, grow a prolific garden, and store food in a root cellar. They make their own beeswax candles, and wash their clothes in a bucket with a plunger. For supplementary income, they make toys and art items from wood and hand-felted wool, to sell locally and through catalogs. Their skills have been honed by decades of experience.

Only a few chores are delegated to twentieth century gadgets. A solar water pump draws from a shallow well to fill storage tanks for the animals and for the kitchen (where a hand pump fills the sink). A 75 watt photovoltaic (PV) module at the toolshed powers their grain mill and blender. A tiny 10 watt PV module powers a radio/cassette player, which is the only electrical device in their cabin. Mary keeps their few plastic kitchen items hidden from sight to maintain a rustic atmosphere.

Ingot pulls a log without spinning his wheels.

Trouble in Paradise

One windy night in April of 1997, tornado warnings were posted for the plains on the other (east) side of the mountains. Mary and Rico were awakened by a violent blast of wind. The cabin trembled. It sounded like a jumbo jet was landing on the roof. When they looked outside in the morning, the scene resembled a war zone. Eighty foot (25 m) tall trees that had once dominated the landscape were mowed down like weeds. A nearby hillside was dotted with root balls torn from the frozen earth.

Rico and Mary were unhurt, but they had a mess on their hands, and a potential fire hazard. They also saw that they had a windfall of potential firewood and spruce lumber that could be sold to local builders.

They considered contracting with a local logging company to clear the fallen trees and to mill the lumber, but they had seen too much destruction left by heavy logging trucks and equipment. They figured they could do the clearing themselves, with much less impact on the land. That summer, they went to work clearing the land using conventional gasoline-powered chain saws and a pickup truck.

Horse Logging

Their first difficulty was dragging logs by truck from a tangled mass of trees, on muddy or snowy ground. They needed a more agile technique. Horse-drawn logging is a northern New Mexico tradition that goes way back. And what could be more solar-powered than a horse who eats grass?

Rico and Mary bought a pair of Norwegian Fjord workhorses from a breeder who was thrilled to see them move to the high country and "get a life." The breed dates back to the Viking era when they were used to pull logs and ships. Rico took a crash course in harnessing real horsepower from some western movie stunt men who were acquaintances of the breeders, and went right to work.

These horses are built for power, not for speed. With a traditional harness they can pull an enormous load. Rico says he has more to learn than the horses, but with gentle patience, they are developing a language of

Brad Rose demonstrates the solar-powered sawmill.

The solar-electric sawmill turns a log into lumber.

nudges and commands. Rico studied old cargo sleds, and then built his own with old skis screwed to the runners. The sled has a hitch ball to pull a trailer—an interface with this century.

The Lumber Mill

Wood can be burned for heat, or it can supply perpetual heat through the construction of solar-heated homes and sun-space additions, which are common in this sunny mountain region. A sawmill makes the difference by turning trees into lumber.

Rico and Mary bought a portable bandsaw mill that cuts with very little waste. Their Norwood Mark 4 mill was supplied with a 9 HP Honda gasoline engine. It turns out fine lumber, rough sawn but not ragged. They had no trouble finding a market for the lumber by word of mouth.

Petrol in Paradise

Mary and Rico love the peace and quiet of the wilderness, so the first year of their salvage logging operation seemed like an eternity. Exhaust fumes from the saws and the mill stunk up the whole valley, and the noise could be heard a mile away. Mary and Rico had enjoyed a nearly petroleum-free lifestyle, and wanted to keep it that way.

Dry weather caused another problem. Due to drought conditions, the Forest Service prohibited the use of gasoline equipment during much of the time when they wanted to work.

They were already using PVs to run their water pump, grain mill, blender, and radio with systems installed by Brad Rose. Brad had been running his home and workshop machinery on solar energy since the early 1980s. Mary wondered if he couldn't rig a system to run the sawmill without all the noise and fumes.

Solar Electricity for the Sawmill

The manufacturer of the mill offers an AC electric motor, but that would have required two large inverters costing close to US$6,000. From his experience with solar pumps and shop machinery, Brad knew that a DC motor would eliminate the need for the inverters, and would use less energy because there would be no inverter losses.

This was a low-budget project that had to pay for itself. Brad wondered where to get a DC motor of sufficient horsepower at a junkyard price. He thought a used electric golf cart motor might do the job. He located a golf cart repair shop with lots of old parts, and an owner who *didn't* think he was crazy. He bought a 36 volt motor from a Cushman cart that was very common in the 1960s and '70s. It used a belt drive, which made the motor adaptable to the sawmill.

Brad bolted the motor to the mill and wired it to six golf cart batteries. It worked perfectly! The golf cart motor had all the power they needed for the soft spruce they are cutting. Electric vehicle motors handle overloads more gracefully than gasoline or AC motors because they respond with an increase of torque instead of partially stalling.

This recycled golf cart motor turns the sawmill blade.

The mill is not only quiet, it eliminates the vibration and pulsations of the gasoline engine. The mill holds its adjustments better, and the blade stays sharp at least twice as long. Blade sharpening is very time consuming, so this was a welcome benefit.

To power the mill, the loggers wired a 585 watt solar array, with sets of three panels wired in series for 36 volts. They bolted this array to the roof of the mill shed. The array consists of three Photowatt 75 watt modules and six Solarex MSX-60 modules. The modules were donated.

The battery bank is six Trojan T-105 golf cart batteries. A B.Z. Products ICC16-36 (16 A, 36 V, temperature-compensated) charge controller prevents overcharge of the battery when there is excess energy. A fuse prevents hazardous overcurrent if the blade gets stuck or if there's a short circuit. The system is really quite simple.

Sawmill Conversion Details

A golf cart motor works perfectly for the portable sawmill. They come in various sizes. Their nameplates don't usually list horsepower, but they do show a rating of current draw that ranges from about 60 to 110 amps. 110 amps X 36 volts = 3,960 watts. At about 75 percent motor efficiency, that's 4 HP.

The mill manufacturer offers a 10 hp AC motor, but softwood like spruce doesn't require that much. The solar loggers used a GE 36 volt, 110 amp golf cart motor, reconditioned. It draws full current (and slows down a bit) only when making 16 to 20 inch (40–50 cm) cuts or hitting hard knots. If more power is required (for cutting hardwood, for example), a second, identical motor could be added using a double belt drive. Sometimes larger DC motors can be obtained from surplus catalogs. New 90 VDC motors are also available from industrial motor suppliers.

The old Cushman motor fit the mill with little more effort than spinning four nuts onto four bolts. Golf cart motors have a tapered shaft and require a pulley to match. Brad got 3 inch and 4 inch (7.6 and 10 cm) pulleys with the motor. The 4 inch pulley would run the saw faster, and it worked fine without overloading the motor. The gasoline engine had a centrifugal clutch, but that wasn't necessary with the electric motor. Speed control is not needed either.

Brad displays a finished board from the solar-powered sawmill.

Welding cable was used to carry the power to the motor on the moving carriage. It is large enough to produce almost no voltage drop. For the on/off switch, they used an inexpensive marine battery switch. It took less than a day to convert the mill to DC power. An emergency stop button will be the next addition.

36 volts is the standard for older golf carts, but it is not a normal standard for PV systems. The PV array and battery bank are easily configured for it, since they come in 12 and 6 volt increments, respectively. B.Z. Products makes 36 volt charge controllers. An

Power Draw of the Mill: On a Typical Full Load Cut (10 inch (25 cm) wide spruce log)

Voltage at the motor, under load	34.0 volts
Average current draw (80 to 130 amps)	105 amps
Average power (105 A x 34 V)	3,570 watts
Starting surge	410 amps

Sawmill System Costs

Item	*Cost (US$)*
Norwood Mark 4 sawmill without motor	$4,560
3 Solarex and 3 Photowatt PV modules	2,925
PV mounting racks, adjustable tilt	380
6 Trojan T-105 batteries	330
Fused disconnect switch & misc. electrical	220
Golf cart motor, reconditioned, 36 V, 4 HP	120
BZ Products charge controller	85
70 feet #4 welding cable	65
Total	$8,685

important feature of the controller is temperature compensation, because batteries require a higher finish-charging voltage during the cold winter months.

Solar Power for the Chain Saws

The sawmill worked so well that the solar loggers decided to tackle the chain saws. Brad knew that the power system could be built using the same components used in remote solar-powered homes. The design process would also be the same. He needed an estimate of the energy needs of the machines—the watts that they draw multiplied by the daily hours of use.

The solar loggers purchased an electric chain saw, and tried it out using some old batteries and a borrowed inverter (to convert DC to standard AC). That gave them the data they needed, plus the inspiration derived from seeing it actually work.

Brad then designed a power system to run two saws for about four cutting hours per day. The 340 watt photovoltaic (PV) array is made up of four BP-585 85 watt modules. Four Exide GC-4 golf cart batteries, a B. Z. Products ICC16-24 charge controller (16 A, 24 V, temperature-compensated), and a 3,600 watt inverter complete the system. It's all mounted on a little home-built trailer, made from an old pickup bed and chassis.

The loggers now use two electric chain saws. The larger saw is a Stihl E220 (115 VAC, 15 A), which performs as well as a good gasoline-powered saw. Their smaller Husqvarna Electric 16 (115 VAC, 13 A) is ideal for trimming limbs and for smaller trunks.

These are 115 VAC power tools. No one makes low voltage DC chain saws because the power cable would be too large, heavy, and expensive. These saws can be ordered from your local chain saw shop.

A solar-electric chain saw quickly reduces fallen aspen to firewood.

Power Draw of the Stihl E220 Saw: On a Typical Full Load Cut (12 inch (30 cm) spruce log)

Voltage at the battery	24.0 V
DC current draw, average	85 A
Average power: 85 amps x 24 V	2,040 watts
Starting surge	256 amps

Both saws can be used for half the day almost every day. Sometimes Rico and Brad cut all day, drawing the batteries down to a fairly low state of charge. If they do something else the next day, the batteries recover after about one day of sun.

Not Enough Macho?

The benefit of electric saws goes far beyond the elimination of fuel and noise. There is no engine maintenance. As with the sawmill, the chain saw teeth stay sharp two or three times as long because the power is applied without the pulsations of a piston engine.

The saws are also much less stressful to use. When you stop a cut with a gasoline tool, the engine keeps idling. It makes you want to hurry to the next cut. The electric saws stop completely between cuts. The operator tends to be more relaxed, and makes better decisions under potentially hazardous conditions.

Most important, Rico figures that he experiences half the physical stress. His hands have been injured by years of gas-powered chain saw use. The vibration causes him pain, but he has no trouble using an electric saw for hours at a time. Each saw has a 100 foot (30 m) extension cord (#12 (3 mm^2) construction grade) to drag around, but that takes less effort than refueling and messing with engines. They keep one gasoline chain saw handy for occasional clearing beyond reach of the cords.

Electric Chain Saw System Costs

Item	*Cost (US$)*
4 BP-585 PV modules, 340 W at 24 V	$1,870
Trace DR-3624 inverter, 3,600 W	1,600
Stihl E220 chain saw	525
4 Exide GC-4 golf cart batteries	220
Fused disconnect switch & misc. electrical	240
Husqvarna Electric 16 chain saw	220
PV mounting rack	85
BZ Products charge controller	75
Trailer, salvaged pickup	0
Total	$4,835

This 10 watt thin-film PV module supplies the only electricity for the home cabin.

The quiet whir of the chain saws is amusing to visitors. One said "it sounds more like a sewing bee here." Another, getting right to the point, grumbled "it just don't got enough macho." Rico lets visitors make a few cuts, and then they see the light.

Is There Enough Energy?

One full day of lumber milling draws the batteries down to a fairly low charge level. It takes about one day to recharge after that. The same is true for the chain saw operation. So by rotating work between the two chores, the loggers can work all they want to. When it's cloudy for a few days, there is always hand and horse work to do, or they can take time off.

These two systems have minimal battery banks. If the battery capacity were to be doubled, it would lengthen the working (and recharging) periods. In a cloudy climate, both the solar arrays and battery banks would need to be larger.

Is Solar Logging Economical?

This project was accomplished using standard, easily available components. It can be reproduced. It isn't cheap, but it can be economical under the right conditions.

One example is Forest Service contracting, especially for thinning in sensitive watersheds where petroleum pollution is unacceptable. It also makes sense where

Other Solar Energy Systems at Edge Habitat

The home cabin uses a 10 watt PV module to charge two golf cart batteries. The only load is a car radio/cassette player. The PV module is the thin-film amorphous type that Brad obtained as a sample, back when it was introduced to the market. Thin-film modules are less affected by partial shading than the crystalline modules used in the logging systems. It was chosen because shadows of tree branches can't be avoided at the cabin.

The toolshed system uses one Photowatt 75 watt PV module, an 8 amp charge controller, and four golf cart batteries. The batteries are ten years old and in poor condition, but they are good enough for intermittent use of a flour mill, a blender, and the blade sharpener for the sawmill. A 300 watt inverter runs the blender and sharpener. The flour mill is belt-driven by a 12 volt, 1/4 HP motor.

The water supply system was the first solar energy system that Brad installed at the site. It took the place of an AC shallow well jet pump and a generator in 1987. The pump is a Solar Slowpump by Dankoff Solar Products. It hangs suspended 5 feet (1.5 m) below grade, just above the high water level. It pumps the water uphill 45 vertical feet (14 m) to a 1,000 gallon (3,800 l) buried concrete tank at the cabin.

Water is delivered to the kitchen sink by an old-fashioned hand pitcher pump next to the sink. The Slowpump also pushes water up 60 vertical feet (18 m) to another 1,000 gallon galvanized tank, for seasonal use, to water the garden and animals.

It was not feasible to bury all the water pipes deep enough to protect them from freezing. The water is pumped about once per week. When the pump is turned off, water drains back down from the pipes. When the pump is not running, solar electricity is stored in a battery bank. The PV array is a single Arco M-53 module (43 watts) charging two golf cart batteries. Rechargeable flashlight batteries are also charged by this system, using a 12 volt battery charger.

noise is a problem, in burn areas, and where fire hazard is frequently declared. The U.S. Forest Service and National Park Service already use PV for water pumping, campground lavatory lighting, lookout towers, and environmental monitoring. They recognize solar power's practicality.

Milling valuable hardwoods can be lucrative, and can pay for the mill and the power system in a reasonable time. When boards come directly out of the woods, transport of material is greatly reduced and waste is returned to the forest. The system also can be used to clear land for settlement, and to mill lumber to build a house. Next, the power system can run construction tools to build the house, and finally, it can power the home itself.

By switching to solar power, the solar loggers have greatly reduced their maintenance time and expenses. Their electrical systems will last much longer than gasoline engines. In the long run, their investment will pay off, and they will probably stay healthier as well. These are the expected benefits. An unexpected benefit has already paid off, in the form of community relations.

Community Flourishes

The solar loggers spread the good word about solar power by offering free firewood to the community, and selling custom-milled lumber. The results have been nothing short of social magic, introducing them to many of the local old-timers, and breaking down cultural barriers.

Some of the local people had grown up helping their fathers and grandfathers to log with horses. There was one older fellow who had never liked the "hippies." He came to see the solar logging operation, and it finally warmed him up. He has since returned many times, bringing gifts, and bringing his family up to get wood. He gave Rico a pile of horse equipment that had been stored in his shed for decades.

Children get a special thrill out of seeing the whole process, from the logs in the woods to the stacks of lumber that will soon be part of somebody's home, all done cleanly and quietly. For the solar loggers, this has been the biggest return on their investment!

It Works!

When a project like this works so well on so many different levels, it becomes a source of enthusiasm and pride. The solar loggers want to share this experience with the world. They want you to know that you too can log on, and on, and on, in a cleaner, safer, more sustainable way.

Access

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windy@dankoffsolar.com • www.dankoffsolar.com

Rico and Mary Meleski, Edge Habitat Mountain Center, HCR 65 Box 16, Ojo Sarco, NM 87521 • Edge Habitat Associates is a non-profit organization. Donations are tax deductible, and visitors are always welcome.

Brad Rose, PO Box 1, Ojo Sarco, NM 87521
505-689-2455

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Converting A Flashlight to LEDs

Peter Jones

The motivation for this project came from reading the review of the LED torches in *HP81.* I've been using LED bike lights for several years now, and have replaced the small bulbs in penlight torches with red LEDs for use in the photographic darkroom, where a localised bright safelight can be most useful. But I had never ventured into the use of LEDs for a "proper torch."

In the United Kingdom, we seem to be years behind the United States with such innovations. When they do become available, we tend to pay dollar prices in UK pounds, so things cost around half again what they do in the States. Internet buying is of course an option, but freight charges, import duties, and customs charges almost double the cost.

I set out to make a simple conversion for an existing torch ("flashlight" to Americans) that would give me the efficiency and longevity of a similar commercial product. This proved to be quite simple to do, and may be of interest to others in a similar situation, or to anyone who prefers to modify a commercial torch rather than buy a manufactured LED torch.

The Choice of Torch

Because this was going to be quite an expensive exercise, it seemed foolish to skimp on the cost of the torch body itself. I wanted to produce a torch that would last for many years. The three main criteria for the torch were robustness, water resistance, and ease of connection for the new light unit. The torch also had to be of a three-cell design to give sufficient voltage for the white LEDs.

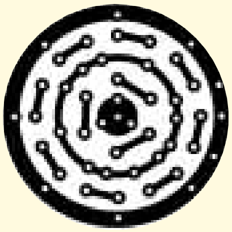
My choice was a three C-cell Mag-Lite, available from any good hardware or camping store. Though expensive on this side of the pond, it fulfilled all of the requirements. It is very robust, has a good positive switch, is fully waterproof, and has a very simple and electrically sound method of making all the connections.

LEDs

Light emitting diodes (LEDs) have improved over the last few years, with extremely high levels of output possible. There could be only one criterion for the LEDs for this project—the highest output possible!

There's not a lot of choice here in the UK, and again we tend to pay about half as much again as in the U.S. The brightest white LEDs that I could find were 5 mm, 20 degree types rated at 3,000 millicandelas (mcd) while drawing a current of 20 mA. (I believe that these are equilvalent to those advertised as 5,600 mcd while drawing 30 mA.)

The output power of a light source can be described in several ways. Light bulbs around the home and for automobile use tend to be rated in watts. The rated output of LEDs is usually quoted in candelas (cd). Early LEDs only gave out a few thousandths of a candela, so they were rated in millicandelas (mcd). High efficiency modern devices emit several thousand millicandelas.



The LED torch's printed circuit card.

LEDs are very efficient, and will give out light even when drawing miniscule current. The current drawn is directly proportional to the voltage applied, so increasing the voltage will give a brighter light. This works up to a point, but just like a flashlight bulb, too high a voltage will burn it out. In practice, I guess it's a case of the best compromise between getting the highest light output, while taking the least current. LEDs reach this point at around 20 mA.

Current Limiting

White LEDs require an operating voltage of 3.6 VDC. For this reason, a two-cell, 3 volt torch is not suitable. On the other hand, connecting an LED directly to a three-cell, 4.5 volt supply will draw far too much current and fry it!

Some kind of current limiting is needed. The simplest way is just to add a series resistance. Rather than connect all the LEDs together and use a single current-limiting resistance to handle the total current, I prefer to use a separate resistance for each LED. This means that each one is balanced with regard to the current it will draw, and physically small resistors can be used.

Before deciding on the level of the limiting resistances required, I had to choose between using 1.2 volt NiCad rechargable cells or standard 1.5 volt alkaline types. Because the torch was for occasional use with a high degree of reliability, I decided on standard alkaline cells, which have a long shelf life and are readily available.

The output of an LED is proportional to the current it draws, but it is at its most efficient while drawing 20 mA. To limit the current to this level at 4.5 volts, a resistance of 330 ohms was needed for each one. Resistors with 1/4 watt power ratings would suffice. I wanted to get as bright a light as possible. After experimenting, I decided to use eleven LEDs, which would fit well into my proposed design.

If you want to use NiCd batteries (with a nominal voltage of 3.6 volts for three cells), the resistors could be replaced with wire links. Each LED will then draw about 23 mA using newly charged cells, dropping to about 8 mA at the nominal 1.2 volts level, so no resistors are really needed. If you do this, you must be careful not to ever put alkaline cells into the torch, since their higher voltage may ruin the LEDs.

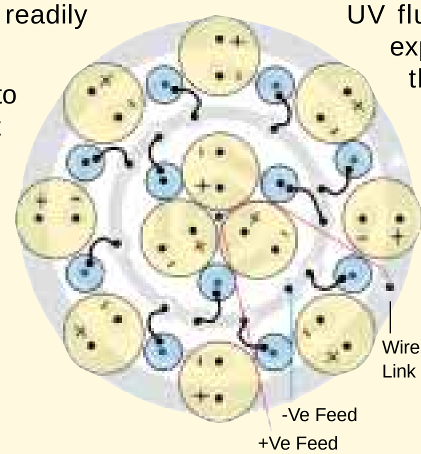
Printed Circuit Card

I could have used Veroboard (0.1 inch pitch, prototype copper strip board), but decided that a printed circuit would be more elegant. CorelDraw software came to the rescue. A simple design was soon drawn up and photographed, and a board made (circuit card shown actual size for direct copying).

A printed circuit board starts off life as a wafer-thin coating of copper that is firmly attached to a sheet of either paxolin or fibreglass. Fibreglass is much stronger and better suited for homebrew construction. Boards can be purchased either plain or with the copper side pre-coated with a light-sensitive emulsion. If plain boards are used, the circuit design can simply be drawn on the board with a special etch-resistant pen. This process works for very simple designs, but for anything more complicated, a photo-resist process is better.

I usually buy off-cuts of plain board in the local electronics shop. After a rub down with fine wire wool, I spray them with a light sensitive lacquer, known as photo-resist. This comes in an aerosol can and is very easy to apply. It is sensitive to ultraviolet (UV) light, so it should not be applied in direct sunlight, and must be used in well-ventilated conditions! After about half an hour of drying, the lacquer is insoluble in the developer (sodium hydroxide).

Exposing the board to ultraviolet light changes the property of the lacquer, making it soluble—this is known as a positive resist. A special light box, housing small UV fluorescent tubes is normally used for exposure. But bright sunlight can also do the job, after a little experimenting to determine the exposure time needed.



The LED torch's component overlay.

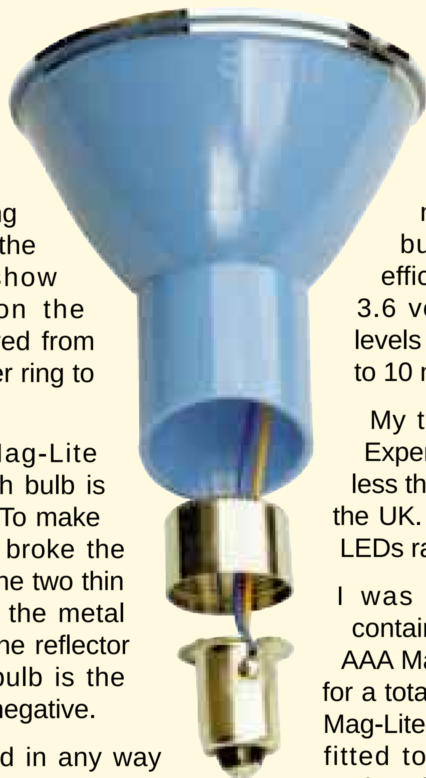
After exposure, the resist becomes soluble, except where the drawn pattern has prevented the light from reaching the lacquer. When the board is put in the developer, the developer dissolves away the exposed parts, leaving the pattern on the board as a thin coating of lacquer. The board can then be put into a dish of ferric chloride, which eats away the exposed, unwanted copper. This leaves the printed circuit pattern

LED Torch Costs

Torch Components	*Costs (UK£)*	*Costs (US$)*
11 white LEDs, 20 degree, 3,000 mcd	£33.00	$49.50
Mag-Lite, 3 C-cell	25.00	37.00
Photo-resist positive aerosol spray, #YM62S	9.99	14.99
Photo-resist developer, 250 ml, #YJ38R	4.99	7.79
Fibreglass board, single-sided, 203 x 102 mm (8 x 4 in.), #HX01B	1.99	2.99
11 resistors, 33 Ω 1/4 watt	0.55	0.83
Wire (scavenged)	0.00	0.00
Bulb for connection (scavenged)	0.00	0.00
Total Cost	£75.52	$113.10

beneath the resist, and the board can then be drilled to take the components.

Easy access to the reflector and connections made the conversion simple.



Putting it Together

The resistors (available from any electronics store) were soldered into the board first. This minimised the heat to the LEDs, which were held in a small forceps used as a heatsink during their installation. As can be seen on the component overlay (enlarged to show details), a small length of wire on the component side of the board is soldered from the inner positive connection to the outer ring to complete the circuit to the outer LEDs.

Connecting the assembly to the Mag-Lite couldn't be simpler. The standard torch bulb is held in with a very robust screw collar. To make the connection to the torch, I simply broke the glass out of an old bulb, and soldered the two thin flexible wires from the PC board into the metal bulb base (first passing them through the reflector and screw collar). The base of the bulb is the positive supply, and the torch body the negative.

The torch doesn't have to be modified in any way whatsoever. The PC board sits in the reflector, and the LEDs just press against the plastic top of the torch. You can do this conversion on any flashlight designed to run on 4.5 volts, providing that the reflector housing is large enough to accommodate the PC board and the LEDs.

Results

The finished product is fantastic! It doesn't give a 100 yard pencil beam, of course, but that wasn't the point. The flashlight gives a very even spread of white light that is easily bright enough to illuminate a room or tent, or to light your way over the roughest of terrain.

I chose to optimise the LEDs for maximum light output, not being overly concerned with battery life. Higher value resistances could have been used to reduce current drain, giving longer battery life. But this would have been at the expense of the light output.

Reliability and occasional use were the main requirements. Overall current consumption at around 220 mA may seem a little high, but nowhere near as much as the standard three-cell bulb at 750 mA. These LEDs are very efficient. Even when NiCds supplying only 3.6 volts are used, they will produce high levels of light, while reducing the current drain to 10 mA for each LED.

My total cost was around UK£55 (US$75). Expensive, yes, but still about UK£15 (US$23) less than buying the CC Expedition Flashlight in the UK. And I ended up with a torch with eleven LEDs rather than seven!

I was lucky enough to buy a twin pack containing a three C-cell Mag-Lite and a mini AAA Mag-Lite at the local wholesale warehouse for a total price of UK£19 (US$30). The mini AAA Mag-Lite is destined to have a single white LED fitted to run from one AAA cell via a single transistor inverter, but that's another story!

The bonus of using solid state lights is their long life—at least 100,000 hours is expected. They also give a constant colour as the voltage of the battery drops, yet they still give a very useable light source.

The converted torch has been running for several weeks now, and after many hours of use, I've seen no noticeable drop in brightness. I took it on the first camping weekend of the season, arriving at the site by motorcycle just after dusk. The even spread of light made it ideal to use while I set up my tent. It also provided a really good interior light, easily bright enough to read by, even when reflected from the roof of the tent.

