The BP Solar

advantage

Premium Performance Crystalline

Laser Grooved Monocrystalline

- World leading efficiency—ideal for maximizing power and reducing installation cost
- Market leading energy generating kWh/kWp performance demonstrated in third party tests
- Leading commercial laser cell processing provides a power boost over other technologies
- Superior power tolerance
- Standard 25 year power warranty and 5 year materials and workmanship warranty.

Performance Crystalline

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- Specialized frame and voltage options for small modules
- Standard 20 or 25 year power warranty.*

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Premium Enhanced Multicrystalline

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- Excellent efficiency and reliability through enhanced cell processing technology
- Superior power tolerance
- Attractive dark frame appearance
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Advanced Millennia™ & Apollo®
Thin Film Technology

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www.bpsolar.com

* Modules 50w and below have power warranties of 20 years or less.

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Features

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Cover: A classic Jacobs 2,500 watt wind generator atop its 65 foot tower. Photo by author, Peter Kuebeck.

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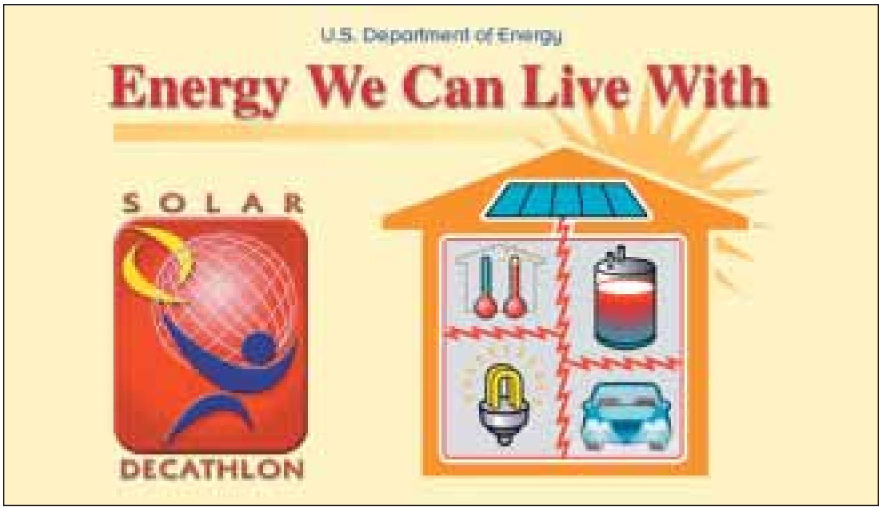

A Race Worth Running

A sharp student from Crowder College in Neosho, Missouri gave us this tip. The U.S. Department of Energy (DOE), with the National Renewable Energy Laboratory (NREL) and several private-sector sponsors, is holding a Solar Decathlon for college students. Unlike the nuclear arms race, this government contest is a winning situation for everyone.

In September 2002, fourteen college teams will converge on the National Mall in Washington, DC to construct the Solar Decathlon Village. Participants will compete to design the most effective solar powered house. This decathlon, like the athletic event, has ten contests that measure decathletes' abilities to capture, convert, store, and use enough solar energy for a modern lifestyle.

The homes will be a living demonstration laboratory, open to the public through October 9. The 500 to 800 square foot (45–75 m^2) buildings will be dismantled after the event. Crowder College's entry is being auctioned off, and will be delivered to the highest bidder by Christmas.

Each home must provide for space heating and cooling, refrigeration, hot water, and lighting—all done with design and livability in mind. Typical energy needs to power personal computers, televisions, fax machines, and other electronic equipment used in a home business must also be satisfied.

To simulate real life, teams will be required to cook three meals for seven people, store foods under adequate refrigeration, and even wash a load of laundry. Each team will be provided with a Th!nk Neighbor EV, which they must use to get groceries and deliver items to a local soup kitchen. The teams will be judged on how much "extra" energy they can generate to get around town in their EV.

The outcome of the contest will be decided by actual measurements of energy production and use. A distinguished panel of architects and solar energy experts will evaluate this, as well as each team's integration of aesthetics with technology.

Each team started with a US$5,000 grant from the DOE. All other funds to design, construct, and transport the houses to Washington, D.C. must be raised by the teams. In addition to designing and building their demonstration homes, the teams must effectively communicate about solar energy and energy efficiency by producing a Web site, newsletters, and outreach materials, and by conducting tours. Links to the team Web sites are on the DOE Solar Decathlon site at www.solardecathlon.com.

The Solar Decathlon's motto is "Energy we can live with." This team effort to promote renewable energy is something we can do more than just live with—we embrace it.