Comparison test: Stock Mag-Lite on left; Peter Jones' converted LED Mag-Lite on right.

My flashlight conversion has generated lots of interest from friends who've seen it. Many of them want to have a go at their own conversion, so it looks like I'll be etching a few more PC boards before long!

Access

Peter Jones, 2 Highcliffe Dr., Sheffield, England S11 7LU, UK • 44 114 230 3704 • g4gri@hotmail.com

Farnell, International Distribution Centre, Castelton Rd., Leeds LS12 2EN, UK • 44 113 263 6311
Fax: 44 113 263 3411 • www.farnell.co.uk
LEDs, #993864, Nspw500, 5 mm white

Maplin Electronics, National Distribution Centre, Valley Road, Wombwell, Barnsley, South Yorks S73 0BS, UK
0870 264 6000 • Fax : 0870 264 6001
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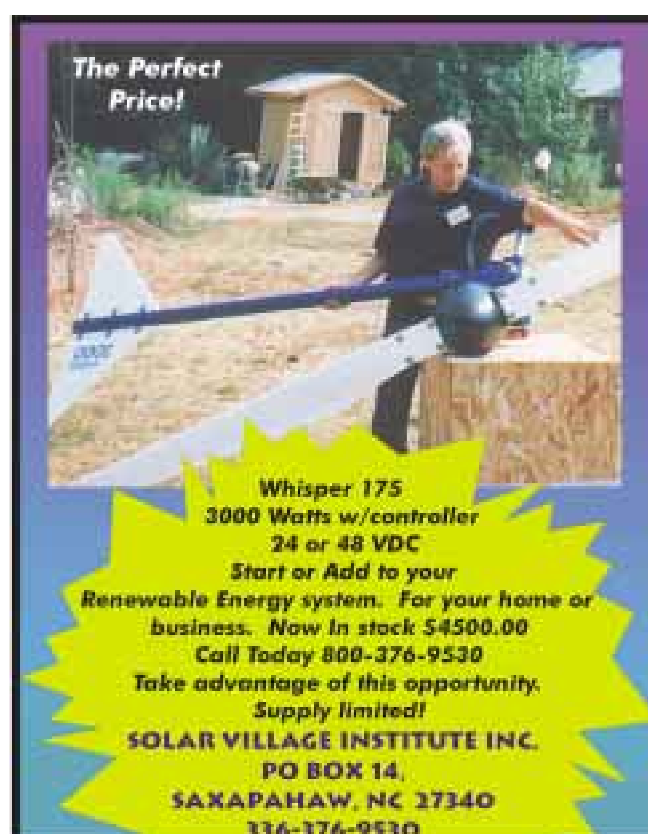
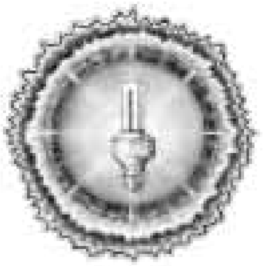


Home Power's Business



"The man who on his trade relies
Must either bust or advertise."
Sir Thomas Lipton — 1870

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TOP SECRET

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

PROFILE: 0015

DATE: May, 2001
LOCATION: Classified
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 100 watts of PV
TIME IN SERVICE: 3 months

We are currently renting a two-bedroom apartment on the third floor of a modest building in a major Canadian city. The balcony faces due north, but a corner of it has western exposure, and gets light between noon and sunset.

We built an aluminum and lumber frame for our two 75 watt Solec modules, which are strapped vertically onto the railing of the deck with rope. We have a 100 watt Trace MicroSine inverter. Although Trace no longer sells this inverter, it is still available from the manufacturer in The Netherlands.

We purchased two 12 volt, 75 watt modules because they were less expensive than a single 24 volt module rated at 100 watts. We wired the two 12 volt modules in series for 24 volt output. The PV output is run through the 100 watt MicroSine inverter. The inverter's 120 volt output is always synchronized with the frequency of the incoming utility power. This allows clean PV power to flow freely onto the grid. The inverter's output is simply plugged into a receptacle, which is protected by the circuit's original breaker.

Our main objective in using this system is to reduce our ecological footprint. We figure that our PVs will displace about 120 KWH of electricity production from a local natural gas plant every year. This will save over 65 kilograms of greenhouse gas emissions per year. And it will also help to reduce emissions of smog-causing NOx and VOCs.

We will never see a financial payback on this investment. Our city has the world's cheapest electricity rates, so our savings is less than the cost of a subscription to the local newspaper. This no great loss to us because we would rather be reading Home Power.

We live in a city that is full of renters and people living in apartment buildings. Imagine if just 10 percent of our city's households and businesses were to do what we are doing. Then we could generate over 10 MW of electrical capacity, displacing over 10,000 tonnes of emissions. If we had the financing programs, incentives, and net metering programs of our neighbors south of the border, there might be a chance that such a vision could be reached or exceeded. Let's catch up with the rest of world with distributed renewable energy!

Why Guerrilla Solar?

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

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

Things *That* Work!

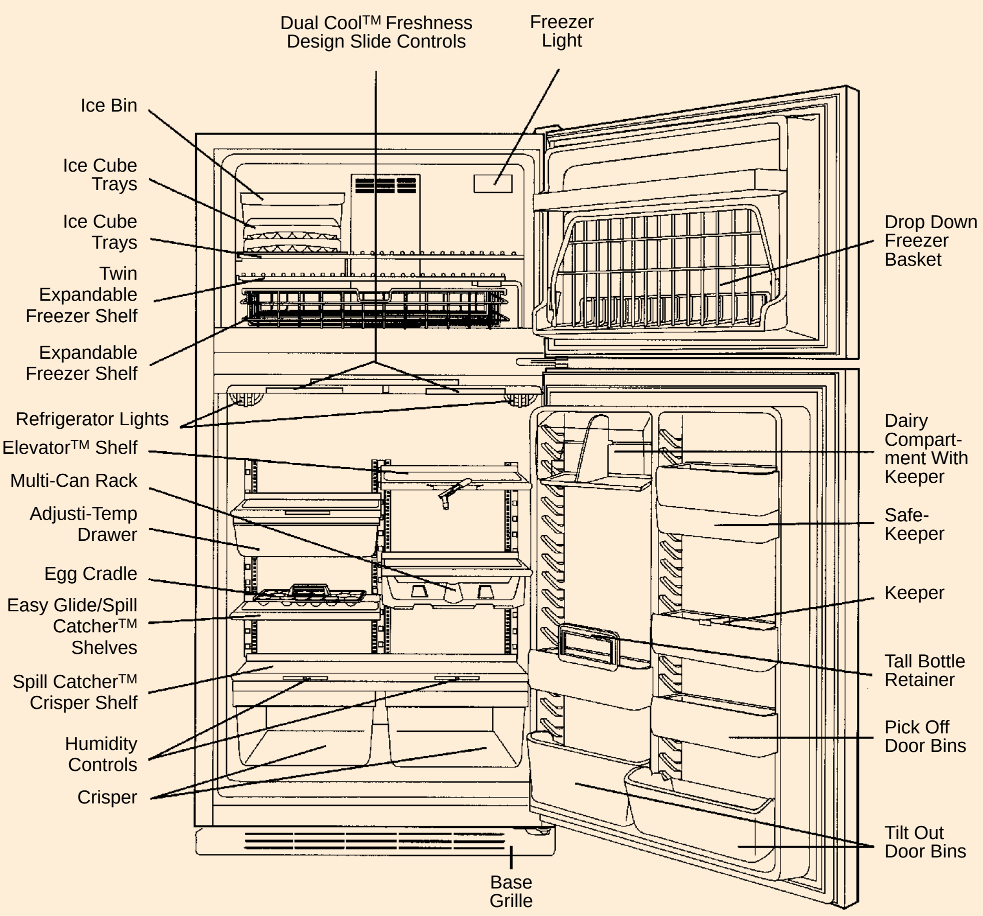
Tested by Home Power

Maytag's model MTB1956DEW, 18.5 Cubic Foot Refrigerator/Freezer

Joe Schwartz

Last year, Karen Perez' mom, Virginia, moved from New Orleans to southern Oregon. She lives on-grid. But we still wanted to set up her new home with the most efficient appliances we could find.

Inside Maytag's energy efficient and economical refrigerator.



For on-gridders, every KWH saved means a lower monthly electrical bill, less pollution, less impact on wildlife, and a reduced threat of global warming. After a bunch of research, we purchased an 18.5 cubic foot (0.5 m^3) Maytag model MTB1956DEW refrigerator/freezer from a local appliance store.

On-grid, refrigeration is typically one of the top three household energy consumers. Off-grid, refrigeration is the largest electrical load in many renewable energy (RE) powered households. Efficient appliances are the basis of any well-designed RE system. Purchasing an energy efficient refrigerator/freezer makes sense for anyone who's into ice cream, cold beer, or whatever else keeps you cool and happy.

During the past few years, mainstream appliance manufacturers have been introducing high-efficiency products. These improvements in efficiency are driven by federal standards imposed on the manufacturers. Mainstream appliances typically have several distinct advantages over products produced by specialty appliance companies. These include substantially lower cost, wider selection, better features, better availability, appliance delivery and set-up, and factory trained service people who come to your house and fix the appliance if it breaks.

Dimensions

To make sure the new Maytag would fit in the space available, I checked the exterior dimensions beforehand. The Maytag MTB1956DEW is 29-5/8 inches (75.3 cm) wide, 66-5/16 inches (168.4 cm) high, and 28-7/8 inches (73.3 cm) deep.

This refrigerator/freezer has a total interior volume of 18.5 cubic feet (0.5 m3). The refrigerator volume is 13.08 cubic feet (0.37 m3). The freezer volume is 5.38 cubic feet (0.15 m3).

We Deliver

The suggested retail price of the Maytag MTB1956DEW is US$869. Mainstream appliance resellers typically work on a high volume and low profit margin basis. This is due to local competitors that sell the same appliance models. As a result, we ended up paying US$780 for Virginia's new reefer.

We opted to have the new Maytag delivered by the local appliance store. Delivery was an extra US$50. But this additional cost is well worth it, in my opinion. Any damage to the appliance during delivery is the responsibility of the seller. On top of that, the friendly delivery dudes placed the refrigerator where I pointed my finger, and unboxed and assembled it.

Assembly included mounting the refrigerator's handles and shelving. Because of their familiarity with the appliance, the assembly took them less than ten minutes. If you're setting up the Maytag MTB1956DEW yourself, detailed instructions are provided in the sixteen page user's guide.

Energy Efficient Appliance Certification

The Maytag MTB1956DEW is Energy Star rated. Energy Star is a division of the U.S. Environmental Protection Agency (EPA) that evaluates appliances based on their efficiency. In January 2001, Energy Star temporarily suspended its certification of refrigerators due to changing federal efficiency standards scheduled to take effect on July 1, 2001. Energy Star's new refrigerator efficiency guidelines will be 10 percent above these new federal standards. So look forward to the next wave of energy efficient refrigerators.

Efficiency First!

With an energy rating of 485 KWH per year, the Maytag MTB1956DEW was the most efficient refrigerator I could find in its size and price range. The 485 KWH per year figure works out to 1.33 KWH per day. Of course we decided to see if this figure was for real.

Maytag's 485 KWH per year figure is based on a freezer temperature of 0 to 5°F (-18 to -15°C), a refrigerator temperature of 35 to 40°F (2 to 4°C), and an ambient operating temperature of 65°F (18°C). I set the temperature controls for both the refrigerator and freezer at 5 (on a scale of 1 to 10, 10 being the coldest). These settings gave us an average freezer temperature of 4°F (-16°C), and an average refrigerator temperature of 36°F (2°C).

Virginia is a New Orleans native and likes to keep her place *hot.* The thermostat stays set at 77°F (25°C)! Knowing this would be a challenging environment for the Maytag to meet spec, I placed a Radio Shack recording digital thermometer next to the refrigerator.

The Maytag MTB1956DEW consumed an average of 1.4 KWH per day in our tests.

Minimum recorded temperature was 72°F (22°C). Maximum recorded temperature was 95.7°F (35.4°C).

The Maytag's energy requirements were recorded using a Brand model 20-1850 power meter. This watt-hour meter recorded the refrigerator's consumption over a 139 day period. Average daily KWH consumption was 1.40 KWH per day. Peak wattage was 812 watts (due to the freezer's auto defrost unit). The appliance's power factor (PF) was 0.86. Running wattage varied between 134 watts and 213 watts.

Our recorded daily KWH rate exceeded the manufacturer's rating by 5 percent. But I still consider the Maytag MTB1956DEW to be within specifications. The discrepancy is based on the high ambient temperature in Virginia's kitchen. Several qualified RE dealers reported daily KWH usage for this refrigerator to be between 0.9 KWH per day and 1.4 KWH per day.

The high efficiency of the unit is largely due to a high quality, single compressor/motor design that cools both the refrigerator and freezer sections. In addition, after the unit is wired, the wall and door cavities are filled

This Maytag looks like any other refrigerator, but it is super-efficient.

with a liquid insulation that hardens as it cures. This process results in a fully sealed insulation envelope with no air gaps.

Most Excellent User Features

The Maytag MTB1956DEW is loaded with great features. It has two easily accessed thermostats—one for the refrigerator and one for the freezer. Two vegetable storage drawers include adjustable air slots to control the humidity levels within the drawers.

If you need to put an oversized item in the refrigerator portion, a hand-adjusted elevator shelf allows you to change the shelf height without unloading it. All the shelves in the unit have sealed edges for easy cleanup of spills. The door shelves are designed to handle large items like gallon jugs and two-liter bottles.

The Maytag MTB1956DEW is a top-mount model, with the freezer located above the refrigerator. The freezer section has shelving, a slide-out wire drawer, deep storage bins on the door, and an ice drawer. The freezer can be fitted with an automatic ice-maker kit (part number UKI1500AXX for the Maytag MTB1956DEW).

This reefer is super quiet during operation. The compressor/motor is fitted with an acoustic insulation package for sound deadening. An automatic moisture control keeps the refrigerator/freezer exterior free of frost and condensation. The freezer is equipped with auto-defrost, keeping its interior free of ice buildup. Both the refrigerator and freezer doors are reversible—they can be hinged from either side depending on the kitchen layout.

Warranty

The Maytag MTB1956DEW has a full one year warranty on parts and labor from the date of purchase. The warranty covers parts but not labor for the second year of service. The sealed refrigeration system and cabinet liner (excluding the door liner) are covered by a five year warranty.

Way Cool

We're super satisfied with the performance and value of Maytag's MTB1956DEW refrigerator/freezer. Virginia commented that she has never had a refrigerator that keeps her food so fresh for so long. This is a good indication of consistent interior operating temperatures.

Mainstream appliances undergo frequent upgrades and modifications. It's important to fully research new models and their specifications before you make your purchase. Check out the Web sites listed in the Access section of this article for sources of current energy efficient appliance information.

Things That Work! Criteria

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

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

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

Access

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joe.schwartz@homepower.com • www.homepower.com

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

Energy Star, U.S. EPA (6202J), 1200 Pennsylvania Ave. NW, Washington, DC 20004 • 888-782-7937
Fax: 202-775-6680 • energystar@optimuscorp.com
www.energystar.gov

American Council for an Energy-Efficient Economy, 1001 Connecticut Ave. NW Suite 801, Washington, DC 20036 • 202-429-0063 • Fax: 202-429-0193
www.aceee.org • Web list of energy-efficient appliances, and publisher of *Consumer Guide to Home Energy Savings,* now in its seventh edition, by Alex Wilson, Jennifer Thorne, and John Morrill

A Low-Cost Propane Generator Conversion

Herb Levitin

Herb Levitin's generator converted to propane, with the new tank in position.

I live in a canyon near Santa Barbara that suffers from power failures from winter winds. Since California deregulated their utilities, the time it takes for downed power lines to be repaired has increased. I recently installed a pair of Trace DR1524 inverter/chargers as an emergency backup system in my grid-connected home. The next logical step was to set up a low-cost propane generator.

Although there are a lot of inexpensive gasoline generators available, I wanted to have a propane generator because of the storage and safety issues with gasoline. The propane generators that I found were considerably more expensive than gasoline models.

Generator & Kit

I found a Web site with propane conversion kits for sale, and another with generators. I ordered a 5 KW generator with an 8 hp Tecumseh engine for US$420, and then ordered the conversion kit. Later it turned out that the generator was on backorder, so I found a more powerful generator at my local Costco store for US$399 and canceled my online order.

The generator I bought was a Generac 5 KW with 6.25 KW surge. It also has a Tecumseh engine, but a 10 hp model instead of 8 hp. The propane conversion kit that I purchased for the 8 hp engine was designed for this engine too.

The conversion kit recommended running the generator on gasoline for an hour to seat the piston rings for proper break-in of the engine. When I started it up to do this, I realized why it was so inexpensive. It was so loud that you could hear it throughout the entire neighborhood—the noise level was obscene.

Luckily I found another Web site that sold a Tecumseh "low tone" muffler for US$60. This made the noise level somewhat bearable. If you do a conversion with an engine like mine, I would highly recommend that you buy this quieter muffler.

Conversion

The propane conversion process took about three hours. It seemed a little complicated after reading the instructions, but the process was not difficult. It involved

Generator Conversion Parts

Item	Cost ($US)
Generac PP5000T generator, 5 KW	$399.95
Conversion kit for Tecumseh engine	159.00
Low tone muffler	59.95
Tank regulator kit PGK-6, with 6 foot hose	29.95
Propane tank	22.88
Total	$671.73

removing the carburetor, float bowl, and main jet. The main jet passage was drilled out, and the propane adapter was inserted into the carburetor. Several holes in the carburetor were sealed with the silicone sealant provided in the kit.

The conversion kit came with adapters for the round tube frame of the generator I originally ordered. I used a 3/4 inch PVC electrical elbow and drilled a 1/4 inch (6 mm) hole in it and the frame to mount the regulator. Ordering the kit for a square tube generator would have eliminated this extra step.

As the picture shows, I mounted the five gallon (19 l) propane tank on the shelf that held the gasoline tank. The shelf will also hold my 500 watt Honda gas generator, which is very quiet. I plan to run the Honda generator to charge the batteries at night if necessary.

The "low tone" muffler arrived and was installed, and I adjusted the idle adjustment on the regulator. I connected two 1,500 watt heaters to the generator as a test load and watched the generator run for 30 minutes. I'm guessing that a standard 5 gallon propane tank will run this generator for over eight hours at full load.

I have a 24 VDC, 510 AH battery bank, monitored by a Bogart Engineering TriMetric amp-hour meter. The battery bank is connected to two Trace DR1524 inverters with a stacking cable. The entire house can be powered by these inverters, except for the washer and dryer. I expect about a ten to twelve hour run time with the inverters, which will allow me to run the generator only during the day.

Reliable Backup

Since deregulation in California, power outages are getting longer. It seems that Southern California Edison has reduced its staff, and repair times are now based on the number of affected users, not how long the power has been out. Minor failures such as a downed line seem to take much longer to get repaired than before deregulation. We have already had several one-hour outages because of the stage three power emergency. We also have had several twelve hour failures over the last three years.

Conversion kit with Herb's custom mount.

My generator, with its propane conversion, will give me reliable backup power through these outages. Dovetailed with the inverters and battery bank, it should be able to keep my critical loads, such as my Takagi tankless water heater and hydronic house heating system operational. I would also like to install a PV grid-intertie system, before California's Buydown program (see *HP82,* page 48) runs out of funds.

Access

Herb Levitin, 1604 State Street, Santa Barbara, CA 93101 • 805-963-4864 • herb@powercom.com

U.S. Carburetion Inc., HC 79 Box 130, Canvas, WV 26662 • 800-553-5608 or 304-872-7098
Fax: 304-872-3359 • sales@uscarburetion.com
www.propane-generators.com • Propane conversion kit

M&D Mower, 32045 N. Roundhead Dr., Cleveland, OH 44139 • 440-914-1252 • Fax: 877-335-8999
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www.m-and-d.com • "Low tone" muffler

The Great Welding Cable Debate Continues

Drake Chamberlin

Welding cable has been used successfully for battery interconnects for decades. Many retailers of renewable energy equipment use welding cable for pre-made battery interconnects and inverter cables. It has not, however, been permitted in areas where the *National Electrical Code (NEC)* is enforced.

Many renewable energy (RE) workers consider welding cable the favorite material to use for connecting batteries and inverters. It is readily available and relatively inexpensive. It is extremely durable and flexible. It is also very resistant to being damaged by battery acid.

What the Critics Say About Welding Cable
In *Code Corner, HP82,* John Wiles stated that many cables do not have "any marks or labeling that ensure that they have been tested and evaluated for safety in any application." These cables are available from "auto parts stores, hardware stores, building supply stores, and welding shops." He also said that the Underwriters Laboratory mark needed to be on the cable. Without the UL symbol of approval, Mr. Wiles notes, the suitability of a cable cannot be determined.

John continues the argument by saying that without this marking, it cannot be known if the manufacturer cut costs in the construction of the cable. The cable's copper might have higher resistance. The sheath of the cable might crack or catch fire more easily. Additionally, a UL mark on a cable guarantees that the product has been thoroughly evaluated by a competent, national testing laboratory. Without a UL marking, the cable may or may not be adequate for any particular application.

UL-Approved Welding Cable
I recently did some research, and found that many brands of welding cable are indeed UL approved. According to the UL Web site, however, there will *not* be a UL mark on the sheath of the cable. The listing mark of Underwriters Laboratories is only to be found "on the attached tag, coil, reel, or smallest unit container in which the product is packaged."

Listed welding cable is in compliance with *NEC* Article 630, Part E, which deals with the secondary circuits of electric welders. It can be rated at 60 to 90°C (140 to 195°F), and 100 or 600 volts.

The listing mark on the tag that comes with these products includes the name or symbol of Underwriters Laboratories, together with the word "listed." It also contains a control number and the product name, "welding cable." The temperature and voltage ratings may be marked on the sheath, as well as on the tag. If they are not marked, the temperature rating is assumed to be 60°C, and the voltage rating 100 V.

When the cable has the higher voltage and temperature ratings, markings will appear on the sheaths. The markings of 600 volts and 90°C will be printed on the insulation. The UL listing mark, however, will not appear. UL-listed welding cable comes in sizes from #8 AWG to 250 kcmil (8 to 127 mm^2), in flexible stranded copper. The individual strands are #34 to 30 AWG (0.02 to 0.05 mm^2).

John Wiles says that cable that does not bear the UL marking cannot be verified to be a tested, safe, and durable cable. Welding cable, however, does not have a UL stamp on its sheath, even when it is listed. Information about UL-listed welding cable can be obtained from the UL Web site. Specific information can be obtained from the manufacturers, whose addresses are provided on the site.

The Acid Test

My article in *HP80* (page 84) documented the effects of battery acid on some welding cable insulation, and certain other types of cable insulation. The welding cable we tested was unharmed. The 1996 *NEC* required battery cables to be acid resistant, and to be chosen from Article 400. This created a contradiction, since there were no cables listed as acid resistant in Article 400. The 1999 *NEC* no longer requires cables to be acid resistant. Theoretically, this is because plastic and rubber conductors are considered to be inherently acid resistant.

A welder throws robust welding cables down from a tower job.

In the RE Lab's "acid test" of various cables, type THHN/THWN cable showed a tendency to dissolve in battery acid. Section 310-13 of the NEC lists this cable as "heat resistant thermoplastic." Yet it slowly melts in battery acid. It appears that acid resistance might still be a reasonable requirement for battery cables. UL-listed "Super ExCelene®" welding cable is rated for acid resistance.

Welding Cable for Batteries & Inverters

Welding cable has traditionally been a favorite material to make battery interconnects. In early systems, welding cable was routinely used to connect battery banks to inverters. Welding cable was often run from battery boxes to inverters without conduit. Although not code compliant, this practice is still common today.

This seemed appropriate, since welding cable is exposed to physical contact when used with arc welders. The cable is energized with similar voltages in RE systems as in welding operations. The electrical potential in both applications is usually DC.

Welding cable is very robust. It may be in frequent contact with molten metal. It is exposed to a wide variety of mechanical impacts. It can lie on shop floors with scraps and shavings of metal, where it can be run over by forklifts and automobiles.

Welding cable is safe to use. Arc welders are used in the construction of metal frame buildings. A truck-mounted welder may be several stories below the location where the arc is struck with the welding rods. Welding cable carries the current from the welding machine to the point of use. Welders and other workers standing on conductive metal framing may be exposed to the cable. Similar situations exist for welding operations on metal towers.

Welding cable is used for applications that are much more abusive and potentially dangerous than renewable energy installations. At least some varieties have been demonstrated to be acid resistant. Welding cable is certainly an adequate product for use with batteries and inverters.

Permitted Cable

Battery interconnections are required to be made with flexible cables as identified in Article 400 of the *NEC* Welding cable is not listed in Article 400. Interestingly enough, some cables that we are permitted to use, such as finely stranded USE-RHH-RHW Hypalon diesel locomotive cable, are not identified in Article 400 either. Since both types of cable are UL listed, and neither are identified in Article 400, there seems to be little logic in allowing one while forbidding the other.

Many suppliers sell battery interconnects made from welding cable. RE systems are still being rejected by local inspectors because welding cable is used. The acceptance or rejection of a system is ultimately based on the code interpretation of the particular inspector. If a system is rejected because of the use of UL-listed welding cable, certification and specifications of the cable can be obtained from the manufacturer. The inspector may accept the cable based on this information. It would be helpful if wrenches would contact Mr. Wiles with their concerns about the welding cable ban.

This investigation into welding cable has been conducted as an activity of the Renewable Energy Lab, as described in *HP80,* page 84. Chris Sinton of Alfred University is actively seeking funding under the name "Renewable Power Installers Advocacy Program."

Access

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See Web site for listing of RE Lab membership.

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UL Web site: www.ul.com/database

To find listed welding cable, search by the keyword "welding cable." For info on UL listing tags click on "ZMAY.GuideInfo."

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They Do It On Renewable Energy!

REmarkable, Unusual, & Inspiring Uses of Renewable Energy Technologies

Solar-Powered Glass Armonica

William Wilde Zeitler

Ben Franklin (1706–1790) was considered one of the world's foremost experts on electricity in his day, and is known for many inventions. What isn't as well known is that Franklin's favorite invention was a musical instrument.

He called it the "glass armonica" after the Italian word for "harmony." It works on the wet finger around the wine glass principle. Franklin's idea was to nest a set of wine glasses inside of each other, one for each note, all mounted on a rotating spindle. Then you could play it with wet fingers, almost like a piano.

Otherworldly Sound

The instrument became very popular in the late 18th century—even Mozart and Beethoven wrote music for it. But around 1810, they decided that its otherworldly sound would wake up the ghosts, so it was banned. It's been on the Endangered Musical Instrument List ever since. For sound and video samples, and much more history, see my Web site.

I've been a musician since I was five, I'm a classically trained pianist, and I have a degree from the California Institute of the Arts in harpsichord. One day I tripped over a CD of "music by Mozart for the glass armonica." Having no idea what a glass armonica was, I took it home, and that was it. I had to play this! I found that Finkenbeiner Inc. was blowing the glasses again, and off I went. I know of only a dozen performers in the world. I do about 75 performances a year, and have three CDs, with number four due out this summer.

Not an Energy Hog

Franklin made his spindle rotate with a foot treadle. The main reason I opted for a motor instead of a foot treadle is that I can play much better standing than sitting. The 1/28 horsepower motor that turns the spindle draws a whopping 16 watts (measured at the wall). But when I play outdoors at weddings or festivals, I often don't have access to an AC outlet.

The instrument is already set up to use 110 VAC, so the simplest thing to do was to get an inverter and a deep-cycle battery. The smallest inverter I could find at the local RV supply was 75 watts. With the smallest battery available at Costco (90 amp-hours), I've run continuously for two to three days without a recharge (we also run a cash register with the same battery/inverter setup).

William Zeitler plays a solar sonata.

Mobile Solar Music

But I was concerned that I wouldn't have enough juice to make it through longer festivals, so I got a solar-electric (PV) panel to add to the system. The panel is a Solarex MSX-30 Lite, rated at 30 watts. It's a tough, bendable panel, which is perfect for taking on the road. At 24.4 by 19.6 by 0.6 inches (62 x 50 x 1.5 cm), it's still easy to find space for it in the truck (along with everything else one needs for a festival).

The solar panel is only connected when the battery is under load, so I don't have to worry about overcharging the battery. I hook the solar panel up to the battery in parallel with the load, with no charge controller. I wired a diode in series with the solar panel to prevent discharge through the PV when the sun goes behind a cloud.

I suppose I could get a larger battery, or find another way to run my instrument. But there's just something right about a *solar-powered* glass armonica. I think Ben Franklin would approve!

Access

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Do you have an uncommon application of renewable energy in action? We'd like to share it with Home Power *readers. Send your submissions to ian.woofenden@homepower.com*

Clearing the Smoke

Electric Vehicle Myths

Shari Prange

The relative handful of electric vehicles (EVs) on the roads today are surrounded by a cloud of smog produced by the vast majority of cars, which still burn petroleum products for fuel. But the EVs are obscured by another kind of cloud as well. It is a cloud of myths and misinformation that permeates the public consciousness.

Some of this has been deliberately spread by, shall we say, dark anti-EV forces. But most of it is simply the result of honest but faulty assumptions. Some of the misconceptions make EVs look bad, and some make them look too good. Let's examine the most common myths and misconceptions about EVs, and compare them to the real facts.

Myth #1: An EV's Range is Too Short

When asked how long a man's legs should be, Abraham Lincoln replied, "Long enough to reach the ground." How long is a long enough range for an EV? That depends on what you need to do with it.

Ninety percent of the cars in the United States travel fewer than 25 miles (40 km) a day. A typical home-built electric conversion can get 50 miles (80 km) or more on a charge. Some can get quite a bit more. Even a very modest, low-performance conversion will get 20 to 25 miles (32 to 40 km).

Range is a function of vehicle weight and aerodynamics, battery pack size, road conditions and terrain, traffic flow, and driving style. You need to examine your real-life driving patterns, and then see whether one type of EV or another has long enough "legs" to do the job for you.

"Well, sure, most of the time I just drive to work and back. But what about when I want to go on vacation?" Again, statistics show that most households have more than one vehicle. Does yours? Many people have a small economical car for daily local use, and a bigger vehicle for long trips. The small one could be electric.

An electric car is like a microwave oven. It can't replace all the functions of a conventional oven. But there are some things that it does much better than the traditional oven, and it does some things the old oven can't do at all. Despite its "limitations," most households have one, and use it a lot.

Myth #2: EVs Are Slow

When people think of EVs, they think of golf carts, or some tiny, funny-looking little thing that their eccentric old neighbor drove in the 1970s. They think 25 or 35 mph (40 or 55 kph) is the best it can do.

This is absolutely not true. Even a very basic conversion can do 55 to 65 mph (88 to 104 kph), and some can do more than 90 mph (145 kph). These are normal street cars, not tricked-out race cars. Like range, speed will be related to the vehicle weight and shape, battery pack size, and terrain.

"Yeah, but how long does it take to get up to that speed?" To paraphrase an old racing saying, "Speed costs amps. How fast do you want to go?" Depending on how the car is designed, it can come close to, or even exceed acceleration for a normal gas car. Acceleration is determined by vehicle weight and battery pack size, as well as battery type and controller type.

Do you simply want to be able to merge safely onto the freeway? Or do you have some unresolved emotional issues that require leaving smoking patches of rubber at the stoplight? There is a very active organization of electric drag racers who will be delighted to demonstrate this for you. The choice is yours.

Myth #3: If I Run Out of Juice, I'm Stuck

First of all, your car will (or, at least, it *should)* have some kind of gauge to let you know how much charge you have left. This may be a voltmeter, a watt-hour meter, or just a plain old state-of-charge gauge that reads from "Full" to "Empty," just like a gas gauge. This does not have to be rocket science.

Second, you need to know that an EV does not just stop dead like a gas car does when it runs out of gas. As you get very low on charge, you will notice a slight sluggishness, especially on hills. This will gradually increase over the course of several miles. If you have miscalculated badly enough, you will eventually need to pull over to the side of the road.

Unlike the driver of a gas car out of juice, however, you do not need to get out your cell phone and call AAA, or start hitchhiking. Instead, you simply let the car rest for a few minutes. You can watch the needle of your state-of-charge gauge rise as the batteries recover a portion of their charge. You can now drive a little farther. If necessary, you can repeat this process several times to get home, although it's not recommended to make a habit of it.

Myth #4: EVs Just Move the Pollution Source

This is a very prevalent myth. People will give you that "Gotcha!" knowing smirk and say, "Of course, EVs just transfer the pollution from the tailpipe to the power plant." Again—not true. This particular myth has multiple fallacies in it, so let's take it apart piece by piece.

Let's say you have a gas car and an electric car sitting side by side at the stoplight. The electric car is cleaner than the gas car, even if you include the pollution from the power plant—even if it's a nasty coal burning plant. That's because it's much easier to control pollution from one large stationary smokestack (where it's possible to install giant scrubbing equipment) than it is to control a million tiny mobile tailpipes. Power plants are constantly monitored and get regular maintenance. Far too many cars are only checked every year or two when the law requires it, and only get maintenance or repairs when something makes noise or falls off.

But is it really fair to compare power plant emissions for the EV to tailpipe emissions for the gas car? What about pollution caused by the oil refinery, and the tanker ships and trucks? (This is the part where the smirk melts into sheepish realization.) In a full (oil) well-to-wheel comparison, the EV comes out even further ahead.

Myth #5: Electric Power Is Less Efficient

A similar myth is that EVs are less efficient in their use of energy, because there are substantial losses in the power transmission lines. Well, yes, there are. But there are even greater losses in the running of an internal combustion engine. A gas engine needs a radiator to carry off the excess heat; otherwise the engine will destroy itself. All that heat represents wasted energy.

Again, if you look at a full well-to-wheel comparison, almost 50 percent more energy makes it to the wheels of the EV than to the wheels of the gas car.

Myths #6-#8: In An Accident, An EV Will...

People are afraid of things that are unusual, or that they don't understand. EVs fit both criteria. People are afraid that, in an accident, an EV will explode, or electrocute them, or melt them like the Wicked Witch of the West in a pool of battery acid. In fact, some people are afraid to drive them in the rain, or to wash them, for fear of getting electrocuted.

When gas cars first came out, there were similar sentiments. Where we live in Santa Cruz, there is an early American dairy ranch that has been restored and opened as a historical park. The tour guide explains that the garage is situated *way* over there because the lady of the house was skeptical of this new-fangled automobile. She wanted it kept far from the house so that if it blew up in the middle of the night, it wouldn't burn the house down.

Sound silly? Well, maybe a little. But do you realize that a single gallon of gasoline has the explosive power of twenty-two sticks of dynamite? Yet people routinely strap their infants into these contraptions and drive around at high speeds with a tank full of ten or twenty gallons of this stuff, often mere inches away from all those scalding hot engine and exhaust parts.

My point here is not to slam gas cars, but to point out a common perceptual error. We tend to exaggerate the

In a full "well-to-wheel" comparison, EVs are more efficient and less polluting than internal combustion cars.

dangers of something new and strange. At the same time, we conveniently forget that familiar items we use without a second thought every day have comparable dangers. If we are going to compare technologies fairly, we have to try to look at them both from a similar perspective. So let's look at these fears one at a time.

Electrocute Me

To get a shock, you have to come into contact with an electrical circuit. A normal car uses the metal chassis as the ground portion of the electrical circuit. An electric car's battery pack does not. It is a "floating," or isolated system. In fact, various components on the car have built-in ground fault detectors, so that they will not operate if there is battery pack current passing through the chassis, even in milliamps. The only place to contact the circuit is directly at the batteries or components under the hood, or at the cable ends.

These cables do not normally enter the passenger compartment, or if they do, it is only minimally to accommodate a circuit breaker. If your car is damaged badly enough to have bare cables somehow protruding into the cabin, the circuit is probably destroyed in numerous places, and you've got much bigger problems to worry about.

And remember that circuit breaker we just mentioned? That's one safety device that will trip automatically under high current, or can be flipped manually to break the circuit. There should also be fusible links, which will blow automatically in case of a short, and break the circuit. Car washes, rain, and normal road splash are not hazards, and will not cause you to get shocked.

Explode

In the movies, all cars in accidents explode. In real life, it seldom happens. There is nothing inherently explosive about an electric car in normal use. The one danger comes from hydrogen gas, which is given off by the batteries under severe abuse or during charging. Hydrogen is lighter than air, and if the battery area is properly ventilated, it will quickly rise and dissipate. A pretty strong concentration of hydrogen is needed before it reaches explosive levels.

The most common situation for a battery explosion is not in an EV at all, but in an old VW Beetle. The battery compartment was out of sight and completely enclosed—a perfect recipe for neglected maintenance and an accumulation of gas. It was also located right under the rear seat. You lean into the back seat to retrieve a package, put your knee on the seat, the springs contact the battery posts and make a short circuit, and ka-pow!

This resulted from poor design, not from inherent danger in using batteries. Sensible EV design overcomes the risks, and eliminates the chance of explosions.

Burn Me With Acid

The acid in a battery is not like the stuff in the movie "Alien" that instantly ate through everything in its path. In fact, it is not uncommon for people working on their cars to splash themselves with battery acid and not even notice. They don't realize it until the next time they launder their blue jeans, and the weakened cotton fibers melt away, leaving a series of holes. The jeans have holes in them, but not the person.

If you know you've been in contact with battery acid, of course it's a good idea to wash it off as soon as possible, but you might not even feel it. It takes some time before it starts to irritate the skin. In fact, gasoline splashed on your skin and not washed off can lead to some pretty nasty skin irritation.

In gas cars, the battery is often in the left front corner of the car—the place most likely to be contacted in a collision—and minimally secured. Yet we have spoken to numerous firefighters, paramedics, and tow truck drivers who are intimately involved with accidents on a daily basis. Battery acid spills are not a significant hazard at accident scenes.

Sure, an EV has a lot more acid on board. But it is carried in lots of small cells. You would have to break a lot of cells open to get any significant amount of acid spilled.

We had a graphic demonstration of this about eight years ago. Our electric kit car is a fiberglass body on a VW chassis. In other words, a little more protection than tissue paper. It was hit by an older American Buick that nailed it dead on the battery pack, right behind the driver. The impact pushed the EV sideways across an intersection, over the curb, and into a signpost.

No one was hurt. The Buick scraped its bumper a little. The kit car body was shattered. Three wheels were bent. One battery box cracked because the frame rail supporting it broke and dropped the box on the ground. Another box split at the seams. Not a drop of acid was spilled.

In another accident, an electric Rabbit belonging to a customer was hit by a Suzuki, right in the middle of the VW grill. The impact was also right in the middle of the front batteries, which were resting in racks only, not enclosed in boxes. The Rabbit lost the acid from one cell of one battery. The Suzuki, on the other hand, split its oil pan and dropped all its oil on the road.

There's actually a safety advantage to all those batteries. In the early days of crash testing gas cars, testing was sometimes done with the batteries drained, because people were concerned about acid spills. Then it was noticed that the cars with full batteries did better in the crash tests. The liquid absorbs some of the impact, just like those water-filled barrels along the highways. If the liquid in a single battery made a noticeable difference in a gas car crash, think about the impact absorption of six or eight batteries under the hood.

In fact, there have been a few instances of racing EVs crashing straight into a cement wall at highway speeds. There have been no explosions, fires, electrocutions, acid burns, or even injuries to the drivers.

Myth #8: Dead Batteries Will Pollute Landfills

When you buy a new battery for your car, the seller will want the old "core" in return, and will charge you a fee if you don't turn it in. For a whole pack of EV batteries, this can really add up, so it makes sense to turn the cores in. They are then deconstructed, and the components are recycled into new batteries. In fact, lead-acid batteries are one of the most highly recycled items in the country, with a rate of 99 percent.

Magic Carpet Myths

Here's where the myths turn in the opposite direction. Instead of making EVs into monsters, these myths try to turn them into magic carpets. Unfortunately, there is no such thing as a free lunch, or perpetual motion. People think they can get free energy and unlimited range if they only attach the right device to an EV. So let's look at a few of these pipe dreams.

Myth #9: Solar Panel

Probably the most popular of these is the solar-panel-on-the-roof. However, PV efficiencies are so low that even with a PV-covered roof, the average EV sitting in full sun all day long would only gain about 5 miles (8 km) worth of electricity. Now, if you drive less than five miles a day and you live in Arizona, or if you drive 15 miles (24 km), but you only do it twice a week, this might work for you. For most people, it would not be enough to justify the cost of the panels. Solar charging is generally only practical from a large stationary array.

Myth #10: Generator

The other top contender is the Honda-generator-in-the-back-seat. Briefly, generators are noisy, they vibrate, and they re-introduce the fuel and maintenance issues of internal combustion vehicles. They also can produce as much pollution as thirty gas cars.

For all of that, they will probably only produce enough energy to get you an extra ten miles (16 km) of range. An EV, simply cruising, will draw 20 KW of power. That's DC power. Most generators are rated for AC output. Converting that to DC reduces it considerably. The math just is not favorable.

Myth #11: Windmill

Then there's the ever-popular windmill-on-the-roof. Or on the axle—doesn't matter where. A similar scheme is the alternator hooked to the axle or motor shaft. The problem for both of these is the same. The energy they capture is not really "free." It has to come from somewhere, and where it comes from is the car's momentum. In other words, the harder you try to turn a windmill or an alternator to charge the batteries, the more you slow down the car.

If you've ever ridden a bicycle with a generator headlight, you know how much harder it is to pedal with the drag of the generator on. If you want to try a wind experiment, mount a small fan on top of your bicycle helmet and go for a ride. See what the wind resistance does to your energy level and speed. Not to mention what the sight does to your reputation in the neighborhood.

Just the Facts

When the smoke finally clears, you can see that EVs are not a magic free ride, but neither are they the crippled, dangerous frauds that they are often portrayed to be. Most misinformation is a result of starting from assumptions instead of checking actual numbers, or not making apples-to-apples comparisons.

An electric vehicle does one kind of driving particularly well. This happens to be the same kind of driving that most cars spend most of their time doing. When they are fitted to the proper use, EVs are very reliable, practical, and clean. Once you get past the myths and misconceptions, it's as clear as day.

Access

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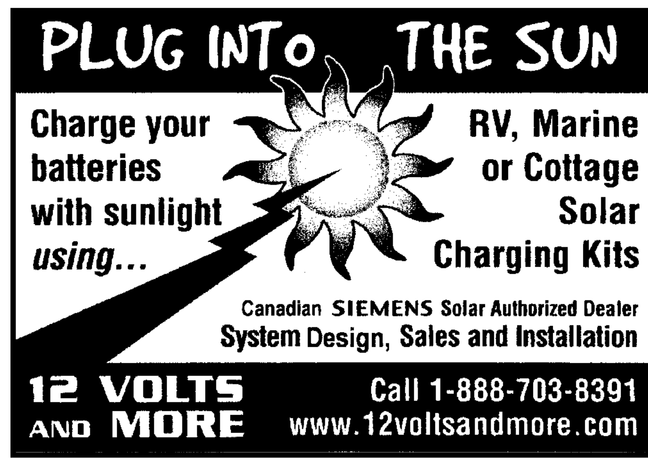

EV Tech Talk

Why Convert A Gas Car To Electric?

Mike Brown

"I have an older compact car that just failed its smog test. What are the benefits of converting it to electric power instead of just scrapping it?"

A gentleman at an electric vehicle show asked me this question last weekend. It's one I get asked often, so I thought it would be a good question to answer in detail for *Home Power* readers as well.

The gentleman had owned the car—a 1989 Ford Escort—since it was new, and he liked it. The car's body and interior were in good shape, and it was in good mechanical condition. The car weighed less than 2,800 pounds (1,270 kg; which we consider to be the maximum a car or truck can weigh and make a successful conversion). It also had a manual transmission, which is essential. In addition to these things, we knew that the car was popular for conversions because we had sold a lot of motor-to-transmission adaptors for it.

So given that the car would make a good conversion, what are the benefits of converting it? Let's look at the benefits to the environment first.

Cleaner Air

There are many reasons that converting a gas car to electric makes environmental sense. An EV is cleaner than a gas car, even if you include emissions from the power plants. Of course, some of the cleanest power comes from hydro plants. EVs charged from hydropower produce 98 to 99.9 percent less greenhouse gases, and 99.9 percent less of all the non-greenhouse gases combined.

On the other end of the spectrum, the dirtiest power is from coal. EVs charged from coal plants produce 55 to 59 percent less greenhouse gases, and 80 to 92 percent less non-greenhouses gases than a gas car. Natural gas electricity falls in between these two extremes.

EVs are also cleaner over time. The power companies are required by law to continuously upgrade their plants to meet tighter emission standards. This means that the longer an EV is driven, the cleaner it gets. In contrast, as a gas car ages, its mechanical condition deteriorates and its emissions go up.

Also, most gas cars are driven 25 miles (40 km) or less in a day, and spend most of their time idling and in stop-and-go traffic (which means they are not fully warmed up). Their emissions are the highest in these conditions. In contrast, the EV sitting at the stoplight is not producing any emissions at all. Instead of idling, the electric drive system simply turns off.

Cleaner Water & Earth

An EV reduces other types of pollution as well. Most cars drip a little oil, coolant, and other fluids as they go down the road. These things create the dark stains on the parking lots and the black stripe down the center of the roads. When it rains, these fluids are washed into the storm drains and from there into the nearest river, lake, ocean, or into the ground, and then into the water supply.

In addition to being cleaner in use, the EV is also cleaner to maintain. A gas car needs regular engine and drive train maintenance, which produces hazardous wastes in the form of used oil and oil filters. When the coolant is replaced, the old coolant must be treated as a hazardous waste if it cannot be recycled. Things like fuel filters, air filters, spark plugs, and other tune-up parts are not recyclable, so they end up in a landfill. An EV doesn't use any of these items, so there are no old contaminated parts to create disposal problems.

In fact, the only things that are periodically replaced on an EV are the batteries. This usually happens after three or four years of use. Even then, there is very little non-recyclable waste involved, since the batteries are 99 percent recyclable. This is not only good for the environment, but also for the pocketbook. If new lead were used to make batteries instead of the recycled lead, batteries would cost much more than they do now.

EVs help reduce the waste stream in even more subtle ways. When a gas car is sent to a wrecking yard, it is stripped of its usable parts for resale, and all the recyclable materials are reclaimed. But 30 percent of the car—the glass, rubber, upholstery, and most of the plastic—ends up in the landfill. In addition, when the new cars that replace the scrapped ones are manufactured, several tons of waste are generated in the manufacturing process. Doesn't it make more sense to recycle a whole car that is in good shape except for its tired or dead engine?

Save Energy

There are several energy-saving reasons that make converting a gas car to electric power a practical idea.

The efficiency of an electric drive system is the first. Let's follow the energy trail from when the energy source is removed from the ground—coal mined, oil pumped etc.—to when the wheels turn and the car moves down the road.

If the car is gas powered, 11 percent of the energy that came from the ground remains to turn the wheels. If the car is an EV, 17 percent is left to propel the car. These U.S. Department of Energy figures take into account all the energy used to produce the fuel and transport it to the car, in the case of a gas car. In the case of an EV, the transmission losses incurred in sending the electricity from the power plant to your charger outlet are included.

This energy saving is true of all EVs, either factory built or conversions. Recycling a used gas car by converting it to electric power instead of replacing it with a new car brings its own unique energy savings. Take all the various types of energy used in the manufacture of a new 2,500 pound (1,130 kg) car and convert them to a common form of measurement (the British thermal unit, or BTU) and total them up. It works out to about 120.7 million BTUs.

Next, use the number of BTUs in a gallon of gas (125,000) to calculate the number of gallons of gas (965) the total manufacturing energy represents. Divide the 965 gallons of gas by the 506 gallons a year the average driver uses.

You'll find that the 2,500 pound car can be driven for almost two (1.91) years on the energy that it took to build it. This is a very real reason to recycle a gas car by converting it to electric power instead of replacing it. Another smaller but satisfying energy savings comes when the EV is stopped in traffic. The only energy it is using is the amount it takes to use the accessories that you have on.

Save Money

While there are many good environmental reasons to convert, there are equally good economic reasons. First, if you already own the donor car, you don't have to pay for 70 percent of your "new" EV. Even if you have to buy a car or truck to convert, it's still cheaper. If you buy a vehicle with a dead or tired engine, the cost should be lower than it would be if you were buying a car that you needed to get several years of reliable service out of.

Even if you have to pay more for your donor car because the engine is in good shape, you can sell the engine and some of the other parts. Selling these parts takes some time and effort, but can put some money back into the EV project. Selling the leftover parts also contributes to the recycling benefit of converting.

Once you have converted the car, the real savings begin. Gone are the periodic oil changes and the expensive tune-ups and maintenance services. The inevitable muffler replacement has vanished along with the rest of the exhaust system. Cooling system failures, which usually occur in the worst place at the most inappropriate time, are a thing of the past. The expensive carburetor replacement, or the fuel injection problem that has the technician scratching his head and saying things like "I've never seen a problem like this before," cease to exist when the fuel becomes electricity.

The complexity of the new cars is putting their service and repair more and more into the hands of dealerships instead of independent repair shops. Even with longer warranty periods and extended service intervals, servicing a car is getting more expensive.

The service and maintenance of a conversion EV requires a specialist who is very familiar with the EV. The ideal service specialist is you—the person who did the conversion. Since you wrote the documentation as you did the conversion, you are the person best qualified to repair and service your EV.

Don't expect to put in too much time, though. The simplicity of an EV drive system and the reliability of the components will limit your service tasks to checking the batteries for water level and cleanliness, and keeping the tires at the right pressure. The front brake pads or shoes should be checked frequently at first, until you get a feel for the effect of the additional battery weight on their wear rate.

The only other parts of the car that require attention are the wheel bearings, drive axles, suspension parts like ball joints, and steering parts like tie rod ends. These parts are usually checked and replaced at the time the conversion is done, and have long service lives. Their maintenance and repair could be left to a professional mechanic if you desire.

The service that is best left to a professional is wheel alignment. This is because of the need for very specialized and expensive equipment. Correct wheel alignment is a factor in the car's rolling resistance, which influences range. Your new EV conversion should have its alignment set as soon as it is finished. This will correct any errors introduced by the suspension modifications made to compensate for the additional weight involved in the conversion. The alignment should be rechecked in about three months, after things have settled in during driving.

Save Time & Worry

Some savings are not as tangible as drastically reduced maintenance costs, or never again getting only coins back in change from a $20 bill after filling your gas tank. By the way, most EV drivers report not being able to detect an increase in their electric bill when they start driving an EV on a regular basis. The amount of electricity the car uses is such a small fraction of the overall household use—it disappears in normal fluctuations. This may change somewhat because of rate hikes brought on by the so-called energy crisis. However, with gasoline prices also rising, operating costs will still be less for an EV.

An EV saves you time. You don't have to take time to find a gas station and fill the gas car's tank. You don't have to make an appointment to take the car in for service as often. This involves arranging to be picked up at the repair shop and taken back at the end of the day to get the car back.

An EV also lowers stress produced by wondering whether your faithful daily-driver and grocery-getter will pass its smog test, since EVs are exempt from testing.

Why Convert Instead of Buying New?

We have shown that EVs help the environment, aid in energy conservation, and have economic advantages. The question still remains, why convert? Why not just buy an EV from a major manufacturer? They all have them—you've seen them in all the magazines.

General Motors' EV1 is the only one of the remaining factory EVs available for lease to the general public, at a rate of from US$350 to US$500 per month depending on battery type. Honda leased their EV+ to private citizens initially, but quit after leasing 300 of them. The other manufacturers only lease their EVs to fleets.

This indicates reluctance on the part of the world's major automakers to put EVs into the hands of the general public. In fact, John Wallace, the executive director of Ford's TH!NK group, which oversees electric and alternative vehicles, said, "God doesn't want us to have full-function electric vehicles. The laws of nature don't allow this." This kind of attitude is prevalent in the rest of the auto industry.

There are two strategies the major manufacturers are using to keep from producing a low-cost, practical EV. The first is the introduction of the high mileage, low emission electrically assisted gas cars that they are calling hybrids (see *HP82* and *HP83* for an explanation of these cars). The second EV avoidance strategy is the promise of fuel cell cars.

Automakers are making a big show of their research on fuel cells to provide the electricity for EVs instead of those limited-range batteries. However, there is much work to be done before there is a fuel cell powered car in the average person's driveway. In the meantime, there is little research being done on batteries, and no freeway-capable pure EVs are being built.

We have talked about the environmental and economic reasons to convert, and in doing so have come to the third reason to convert a car to electric power. That reason is that doing a conversion is the only way an average person can get his hands on an affordable EV.

"How do I . . .?" Ask Me!

This column turned out to be a long answer to a short question, and it's the same answer I gave to the man who asked the question at the show. I don't know yet what he will do with his car, but I hope I gave him some things to think about. Please send me some more technical questions, and get me off the soapbox and back into the shop!