—Linda Pinkham for the *Home Power* crew

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Benjamin Root
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Dave Wilmeth
Ian Woofenden
Rue Wright
Solar Guerrilla 0020

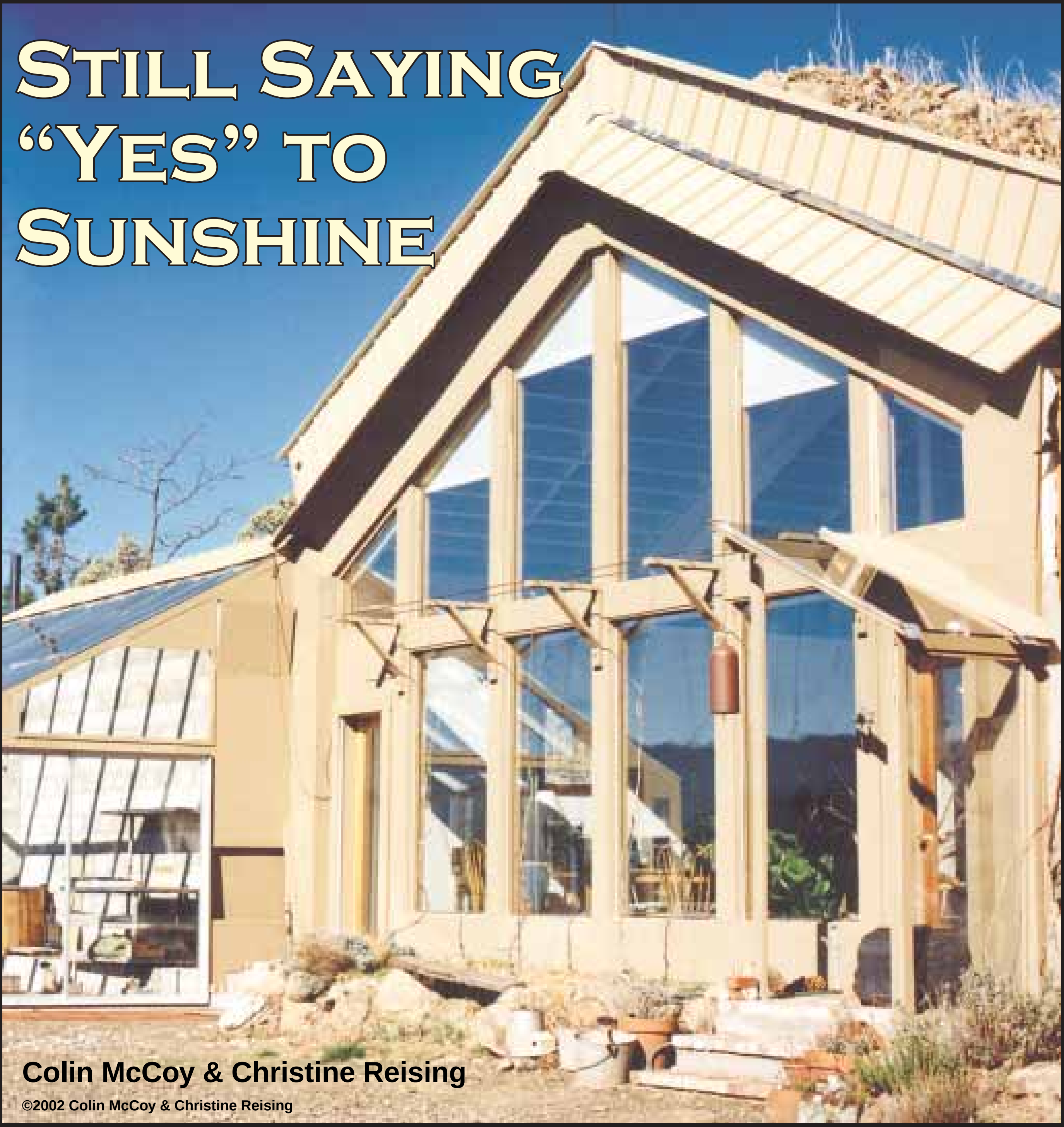
"Think about it…"

"The amount of sunshine energy that hits the surface of the Earth every minute is greater than the total amount of energy that the world's human population consumes in a year!"

—U.S. Dept. of Energy Photovoltaics Program

Still Saying "Yes" to Sunshine

Colin McCoy & Christine Reising



Colin McCoy and Christine Reising's earth-sheltered and passive solar home in sunny southern Oregon stays cool in the summer and warm in the winter.