Access

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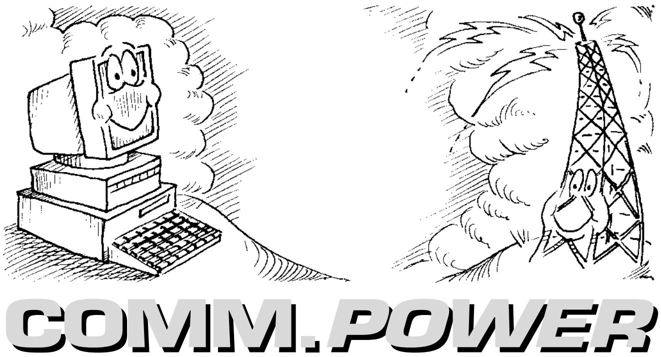

StarBand Broad Band Internet Service

Todd King

Getting an internet connection in an urban area is mostly a decision-making process. You can choose from phone line internet providers, digital subscriber links (DSL), T-lines, and cable-based systems. For a rural homestead, the choices narrow, and until now, all but disappear for the very remote home. But a new system exists for anyone in North America, whether you live in town or not. It's called StarBand.

The StarBand system is a high speed satellite Internet product that allows you to access the Internet from a personal computer with no traditional modem or phone connection. This system allows up to 500 kilobits per second (kbps) download and 150 kbps upload, directly through coaxial cable and a satellite dish. Depending on the time of day, speeds may even exceed these values. More users impact the server and slow it down, but I have never seen my system go below 400 kbps.

StarBand generally markets the download speed as ten times faster than the fastest dial-up service. I have seen the speed at fifty to sixty times faster than phone-based connections. StarBand allows real-time audio, video, and data through a broad-band, high speed, two-way Internet connection that's always on and has no dial-up. There are no Internet providers involved other than StarBand.

Product Info

The system consists of a 24 by 36 inch (60 x 90 cm) satellite dish, usually mounted on a pole (2 inch schedule 40) at least 5 feet (1.5 m) above ground level. Two coaxial lines, one for sending and one for receiving, run from the dish to a satellite "modem." (It's not technically a modem, but that's what StarBand calls it, since it has the same function.) The modem plugs into a USB port on the back of your existing computer. Most computers manufactured within the last year will have a USB port.

Computer Requirements

This two-way Internet access system requires a fairly powerful computer. But most people have a minimum system already, or could easily upgrade with aftermarket products readily available from a number of

The author's StarBand dish—his first intstallation.

different suppliers. Basically, the minimum computer capabilities are:

- Pentium class CPU
- 32 MB of RAM
- 10 MB of free hard drive space
- CD-ROM drive
- USB port
- Windows 98, Windows98se, Windows 2000, or Windows Me. (Sorry MacHeads, the StarBand system is not yet Mac OS compatible. So far, networking Macs to the Windows StarBand machine is the only choice.)

If your existing computer meets these minimum requirements, you can hook the StarBand system directly to your USB port. If your system doesn't have a free USB port, you will need to add a USB expansion card or hub.

Installation

StarBand installation requires an authorized installer. I was one of the installers chosen for a six-month beta test of their prototype. It arrived in several boxes via UPS ground. The manuals were very clear and easy to read. The process for installing was straightforward, with only a few terms that I did not understand without the manual's explanations.

The dish comes with wall mounting hardware. If it is installed on a pole, the pole must be 5 feet (1.5 m) high, with another 3 feet (0.9 m) in the ground in concrete. The hole should be about 8 to 12 inches (20 to 30 cm) in diameter. I used an 8 foot (2.4 m), 2 inch schedule 40 pole that was purchased locally. I set the pole in concrete and verified that the pole was plumb (vertical). This is extremely important! The satellite is approximately 22,000 miles (35,000 km) above earth, and one degree of misalignment on earth equals miles of error at the satellite.

I let the concrete cure for two days. While I was waiting for the concrete, I assembled the satellite dish with the enclosed instructions. The system comes with the hardware and wrenches required for assembly.

I referred to the charts provided to establish the elevation, skew and azimuth angles for my latitude and longitude. I set the elevation and skew before I put the dish on the pole. Elevation is the angle up and down. Skew has to do with the angle needed when the dish is rotated. The azimuth is the angle side to side. When the concrete had cured, I set the dish on the pole and slid it all the way down to the seat, a tab that keeps the dish collar from sliding too far down.

I ran two RG-6 coaxial cables from the satellite modem to the dish, and crimped on standard coaxial

StarBand—A User's Testimonial

Richard Perez

The Way It Was

Over the last fourteen years, we have had seven different radiotelephone systems spanning the 6 mile (10 km) distance between our editorial office and the nearest telephone line. We've never been able to get any modem to move faster than 7,200 bits per second (bps) on a radiotelephone system. Most of the time, our modem speed varied between 2,400 bps and 4,800 bps. The scene during deadlines was ugly—six stressed-out nerds fighting over a single slow data connection.

The Way It Is

We now have a blazing fast Internet connection, with download speeds averaging around 500 kbps and upload speeds about half that. This is over one hundred times faster than our fastest radiotelephone connection, and about ten times faster than a modem-based hard line telephone connection.

And best of all, we have had up to eight computers using the single StarBand "modem" at the same time, with no noticeable slowdowns. No more fighting over the data communications line—everyone can do email and surf the Web at the same time. The speed increase has made telecommuting blossom for us. No longer do I have to let my computer run all night just to download a 4 MB file from one of *Home Power's* advertisers or authors. Now that file arrives in a matter of a few minutes at most.

Computer Details

We are a Macintosh office. StarBand is currently available only for PCs running Windows. We solved this problem by installing a PC and making it both an Internet proxy server for the StarBand system, and a file server for all the Macs. My rationale for using this PC as a file server is that since it's a PC, no one in this office will want to use it as a stand-alone computer—we are mostly Mac jockeys.

The PC is connected to the StarBand SB180 "modem." We use WinProxy software as an Internet proxy server and it services both PCs and Macs. We use PCMacLan software to emulate AppleTalk, which enables our Macs to use the hard drives on the PC just as if they were Mac drives on a network.

All the various computers communicate via an Ethernet local area network (LAN). Most of the machines are operating at 100 base T speeds. This means we can move about 1 MB per second over our LAN. So all the Macs are talking to the PC proxy server at high speeds, and they all have very fast Internet connections via the StarBand system. Pretty slick, and it works great!

connectors at each end. I applied heat shrink tubing to the crimped connections to make sure these connections stay watertight. I ran a #6 (13 mm^2) bare, solid copper ground wire from the dish framework, the LNB (low noise block converter), and the coaxial ground block to a dedicated 8 foot (2.4 m) ground rod.

With the elevation and skew already set, all I had to do was find the azimuth. Most installers will use a spectrum analyzer to arrive at the best azimuth for your area. This is an expensive meter that measures the strength of the signal received by a satellite dish. But I live in a remote little town, and the closest spectrum analyzer was about 100 miles (160 km) away. Fortunately, there is a computer-based signal strength meter provided to StarBand installers. It is used to set the dish at the best azimuth.

With the signal strength meter on my computer screen, I approximated the degrees azimuth out at the dish and just kept turning it back and forth until I got the highest reading. For my installation, I was able to get a signal strength of 83 percent. I did hit 84 percent once, but was never able to get it back again.

A signal strength of 70 percent or better is needed for reception. Most installers achieve reception strength somewhere between 75 and 85 percent. There are too many factors involved to get 100 percent—dust, clouds, solar flares, trees, buildings, pollution, etc. After I'd tuned to the best signal I could get without a spectrum analyzer, I tightened all the nuts and bolts to keep the dish from moving.

The system was wired! Now the software had to be loaded onto the computer, and a few parameters needed to be set manually. This went fairly easily with a call to StarBand's toll-free technical support number. They ran me through the setup, and helped me plug in the right parameters for my zip code. After about a half an hour on the phone, I was surfing!

For new installations today, there is no on-screen signal strength meter. I have to call and set up the bandwidth before I get to the site. After installation and rough antenna alignment on site, I call an automated system to check the co- and cross-polarization figures. Co-polarization is the signal strength and cross-polarization is the noise involved in any broadcast signal. They are a ratio and must meet FCC criteria in order for the StarBand system to be activated.

Performance & Power Requirements

The system is extremely fast. Live stream video and audio require no downloading—it's instant and clear, with great reception and no static on the audio. Surfing is enjoyable, with Web sites loading faster than I have ever seen.

A friend with a Digital Subscriber Link (DSL) at his home in the San Francisco Bay area recently visited me. He couldn't believe the speed of StarBand. Remember, StarBand is a digital satellite unit—not a link to a phone-based system somewhere else. It is not shared with anyone; it's always on and has no dial-up.

I ran the prototype unit on a Trace 2012SB modified square-wave inverter for an off-grid test, and had no trouble whatsoever. I hooked all the power supplies for the system to a watt-hour meter to see if the system would easily kill a small battery bank. Here are the results:

- With CPU, ink jet printer, 15 inch (38 cm) monitor, speakers, and modem turned on, startup drew 130 to 135 watts.
- With CPU, ink jet printer, 15 inch monitor, speakers, and modem turned on, it drew 120 to 122 watts.
- With CPU, ink jet printer, 15 inch monitor, speakers, and modem turned on, surfing drew 125 to 140 watts.
- With only the CPU and speakers on, the system drew 72 watts.
- With everything plugged in, but not running, there was a phantom load of 2 to 8 watts.

System Cost

Assuming that you will use your current computer, the system costs will be determined by what you want to receive in programming. The satellite system costs US$400, including modem, dish, wall mount, and software. You own the equipment. Installation will run US$200 local—more for travel. Unlimited Internet access only is US$70 per month. Unlimited Internet, 150 channels of digital TV, and 30 channels of constant music, through Dish Network is US$100 per month.

Please note that you can be on the Internet and watch TV at the same time. There is some additional cost to Dish Network for parts and installation of the components needed to access digital TV. Dish Network receivers start at US$100.

Internet Off-Grid!

Never before has there been such a product for the private homeowner. All other satellite Internet systems thus far can only download from the net and must use a phone line to upload. This is of little help to the remote home. These systems needed to tie up the cell phone at exorbitant rates, or operate through a radio phone at the normal slow rate of data transfer.

The StarBand system can be used anywhere in North America. Trees, hills, snow, etc. will affect reception. The satellite footprint can be viewed on the StarBand's Web site. The "modem" is a significant phantom load, so you have to turn it off when it's not in use. Sometimes the system will need to go through a short "wake-up" period after being turned off.

The very reliable StarBand components have been used for many years in other countries and for commercial purposes. The FCC has made this technology available to the common consumer now, and it is sure to be used extensively by urban and rural dwellers alike. The benefit to the off-grid home is invaluable.

Until now, Internet access was the last great technological hurdle of off-grid living. If a person wants to live remotely and communicate with their ".com," or wants Internet access on a reliable basis for any other reason, the StarBand system is just the ticket.

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Dish Network • www.dishnetwork.com

Wŏrd Pow´ẽr

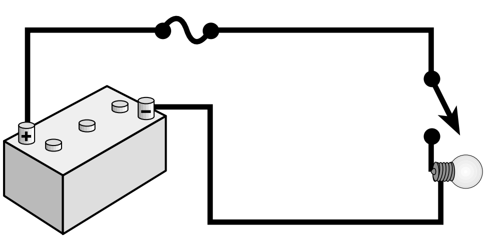
Renewable Energy Terms

Parallel—Side by Side

Ian Woofenden

Derivation: From Greek para, *beside, and* allelon, *of one another.*

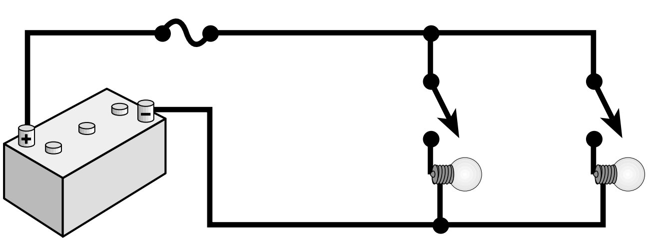
Series circuits are single loops, with all circuit components in a row, and no branches. The electrons in series circuits are like a simple toy train setup. All the cars in the train are connected, and whatever happens to one car happens to them all.



Series Circuit

Electrons in parallel circuits are like multiple trains traveling on more than one track. Or you could imagine bicycle commuters leaving the suburbs and heading for their jobs downtown. They can take many different routes to reach similar destinations.

In the simplest parallel electrical circuit, there will be a source of energy (battery, PV, or utility grid) and two loads. As an example, let's use a battery and two light bulbs.



Parallel Circuit

Some of the electrons in the circuit will flow through each bulb, and they will both light up. The two bulbs are operating independently, energized by one source. If one bulb fails, the other will still run. In contrast, if two bulbs are wired in series (all in one loop), when one fails, the circuit is opened and the other bulb will go out.

Just as multiple roads allow a greater traffic flow, parallel circuits allow greater electron flow (compared to a single series circuit with the same wire size). You are increasing the amount of conductor material, so more electrons can flow.

Parallel circuits also make using electrical energy much more flexible and convenient. You can wire multiple circuits and control them independently. Wiring and circuit components only need to be sized for the specific loads on each circuit. In the same way, having multiple roads allows our bicycle commuters to travel to a variety of places by different routes.

Renewable energy systems are full of parallel circuits. Most PV arrays are made up of series strings of modules that are paralleled together in a combiner box. Voltage remains the same when you wire in parallel, while amperage is the sum of the output of the sources. So if two 12 volt (nominal) PV modules that produce 5 amps are wired in parallel, the output will be 10 amps at 12 volts.

Batteries can also be wired in parallel. If you have two 12 volt batteries to use in a 12 volt system, they will be wired in parallel. Again, voltage will remain the same, while amp-hour capacity will increase. If each of your batteries is rated at 200 amp-hours at 12 volts, two wired in parallel will supply 400 amp-hours at 12 volts.

Conventional house wiring systems are made up of parallel circuits—it's the normal wiring mode for most electrical systems. The main energy supply can be the utility grid or a renewable energy system. The energy comes into a main circuit panel, where the wiring divides into multiple circuits. Each circuit leads to a group of loads, which are also wired in parallel within the circuit.

Parallel and series circuits are wired together in various ways to make up electronic devices and wiring systems. All circuits are either series, parallel, or some combination of the two. Series circuits are in a single loop. Parallel circuits are, as the original Greek says, "beside one another."

Access

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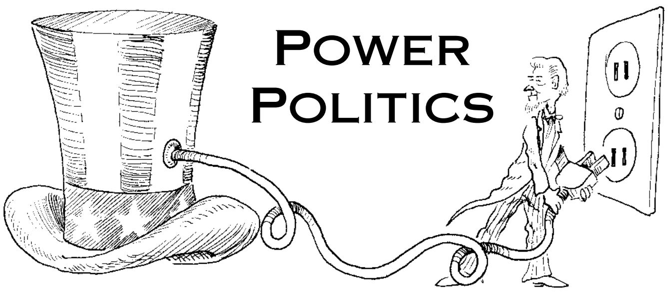

BANKRUPT!

Michael Welch

On April 6, 2001, Pacific Gas & Electric Company (PG&E), one of the world's largest investor-owned utilities, declared bankruptcy under Chapter 11 of the U.S. Bankruptcy Code. "How could this possibly happen?", queried the multitudes.

I'm in PG&E territory, and so is Redwood Alliance, the non-profit environmental group I've been active with for years. Since 1978, Redwood Alliance has been fighting PG&E for fewer nukes and more renewables. With this kind of history, you might ask how I could remain unbiased enough to write about this subject.

But look at it the other way. The reason we have *had* to fight PG&E is that they constantly inflict their corporate greed and hostility on their ratepayers, who are captive customers. Pacific Greed & Extortion is a common take-off on their name. This bankruptcy does nothing to change that reputation.

Over the years, Redwood Alliance's successes dealing with PG&E on a local level have come easier. The local PG&E plant manager now calls us to respectfully discuss our position whenever something new comes up. They've figured out that we are strong in our community, and that what we have been asking for is the right thing to do. (Of course, it also helps that our ideas have proven to be the least costly for the company.)

But on a state-wide level, our group is insignificant to PG&E—we are unable to be a big league player. Believe me, we've tried. But no group is able to play on the same level as PG&E. They have the big bucks to throw at anything they want to influence. And they also have long-term investments in the legislature and the Public Utilities Commission. This clout, by the way, enabled them to get almost everything they wanted in California's "deregulation" debacle.

Corporate Spin-Off

Part of what they got was the spinning off of the local utility, separating it financially from the parent corporation. Well, it wasn't really a separation. It was more like a one-way street for cash assets. This spin-off allows profits to flow from the utility to the parent company, while at the same time insulating the parent from the utility's problems if something goes wrong.

There is one major reason for such a spin-off—the potential for debt relief by declaring bankruptcy. PG&E knew very well that if the cost of doing business in California got high enough, they would not be able to collect enough money from the ratepayers to pay their bills. So they needed to protect all their profits from attack by future debts.

Nuclear Power a Culprit

Nuke power caused deregulation, and the California "crisis" was the result. Diablo Canyon Nuclear Power Plant was forced into the rate base by PG&E clout in such a way that nearly all of PG&E customers' electricity bills increased by 50 percent. Manufacturers and other businesses hollered loudly, wanting whatever it would take to bring prices down. Their goal became figuring out a way to decrease their prices with true deregulation, allowing power suppliers to compete for their business.

But things did not work out very well. Once again, PG&E's clout allowed them to influence deregulation legislation. They influenced the legislation so that it would pay them vast amounts of ratepayer money for their past investments in "stranded assets." These are power plants they were allowed to build that would theoretically no longer be cost-effective under deregulation. The price tag for those stranded assets? Nearly US$30 billion, US$20 billion of which got laundered off to PG&E's parent company. (At the time of bankruptcy, PG&E's debt was about US$9 billion.)

At the same time, PG&E was forced to sell off its conventional power supply assets to California's new energy suppliers. I say forced, but actually it was PG&E that influenced the deregulation law. How can a company force itself to do something it doesn't want to do? The profits from the sales of those plants also went up the hill to the parent corporation.

In the meantime, PG&E, under its favorable deregulation scheme, was having to pay higher and higher wholesale rates for the electricity that it was selling to its customers. Even though California had been "deregulated," the only way the legislation would pass was if there were rate rollbacks and a freeze built into the law. So PG&E could not raise retail rates, while its wholesale electricity costs were increasing dramatically. In this way, the local utility started amassing debts. And of course, it was not at all interested in tapping into the money it had laundered off to the parent company.

But why should they care? Their profits were well insulated by the parent company. And besides, the parent company also owned natural gas and electric production facilities, and was in the process of charging its wholesale customers the same outrageously high rates that the local utility was now complaining about.

The utility feared all along that they might have to declare bankruptcy. In fact, their board had given management the leeway to do so nearly four months before the declaration. So what finally threw them over the edge? It was California's governor, Gray Davis. He had come up with a protection scheme to keep California's utilities solvent. He knew he couldn't pass debts up to the parent company, and he also feared that having bankrupt utilities could cripple the California economy. He came up with plans to funnel lots of state money to the utilities to bolster their finances until such time as the deregulation laws could be fixed.

Trade Grid for Bailout

But Davis wanted something in return for giving this bailout money to the utilities. He was moving forward on a proposal to trade the bailout for state ownership of the utilities' transmission lines. PG&E balked at this idea, and I don't blame them. How the heck could a utility continue in business without anything to do business with?

Deregulation had forced them to sell off most of their production assets. With the exception of their nuke plant, hydro facilities, and a handful of other assets, the only thing they had for moneymaking was selling power access. This requires ownership of the transmission lines.

So, in spite of Herculean efforts to get cash to the utilities, PG&E figured out how to have their cake and eat it too. Under federal bankruptcy laws, a company is allowed to continue doing business while the disposition of company assets is placed in a court's hands. Which debts are paid and how much is paid are left to the court as well.

While the utility may yet lose its transmission lines to the state or other creditors, this is going to be one of those courtroom battles that will take years to play out. All sides will have their bevies of attorneys. They will file one motion after another, mostly delaying finality.

This is the largest investor-owned utility ever to declare bankruptcy, and the third largest bankruptcy in history. The assets of the utility that will be distributed to creditors are mostly future utility bills. So one question is, can the bankruptcy judge increase rates in order to pay off debts? And that leads to a second question: what interest should take priority—the consumer or the creditor? And then there is yet another player, the state, which has been funneling funds into the utility to keep it solvent. Where do they fit into the lineup for dividing up ratepayer money? Yikes, it's enough to make my head spin!

Other Shenanigans

PG&E is primarily concerned with its own interests. Just before declaring bankruptcy, which has the effect of freezing assets, PG&E distributed about US$50 million in bonuses to its managers. Governor Davis concluded that, "Management at PG&E is just focused on padding their own pockets, not in discharging their duty to serve their many customers in California."

Other victims of PG&E greed include the independent companies that were selling green power in California. For customers that had PG&E as their electricity provider, billing was as it had always been. But those who were purchasing power from companies like Green Mountain had two bills. One was from the provider, and the other was from the utility, for transmission costs and other costs related to deregulation.

But because of the mandated rate rollbacks and freeze mentioned above, the billing was very convoluted. The energy providers passed their increasing costs on to their customers, which led to higher bill amounts than PG&E customers had. The mandated rollbacks and freeze were dealt with via a credit showing up on the consumers' PG&E transmission bills.

The problem was that PG&E would not pay out those credits, but just let them build up. In the meantime, folks were having to pay the fully increased rates via their providers without the relief of refunds from PG&E. Eventually, Green Mountain and other providers turned over all their customers to the local utilities. It was the best thing they could do for the customers, to avoid sending us all to the poorhouse. In this way, PG&E forced their competitors out of business in the amount of time it took electric rates to climb in California.

Too Complex for Me
This is a very complex situation that I have tried to describe in a few hundred words. Books will be written on this subject in the next few years. Classes will be taught. Lawyers will make millions. In fact, PG&E bankruptcy attorneys had already been paid US$1.5 million by April 9, three days after the filing.

But you should be left with a single perception. It is corporate greed that fueled this entire debacle, from the first plans for the Diablo Canyon nuke plant, to the eventual dividing up of the leftover assets of a California utility that was gutted by its own parent.

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Don Loweburg

Fuel Cells— A Red Herring?

Fuel cells using hydrogen represent a non-polluting energy conversion technology. Yet many articles in the popular press miss the mark in a major way by referring to fuel cells as alternative or renewable energy. Fuel cells are not a source of energy in themselves.

Fuel cells are a conversion technology, transforming the stored chemical energy in hydrogen and oxygen to electrical energy. In a true hydrogen fuel cell, this process is accomplished without pollution. However the fuel (hydrogen) must come from somewhere. In order for this process to be renewable, the hydrogen must come from a renewable source. This is possible, but most fuel cells today do not use renewably produced hydrogen. Rather, these cells are designed to use natural gas, or in mobile applications, gasoline.

Fuels cells that operate on hydrocarbon fuels have an extra step using a "reformer." This process strips the hydrogen away from the carbon backbone of the hydrocarbon molecule, leaving CO_2 as a byproduct. In some cases, the fuel cells operate on biogas (methane). In these instances, it would be correct to refer to the system as renewable.

In most articles in the popular press, the fuel cells being discussed are operating on non-renewable hydrocarbon fuel. Yet the word fuel cell is often allowed to imply renewable. I consider this to be a dangerous trend. Consciously or unconsciously, the authors allow this distinction to be fuzzed over.

Of course hydrocarbon fuel cells have merit. They convert energy contained in the fuel with higher efficiency than an internal combustion engine. However, these fuel cells represent only an incremental efficiency improvement. In no way are they renewable or revolutionary. And, since they are fueled with hydrocarbons, they will emit CO_2, and they are greenhouse gas polluters! I think the vigorous media attention paid to fuel cells is a red herring, distracting the public from truly renewable energy sources like PV and wind.

Though PV and wind systems in operation far outnumber fuel cell installations by several orders of magnitude, you wouldn't know it from the press exposure. Though a hydrocarbon fuel cell may free you from the electric monopoly, you must purchase gas from a hydrocarbon monopoly. This is not independence.

Also keep in mind that residential-sized fuel cells are not yet for sale, and the price of natural gas (the preferred fuel) is going up steeply. These issues challenge the view that the hydrocarbon fuel cell will be a bridge technology, easing the transition from a non-renewable to a renewable energy economy. Perhaps we can jump the gap and do away with the bridge!

Good News

During the last several issues, I have reported on programs and legislation related to photovoltaics in California. Among them was the ICE-T proposal (the elimination of all standby charges on PV systems up to 1 MW) before the California Public Utilities Commission (CPUC), net metering for large systems, and a proposal before the California Energy Commission (CEC) to increase the rebate for renewables.

PV has scored a home run in California, thanks to some very hard work by members of the PV industry, CALSEIA's legislative advocate Kathryn Lynch (who has a PV system on her own home), and some progressive legislators.

On April 11, 2001 Governor Davis signed AB29, extending net metering to systems up to 1 MW, and removing capacity restrictions, previously capped at 0.1 percent of system capacity. There is one caveat. Due to strong behind-the-scenes lobbying by PG&E, the 1 MW net metering legislation was amended at the last minute to sunset in two years. The PV industry plans to make every effort to extend the law.

The PV industry got another big boost on May 16, 2001, when the CEC increased the Emerging Renewables Buydown Program amount to US$4.50 per watt or 50 percent of system cost. While 60 percent of the funding is reserved for small systems under 10 KW, 40 percent is available for systems of all sizes.

Bad News

At the same time as these positive changes, electric rates in California have gone up significantly. Not surprisingly, the U.S. demand for PV systems has now reached record levels. This increased demand, coupled with already high demand in Europe and Asia, has resulted in significant backorder and delays. Bottlenecks are particularly acute in the availability of some inverters and PV modules. Many module suppliers are about two months backordered.

Xantrex (Trace) has had particular problems delivering their ST2500 line tie inverter. Numerous and contradictory reasons have been presented, ranging from software problems to production and engineering problems. At the time of this writing, one major distributor is backordered by two hundred units. This means that two hundred customers and dealers are waiting to complete their system installation, and this is just one distributor's backorders.

To make matters even more aggravating, Xantrex has announced a July 1 release of an upgraded ST referred to as the XR. A Xantrex spokesperson explained that the XR had a number of production improvements and a new "Power Sweep" maximum power point tracking design. It also has a price increase of US$259! Though the spokesperson did his best to put a positive spin on this situation, my conclusion is that Xantrex could not meet market demand at the original price, and needed to re-engineer their troublesome maximum power point tracking software.

Fortunately, Xantrex is not the only product on the market. Other manufacturers such as Omnion and AES seem to be doing a better job of fulfilling their customer commitments. Also, a new player is in the U.S. market, SMA, manufactures the Sunny Boy line of inverters. Their 2.5 KW inverter has just received UL listing and CEC certification. John Berdner, SMA America, reports that units are now being shipped to distributors from the manufacturer in Germany.

Though most module manufacturers forecast a doubling of production this year, we can anticipate supply problems for some time. More than ever, it is important to work with established and knowledgeable dealers.

California Buydown Concerns

Concerns about system quality and an anticipated rush on the California market prompted a recent (May 22, 2001) PV Summit meeting in Sacramento, California. Hosted by the CEC and moderated by Bill Brooks (Endecon Engineering), attendees included module manufacturers, CEC staff, IPP, CALSEIA, and SMUD.

Two primary concerns surfaced during the roundtable discussion. On the part of the CEC, it was that the generous rebate coupled with supply bottlenecks would increase system prices, a result diametrically opposed to the goals of the CEC buydown program. The other major concern, expressed by Bill Brooks, was that in California, we could have a replay of the solar hot water debacle of the 1980s. (I don't agree with this conclusion, but that's not the point here.)

Though module manufacturers assured the CEC that supplies could be maintained, they made no comment on prices. There were no inverter manufacturers present. As already noted, Xantrex has increased the price on the ST2500 by 10 percent.

IPP pointed out that installers generally are competitive on hardware and labor, but cannot control the prices they are charged by manufacturer-distributors (maybe we should look at this!). The CEC representative made it very clear that they would be looking at system-pricing behavior over time, and that they had the power to adjust the rebate level at any time.

Regarding the schlock factor, a couple of points were made. Chuck Whitaker (Endecon Engineering) pointed out that unlike solar thermal collectors, no one would be building PV equipment in their garages. In fact all components used in the CEC program must be approved, and as a minimum requirement, modules and inverters must be UL approved. This fact represents a big difference between the PV industry of today and the solar thermal industry of the early 1980s. Bill Brooks countered by saying that even the best equipment could be installed incorrectly, components mismatched, wire sizing goofed, and PV modules sited poorly.

The group had consensus in three main areas. First, the CEC should maintain a program of random sampling of system quality and performance. General problems or egregious offenders would be identified.

Second, many customers may not know how well their systems operate. A simple remedy, benefiting both customer and installer, would be to include system output metering. Many dealers already include this, and no one objected to this being a program requirement.

The third item of consensus was that training and certification standards should be developed for installers and designers. It was noted that efforts in this area are already well underway in some sectors of the PV industry. The group decided to explore the work already developed, and possibly implement a program requirement over the next few years.

Module Energy Output

Sandia National Laboratories does research and support activities related to photovoltaic components and systems. I recently received an issue of their *Quarterly Highlights* titled "Modeling Annual Energy Production From Photovoltaic Modules." The article details research and work done by David King and others using modeling software developed by his group at Sandia. This and many other important reports are available from Sandia's Web site. A commercial implementation of the software is available from www.mauisolarsoftware.com (reviewed in *IPP, HP79).*

PV installers and many *Home Power* readers are aware of the basic routine for estimating PV module output. A south-facing orientation with a tilt angle equal to the location's latitude is assumed as a standard. King's article takes on the more complicated, real world issues of estimating module output, and quantifies the results. It answers questions like: What is the effect of horizontal or vertical placement of the module? What are the differences in performance between different cell technologies? How important is diffuse light to performance? How do different modules perform in different climates?

To answer these questions, the author first establishes a methodology to normalize the different modules tested, using output at standard test conditions. In order to level the playing field, the module's annual energy output was used. By focusing on annual energy output, many small, seasonal effects were averaged out. This makes sense, since the annual energy output is what should be the measure of merit, not the various and sometimes confusing terms like Isc, Vpp, etc.

King makes one very important conclusion. The standard reporting condition (SRC), also called the standard test conditions (STC), can be a good basis to evaluate module performance. Modules with equal power ratings were found to produce equivalent annual energy output within a 10 percent variance across a range of geographic locations. However, since SRC ratings form the basis of the "nameplate" rating for a given module, any errors in this rating will translate into errors in annual energy output.

Mr. King states, "As a result, consumers must insist that manufacturers provide accurate nameplate ratings for their product, ideally with the nameplate value representing a production average, with some modules slightly above that value and some slightly below." He makes this point because he is well aware that some manufacturers cherry-pick the modules.

For example: A 100 watt module may typically have a 10 percent specification for output variation. A manufacturer could (and some do) select all 90 watt modules and sell them with the 100 watt rating, asserting that they are within the 10 percent specification. One would expect a "normal" distribution of module output around any rated output value. Because so much rides on the SRC rating, there's a real case for independent module testing, something along the lines of a *Consumer Reports* for modules.

A final and most important point is made in the Sandia article. Since equally rated modules (equal SRC output) differ by at most 10 percent in annual energy output, we must look at system issues that can affect output by much larger amounts. The article concludes, "Reliability of power conditioning equipment is the single most important concern related to system-level annual energy production and user satisfaction. The Department of Energy program needs to continue to emphasize research in this critical area."

System Energy Output

Quantifying system performance is the next big step for the PV industry. There is a deep need here for an independent entity to perform this function. Again, a *Consumer Reports* of the PV industry could fulfill this function. Consumers must now deal with performance claims based on the disparate perspectives of the various component manufacturers. Module manufacturers emphasize features like "cell efficiency," "low light performance," and "shade tolerance," while inverter manufacturers promote "peak efficiency" and "clean output."

These aspects of component performance are important, but the primary question should be, "How much energy does a system produce per year?" Of course, experienced installer-designers do have a better handle on this question because they have empirical results based on their specific geographical area.

However, it's time the industry became accountable for system performance. Naive, overly optimistic estimates need to be replaced with knowledgeable data. We have good system modeling software available. When it is used in conjunction with good empirical field data, reasonably accurate predictions of system performance are possible.

The View From Offshore

PV Power is the newsletter of the International Energy Agency (IEA). This group provides very good global information on the PV industry. The newsletter and a large number of reports are available at its Web site. I won't drag you through all the numbers, but this is some of the best information (and very nicely presented) that I have found. It's free, and comparable in quality to the stuff that is sold in some of the U.S. "PV insider" rags. Those darn European socialists!

Jade Mountain Correction

In *IPP, HP82,* I discussed the Gaiam purchase of Real Goods, and mentioned that Gaiam also owned Jade Mountain. I got a message from Steve Troy correcting that statement. The fact is that Steve owns 51 percent of Jade Mountain, while Gaiam owns the other 49 percent.

Steve also took strong issue with my use of the term "consciousness widget" as a description of the future direction of Real Goods and Jade Mountain. He sent me a copy of Jade's catalog to support his point. The catalog indeed maintains a strong focus on renewable energy equipment and systems. I apologize for the slight to Jade Mountain, and to Real Goods too.

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Overcurrent Devices

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

In the *Code Corner* columns in *HP76–83,* I addressed the selection and sizing of conductors for renewable energy systems. How do we protect these conductors from long-duration overcurrents that might cause fires or shocks if allowed to continue? Overcurrent devices provide the required protection, and this *Code Corner* will be the first of several addressing these devices.

We have sized the conductors in our system to operate within the rated temperature of the wire insulation at some maximum current. If that current is exceeded for significant periods of time (depending on the magnitude of the overcurrent), the conductors and the insulation will be heated. As the conductor temperature passes the rated temperature of the insulation (60, 75, or 90°C; 140, 167, or 194°F), the properties of the insulation will change. The hotter the insulation gets above the rated temperature, the faster the insulation characteristics change, and the more they change.

Some insulation (thermoplastics like THHN) may soften, melt, and then smoke before catching fire. Others (thermoset plastics like RHW) may start to char and become brittle before catching fire. Operation above the rated temperature for any significant length of time will change the insulation properties that make the wire safe, and will reduce its life. These changes in the insulation may not be perceptible, but they may be hazardous.

Types of Overcurrents

Overcurrents can be grouped into categories. Starting surge currents from motors or electronic devices at two to ten times normal running current can last 1 to 8 seconds. Overloads are in the range of two to six times normal rated circuit current and can last from minutes to hours. Fault currents are unexpected and unwanted currents, at varying levels, that can occur on the normal circuit conductors or on grounded conductors. They can be continuous (low levels) to very short-lived (high levels) in a well designed system.

Overloads are the result, as the name implies, of connecting too many loads to a given circuit, or connecting loads that draw more current than the circuit is rated to deliver. Most electrical circuits are designed to be operated at only 80 percent of their rating. While operating above this level may not cause the overcurrent device to trip, it may result in long-term degradation of the circuit wiring and overcurrent devices.

Overcurrents from faults can result from mechanical failures of insulation, failures of connections, or abuses of the wiring such as nail punctures, saw cuts, or general wear and tear. Fault currents are called line-to-line faults if the fault or short circuit involves both of the current-carrying conductors. If the fault involves a circuit conductor and a grounded conductor, an equipment-grounding conductor, or a grounded surface, the fault is said to be a ground fault.

Fault currents may be in the milliamp range when leakage currents or high-resistance faults are involved. Very high fault currents, up to the ability of the power source (which may be thousands to tens of thousands of amps) may occur when a direct, low-resistance, unwanted connection is made.

Overcurrent Devices

The main types of overcurrent protection devices used in renewable energy systems are fuses and circuit breakers. These devices have been around for over 100 years and have been steadily refined in that time. These devices are very sophisticated in their internal construction. They use electrical, mechanical, magnetic, thermal, and chemical processes to achieve the desired characteristics.

The characteristics that are required in an overcurrent device are stringent and difficult to achieve. Not all overcurrent devices meet all of the criteria for all applications. This is why there is a large selection of overcurrent devices, with a wide range of appearances and costs.

In general, all overcurrent devices are designed to open a circuit when subjected to overcurrent, and then reduce that current to zero. These devices have a specific opening current rating, also known as the ampere rating. They must also have a voltage rating and an interrupt current rating.

The voltage rating specifies the maximum voltage that the device can be subjected to, including device-to-ground voltage and the voltage across the device after it has opened the circuit. The interrupt current rating is the amount of short-circuit current that the device can interrupt (reduce to zero) when opening. All overcurrent devices must be able to function properly and safely when subjected to any voltage up to the rated voltage and any current up to the interrupt current rating.

Strangely enough, short-circuit currents and voltages below the maximum values are far harder to handle than those near the maximums. High short-circuit currents tend to cause internal fuse elements to melt rapidly and completely, creating a long open circuit path that the current must jump. Lower short-circuit currents do not melt the fuse elements as completely, which leaves smaller gaps in the internal element. The currents jump across these smaller gaps more easily than the longer gaps, and the internal fuse mechanisms have more trouble extinguishing the arcs.

Circuit breakers have slightly different problems related to the strength of the magnetic fields that cause their internal contacts to open. Lower short-circuit currents cause the contacts to open more slowly, and the arc is harder to extinguish than when higher short-circuit currents force the contacts to open rapidly.

Each device, fuse, or circuit breaker is designed for its specific application. “Slow-blow” fuses or time-delay circuit breakers are designed to not respond to current surges, but only to longer duration overloads. “Fast-blow” fuses and short-delay circuit breakers are designed to respond very quickly to overcurrents above their rating, and may even open if subjected to normal starting surges from motors and electronic devices.

Both slow- and fast-acting overcurrent devices may be used for overcurrent protection in code-compliant systems. The specific application will determine which device should be used. In another category are “semiconductor” fuses, which are designed to respond extremely quickly to protect semiconductors inside electronic equipment. Unfortunately, this characteristic cannot be achieved while meeting the code and UL requirements to respond properly to overloads in the two to six times rating area. So these fuses are not approved for use in code-compliant systems.

AC & DC Are Not the Same

It is not safe to use an overcurrent device listed only for AC in a DC application. AC currents go to zero and reverse themselves 120 times per second (on 60 Hz systems). Any arc formed when an overcurrent device opens is extinguished and restruck 120 times per second. This greatly assists the overcurrent device in interrupting the current and forcing it to zero. DC current does not provide this self-extinguishing effect, and since it flows in one direction only, the overcurrent device must bear the complete load of breaking the circuit and extinguishing the arc.

The difficulty in interrupting DC currents is quite evident in the ratings of the common 100 amp type RK-5, DC-rated fuse. This fuse is listed for use on both AC and DC systems. The ampere rating is 100 amps AC and DC. The AC voltage rating is 250 volts. The DC voltage rating is only 125 volts. The fuse can interrupt AC short-circuit currents up to 200,000 amps. The DC interrupt rating is only 20,000 amps. Half the voltage and one-tenth the interrupt rating highlight some of the difficulties associated with DC circuit overcurrent protection.

Fuses

Fuses act once in protecting a circuit from overcurrents, and then they must be replaced. Special fuse holders must be used to allow safe replacement of the blown fuse. These protect the user from coming into contact with energized circuits. In many cases, the fuse holder is incorporated into a disconnect switch that removes voltage from the fuse when opened.

Listed fuses are available in two categories. “Class” type fuses are subject to more rigorous testing in terms of the interrupt rating, the number of cycles at full load, environmental conditions, mechanical design, and other factors.

“Supplementary” fuses, on the other hand, are designed to be used in circuits where the conditions of use are much less severe. They are usually protected from high short-circuit currents by class type fuses—hence the name supplementary; they supplement other overcurrent protective devices in the system.

Class type fuses are more robust, and can be used in all applications. When used in DC circuits, the fuse must also be listed for DC use. The RK-5 fuse mentioned above is a class type of fuse. Other fuses that may have DC ratings are class RK-1, CC, J, T, and L. These fuses are available with various ampere ratings, voltage ratings, and interrupt ratings. Class type fuses may have standard ampere ratings of 1, 3, 6, 10, 15, 20, 25, 30, 35, 40, 45, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, and higher, up to 6,000 amps.

“Supplementary” type fuses can be used only in DC PV source and output circuits. This type of fuse includes the midget fuse and one or two ceramic fuses in the 1/4 by 1-1/4 inch (6 mm x 32 mm) size. These fuses have limited interrupt capabilities (500 to 1,000 amps or so), and are allowed only in the PV source circuits that are some distance from the sources of high, short-circuit currents like the battery. Ratings are usually in one-amp increments from one to 30 amps.

Very few of these fuses are listed for DC. Care must be used when selecting these fuses or replacements to ensure that the replacement has a DC rating and listing. Fuses available at electronics hobby stores may look similar, but usually do not have the listing or DC ratings. Where possible, it is suggested that the more robust class type of fuse be used in all applications. Due to volume production, the class fuses are, in some cases, cheaper than the supplementary fuses.

Circuit Breakers
Circuit breakers can be reset after opening, and can be reset numerous times. They can also be used as disconnect switches. Replacement is not needed after every operation. Only the operating handle is exposed, and the energized contacts are not accessible to the system user during normal operation. Circuit breakers are known as inverse-time devices, and they have various time delay curves, just as slow-blow fuses do.

For example, a circuit breaker rated at 30 amps must carry 30 amps continually without tripping. It must open within one hour when carrying 135 percent of 30 amps (40.5 amps), and it must open in 2 minutes when subjected to 60 amps (200 percent of rating). Within these ranges, the circuit breaker may be designed for slow or fast response to short-term (1 to 2 seconds) and long-term (2 to 8 second) surges.

Circuit breakers are also available in two versions. The “branch-circuit-rated” circuit breaker is equivalent to the “class” type of fuse. There are also supplementary rated circuit breakers that could be used in PV source and output circuits, but these are not commonly available. In all cases, DC-rated and listed circuit breakers should be used in DC circuits.

Time Constants
When a short circuit occurs, the fault current does not rise instantaneously to the maximum value determined by the source voltage and the circuit resistance. There is a time constant involved that is determined by the resistance, inductance, and capacitance of the circuit. These in turn are controlled by the insulation type, conductor spacing, and length of each circuit.

Fuses and circuit breakers for DC systems are tested and listed to operate with time constants of 10 milliseconds or less. This time constant impacts overcurrent device performance in two ways. First we have the useful current-limiting fuses, and second we have the problems associated with time constants that are too long.

Current-Limiting Fuses
A normal fuse (non-current-limiting) will sense the short-circuit current as the current increases past the fuse ampere rating on the time-constant slope toward the maximum value. These standard fuses will eventually open the circuit and extinguish the arc, provided that the maximum available short-circuit current is lower than the interrupting capability of the device. However, the current through the circuit may reach or nearly reach the maximum available short-circuit current for the circuit. These high levels of current may damage other components in the circuit.

Current-limiting fuses will also sense the rising current as it passes the ampere rating of the fuse. They will, however, act much faster than the non-current-limiting fuse to open the circuit and extinguish the arc. The action is so fast (substantially less than 10 milliseconds) that the current never has a chance to increase to the short-circuit maximum current. The short-circuit current is held to a much lower value that results in considerably less stress to circuit components. Current-limiting fuses are sometimes required on battery circuits where the available short-circuit currents can be very high. There are no current-limiting circuit breakers listed for use on DC systems.

Long Time Constants
DC overcurrent devices may not work properly if the circuit time constant is substantially longer than 10 milliseconds. The overcurrent device may have trouble extinguishing the arc. At voltages below the maximum rated voltages and at low short-circuit maximum currents, long time constants prove especially troublesome.

As the length of the circuit conductors increases, the resistance of the circuit increases. As the spacing between parallel circuit conductors (positive and negative) increases, the inductance of the circuit increases. Capacitance varies with spacing, but not in a uniform manner. These three factors (resistance—R, in ohms; inductance—L, in henries; and capacitance—C, in farads) serve to determine the time constant of the system.

The *NEC* requires that all conductors in a circuit, including the equipment-grounding conductor, be routed together and remain in close proximity. In DC circuits, this action keeps the time constant as low as possible. In AC circuits, impedance is minimized.

PV system designers and installers should keep this requirement in mind when working on module and battery wiring. All of the conductors for each circuit should be grouped together in the same conduit or sheathed cable to keep the time constants low.

Overcurrent Devices for Other Systems
Yes, there are many overcurrent devices (both fuses and breakers) that are used on other DC systems such as electronic, appliance, telecom, automotive, boat, and

mining systems. Most of these overcurrent devices have not been evaluated by the listing organizations against the UL standards and *NEC* requirements of fixed electrical power systems.

For example, automotive fuses and circuit breakers are designed (at very low cost) to be used in relatively high-resistance circuits (one conductor is the steel auto body; or small wires are used) that limit the available short-circuit currents to a low value. They do not have sufficient interrupting capability to deal with the much higher short-circuit currents found in fixed-power systems. When used in fixed-power systems, such as PV systems, they may create hazardous conditions when they are required to function.

Very expensive, high-reliability, overcurrent devices made for industrial and telecom systems may meet the technical requirements for use in a PV system. But they have not been evaluated or listed for use in RE systems that must meet *NEC* requirements.

Generally, the overcurrent devices available and listed for use on fixed electrical power systems are the lowest cost means of achieving the required protection. To use overcurrent devices that are not listed, or that are intended for other industries, may either sacrifice safety or increase cost.

Summary

Ungrounded conductors in all circuits are required to have overcurrent protection. The proper fuse or circuit breaker can provide this protection. DC ratings are required for overcurrent devices used in DC circuits. Keeping all of the conductors of a particular circuit in close proximity will keep the time constant low and allow the overcurrent devices to function properly. In future *Code Corner* columns, I will address where overcurrent devices should be used, and how to size and select the proper devices.

Photovoltaic Power Systems and the* National Electrical Code: *Suggested Practices

This 117 page manual, written by the *Code Corner* column author, and published by Sandia National Laboratories, has been revised to the 1999 *NEC,* and is available in PDF form on our Web site: www.nmsu.edu/~tdi/pvandnec.htm

This manual is also available from Sandia National Laboratories by calling Connie Brooks at 505-844-4383 or e-mailing her at cjbrook@sandia.gov.

Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC,* feel free to call, fax, e-mail, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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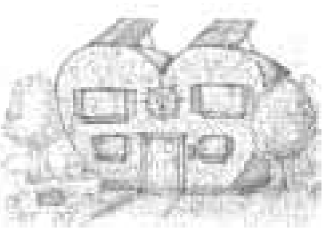
800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org

Home & Heart



Kathleen Jarschke-Schultze

We had a power blackout at our house the other morning! When we woke up, our power was off. Unlike grid blackouts, this one was caused by too much power. Our creek was still running our microhydro unit, the sun was shining on our panels the day before, and the wind cranked our turbine all night long.

When our batteries are full, the excess electricity goes by shunt regulation to a heating element in our water heater tank. That had maxed out, so our system turned itself off—the inverter shut down due to high voltage. Bob-O turned it back on, and I had a day of doing laundry, vacuuming, and running air cleaners with the TV on in the background for company. When the batteries are full, the only way we can waste power is to not use it.

Mousie Wars III

Ever since I moved to the country from town sixteen years ago, I have had a hate/hate relationship with mice. Brown or gray, it just doesn't matter. I have had several rodent adventures. I refer you to *Muddy Roads* in *HP12* and *HP21*. Just to spark your curiosity, the first story involves a snake in my oven, and the second, a gun in my kitchen.

I always had cats as pets and mousers before I met Bob-O, so mice were never a problem. Bob-O, however, is an asthmatic. Cats are the catalyst for him. I gave my best mouser, Maxine, to my friend Joan when I moved into Bob-O's cabin. We must avoid any contact with cats. This means all my clothes must immediately go into the wash after visiting my cat-keeping family. We can't stay with friends who have cats. I have gotten very good at bringing our own sleeping environment on trips.

House Mouse

Whenever we noticed indications of mice, we would set a trap line. We used the old fashioned Victor snap trap, about ten at a time. It would take up to a week of checking and emptying them all every morning to manage the problem. Peanut butter is good bait, and so are cotton balls soaked with bacon grease. Contrary to the cartoons we grew up with, cheese only works so-so.

My food pantry is down in our basement. When I first started using it, I could see where the mice had chewed holes in the ceiling and corners for unrestricted entry. I mixed cayenne pepper and powdered mustard with mortar, and filled all the holes. This kept them from using those routes, but they eventually made new entrances elsewhere in the room.

My old office was in our basement. I worked down there in the summer when the coolness was a relief. In the winter, I would move my computer upstairs, closer to the wood stove. As soon as I was not a daily presence, the mice would move in.

The Rat Bastards

A friend got me a little miniature Zen rock garden in a small wooden tray. After artfully placing the rocks, I make lines in the sand with a tiny rake to represent flowing water. I even have a tiny porcelain fisherman who sits on the edge and fishes in the garden. Another porcelain couple picnic on the opposite side.

After I moved out of the basement office, every time I returned, there were mouse tracks all through my Zen garden. Like bullies at the beach, the mice would knock over my little porcelain people and kick sand in their faces. By checking my little garden, I knew whether or not I had to set the trap line in the office.

Mouse-No-More

Then Bob-O brought home some Vermin-X® electronic indoor pest repellers. Huh? That's what I thought. They are little white boxes that plug directly into an outlet, like a night light. They repel mice, spiders, cockroaches, fleas, and most flying and crawling insects. That's what the label says. Since mice were my only problem, that was all I cared about.

They work! Yippee, skippy! I can tell you, I'm thrilled. First we put them in the basement—one in the pantry and one in my office. Every time I would check, there was no mouse sign or scat. My little Zen garden remained raked and pristine. My porcelain people were unscathed by rodentia.

Bob-O went out and got more. He found them at Price/Costco in a four pack for US$29.95. They can be found at many home supply stores. We placed the units in the kitchen, guest room, and greenhouse. We have not seen a mouse or any indication of one (in the house, that is) in months.

The Vermin-X gizmo guarding Kathleen's Zen garden.

How It Works

These rodent repellers work because most household pests hear sounds far above the hearing range of humans, a range called ultrasonic. The unit's electronic sound technology uses ultrasonic sounds to effectively repel household pests.

Pests are repelled because they can't adapt to the Variable Frequency Technology™. The units can be used to drive household pests from homes, garages, attics, crawlspaces, or basements. They'll work anywhere you have an outlet. They are not weatherproof though, so if you use them outside, bring them in during wet weather. I have to be careful not to get the ones in my greenhouse wet when I water in there.

They are safe for use around pets, fish, infants, and small children. The product literature does warn not to use them around pet mice, hamsters, gerbils, etc. The units plug directly into any standard 110 VAC electrical outlet. Some models have a night light; mine do not.

There is a small red LED light on the front to tell you that the unit is on. I plugged mine into a Brand meter (model 4-1850 DR), and the draw was so small that it didn't even register. Our power system can afford such small phantom loads. Note: This unit is a tiny load, but that also means it will not bring the inverter out of search. And it becomes a large load (combined with the inverter) when it's the only load.

Technical Specifications

For Model #100/1000, the unit dimensions are 4-3/4 x 2-3/4 x 2-1/8 inches (12 x 7 x 5.4 cm). The device weighs 4 ounces (113 g). Coverage is 1,000 square feet (93 m^2), and the frequency range is 26,000 to 42,000 Hz. Power input is 110 or 220 VAC, and power consumption is 0.090 W. This UL-listed device has a two year limited warranty with refund or replacement.

I Hate Mieces to Pieces

Will I miss the thrill of the chase? Will I miss finding a sheet in the linen cupboard with holes chewed into the folded edge, so that there are holes every 12 inches when the sheet is unfolded? Absolutely not. Millions of people love Mickey Mouse. If you are about my age, you got your first taste of opera from Mighty Mouse. Speedy Gonzales was amusing, way back when. But what I look forward to now are nights where nothing is stirring, not even a mouse.

Access

Kathleen Jarschke-Schultze is busy as her bees in her yard and garden in Northernmost California, c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520
kathleen.jarschke-schultze@homepower.com

Weitech, Inc., PO Box 1659, 601 N. Larch St., Sisters, OR 97759 • 800-343-2659 or 541-549-0205
Fax: 541-549-8154 • info@weitech.com
www.weitech.com • Vermin-X pest repellers

HAPPENINGS

INTERNATIONAL

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

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

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

CANADA

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

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

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

INDONESIA

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

JAPAN

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

NICARAGUA

Jan. '02, Nicaragua. Intro to PV for developing countries, course offers lectures, field experience, & eco-tourism. Taught in English by Dr. Richard Komp & Professor Susan Kinne. US$850. Contact Barbara Atkinson 215-942-0184 • lightstream@igc.org

SPAIN

Oct. 29-31; First International Conference on Solar-Electric Concentrators, Marabella, Spain. Technical discussions of achievements in concentrating solar electricity, primary emphasis on PV. Contact: Robert McConnell, NREL 617 Cole Blvd. Golden, CO 80401 • 303-384-6419 Fax: 303-384-6481 • robert_mcconnell@nrel.gov www.nrel.gov/icsec

TURKEY

Aug. 29–31, '01. 2nd International Sarigerme Solar Electricity Workshop, Iberotel Sarigerme Park, Ortaca, Turkey. Contact: Tanay Sidki Uyar, +90 252 2868031 • Fax: +90 252 2868043 sarigerme@superonline.com

NATIONAL U.S.