We opted to build an underground, passive solar house, due to the success of this building method for our previous homes. Surrounding a house with earth tempers the fluctuations of temperature within. The site we chose for the house was the crown of a small, rocky hill with excellent southern exposure. This enabled us to receive the maximum amount of sunshine during the short days of winter. The rocky site would be difficult to excavate, but would provide excellent stability and sturdiness of construction.

A Whisper H900 wind genny with 600 watts of PV meet the family's power needs.

Earth-Sheltered Past

With my seven-year-old daughter, I moved from the suburbs of Medford, Oregon, into the mountains of southern Oregon in the fall of 1973. At first we lived in a cabin, and then moved into a house I built, using wood for heating and cooking, and kerosene lamps for light. We were joined by Christine in 1976, and we built our first earth-sheltered, passive solar home in 1980. We used our own sawmill to saw most of the lumber for the new house.

In 1981, we purchased photovoltaic panels to power electric lights and a refrigerator. We sold this house and property in 1986, and moved to 80 acres near Jacksonville, Oregon. In 1989, we built our second earth-sheltered, passive solar house. (See *HP24.*) Due to the encroachment of suburbia, we sold this house and acreage in 1994, and moved into a barn on 320 acres near Lake Creek, Oregon. In 1998, we finally were able to grind our way through the Jackson County permit process and started our present home.

Approval & Excavation

Before moving, we had a road built into our homesite. This gave us access to our barn. After making part of it into a living space, we moved. We planned on living in the barn (all 528 square feet of it) for a year. But the permit process took longer than we expected, and we ended up living there for five years.

The county, pleading ignorance about earth-sheltered structures, was hesitant to approve our building plans. I was prepared with research from the University of Minnesota, magazine articles, and *The Underground House Book*. The county's viewpoint was that this just wasn't Minnesota. County planners tend to favor building methods with which they are familiar, and this would prove to be a lengthy learning experience for all of us. With the help of an engineer, we were finally able to proceed.

We realized right away that hiring all of the excavation work we planned to do would cost a fortune. So we purchased a used John Deere 310 backhoe for US$12,500, and used it to excavate for our house. It also came in handy to dig water lines, drainfield lines, water sumps, ponds, holes for tree planting, drainage ditches along the road, and several other jobs. After four years of use, we sold the backhoe for US$10,500.

The site for the house hole was solid rock. We went as far as we could with the backhoe, but eventually we had to have the rock drilled and blasted, using a total of 150 pounds (68 kg) of ammonium nitrate and 25 sticks of dynamite. The total size of the hole was about 40 feet (12.2 m) wide, 46 feet (14 m) long, and 12 feet (3.6 m) deep at the sides. Most of the excavated rock was pushed to the front of the house area to provide some flat space.

Concrete Forever

We dug the trenches for the footings, but hired out the concrete work. Since the house was to be buried, it needed to be strong. The footings for the walls are 5 feet (1.5 m) wide, and 18 inches (45 cm) deep; the walls are

After the excavation produced a home-sized hole, construction began on the concrete walls.

McCoy/Reising Home Construction Costs

Item	*Cost (US$)*
Concrete	$ 36,247
Lumber	9,965
Septic system	9,414
Misc. hardware, paint, doors	9,051
Structural steel and installation	7,615
Insulation	3,981
Glass	3,475
EPDM rubber for roof	1,815
Window shades	1,419
Fixtures and plumbing	1,368
Stove and chimney, est.	1,200
Electrical wiring, boxes, switches, etc.	950
Total	$ 86,500

16 inches (40 cm) thick and 10 feet (3 m) tall. Several tons of rebar went into the concrete.

The back wall is two stories tall, with the second story walls 12 inches (30 cm) thick. An 8 foot (2.4 m) wide by 12 foot (3.6 m) long by 8 foot high room at the second floor level provides a rear exit. Total concrete in the house came to 130 cubic yards (98.4 m^3).

After the walls were poured, they were waterproofed on the outside with Thoroseal, a cement sealing mixture, and insulated to R-16 with 4 inches (10 cm) of closed cell foam. The ambient earth temperature here is 55°F (13°C). Four mil plastic sheeting was placed against the insulation, and held in place by $^3/_8$ inch (10 mm) reject particle board.

A 4 inch drain pipe was placed at the base of the walls on the outside, and covered with drain rock. This French drain ensures that water going down the outside wall is directed away from the building to prevent seepage and hydrostatic problems. Soil fabric was placed over the drain rock. This fabric is permeable to water, but keeps soil from clogging the drain pipe. The drain pipe is placed around the perimeter of the walls below the footing, and diverts the water away from the walls to where the pipe emerges in the daylight on either side. The ends of the pipe are covered with screen to keep rodents out.