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

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

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

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

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

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

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

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

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

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

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

ALABAMA

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

ARIZONA

Sep. 14-16, '01; SW RE EXPO. Prescott Valley, AZ. Info: Prescott Valley Economic Development Foundation • 888-240-4256 • www.pvfdf.com

Glendale & Scottsdale, AZ. Living with the Sun: Lecture series by AZ Solar Energy Assoc. History & current overview of concepts, design, applications, & technologies on solar heating/cooling, architecture, landscaping, PV, & cooking. 7–9 pm, 1st Wed. of month at Glendale Foothills Branch Library, & 3d Tues. of month at Scottsdale Redevelopment & Urban Design Studio. Jim Miller • 480-592-5416

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

ARKANSAS

Sun Life Constr. by Design: Seminars 3rd Sun. of month. Hands-on, incl. ferro-cement, building dwellings for minimal materials expense. Loren Impson, 71 Holistic Hollow, Mt. Ida, AR 71957 870-867-4777 • loren@ipa.net www.Sun4Life.com

CALIFORNIA

Oct. 20, '01; Solar Cooking Summit, Agua Caliente Park, San Diego County, CA. Boiling Water Recipe Contest, share info & technical innovations, solar oven building classes. For event questions or rule list, contact Ian Zalewski, boilingwatercontest@spreemail.com

Sept. 22–24, '01; Take Your Bedroom Off the Grid; Arcata, CA. Hands-on workshop: How to install PV as your budget allows. Workshop with Johnny Weiss. Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884 redwood.alliance@homepower.com www.igc.org/redwood

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State University. Ongoing workshops & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551

ccat@axe.humboldt.edu
www.humboldt.edu/~ccat

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm., 800-555-7794 or 916-654-4058 CallCntr@energy.state.ca.us www.energy.ca.gov/greengrid

Dec. 11-14, '01; Sacramento, CA. EVAA Electric Transportation Industry Conference. Battery EVs, hybrids, path to commercialization. 650-365-2667 • www.evaa.org

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

Sep. 30-Oct. 5, '01; UPEx'01: Photovoltaic Experience Conference & Exhibition. Hyatt Regency, Sacramento, CA. PV & distributed generation. Solar Electric Power Assoc. Contact: Julia Judd, 1800 M Street, NW, #300, Washington, DC 20036 • 202-857-0898 Fax: 202-223-5537 • jjudd@ttcorp.com www.SolarElectricPower.org

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

FLORIDA
Sep. 17-21, '01; Biomass Conference of the Americas. Orlando Rosen Centre Hotel. Bioenergy & bio-based products, technologies, markets, & policies. Info: 321-638-1527 www.nrel.gov/bioam

IOWA
Sept. 8–9, '01. 10th Annual IRENEW Energy Expo. Hiawatha, IA at Prairiewoods. Electrathon cars, straw bale constr., wind, solar heat, PV, & energy conservation workshops. Iowa RE Assoc., 319-875-8772 • studegh@earthlink.net

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

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

KANSAS
Oct. 22-27, '01; Matfield Green, KS. Women's Wind Power workshop. Wind system design, components, site analysis, system sizing, and a hands-on installation of a full-size wind turbine and tower. US$550. Solar Energy International. See "COLORADO" for SEI access.

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

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

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

MINNESOTA
'01 MREA Workshops. See "WISCONSIN"

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

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

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

NEW MEXICO
Oct. 4-6, '01; Photovoltaic System Installation course, Albuquerque. A hands-on, how-to course. Supplement distance learning with practical hands-on skills. Solar-on-Line. See "International" for access info.

NORTH CAROLINA
Sep. 24-29, '01; Asheville, NC. PV Design and Installation workshop. Site analysis, system sizing, component specification, appliances, lab exercises, and a hands-on system installation. US$550. Solar Energy International. See "COLORADO" for SEI access

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

NEW YORK
Tax credits. Info on grid connection & tax credits: NY State PSC, www.dps.state.ny.us/photovoltaic.com

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

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

OREGON
Aug. 9, '01; Ashland, OR. Energy workshop, 7-10 pm, 51 Winburn Way. Home energy efficiency, solar power, cut and manage energy use. With Christopher Dymond, Geoff Dawson, & Bob-O Schultze. Free. No contact info, just show up.

Aug. 10–20, '01. Williams, OR. Adv. Permaculture Design Certificate Course—Keyline Water Management: A Whole Systems Approach. Become more competent designers. Cost: US$1,100. Seven Seeds Farm, 3220 E. Fork Rd., Williams, OR 97544 • 541-846-9233 sevenseeds7@hotmail.com

Sept. 14-15, '01; Roseburg, OR. Alternative Energy Fair, Umpqua Community College. Fair on 15th, kickoff dinner the 14th. Lectures, booths, & exhibits in hydrogen, solar, wind, hydro, biomass, and hybrid vehicles. Info: Bonnie Kyle, 541-496-0357 dallas1t@internetcds.com

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

Sept. 8, '01; Seneca, OR. Oregon Tree Farmers of the Year. Sustainable forestry & sustainable living tour at Lance & Jennifer Barker's Morning Hill Forest Farm. EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 info@solwest.org • www.solwest.org

Nov. 3, '01; EORenew Annual Meeting. John Day, OR. Elections, program, summary of the year's events. See above for EORenew access.

RHODE ISLAND
Energy Co-op is being organized to provide RE, energy efficiency & conservation services, & group purchases of "Energy Star" products. Erich Stephens, • 401-487-3320 erich@sventures.com

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

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

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

El Paso Solar Energy Association: meetings normally held 1st Thur. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 epsea@txses.org • www.epsea.org

Houston Renewable Energy Group: meets last Sun. of odd months at TSU Engineering Building, 2 PM. HREG, PO Box 580469,

Houston, TX 77258 • jferrill@ev1.net
www.txses.org/hreg/HREGhome.htm

WASHINGTON STATE

Oct. 11–14, '01; Guemes Island, WA: Microhydro workshop. Class & labs followed by tours, incl. Canyon Industries, turbine manufacturer. US$400. See "COLORADO" for SEI access • Local coordinator: Ian Woofenden, PO Box 1001, Anacortes, WA 98821
360-293-7448 • Fax: 360-293-7034
ian.woofenden@homepower.com

Oct.15–20, '01; Guemes Island, WA: PV Design & Installation workshop, with Windy Dankoff. Site analysis, system sizing, equipment, appliances, demonstrations, lab exercises, & a complete hands-on installation. US$550. See "COLORADO" for SEI access. See above for local coordinator.

Oct. 22–27, '01; Guemes Island, WA: Build Your Own Wind Generator workshop, with Hugh Piggott of Scoraig Wind Electric, Scotland. US$550. See "COLORADO" for SEI access. See above for local coordinator.

WISCONSIN

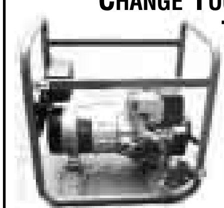
Sep. 8, Basic PV, St. Paul, MN. Sep. 9, Intermediate PV, St. Paul, MN. Sep. 16-22, Wind Systems Install, Blue Mound, WI. Sep. 21-23 & 28-30, Straw Bale, Browntown, WI. Oct. 6, Basic PV, Custer, WI. Oct. 7, Intermediate PV, Custer, WI. Nov. 10, Masonry Heaters Intro, Custer, WI. Nov. 26-30, RE for the Developing World, Custer, WI. Call for cost, instructors, & more info. Significant others half price. MREA, 7558 Deer Rd., Custer, WI 54423
715-592-6595 • Fax: 715-592-6596
mreainfo@wi-net.com • www.the-mrea.org

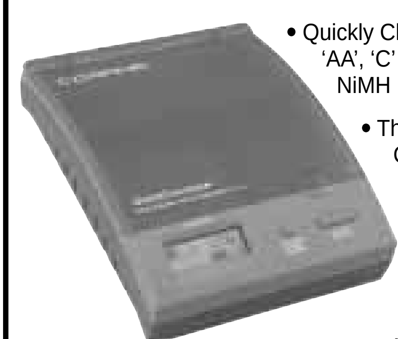
the Wizard speaks...

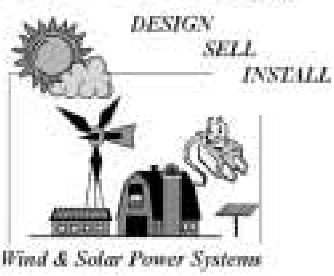
Fleeting Glimpses

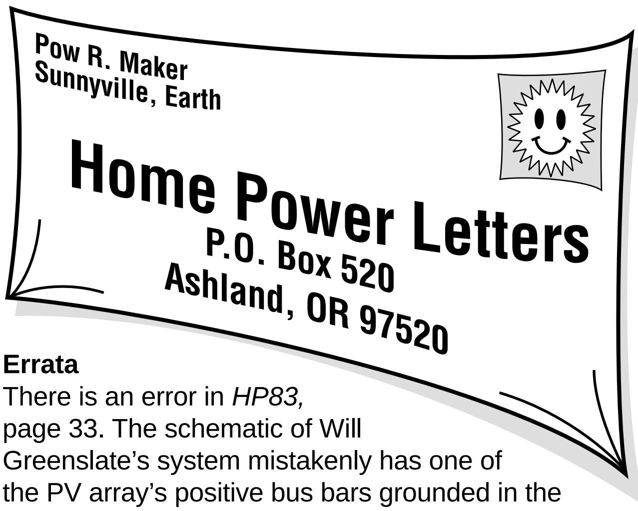
Here's a look into the idea well that constitutes the mind of the wizard. I hope you find it interesting.

- Chaos, or complexity, theory could possibly provide a basis for creating a unified field theory.
- A space-time that is curved implies that some form of energy is stored in the curvature.
- The Heisenberg Uncertainty Principle is both a theoretical and an observational problem, yet it may not be a reality problem.
- A unified field theory may be derivable from a single multi-valued, multi-variable scaler function.
- It may be that the operating system of the human brain is based on the principles of chaos theory.
- What happens to the charge when a particle and its anti-particle annihilate each other?
- Some gamma-ray bursts may be caused by the explosion of black holes.
- Although low probability states are infrequent, they are accessible.
- Is mass related to or a partial function of intrinsic spin?
- Perhaps the quantum wave function never really collapses.









Errata
There is an error in *HP83,* page 33. The schematic of Will Greenslate's system mistakenly has one of the PV array's positive bus bars grounded in the combiner box, creating a short circuit. The negative bus bar on the left side of the box should have been shown as grounded instead, as this system is actually wired. We apologize for this error.

Civic Irresponsibility
Dear Mr. Perez, Hello from western Michigan! We have a story unfolding that you may want to take a look at. It's a tragedy in the making, and has national implications.

We live in Kentwood, Michigan, a city just southeast of Grand Rapids. We live in a rural area (cows, chickens, windmills, goats, etc....). We feel strongly that we should do our part of solving the energy crisis looming in front of our country, And we don't want to see our energy bills climb any higher. So our family decided to make the move to solar energy. We began an odyssey of research, trying to decide what renewable energy system would work best for our area of the country.

Prior to purchasing anything, we called the city of Kentwood Zoning Board office to get the rules and regulations regarding the installation of a solar energy system. The woman we spoke with told us that the city had nothing on the books regarding the installation of solar energy systems, and that we could proceed. So we did.

We bought a state-of-the-art solar-electric system. It consists of twenty solar-electric panels on a tracker—the panels move with the sun. It starts off facing east in the morning, tracks south as the sun rises in the sky, and ends the day facing the sun in the west. A solar array such as this nets an average of 40 percent more energy than a fixed array that you typically see on someone's house or garage roof. The total cost was in excess of US$25,000. So far, we have been able to be off the utility grid (Consumer's Energy) nearly 100 percent of the time.

About one week after the installation of this fabulous system, we received a letter from the city stating that we were in violation of the city height restriction ordinance, and that two neighbors were complaining about it because they said it was ugly.

To make a long, awful story short, we took it to the Zoning Board of Appeals and lost—miserably. The board's decision was made before we even stood up to talk. They said that these types of systems have no place in Kentwood, that they are ugly (Yes, board members were actually expressing their personal feelings about the system's appearance!), and that it diminished Kentwood in general!

This board meeting was a sham. To begin with, only five of the seven board members even showed up. One was away at an "outing" and didn't bother to show up until 9:00 PM, despite the fact that the meeting convened at 7:30 PM. They simply didn't know where the other two board members were—they just "didn't show." Unprofessionalism at its very best! The members who were there flatly refused to look at the scientific reasoning for positioning the tracker where it needed to be. They said shadows from trees located east and west of the tracker had nothing to do the function of the solar panels, an opinion which couldn't be more incorrect. We had all kinds of charts and information there that substantiated the necessity for the tracker position, but they would not even listen. They also refused to consider the merits of the system itself.

Two days after the meeting, our local newspaper ran an AP story about the city of Chicago embracing green technology, both wind power and solar power. They, as a city government, are acknowledging the absolute necessity for all of us to open our minds to alternative ways to power our lives. What a shame that Kentwood is moving in the opposite direction.

We're writing to you because this is an important story for all of us. Our president is encouraging all of us to make conservation measures, and is even offering incentive programs for people like us to put in alternative energy systems. We need local governments to get out of the way, in the name of progress and energy conservation, and allow people to make their own power!

We're the first in Kentwood to ask for this variance in the height ordinance for a solar-electric system. They flatly refused us. I'm sure there are others in the country going through this same battle. We have a *major* contradiction between what our federal government is asking us to do and what our local governments are allowing us to do. It's only going to be through major national discussion and exposure that we are going to put these closed-minded zoning board members in the uncomfortable position of having to conclude that they need to wake up and join us in the 21st century.

Power in the future simply *must* included renewable energy systems. Ours is the latest and greatest, cutting-edge technology. It's powerful, it's efficient, and it's powering our entire home—lights, heating, cooling, appliances, TV, computers—everything. It's unconscionable that a city government in this day and age would condemn citizens who courageously spent a lot of hard-earned money to do their part in the energy crisis.

So at this point, we are faced with taking the system down and trying to find someone to buy it used—not likely in a timely fashion. Or we can lower it to conform with the local ordinance, which would put the top of the panels no higher than 14 feet. The consequences of that are tremendous. First and foremost, it will result in a significant power production loss—40 to 60 percent! We'll be back on the utility grid immediately, and back to paying an electric bill again. Second, this will mean that the bottom of the panels will be at a height of about 4 feet, rendering it a safety hazard for our children. And third, it certainly lends itself to vandalism at that height. This is a major piece of costly technology. We feel very uncomfortable having it at 4 feet, subject to anyone's approach. I doubt that any of those board members would be comfortable leaving their prized laptop computer sitting on a table in their back yard for anyone to touch. This solar array is far more costly than a laptop computer.

Please, this issue is vital to all of us who are concerned about the success of renewable energy systems. If you know of people who can help us, advise us, or help find quality, environmentally-savvy legal representation, please contact us immediately. Time is of the essence. We would really appreciate your help in getting the voice that we need this issue to have. Not just for us, but for all those energy pioneers who will be following us. We're just the first one going through the tall grass here in Kentwood. That's always the hardest. We want to help make sure that those who follow don't have to fight this battle again. Dennis and Beth Graveldinger and family • 616-656-0701 • dbgravel@altelco.net

Hello Dennis and Beth, What a ridiculous situation. You're doing the right thing by trying to provide your own energy without causing pollution or blackouts to your neighbors. In return, they are trying to impose their aesthetic values on you, and attempting to control your use of your own property. Sure, we need to get along with each other, and that can mean compromises, but this is too much.

How about it, readers in Michigan and elsewhere? What can we do to help Dennis and Beth educate their neighbors and their zoning board? Send e-mail to them and to Home Power *with your ideas. Solar energy can free people, which may be threatening to the control freaks in Kentwood, Michigan. Let's find ways to overcome the ignorance, and the impulse of some people to try to run others' lives. Ian Woofenden*

Hi Beth and Dennis, What a backward-thinking bunch of oafs! OK, now that I have had my rant, here are some real things you can try. Find like-minded folks in your community who can back up what you want to do, and get them to attend the next board meeting. Involve your installing dealer and any local environmental groups in educating the board, local businesses, and city officials about the benefits of renewable energy.

If things cannot be changed in the short term, you may need to make their mandated changes to your system for now, and rely on the above efforts to change the board's minds over the long term. If that does not work, try the initiative or referendum process. This is a valuable tool that most local governments have that allows the public to go over the head of the government if it is not responsive to public needs. Michael Welch

GFCI Phantom Loads

I enjoyed Dan Chiras' article in *HP82,* page 40. But I'd like to suggest an alternative to just chucking out all the GFI outlets. After all, they have value in saving lives, even if they add a small phantom load.

My tract home has twelve GFI-protected outlets, but only two actual GFI units (or 5 watts total if my GFIs have the same load as Dan's). I assume (perhaps stupidly) that this is up to code (any comments by experts?). Near my washer/dryer is a GFI unit that protects one standard outlet in each of my three bathrooms, as well as the backyard weatherproof outlet. My kitchen has a GFI unit that protects standard outlets around the kitchen and the front yard weatherproof outlet. At first I thought this was a dumb, cheapskate design to save the tract builder cash. However, learning from Dan of the 2.5 watt phantom load, I'm glad I have only two instead of twelve GFIs!

It may be worth a simple, half page article in *HP* to identify brands of GFIs with little or no phantom load, and to highlight (if up to code) this ability of a real GFI outlet to support a string of common $0.50 outlets. Best Regards, Lynn August Linse, Foothill Ranch, California lynn@linse.org

More GFCI

Dear Editor, The letter concerning GFCIs (ground-fault circuit interrupters) and phantom loads in *HP83* caught my attention. Ward Bower at Sandia National

Laboratories and I measured quite a few receptacle and circuit breaker GFCIs last year, including the Leviton model 801-6599. We were evaluating them for use with AC PV modules. None were found acceptable.

All of these AC GFCIs have an integrated circuit that monitors the AC hot and neutral lines for an unbalanced current that represents a ground fault. Any unbalance that is sensed over about 5 milliamps triggers the GFCI, which disconnects the output from the AC line. This electronic circuit is continually powered by the AC line (inverter output in RE systems).

I purchased a new Leviton model 801-6599 last week and tested it. The DC resistance between the hot and grounded neutral terminals was over 20 megohms, which might indicate a very low phantom load. I hooked it up to the AC output of a Trace SW4024 inverter and measured an AC current of 8 milliamps into the GFCI with nothing else connected. This indicates a phantom load (due to the internal circuitry) of about 0.96 volt-amps. I then used a Valhalla Scientific Inc. model 2000 Autoranging Digital Wattmeter to measure an actual real power draw of 0.87 watts.

In summary, the Leviton model 801-6599 does represent a small phantom load of a little less than 1 watt. I think that this small load is acceptable for the degree of safety provided by the GFCI. They have prevented many deaths from electrical shocks. John Wiles, Program Manager, Southwest Technology Development Institute, Las Cruces, NM • 505-646-6105 Fax: 505-646-3841 • jwiles@nmsu.edu

Jarring Note
I found a jarring note in the article by Dan Chiras *(HP82)* on phantom loads. He says “My natural gas-powered backup radiant floor system consumed an enormous amount of electricity.”

I don’t understand this. He is burning fuel and *not* cogenerating electricity? In thermodynamic parlance, we call this “losing availability.” When you are using natural gas to make low-grade space heat, there is no physical reason not to use a “topping cycle” to skim off some of the energy as electricity, and taking the waste heat for space heat. Anyone used to living on solar-electric panels would have all the electricity they could use as long as the furnace was required. Wasting the potential is foolish.

There must be people who are burning fuel in a furnace to heat air, and burning more fuel in a backup generator to make electricity while throwing away the waste heat from the engine. This is doubly foolish.

I’m sure that all *HP* readers have laughed at the silly people from San Diego who complained that the electric rates meant they couldn’t afford to take hot showers, while sunshine poured free heat onto their roofs every day. I laugh at the people who use fuel in a stationary application (like a furnace or generator) without getting the most out of it. Cogeneration isn’t renewable, but it is vastly more efficient than having someone burn fuel 100 miles away and throw away 70 percent of it as heat while you burn fuel to make heat and buy electricity to move it around.

Cogeneration is a key to making renewables work. Because cogeneration makes electricity at the same time as other things, it forces systems to be interconnected. Interconnected systems are “omnivorous”; they can run from renewable energy whenever it is available, or from other supplies when it is not. This creates a guaranteed market even for irregular supplies of energy, without which renewables are not likely to succeed. Russ Cage russcage937362@yahoo.com

Hi Russ, Thanks for your good comments. How about writing an article on practical, small-scale cogeneration for Home Power? *Ian Woofenden*

Phantoms & CF Power Factor
Dear *HP,* After reading Dan Chiras’ article about phantom loads, I decided to test the idle current draw of my own GFCIs and smoke detectors. Readers may be interested to know that some brands are better than others in this respect. My GFCIs (Leviton brand) use under 1 watt, rather than 2.5, and my smoke detectors (Firex brand) use 6 watts, rather than 12.

Also, I doubt that any code requires a house to have fourteen GFCIs. It might be more accurate to say that there are fourteen locations requiring GFCI protection. Since a GFCI may be wired to protect additional outlets on the same circuit, careful design may reduce the number of GFCIs needed.

According to the 1999 *NEC,* the following locations require GFCI-protected outlets:

- Kitchen counters: minimum two dedicated circuits, therefore two GFCIs
- Bathrooms: minimum one dedicated circuit for all bathrooms, thus at least one GFCI
- Garages, outdoor outlets, basements, sheds, workshops, anywhere within twenty feet of a swimming pool, or within six feet of a sink or fish pond or similar wet location: no minimum circuit requirement, one circuit (thus one GFCI) could serve all.

So the bare minimum is four GFCIs. There may be other reasons why you don’t want to wire this way. The workshop may need its own circuit, for example. But for someone trying to economize on phantoms, it could be done.

On another subject, I have had a tirade brewing about compact fluorescent energy consumption for some time. It seems everyone, from the manufacturers to the government to *HP,* is convinced that they are four times as efficient as incandescents. I have long wondered why a manufacturer is permitted to label a bulb as using 15 watts when it actually uses closer to 30. The Lights of America 15 watt Twister, for example, has fine print at the bottom reading "15 watt/0.25 A." 120 volts x 0.25 amps = 30 watts. I have tested one with my Fluke 87, and the calculated figure comes much closer to the truth than the advertised figure.

I stopped wondering today, after receiving my new Brand Electronics 4-1850 power meter in the mail. I used it to test several appliances and some compact fluorescents. Strangely, the Brand meter showed the 15 watt Twister to be using 14 watts, which is within the meter's tolerance of the bulb's advertised wattage.

I scratched my head for a while, then read the Brand instruction manual again. It said that the meter measures "real watts," regardless of power factor (PF). Could the Twister (and most other CFLs) have a PF of 0.5? I had heard that some electronic ballasts have poor power factor, but I had no way of measuring it until now.

Power factor, for the benefit of readers who don't already know, is an inefficiency in AC circuits caused by the "time lag" between voltage and current waves. The greater the lag, the lower the PF. This isn't exactly a scientific definition (maybe Ian has one?). PF is expressed as a ratio of true power (watts you can actually use) to apparent power (line voltage x line amps). A purely resistive load, such as an incandescent bulb, has a PF of 1.0 (perfect PF). An induction motor might have a PF of 0.7, or perhaps 0.8 if it's a high efficiency motor.

So a CFL with 15 watts of "true power" puts out as much light, more or less, as an incandescent with 60 watts of "true power." This would not make the CFL four times as efficient, however, since its PF is 0.5, while the incandescent has a PF of 1.0. At best, the CFL is twice as efficient.

To prevent confusion (which is inevitable in any case), engineers express pure power factor loads in watts, and impure loads in volt-amperes, or VA. This is why transformers and generators, for example, are usually rated in KVA.

So what does this mean for the user? Well, for the grid customer who measures his or her energy use in dollars, maybe not much. If utility customer meters measure only true power, which I believe they do, your meter will say you used 25 percent of the power you would have used for incandescents, and you will be charged accordingly.

On the other hand, if you are off-grid, you should be aware that as far as your inverter and batteries are concerned, 15 watts is not really 15 watts. What matters is the actual current draw, so get out the ammeter.

Power factor is not a concern in DC circuits, so for those with smaller systems, I would say that it is best to stick with DC CFLs. These really are four times as efficient, and you also eliminate inverter losses.

This also calls into question the claims about how many power plants we could shut down if everyone were to use CFLs. If people are using true power in their calculations, they overestimate grossly.

That said, I use CFLs exclusively. During the summer, they probably are four times as efficient, once you factor in the reduction in waste heat that air conditioners must remove. They are the wave of the future, so everybody might as well start using them now. Thank you for publishing such a wonderful magazine. Eric Kay, Austin, Texas • waxyak@yahoo.com

Hi Eric, Power factor is confusing. But it is not true that off-grid users are having to supply compact fluorescent lamps with twice the rated power. The inverter has to deliver twice the AC current, but a good inverter can do this without drawing twice the DC current from the battery.

What is going on? There is twice as much current sloshing around in the AC circuit, but it is not delivering any more power, because of the timing. Some of the time the load is actually feeding power back to the source, because the direction of current (flow) reverses at a different time from the direction of the voltage (push).

The higher current means more loss in the resistances within circuits, transformers, fuses, and everything involved in power transmission, but it does not have to mean you are using much more energy from the source (battery, wind turbine, solar panel). A bad power factor lowers the efficiency of the system slightly, but a good system will cope well. "Real power" (W) is real power and "apparent power" (VA) is actually only apparent. Check on this by measuring the actual current from the battery when you are using some of these lamps. Hugh Piggott • hugh.piggott@enterprise.net www.scoraigwind.co.uk

Nix on Manufacturer Input to NEC
Steve Willey responded to *Code Corner, HP81* about using aluminum wire for DC. And John Wiles then responded to that with, "We may need to put some sort of advisory (not a requirement) in the code if we can satisfy any objections raised by the cable manufacturers." If the *NEC* is supposed to protect the public, the cable manufacturers shouldn't have any say in it. Homer Welborn • HomerWelborn@worldnet.att.net

Hello Homer, The code is not only implemented to protect the public, but to protect the operators and maintainers of electrical systems. There are always tradeoffs to be made when requirements are added to the NEC. *They involve costs, complexity, availability of materials, components, systems, and most important—safety.*

As I have stated on many occasions, the code is formulated by the electrical products manufacturers, the electrical inspectors, electrical users, Underwriters Laboratories, IEEE, the national labs, the insurance industry, and a host of others. Documented, substantiated, proposals submitted to the NFPA are carefully reviewed over a three-year cycle by all interested parties.

All of these parties carefully review the proposals and jointly decide whether the safety concerns outweigh the costs associated with implementing the proposal. There are two review and comment periods available to the public, and the inputs on each proposal may be numerous. There are few "knee-jerk" requirements that get into the code. Thank goodness for that—it is big enough as it is. John Wiles • jwiles@nmsu.edu

Homer, Actually, getting the manufacturers' input might be a very good idea. Here's why: While the folks that write the code don't exist in a vacuum, they are not, by and large, wrenches. Their opinions and interpretations are based more on theory than experience. A pity, but there it is. The cable manufacturers, in this case, respond to market pressures. Wrenches buy their products. If they don't give the wrenches what they want and need, they go out of business. So in a roundabout way, involving them in the process brings in some wrench input as well, which is a good thing. Bob-O Schultze • econnect@snowcrest.net

Interested In Helping With Guatemalan Solar?
Hi Richard, I really enjoyed the article on the homebrew biodiesel in Humboldt. Here in Thailand, villagers have been mixing coconut oil (20 parts) with kerosene (1 part), and can burn it directly in diesel engines! Apparently coconut oil is pretty light already and doesn't need the esterfication process.

See the letter below—This gentleman really wants someone to come down and check out the scene and guide this project from a technical viewpoint. People with Home Power *technical skills are in high demand in developing countries! Cheers, Chris Greacen cgreacen@socrates.berkeley.edu*

Uaxactun is an 80+ year old village in Peten, Guatemala. There are 140 families, 65 with solar-electric panels already on their houses (for 2-1/2 years now). This is a very conservation-minded community. They manage 83,558 hectares of Maya Biosphere Reserve as a biological corridor in the heart of the Maya Forest.

American oil companies and the Guatemalan government are pressuring development, starting with "social development" in the form of a water pumping project, which the villagers want, but which is being stalled because the villagers are fighting planned petroleum/military development nearby. So, the villagers want to finish the water pump themselves, with solar (they have a generator option, but would rather stick with renewable energy). *And* they want to go further and become a fully solar-powered community (they'd like modest household lighting and electrification). Development is coming, and they want to shape how it happens to them. And they want to go solar! Contact Roan Balas McNab, Wildlife Conservation Society, Guatemala Programs 502-926-0569 • wcspeten@secmas.gua.net

I'm On Your Side...
I too am of the opinion that small-scale RE systems can meet the needs of society. If we follow the example of the Internet, we'll network all these small clean systems and get a green grid. Pretty cool. Let's change the world one house at a time.

Now on to what really sparked this letter. I was reading the April/May 2001 issue downloaded from the Web and couldn't get past the first few paragraphs of "Both Sides Now—Hybrid Vehicles." I was certainly glad to read "(Author's note: This reflects the somewhat cynical opinions of this writer, which are not necessarily those of *Home Power* staff and management.)"

Until battery technology is quick to recharge (say 5 to 10 minutes) and they are made of less toxic stuff than lead, nickel cadmium, or other more exotic materials, I think the hybrid is the answer. I commute to work, a 220 km round trip in a country that has no high speed rail (Canada), so here are my requirements for a practical electric car. I could take the bus, but it is too expensive; there's something wrong when I can drive my car for less than I can ride the bus with 45 other people. Oh, I drive a diesel VW for a commuter, and I carpool.

For me, an electric car must be able to drive at 100 km/h for an hour and a half in -20°C temperatures. It must be able to do this with the headlights on, and provide heat for the interior as well as power for the rear defroster. While I'm at work, the vehicle will sit in a parking lot (with no electricity available) for eight hours at -10 to -15°C), after which it will be called upon to make the hour and a half trip back home under the same conditions. Today's battery technology just is not up to this kind of task.

It is unfortunate that not everyone lives in a year-round warm climate with plenty of sunshine, so truthfully, an all electric vehicle for the mass market does not seem practical, yet a hybrid works quite nicely. I'd *love* to be able to drive an electric vehicle to and from work, generate my own power to re-fuel it, and make my life a lot less expensive, while at the same time keeping things green. One must keep in mind that an electric vehicle today simply offloads the emissions to the grid, which is powered (for the most part) by nuclear, natural gas, coal, or hydro.

I have to tell you that I am also a car buff—sorry, I love them. Making them green and keeping them fun would be a hoot. I drive a diesel to work, but I also own a V-8 Firebird and I'm amazed at its efficiency. Yup, you read it correctly—an efficient V-8 muscle car. Look at the VW and Firebird side by side.

Car Efficiency Comparison

Make & Model	*Fuel Type*	*Horsepower*	*MPG*
VW Golf	Diesel	52	47
Pontiac Firebird	Gas (92+ octane)	305	35

The mpg to power ratio puts the Firebird *way ahead* of the Golf, but the Golf can burn biodiesel (something I'm experimenting with) and its (dino) fuel costs 66 to 69 cents a litre... about CDN$3.00 an imperial gallon on average compared to the Firebird's 84 to 89 cents a litre. For the V-8 to cost the same to operate as the Golf, it would have to get around 70 mpg!

Overall I love *Home Power* magazine, keep up the good work. Now I'm going to try to get past the author's bias and see if there's any salvageable info in that article. Kindest Regards, Stephen Bungay sbungay@ionsys.com

Hello Stephen, I'm glad you were interested in the Honda Insight article, and I hope you read the Toyota Prius article in the next issue as well. If so, you found that I agreed that hybrids serve a useful purpose for some situations. You certainly are a perfect example of a driver for whom a hybrid would be an excellent choice, due to your long commute.

As for issues of battery toxicity and power plant emissions... funny you should mention them. I just happened to address those topics in my article in this issue (see page 98). I also notice that, as I mentioned in the hybrid articles, you are one of many households that have multiple cars. Perhaps one of your fleet that is used only for local errands could be pure electric. Biodiesel is also an excellent alternative.

No, electric cars cannot fill everyone's needs all the time. But there are a huge number of vehicles on the road that could be pure electric, without cramping the owner's style in the least. If we only replaced those cars with electrics, it would make an enormous difference in our air quality and our petroleum dependence.

By the way, since you are in Canada, I hope you will contact the Vancouver Electric Vehicle Association listed in the Access section of my article in this issue. Even if you live on the other side of the country, they can supply useful information, and may be able to put you in touch with an EV club near you. Shari Prange electro@cruzio.com

Hi Stephen, I have two major disappointments about the two "hybrid" vehicles on the market. First is that they are completely gas powered. You cannot plug these cars in. It would be nice if you could use RE or even grid electricity for battery charging, since it is both cleaner and more convenient. Second is that the electric component is so minor. The Prius' battery is only 110 pounds, while the Insight's is half of that. These are small battery banks, so they primarily offer a "boost" to the car for acceleration and some slow-speed operation with the Prius. However I look at it, these "hybrid" designs seem to be completely stacked in favor of non-renewable fuel use.

These new vehicles are certainly a step in the right direction, but I don't see it as a big enough step. But, it's not an either/or situation. We can have these types of vehicles and *pure electrics, since there are many different needs to fill. Ian Woofenden*

Lightning and Boilers

Richard, I just noticed your comment in *HP83* on page 142 on boiler systems, and page 151 on lightning problems. I have short comments on those two topics to share experience and opinions that are exceptions to what you stated.

On boilers, those I have encountered have been bad phantom loads, though one was possible to modify by using a line voltage thermostat on the AC side of the transformer. But the boiler does not store water, so there is an extra pumping stage plus the control loads that makes them electrically inefficient. Of course, a good quality tank style gas water heater eliminates all the electrical problems of the boiler, but trades them for inefficiency of BTUs going up the stack.

On lightning, my experience says that systems with buried wires have the *most* lightning damage to inverters and sometimes charge controllers. Wires going underground to PV, or underground AC wires to outbuildings always seem to be present in lightning damaged systems. We recommend placing the arrestors on these wires where they enter the power room. It seems that a lightning strike to a tree will send emf ripples centrifugally outward like ripples in a pond, and a wire parallel to those lines will pick up the inductive pulse. In fact I have seen the sparks jump out the ends. Systems with modules on the building and no outbound wires at all have to suffer a direct hit to be damaged. That said, lightning—being unpredictable—will prove us both wrong.

And a request: I have long been sending folks to the California state energy Web site for comparisons of efficiency for appliances like refrigerators and freezers. They seem to have cancelled that page now, and I find more difficult to use data at www.energy.ca.gov/efficiency/appliances and also www.energystar.gov/products in spreadsheet form. Is this the best you know of presently?

Finally, thanks for the guide to RE incentives at www.homepower.com/stateincentives.htm—it's just what customers need. I will be promoting that in our next Backwoods newsletter. Steve Willey, Backwoods Solar Electric Systems • steve@backwoodssolar.com

Hello Steve, Thanks for this information on boilers and lightning. I totally agree with you on the fickle nature of lightning. My experience with buried conductors has been the opposite of yours. Perhaps this has to do with soil composition and moisture content. The more I hear from others about lightning damage, the more I realize that our understanding of lightning is akin to the parable of the five blind men describing an elephant.

I find the best source of info for efficient appliances is: American Council for an Energy-Efficient Economy (ACEEE), 1001 Connecticut Ave. NW, Suite 801, Washington, DC 20036 • 202-429-0063 info@aceee.org • www.aceee.org Richard Perez

Guerrilla Inverters Still Available

Dear friends of guerrilla solar, I have heard of lots of disappointment in our world of rebel solar because Trace Engineering is no longer selling their MicroSine inverters. These little units allowed guerrillas like us to slap together a 100 watts of modules, stick them in the sun, and plug them into our household circuits, for our own use or to turn the meter backwards. They are safe, and they work pretty well. It is too bad that Trace stopped selling this great little tool.

But the very same OK4U-100 inverter is still being manufactured by the maker in The Netherlands, and is still available. They have about 1,000 in stock that carry the original UL listing. And once those are gone, the newer units' safety is still certified by the strict European CE and by the Dutch Kema Keur rules. They are also still making the OK485 computer interface to allow monitoring and fine-tuning of the inverter's operating parameters.

They can be ordered individually or with price breaks for greater numbers directly from the manufacturer. Shipping to the U.S. is no problem. To order or get pricing information, call, write, fax, or email to: NKF Electronics B.V., PO Box 415, NL-2800 AK Gouda, The Netherlands • +31 182 592 497 • Fax: +31 182 592 123 Diederik.Jaspers@nkf.nl www.nkf.nl/electronics/photo.htm. Sincerely, Maka Rukus & Jenny Freely, solar guerrillas

Net Metering Help for Missouri

Dear Michael, I live in a state that I believe could care less about renewable energy. Missouri has no net metering law, and I would like to start writing some of the representatives in my state to encourage them to pass the laws I need. I want to have my own grid intertie system and keep my electric company from messing with me. I've looked at the net metering link on your Web site, and I've seen what some states have and what others are proposing. I don't know the politics and what's fair between me and my utility. I figure this is something you guys talk about all the time. What I'm wanting is for *Home Power* to tell me what I should propose in my letters so I can help the energy-conscious in my state who have my interest, but who will never write a letter. Can you help me? Donald R. Culver, 15448 Old 40 Hwy., Higginsville, MO 64037 jiami@ctcis.net

Hello Donald, We are printing your letter so that others in Missouri can contact you and help out. A good resource for net metering laws is Tom Starrs 206-463-7571 • kelstar@nwrain.com. Michael Welch

Alastair's Desulfator Circuit

Hi Richard, Alastair Couper has suggested that I get in touch with you to let your readers know that parts kits are available for his battery desulfator (see *HP77,* page 84 or www.shaka.com/~kalepa/desulf.htm). I've modified the linked circuit to use a programmable micro controller—a "Stamp"—to drive the FET. The BASIC Stamp 1 is a small computer (about 4 times the size of a 555 timer chip or a 28 pin DIP) that runs Parallax BASIC (PBASIC) programs. The BASIC Stamp is programmed via a custom cable that attaches to your computer's parallel printer port.

I sell the parts kits for both the original and Stamp-driven circuit for those folks having a difficult time finding the parts (see www.shaka.com/~kalepa/desulfparts.htm).

Motorcycle batteries seem to sulfate just by looking at them. I have saved a ton of money desulfating motorcycle and UPS gell-cell batts using the original circuit. The Stamp is a bit easier for most folks to set up. I am currently developing a battery analyzer (conductance testing) using the Stamp and a small part of the desulfator circuit: www.shaka.com/~kalepa/gbook.htm. The Stamp is a hoot to play with. Have fun! Don Denhardt, Clinton Township, Michigan • ddenhardt3@home.com

Solar Clothes Dryer to the Rescue

Hi, Richard, My daughter-in-law just dropped off the Feb/Mar and Apr/May issues of your magazine. I hadn't looked at one for a while, and I was very impressed with the quality of your information and everything else. Good work. I especially was impressed by the article about passive cooling in hot, humid climates (although there is obviously a lot more to be told in the next issue). It was an excellent primer in the basic physics of energy, heat, etc.

In the Feb/Mar issue, you wrote, in *Ozonal Notes,* on the subject of infrastructure, and how we will eventually produce a lot of our energy with PV, but with the utility companies still being involved in transmission. You also mentioned that, eventually we could use some of this solar energy to produce hydrogen, which could then be used in pure hydrogen fuel cells for those times when the sun isn't shining. I agree with this idea; however, I also think that, in the short term at least, perhaps the problem of no insolation at night could be overcome by storing energy by pumping water up to storage sites during the day, then retrieving the energy by running the water back through turbines for nighttime production. If we put storage facilities at a high enough elevation above the pumps and turbines, we could minimize the size of the storage facilities.

Another thing: recently on the Jeff Golden show on NPR, a man called in, and claimed that if everyone in California stopped using their clothes dryers, there would not be an energy "crisis." Nothing else. I strongly suspect this to be true. Flash—I just went to your PDF on load calcs, where your two example families each run their clothes dryers for four hours per week. The loads given in your example were for a gas dryer, I guess. I didn't see any figures for electric clothes dryers on your site, so I found a number on another site: 4,350 watts. This seems reasonable; a dryer circuit requires a thirty amp, 240 volt circuit. So if we assume there are 8,000,000 families in California, and all of them converted from electric to solar clothes drying, that would be 8,000,000 x 4.35 KWH x 4 hours per week = 128 gigawatt-hours per week.

Another way to look at it is, assuming that an average family uses 1 KW continuously, on average (a number I've heard kicked around, but can't confirm), then switching to a solar clothes dryer would save about ten percent of their total energy use. Rolling blackouts are only occurring when the "margin" at the power plants gets down to, what, 1 percent? This means that just the clothes dryer issue would give them plenty of margin to stop the blackouts, while we convert to RE sources.

I realize that everyone in California doesn't have an electric clothes dryer, but even if they have gas dryers, they still use a similar amount of energy. I also realize that there are a few brave souls who already use clotheslines, but as far as I can tell, we're a tiny minority. One of the callers on Jeff Golden's program said that he gets teased because he uses a clothes line! Another says that clotheslines are prohibited in her neighborhood.

I have another question: since California pays up to half the cost of a PV system, do you think it is prudent for us Oregonians to wait on purchasing a PV system until Oregon follows suit? After all, we're a progressive state, right?

Along these lines, do you know of any efforts being made to influence the Oregon Energy Department, or legislature, or governor to move in this direction? What can I do? Who should I write? Who should I *shake?* Great magazine you guys have going there. Thanks, Malcolm Drake, Grants Pass, Oregon • Jumpoff@echoweb.net

Hello Malcolm, I think your calculations regarding electric clothes dryers are right on target. In sunny California, a simple, outdoor clothesline is a real winner. I'm often distressed when I receive email from Californians living in subdivisions that prohibit outdoor clotheslines. Get a grip, folks!

I wouldn't hold my breath for Oregon to have a PV buydown program similar to California's—Oregon just isn't that rich. But Oregon does have some very attractive RE tax incentives. Contact Christopher Dymond, Oregon Office of Energy, 625 Marion St. NE, Salem OR 97301 • 503-378-8325 Christopher.S.Dymond@state.or.us

In terms of political organizing for RE programs in Oregon, contact John Patterson of the Oregon Solar

Energy Industries Association (OSEIA) john@mrsunsolar.com. Richard Perez

Electric Tricycle
Hi Richard, I liked the "Electric Tricycle" article very much *(HP83,* page 84); it gives enough detail to inspire doing your own not identical but similar design.

There is one thing that gives pause—the charger circuit. There is a shock hazard with this design, and whereas I'm glad to see that people are still winding transformers, this is an auto-transformer with no line isolation and where one side of the AC line is directly to the battery/motor. In the U.S.A., 220 volts is either side of neutral rather than one side being neutral.

Also, it is worth reminding people that they can die touching twelve (even four!) batteries in series. It only takes about 7 watts to kill you (locked up chest muscle). I hope no one gets hurt and we continue building stuff, but I continue to be concerned that *HP* doesn't seem concerned about publishing material that may be hazardous to inexperienced users without safety disclaimers. I want *HP* to continue to publish forever (Fuel Cells From Plastic Wrap?).

In this particular article, the charger isn't a requisite part of the fundamental design. On the other hand, I'm wondering where all these cheap Chinese drills are (grin). Anyhow, thanks for the wonderful magazine! Premena • premzee@juno.com

Hello Premena, You are correct, the autotransformer design carries with it a shock hazard. Folks either buying or winding their own transformers should use models with fully isolated windings, not autotransformers. My apologies for letting this slip by in print without warning folks. Richard Perez

Hydrogen Technology
Thanks for a great magazine. I have subscribed to *Home Power* since issue #2, and all issues since are part of my library. I have gained most of my knowledge about alternative energy by reading *Home Power.*

I live on a farm (off the grid since 1992) in central Portugal. I have a 2.6 KW solar-electric system that supplies all the electricity for my two houses (one is a guest house). The energy is stored in two battery banks of 900 amp-hours and 1,850 amp-hours. I also have a backup generator, but I have only used it for 800 hours in nine years. Keeping in mind that it is cheaper to save energy than to produce energy, I only use energy-saving lamps, and always buy the most energy efficient appliances I can find. My houses have all the modern amenities like any house in the city. I also have a submersible pump, which lifts all my water from a 70 meter deep well. So far, I always have had enough electricity, even in winter.

This winter it was a different story. It started raining in early November and it did not stop until the beginning of this month. We had storms and floods in Portugal unknown in the history of this country. In six months, there were only fourteen days of sunshine. My solar-electric system survived this extreme weather, but my diesel generator broke down. For the first time, I experienced an energy shortage.

The experts say that this extreme weather is only the beginning, and that it will get worse. We have to live with this kind of weather extremes in the future—the consequences of global warming. It seems that the climate change is accelerating. Higher temperatures mean more evaporation. The more water goes up, the more comes down. Higher temperatures also mean more heat radiating from the surface, creating more powerful storms.

If there is no sunshine for six months of the year, I must reconsider my energy supply. I have no stream nearby and therefore no hydro power option. I live in a valley and I cannot make use of wind power. In the summer months my two battery banks are fully charged at around 11:00 in the morning. If only I could store all the electricity that I could harvest after 11:00, it could be enough for the long winter.

The answer could be hydrogen storage and fuel cells. How long will it take until I will be able buy the necessary hardware, as I now buy charge controllers, inverters, and batteries? I would very much appreciate if you could run some articles about the availability of the hydrogen technology for home power applications. Best regards, Robert Kuchta, Tábua, Portugal kuchta@mail.telepac.pt

Hello Robert, We ran a fuel cell article in HP72 *and the situation has not changed very much since then. I wish I had a crystal ball and could predict when fuel cell technology would replace engine-generators as backup energy sources for RE systems. My best guess is that we are at least two to five years from this happening. Richard Perez*

***HP* Advertisers: Take Note**
Hello everyone, Today (5-1-01) I made the decision to put Hydrocaps on two flooded deep-cycle batteries in the solar-electric system that powers my ham radio rig. Naturally, I grabbed the latest issue of *Home Power* to find a friendly dealer for this product by going to their Web site.

Guess what? This simple task consumed more than one hour! And why did it take soooooo long for me to part with about $60 of my money? Because not too many of the advertising sites have enough brains to put search functions into their sites!

I and others are not going to spend stupid amounts of time wandering around in product listings and other trappings of a Web site. If your living depends on selling the various products of renewable energy, don't waste my time! Get smart! Review your site and make sure that the search function is right out front, or your site will not make it into my (and perhaps others') favorites folder. Bill Bowes, N7MOB, Federal Way, Washington solarham@hotmail.com

Todd Engineering $$
Howdy *Home Power,* I, unfortunately, purchased two Todd Engineering chargers last year. The chargers failed and the folks at Todd were real nice. They sent replacements and took a credit card number to guarantee the return of the defective units. I returned the units last year, and I thought the matter was closed.

I was wrong. They charged my credit card for one of the returned units. I tried for three weeks to contact Todd Engineering to no avail. Finally, I challenged the charge with my credit card company. Soon I heard from Todd Engineering's bank. They are out of business and the bank has taken over their accounts. They are charging everybody everything they can because Todd's problems also led to a huge debt that the bank wants repaid.

The person I spoke with at the bank was very nice and agreed to cancel the outstanding debt that they showed on my account. I suppose many of your readers have had similar problems. My main reason for sharing this information is to pass on the contact information for the bank. You cannot get through to Todd because they are gone. The contact is: Kenneth E. Lust, Vice President, Special Assets Manager, National City Bank of Indiana, Fort Wayne Office, 110 West Berry St., Fort Wayne, IN 46802 • 219-461-7404 • Fax: 219-461-7471.

Please pass this info on to your readers who might be pulling their hair out trying to get in touch with Todd Engineering. Please withhold my address because I don't want my whistle blowing to alter my status with the bank. Thanks. (Name withheld at writer's request)

To Light Our Darkest Hour
Greetings, I have been following *HP* since my interest in RE turned from fantasy to fact in 1991. Recently, I built a small 100 watt RE system to provide energy in the event of a blackout. Power outages are not common for Austin Texas. Usually when they occur, it's due to downed power lines from high winds. On May 20, we had a severe storm blow through our northeastern Austin neighborhood.

As many as 25,000 customers were without electricity. The darkness came across my block as power lines snapped in the 80+ mph winds. The only light was from the lights reflected from the city and the light in my house. Thank you *HP!* If it were not for your insightful magazine, I would not have been able to light our darkest hour. My system was assembled for less than US$500.

I would like to add on a sad note that the solar-electric panel I used in my system was taken from me by the high winds. Ironically, it was just after I read an old article on how to properly mount PV panels. Cheers, Thomas, Austin, Texas • tcthomas@hotmail.com

Greed
Richard, Renewables are great, but the California energy problem is a lot more about *greed* then it is about a real shortage of electrical energy. The PUC got us into this mess and I really doubt if they can get us out. Thanks for keeping *Home Power* available on the net. I hope you keep your advertisers informed of this unbelievable benefit. Mike, Vacaville, California quilters@telocity.com

Apartment PV Retrofit?
I've begun searching for any PV product or prototype that would work in an apartment building with excellent solar exposure. I'm envisioning a product like mini-blinds, with each blind turning sunlight to KWH (with or without battery backup). I have about 39 square feet of south-facing glazing, with no obstructions, and the same east-facing, for a total of 78 square feet. In spite of the view of Mt. Rainier from two windows, I often have to keep my blinds partially closed to block glare on computer screen. Also, if I return to working five days a week away from home, the blinds could be closed with no loss of light or view.

Is there anything like this under development? I would be happy to cooperate with product developers if they need a test site. With more than fifteen years experience in energy efficiency and renewable energy (including solar site survey thirty years ago), I would be a conscientious product tester. Of course, I would prefer that the building owner take advantage of the electric utility's 70 percent loan to weatherize this 1912 building, and then go a step further and add solar rooftop panels. But she has not responded to the info package I provided. Therefore, anything I can do with the interior of my apartment that does not violate the tenant/landlord contract would be my next best option.

It seems to me that window washers and mini-blind cleaners would be proactive on any emerging product that turns window treatments into solar collectors. Looking forward to reading an article in *HP* if the industry is already heading this way. Thanks. Dulce Setterfield • local.global@home.com

Hello Dulce, Several PV manufacturers, notably BP, are developing semi-transparent photovoltaic glazing. These thin-film products are being very slowly introduced into the commercial, building-integrated PV market. There are no similar products on the near horizon for the residential market. And if and when they do arrive, they'll probably be in the form of window glazing. So installing the systems will mean replacing the windows—not a solution for people in rental situations.

I'd suggest approaching your landlord again about a rooftop PV array. With all the energy issues in the news, they might be more willing to work with you. If your building has a flat roof, the array could be ballasted (weighted down) and the roof membrane wouldn't even need to be penetrated. I've been thinking about writing an article detailing the status of building-integrated photovoltaics. Thanks for your input. Joe Schwartz

Voltage Drop

Dear *Home Power, Code Corner, HP81* dealt with sizing wire for a small simple system. As usual, Mr. Wiles did a very thorough job of explaining the issues and showing sample calculations. As sometimes happens, I would reach a somewhat different conclusion. I'll lay out the issues as I see them.

1. I agree with John that 5.5 volts drop (23%) on a 24 V RE system is way too much.
2. John describes what I think is more accurately called a 34.6 volt system, and not a 24 volt system, based on the peak power point (per ULCI703) and no battery, with a 24 volt load (motor/pump).
3. Using John's calculations, the 5.5 V drop (using peak power point as John did) leaves us with 29.1 V at the motor—over 21 percent higher than nameplate. If the 2 percent drop is used, the motor will see about 34.1 V—about 42 percent higher than nameplate. On a clear cold winter day, the voltage could be higher yet, while a hot hazy summer day reduces the voltage. As an engineer who has worked with two different motor manufacturers, this concerns me. Most 24 volt motors should work just fine up to 28 volts or so, with higher voltages resulting in reduced life. Check the motor/pump information. Many solar pumps will work PV direct with up to 30 volts. Higher PV current output can be achieved under some conditions, but it would be very surprising to end up with a low motor voltage under high current conditions.
4. Depending on the type of motor and pump, the higher voltage can result in short motor life due to higher loads at high speed, brush arcing and excessive wear, and a host of other factors. High voltage, and hence high speed, can also quickly wear out some types of sliding vane and diaphragm pumps. Under low light conditions, the power available can drop substantially, stalling out the motor.

So what do we do? I would recommend using a #14 cable. With more information on the motor than is given in John's prelude, we could fine tune this. A lower rated motor current than 4.33 amps might convince me to use a #16 control cable, if this was my own system.

The user should talk to a local RE dealer or electrical supplier. They can probably obtain a suitable cable, or may suggest a conduit from the panels to the ground to eliminate the need for sunlight resistance. The disconnect could then be located in a weatherproof box adjacent to the panels, with the transition from conduit to buried cable made at the junction box. Low temperature (60°C) wet-rated wire can be used from the box to the pump. Your final purchase may involve a linear current booster. That will keep the pump pumping under conditions that may not normally allow the pump to operate. I'd much rather see the few hundred dollars spent on an LCB than heavy wire—I believe you'll get more water for your buck!