The walls were then backfilled with the dirt and rock from the house excavation. Huge, junk, earthmover tires, filled with rock, act as riprap to hold the west wall's backfill. On the east end, we stacked huge boulders to create a retaining wall to hold the backfill in place. For an amateur backhoe operator, this was a bit tricky.

Roof Construction

The peaked roof is held up with four, huge, steel I-beams, with three center posts in the house and five steel uprights across the front. The span across the front of the house is 30 feet (9.1 m). The span from front to rear is 40 feet (12.2 m). Our engineer, Phillip B. McCulloch of Medford, Oregon, specified the placement of the beams after calculating the roof loads. He assumed 25 pounds per square foot for snow load, and a saturated earth load of 140 pounds per cubic foot.

The ends of the I-beams were welded to steel plates embedded in the tops of the walls. Bolted to the top of the I-beams are 2 by 12 (5 cm x 30 cm) Versa-Lam purlins (made from fingerjointed, laminated Douglas-fir veneers). Next, we glued and nailed $1^1/_8$ (2.9 cm) inch tongue and groove plywood to the purlins as roof sheathing. Then came 30 pound felt and 12 inches (30 cm) of closed cell foam insulation (R-36), glued in place. The 12 inches of insulation was necessary

The steel I-beams arrived by truck, and were hoisted into place by a crane.

Roof layers—shown are the roof felt and closed cell foam over tongue and groove plywood.

because, according to the building department, "Dirt has no insulating quality."

This was confirmed by Ralph Smoot, a builder of earth-sheltered homes in Austin, Texas. Basically, the benefit of an earth-sheltered home is that the earth moderates the temperature swing by storing heat. So, he recommends that you first find out what your yearly average daytime temperature is, and use the following guidelines:

- 3 feet (0.9 m) of dirt covering will yield a plus or minus 9°F (5°C) variation from the average;
- 9 feet (2.7 m) of dirt covering will yield plus or minus 5°F (3°C) variation; and
- 27 feet (8.2 m) of dirt covering will keep the temperature constant.

The finished roof in full bloom—with weather vane and chimney.

Ralph says that if your area gets frost, the structure needs to be insulated (high density foam) and waterproofed, again! Adding insulation helps prevent stored heat from escaping. (For an article about earth-sheltered homes, see *HP29,* page 22.)

After the insulation, two, 50 by 20 foot (15 m x 6 m) sheets of EPDM rubber roofing came next. Each sheet weighed 450 pounds (204 kg), and was very difficult for two people to handle. The EPDM was placed on both slopes and overlapped by two feet at the center. Contact cement was used to glue the overlaps. A sudden rainstorm while we were gluing proved that contact cement really won't hold when wet. Tempers got short, and cooling off, drying out, and regluing were in order.

Two layers of horse fencing (road wire) were laid down on top of the EPDM to act as reinforcement, and 3 inches (8 cm) of concrete was poured on the roof. We hired a concrete crew that specialized in sidewalks to complete this stage. Working on the steep pitch of a roof proved to be a challenge for these guys, and provided a bit of comic relief.

The house's open interior, looking toward the north exit.

We placed $^3/_8$ (10 mm) inch reject particle board on the concrete to act as a cushion, and to protect it from damage during backfilling. About 3 feet (1 m) of dirt was then placed on the roof. A 3 foot parapet across the front and back of the roof keep the dirt from spilling over the ends. This spring, wildflowers were in full bloom up there.

Interior

The floor of the house is a 4 inch (10 cm) concrete slab, covered with 14 inch square (35 cm) floor tiles. We chose a tile that varies from light color to a medium dark. This gives good heat absorption from sunlight without making the house seem dark

The loft's view—the passive solar design includes a window-to-floor ratio of about one to eight.

The kitchen, Russian masonry heater, and wood cookstove that doubles as a hot water heater.

inside. We did not insulate under the slab because we were afraid that the house would overheat.

The walls inside have a thin coat of plaster, floated to a sand finish. The back wall of the bedroom loft is covered with cedar we milled ourselves.

The layout of the interior is open, with the bedroom loft overlooking the great room. Under the loft, is our library, with a bathroom off the side. Also under the loft is a pantry, opening off the kitchen area. Upstairs, at the rear of the loft, a closet-lined hallway serves as the second-story egress. Additional storage space is located under the eaves.

Dominating the great room is a Russian masonry heater and its chimney. We had lost the plans we had gotten from a friend for this heater, but since it was the same as the one in our last house, we were able to build it from memory. The heater is seldom used because of the solar gain we get in the house. If the heater is needed, a couple of armfuls of wood, burned at a high temperature, heat the stove's five tons of mass. The outside of the stove never gets too hot to touch, and will stay warm for two to three days.