One last issue from the article I'd like to clarify involves grounding. In the same *Code Corner* column, John unintentionally suggests that the negative "may be" attached to the ground rod at the PV, and "will be" connected to the ground rod at the pump location. In general, I suggest avoiding ground loops. I would ground the electrical system at one location only, if at all. I would not ground the negative at both the PV module ground rod and at the pump. Bonding both the module frame and pump to ground is a different issue. Patrick Cusack, Arise Technologies, Waterloo, Ontario, Canada

Hello Patrick, It is good to see these types of letters in Home Power from our friends in Canada. You raise some good points. It was not my intent to present information on designing a water pumping system, but to show how voltage-drop calculations are made. While my experience with PV water pumping is somewhat limited, I do not recall any limitations on the maximum voltage, other than the nominal system voltage (12, 24, or 48 volts). I have seen few discussions of voltage drop or high open-circuit voltages in cold weather. As the voltage goes higher (above 48 volts nominal) with the electronically commutated designs, I suspect that the *voltage range may be more carefully restricted. I'll leave it to the PV pump suppliers to discuss this in more detail.*

As far as the comments on wear and tear on conventional DC motors operating at higher voltages, I agree with Patrick's comments. We must keep in mind that many of these PV power pumping systems do not use conventional DC motors, but use solenoid types of pump drivers and electronically commutated AC motors. I agree again with Patrick—check with the pump supplier.

Copper is pretty cheap these days. Up-sizing the conductors should always be evaluated in a cost vs. performance tradeoff, keeping in mind that the upgrade is a one-time cost that must be balanced against the power and energy losses over thirty years or more. Power lost due to increased resistance in smaller copper conductors is lost forever. Even when a current booster is used, they too, can benefit from higher power inputs (less voltage drop). The output power (higher currents at lower voltages) of such a device will always be limited by the input power (usually at higher voltage and lower currents), minus any losses in the current booster. When the input power is reduced by wire losses, so will the output power.

Where the PV array is located some distance from the power electronics/battery/pump, it is acceptable to bond the negative circuit conductor to ground at the PV array and *at the power center, as long as no equipment grounding conductor or other metallic path is used between the two locations. This saves the cost of one conductor (the equipment-grounding conductor), and that money can be used to upgrade the size of the circuit conductors. See "Grounding the South 40" in* Code Corner, HP74 *and* NEC *section 250-32.*

I visited the local building supply store yesterday and found that all of their THHN was dual marked THWN-2 (an excellent conductor for use in conduit), and that the price of that wire was less than conductors with lesser ratings from other sources. In many cases, the larger production runs and demands in other industries for the better cables gives those of us in the PV world the opportunity to get the best cables at a lower price than would otherwise be possible. John Wiles, Program Manager, Southwest Technology Development Institute, Las Cruces, NM • 505-646-6105 • Fax: 505-646-3841 jwiles@nmsu.edu

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Ozonal Notes

Deja Voodoo

Richard Perez

On 24 May 2001, I received the following email from a *Home Power* reader:

"Hello again, Richard. Since I got your four Solar CDs from my son for Christmas, I have spent many hours reading the back issues. One page stood out today—HP22, *page 4, and I thought you might want to be reminded of it. Perhaps you could run it again and save yourself a little time! Reminds me of the old saw, "Like father, like son." Hope to see you at the MREA fair in June. Cliff Anderson, Brooklyn Park, Minnesota."*

I didn't remember what Cliff was referring to, so I pulled out a copy of *HP22* and looked. Here is a verbatim reprint of that editorial. We first printed it in the April/May 1991 issue of *Home Power.*

Bush's Energy Non–Policy for the Suicidal and Terminally Stupid

Bush's new energy policy assumes we are fools with a death wish. There is nothing new in drilling Alaska till it hurts, or in building more nuclear power plants. This is the same short-sighted BS that has gotten us in environmental trouble and into war. Let's look at the facts.

Sucking Alaska Dry
There really isn't that much oil in Alaska. How much? Well, look at it this way. Alaska contains less oil than we'd have saved by sticking with the EPA automobile mileage guidelines modified in the 1980s. When the government lessened these EPA requirements, auto makers stopped making more efficient vehicles. This one dumb move has consumed more than all the oil in Alaska. Drilling Alaska only postpones the inevitable, destroys Alaska, and pollutes us all in the process. We need alternatives to oil burning, not more oil.

More Nukes
No one is building new nuclear power plants. Nukes under construction are being decommissioned. The reasons for this are simple: One, no one knows what to do with the radioactive leftovers. Two, the nukes operating now are more expensive and have more down-time than any other type of power plant. Three, when the Washington Public Power System (WPPS) failed financially, it took the entire nuclear power industry with it. The third reason is what has really stopped nuclear power. The WPPS bonds (AAA rated municipals) went from valuable to worthless in a single day. No one will finance new nukes because they are financial disasters. Let us give thanks for small favors because if nukes were cost-effective, then we'd have to deal with their radioactive waste. And no one has the answer to that.

Something Else?
Yes, we want something else! We're tired of the same old dreck that is visibly poisoning our planet and picking our pockets. We're ready to do whatever it takes to give this planet a sustainable energy future. And here's what it takes.

Use Renewable Power Sources
Make power from sunshine, wind, and falling water. There are between 30,000 and 50,000 households now doing this in America. Home power producers have their own power company. No monthly bills, no blackouts, and no pollution.

Conserve Electricity
If you can't get your power from a renewable source, then conserve every watt-hour. Use efficient appliances. Turn off appliances when not in use. Be aware that the cost of grid power is much higher than your electric meter shows. Treat every watt like it will come back and bite you—because it will. Coal, nuclear, and oil power plants all extract a high price from our environment.

Drive Clean
Keep your vehicle in top shape. Drive only when necessary. Drive slowly. Keep your tires pumped up. Use an electric vehicle. Demand automakers produce emission–free vehicles. Then buy one and smile as you drive it.

A Green Dream
Green certainly, but this is no dream. Look at the articles in this issue alone. These are people who are living the Green Dream. Check out Huckleberry Homestead on page 6—they're doing it. Check out the electric car on page 85—they're doing it. If we just plain ole' regular folks can accomplish this on our budgets, then government and big business has no excuse. It's a dream until you decide to live it...

After reading this, I got slack jawed. Did I really write this ten years ago? I thought about opening up a hotline—call 1-900-Solar Psychic. Then I realized that I'm not psychic, it's just that nothing has changed in the U.S.A.'s energy policies during the last ten years. About the only thing out of date in that editorial is the number of RE users, which is well over 180,000 now. As far as our government's energy policy, it's the same old BS.

President Bush is following his dad's ten-year-old policies—more oil, more coal, and more nukes. Is this effective? Hardly. We are now having utility blackouts, and the price of gas is higher than it ever has been. We have train loads of nuclear waste waiting to cruise the tracks looking for a home.

Psycho-logic Dark Age Mindset

Jason Powell

A psycho-logic, Dark Age mindset
manipulates many of the two-leggeds

A psycho-logic, Dark Age mindset
masquerades as yet another emperor
wearing yet another new skin
In Washington, it's Bush 2, son of Bush 1
same stage, same storyline
more "family values"
from the family with killer connections
CIA, defense industry, big oil that is
NEW and IMPROVED!
sugarcoated (lines of junk)
ON SALE!
BUY NOW!

(The children watch)
puppets of politick play
hand in hand with priests of industry,
making war and drilling for oil
in the Garden of Eden

(The children watch)
the stewards turn junkie
pumping the juice
like a mainline habit
never getting enough,
even though it kills

Sin, sham, or shame,
what's the difference?

(The children watch)
a psycho-logic, Dark Age mindset
toasting tomorrows, as in burning futures
with clean air and clean water sacrificed,
blown away, as in wasted,
by the engines of profit and progress
who needs clean air and clean water anyway?

(The children watch)
a psycho-logic, Dark Age mindset
babbling on and on
blah, blah, blah
in crazed, grinning self-delusion
spewing a litany of garbage philosophy
"acceptable" levels of pollution
and "clean" coal brainwash propaganda
is the junkie's junk trying to shoot you
in the head
psycho-logic warfare

On sale!
Buy now, while supplies last!
hits of oxygen and plastic bottled water
(hey kid, get to the back of the line)
will that be cash or charge?
paper or plastic?

Bush's energy policy doesn't work and history shows this. It seems like the folks making real progress in the energy field are home power people—we've tripled in number in the last decade. What do we know that they don't?

PV Module Alert

If you are planning to buy PVs this summer, you may be disappointed. Demand for PV is now exceeding the supply. People are buying PV modules faster than they are being manufactured. This increase in PV sales is being driven by the recent utility blackouts.

In late May, I surveyed over 124 renewable energy dealers nationwide. I asked them how long it would take to get a PV module if they ordered it at that time. I also asked them if their businesses had grown within the last six months. Thirty-six dealers responded. They are waiting an average of two weeks for delivery of smaller PV modules, and an average of two months on modules larger than 85 watts. They also reported business increases from 50 percent to over 300 percent.

This clearly shows that many more folks are considering PV as an alternative to grid power. It also shows a need for more PV production to meet this increased demand. We need more PV dealers too, especially those who design and install complete systems.

Solar Energy Future

Bush's energy policy takes us back ten years into an instant replay of his dad's energy policy. This policy of increased coal burning, increased oil burning, and increased use of nuclear power didn't work ten years ago, and it won't be any more successful today. This policy is what has gotten us into today's energy shortages, high energy prices, blackouts, and environmental degradation.

While Dubya is stuck in the past, many Americans seem to have other ideas. They are buying photovoltaics faster than ever before. They see the bright future of solar energy, even if Bush cannot.

Access

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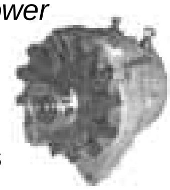

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Q&A

Homebrew Microhydro Problems
Hey gang! I've been trying to get a homegrown Pelton wheel to "pull its own" for the past three years or so by using a Delco alternator with various creative wheels attached to its shaft. It really zings along at about 55 psi with a quarter inch nozzle. But as soon as I activate the electromagnets in the alternator, it slows down so much that it just won't put out enough to actually charge my batteries. I get low volts and amps.

Of course I'm too cheap to buy real expensive parts, but is there a better permanent magnet motor to use, or a source for less expensive wheels you could suggest? Efficiency isn't my strong suit, at any rate. I get 10 amps in from solar, and in the winter I burn too much fuel. Anyway, I'm almost at the end of the creative, no spending stage, and thought I'd just ask. Thanks, Todd • toddcalvert@hotmail.com

Hiya Todd, First, you are probably using an internally regulated Delco. You need to rip that regulator out or get an externally regulated machine. Then you feed the field through a 25 Ω, 50 W rheostat (assuming you have a 12 V system). HP2 *has a schematic of a engine/generator set up this way. It's available on CD-ROM. Hydro works the same. Basically, you have limited torque produced by the water pressure and volume. You need to control the amount of current and voltage going into the field so you can keep the RPM up and produce some power.*

In a car, it's pretty much a full-on field or full-off field scenario. If the alternator needs to grab a few horsepower from the motor to do that, you never even notice. You haven't got *a few horsepower at your wheel. You could use a permanent magnet motor to eliminate the field problem, but you have to use an in-line diode to prevent draining the battery if the nozzle clogs or you run out of water. Also, you'll need to find a motor rated to run at 24 V* at least. *Higher is better. The Lil Otto motor, for example, is a 120 VDC motor. Unless you have scored an actual Pelton somewhere, your wheel is probably pretty inefficient as well. It all adds up, one way or the other. Good Luck, Bob-O Schultze, Electron Connection, Hornbrook, California econnect@snowcrest.net*

Computer Phantom Loads
I am a new subscriber and I'm at the research stage of implementing some renewable energy sources in my home. I'm floored at the wealth of information in *Home Power* magazine—thank you.

My first step is evaluating our usage and taking the necessary steps to get it down to a smart, comfortable, and affordable level for renewable sources (what gluttons we've become). I loved the article on phantom loads, and I'm discovering that every KWH conserved helps, but I have a question.

This may not actually be a phantom load because I know it's happening. But I have always heard that it takes more energy to turn a computer on and off if you use it every day (and I do, since I work from home as a Web designer/researcher) than if you just let it go into screen saver mode or sleep mode and turn off the monitor. Is that true? After reading the phantom load article, I'm wondering just how many KWH that sleep mode is sucking away night after night. Any information you might have on this would be greatly appreciated. Thank you. Trish Boyles, North Carolina trish@main.nc.us

Hello Trish, This is something we know a lot about because we run an office with six assorted computers, all powered by PV and wind. Without any doubt, you will save energy by completely powering down your computer when it's not in use. Exactly how much depends on your computer system, its monitor, and its peripherals.

The biggest energy consumer is the monitor. The newer "Energy Star" compliant monitors use less energy when "asleep" than the older monitors do, but they are still using some energy. The rule of thumb we have here is that if we are not going to use the computer for half an hour, we completely power down the monitor and put the remainder of the computer to "sleep." If we are not going to be using the computer for an hour, we power down the whole thing, including display and peripherals.

Pay attention to the peripherals. Their energy consumption will add up if they are left operational whenever the computer is running. So power down unused peripherals, especially printers. I have many of my peripherals (modem, removable media drives, scanners, etc.) on a separate plug strip, and I keep them powered down until I need them.

The idea that a computer system uses more energy to start in the morning than it would consume if left running all night is a myth. Richard Perez

Tires for Light Trucks
I read Shari Prange's article some time ago *(HP71)* on choosing tires for EVs. Her observations about rolling resistance should be applied to gasoline-powered vehicles as well as EVs. I have a light pickup truck and would like to put D-rated street tires on it. What should I look for to decrease rolling resistance in such a tire? Michael

Hello Michael, The "D" rating on tires means they can handle heavy loads. The good news, in terms of rolling resistance, is that the tire structure flexes less. The bad news is that the tires weigh more. Nobody is working on low rolling resistance tires in this category. There are a few things you can do to help your gas mileage, however.

First, if you don't need an aggressive tread for off-road or snowy conditions, stick to something with a "highway rib" tread, which means fairly straight grooves, not knobs. Second, run your tires at their maximum rated inflation. On D-rated truck tires, this is probably 65 psi. Shari Prange

Thermal Exchange

If a PV panel collects enough solar thermal energy during the typical summer day, what if a thermal exchanger could be incorporated to transfer this heat to the dwelling's hot water system? Many benefits could come from this: Your solar panels would run more efficiently as a result of their lower operating temperature. Your resource consumption in supplying hot water would be reduced, especially if this were in addition to other practices like a pre-existing solar and/or waste drain thermal collector. You would also conserve space by reducing the footprint of individual systems on the land or rooftop, to allow for either greater land cultivation or more room on the roof for expansion or other needed systems. Thanks again for your time, Chris Darul • re42@sover.net

Hello Chris. Over the years, several companies have tried to make a combination solar hot water collector and solar-electric collector. All failed. Here are some technical reasons why.

PV and solar DHW operate in different temperature ranges. PVs like to be as cool as possible, at temperatures far below what we would want for "hot" water. Ideally we would like to never see a PV's temperature go over 50°C, while this is just the beginning of the temperature range we need for hot water.

Expansion and contraction on any solar collector is a real problem. Electrical and plumbing connections work loose from expansion and contraction. To compound this problem, PV modules expand and contract at different rates and amounts from a liquid-based thermal collector. PV module encapsulation can be damaged by uneven expansion and contraction, reducing module life.

Combining PV and solar DHW into a single collector sounds like a good idea, and it is. We just don't have the technology to pull it off yet. Richard Perez

Solar Tilt Angle

We own a small cabin far away from the grid in Northern California, so we have decided to go solar-electric. Our estimated load is between 1 and 2 KWH per day. We are looking at six to eight 100 watt PV modules.

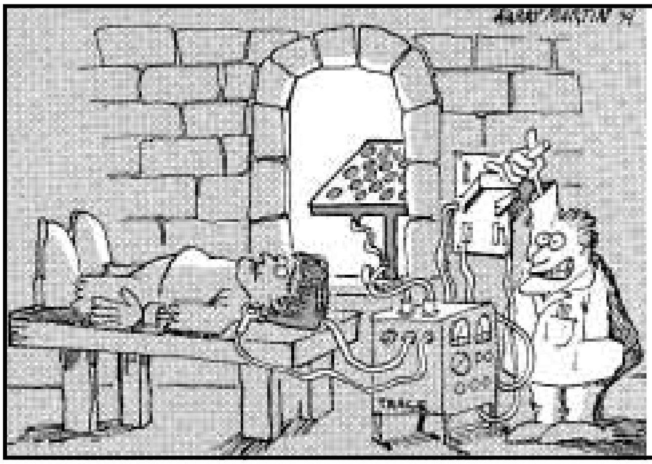
We want to mount our modules flat on our high-pitched, 55 degree roof. As I understand it, that pitch would be suitable for winter, but not for summer. My question is, what percent power loss can we expect from mounting at such an angle? Thank you, Harry Deemyad, Fairfield, California

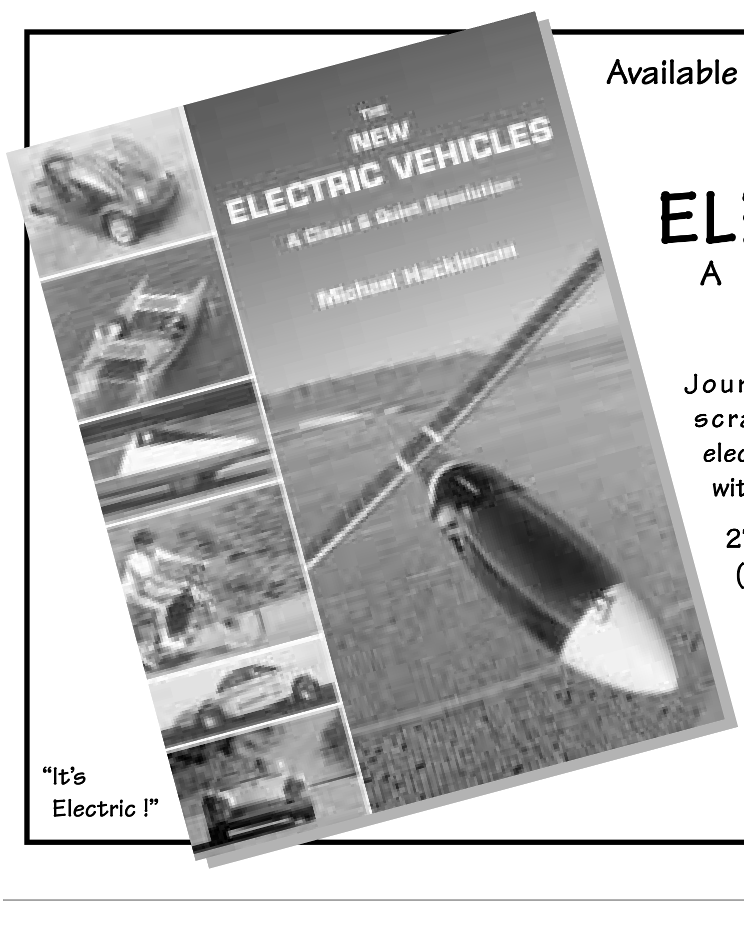
Hello Harry, Folks who manually adjust the angle of their PV arrays usually do it four times a year. For spring and fall, the array is set at the angle of the site's latitude. In summer, the array is set at latitude minus 15 degrees. In winter, the array is set at latitude plus 15 degrees. Check out Richard Perez's "PV Module Angles" article in HP36, *page 14 for a detailed look at array angles.*

Depending on the exact latitude of your cabin in northern California, 55 degrees is close to perfect for your winter PV angle (latitude + 15 degrees). When compared to seasonal angle adjustments, having your PVs fixed at this angle will result in approximately a 5 percent decrease in output in the spring and fall. In the summer, the decrease in output will be about 20 percent.

Correctly sized PV systems typically show a significant energy surplus in the summer. Since your array angle will be fixed, and assuming you're using the cabin year-round, having the PVs set at the winter angle is preferable since winter months are when the least solar insolation is available.

The reality is that people often leave their roof-mounted arrays set at the winter tilt angle. Adjusting roof mounted arrays can be inconvenient and dangerous, and adds wear and tear to the roofing material. Depending on your site, another option would be to pole mount your PV array. This will allow you to easily make seasonal adjustments. And because they are not mounted close to a hot roof surface, it will keep the PVs at a lower operating temperature, which increases their output. Joe Schwartz





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Michael Hackleman

Writing for *Home Power* magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small-scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your renewable energy (RE) experiences printed in *Home Power.*

Informational Content

Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough that our readers can actually use the information. Name names, and give us actual numbers, product names, and sources.

If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article.

Article Style and Length

Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible.

We prefer simple declarative sentences that are short (fewer than twenty words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power.* After you've studied a few, you will get a feeling for our style.

We edit all articles for accuracy, length, content, organization, and basic English. You can help by keeping your sentences short, simple, and to the point. Our editing crew will make your text shine.

Photographs

We can work from any photographic print, slide, or negative. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs, since the ink can transfer to the front of the next photo. Please provide a caption and photo credit for each photo. Include some vertical format photos—you might even find your system on *HP's* cover. People are nice in photos; a fuse box is only so interesting, even to solar nerds.

Digital photos should be at least 280 pixels per inch (ppi) at the final printed size. This means that a column width photo should be 1,000 pixels wide or more. A full page width photo should be at least 2,300 pixels wide. Basically, set your digital camera at its highest resolution, and crop thoughtfully. We prefer Photoshop files, but we can handle the following formats in descending order of preference—EPS, TIFF, and JPEG.

Art, Schematics, & Tables

System articles must contain a schematic drawing showing all wiring. Our art department can make gorgeous diagrams, charts, and schematics from your rough sketches. If you want to submit a computer file of a schematic or other line art, please call or email us first.

For system articles, we require a load table listing all loads, with wattage and run time. We also require an itemized cost table listing each system component and its cost. We prefer to have the tables come to us in Excel format. But we can use them from any word processor or spreadsheet format if they are saved as "text only," with tabs as the delimiter between cells.

Computer Talk

We can take text from most word processors. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use the "Save As Text" option in your word processor.

If you want to send files larger than 5 MB (such as digital photos), use removable media and snail mail it to us. We can read ZIP disks (either Mac or IBM) and CD-ROMs. You can also FTP your large files to us at ftp.homepower.com, to the "incoming" folder. Please let ben.root@homepower.com know after you have sent us files via FTP.

Putting it All Together

We get many more articles submitted than we can print. The most useful, specific, organized, and complete get published first. Here are the basic components of a great *Home Power* article:

- Clearly written, well organized, and complete text, with a strong introductory paragraph, subheads for each major section, and a strong closing paragraph.
- Photos (plenty) with clear captions.
- Cost table.
- Load Table.
- Other tables, charts, and diagrams as appropriate.
- System schematic.
- Complete Access information for author, installers, consultants, suppliers, and manufacturers.

Have any questions? Give us a call Monday through Friday from 9 to 5 Pacific and ask. Or send e-mail. This saves everyone's time. We hope to see your RE project in *Home Power* soon!

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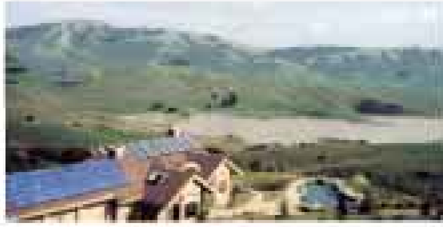

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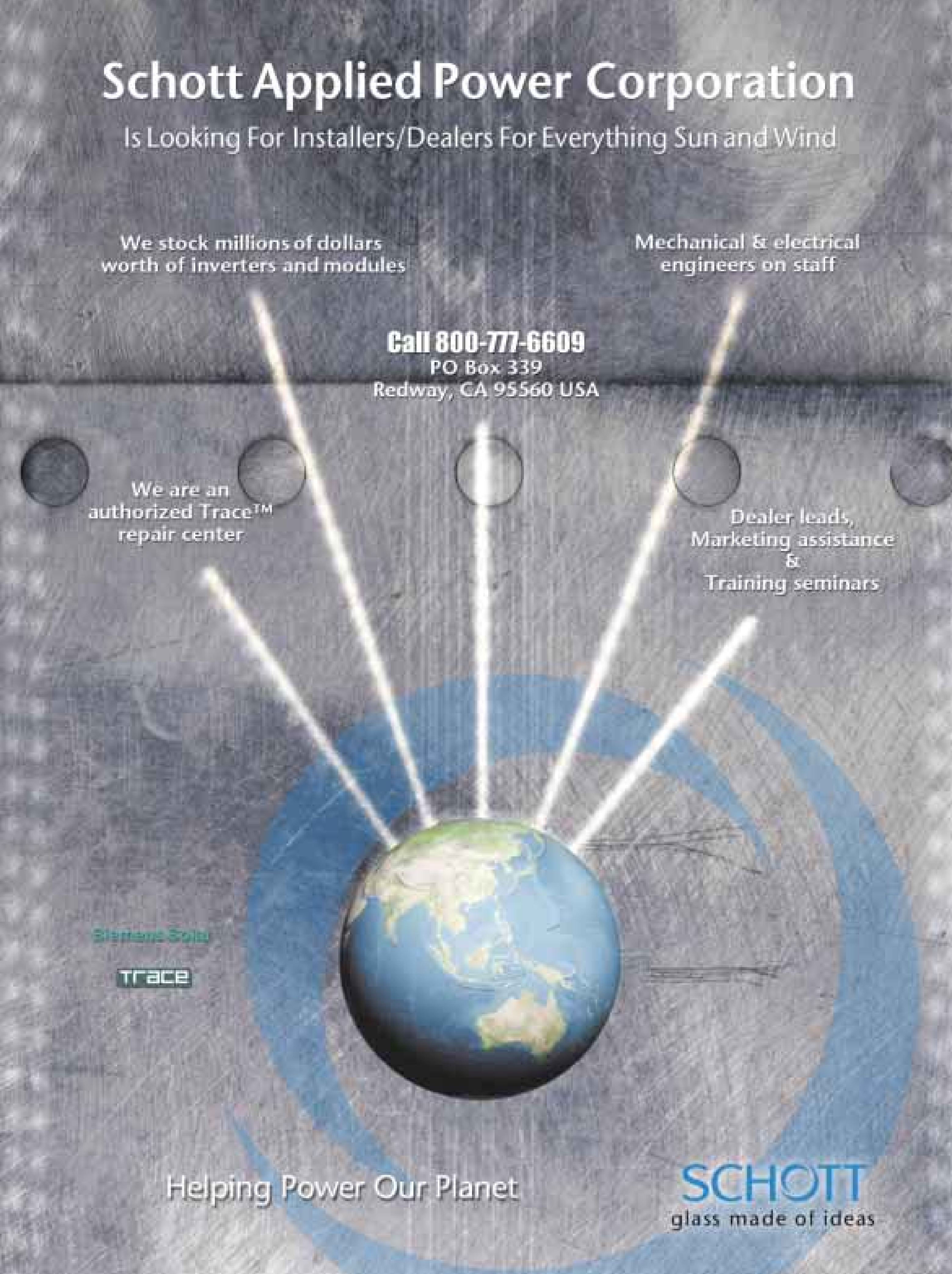
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- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
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- ☐ Recreational electricity (RVs, boats, camping)
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The GRID: (check all that apply)

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

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