The front of the house is all windows, which provide lots of light, as well as solar heating. The windows are regular, double pane glass. Pleated shades are used to keep excess summer and fall heat out and winter nighttime warmth in. We use an antique wood cookstove for fall, winter, and spring meals. This also adds heat to the house, so in the summer, we use solar ovens and a small, two-burner, propane stove.

The total area of the house is about 1,800 square feet (167 m^2). If a passive solar house is too large, it will usually not maintain an even temperature, and if too small, will likely overheat. We have a very good ratio of window area to thermal mass to house volume. The temperature year-round is 68° to 74° F (20–23°C). The ratio of window to our floor area is about one to eight.

Water System

When we decided on our domestic water system, we went with one that had proven adequate for our needs in our last two houses. Collection of rainwater in storage tanks provides all of our domestic water. Our rainwater has no minerals, while some local wells have arsenic and heavy concentrations of other minerals.

The collection system consists of a galvanized shed roof over two, 1,300 gallon (5,000 l) drinking-water-grade, black tanks. The rainwater is collected from the shed roof and channeled through a screen and into the tanks. Once a year, during a heavy rain, we put $^1/_4$ teaspoon or so of chlorine bleach into the intake. The heavy water input mixes with the bleach, which prevents any bacterial or algae buildup.

The water tanks are located about 150 feet (46 m) higher than the house, so we have plenty of water

Rainwater, collected in these tanks, provides all of Colin and Christine's domestic water.

The underside of the PV rack showing its homemade mounts.

McCoy/Reising System Loads

Load	Watts	Hrs./Wk.	Avg. WH/Day
VestFrost fridge, 12 cu. ft.	64	140.0	1,280.0
Radio/stereo	38	50.0	271.4
Lights, 12 VDC	15	112.0	240.0
Computer	138	3.0	59.1
Hot tub filter	22	7.0	22.0
Circular saw	1,500	0.1	21.4
Sewing machine	100	1.0	14.3
Electric drill	700	0.1	10.0
Blender	400	0.1	5.7
Ceiling fan, 12 VDC	8	5.0	5.7
Lights, 120 VAC	13	2.0	3.7
		Total	1,933.4

pressure. Water exerts 1 pound per square inch (psi) of pressure for every 2.3 feet of elevation gain. So our operating water pressure is about 60 psi at the house. Inside, we have a shower, toilet, and bathroom and kitchen sinks, with a low-flow shower head and flow restrictors throughout. With careful use of water we have enough for our needs. Our laundry is done at a laundromat and our dishes are washed by hand. We choose to have neither a washing machine nor a dishwasher—the two biggest water users in the average house.

Our hot water is heated by a custom-fabricated water jacket, installed in our wood cookstove. Hot water is stored in a super-insulated, standard hot water tank, and is circulated through the stove by thermal convection. One or two meals a day cooked on the stove provide plenty of hot water during fall, winter, and spring. During the summer, when we are not using the wood cookstove, we use solar showers. Careful layout of kitchen and bathroom plumbing eliminated long runs of hot water piping. The use of rainwater eliminates any buildup of minerals in the hot water jacket.

RE System Evolution

While we were living in the barn, we had minimal room. We had a Wind Baron Neo Plus 750 watt wind genny and six Siemens SP75 PV modules. Their output was stored in twelve Interstate L-16 batteries. A Trace 2512 inverter provided AC power for our VestFrost refrigerator/freezer. We chose the VestFrost because it does not use ozone-destroying CFCs. Lights were all 12 volts DC. The size of this system was overkill.

The loft's north exit leads outside to these electrical compartments. Also pictured are the wind genny's tower base and the PVs.

The barn living quarters have since been converted to a shop that is powered by the Wind Baron and an old Arco M75 salvaged from our first use of solar-electric panels in the mid-1980s. Energy is stored in six, ancient T-105 batteries. The Trace 2512 serves a few 120 volt power tools, a concession to the fact that I am not as young as I was when I started my off-grid lifestyle 29 years ago.

McCoy/Reising PV/Wind System Costs

Item	*Cost (US$)*
Trace SW2512 inverter	$2,600
6 Siemens SP75 modules, 75 W	2,530
12 Interstate batteries, L-16	1,548
Whisper H900 wind genny & controls	1,500
Tower and installation	1,500
2 AstroPower AP7105 modules, 75 W	790
2 Breaker panels, 12 VDC & 120 VAC	450
Disconnect switch, 12 V, 400 A	300
Ananda PV60 charge controller	250
Misc. wiring and parts	225
DeSulfator, DS-1000	144
Total	$11,837

For our new house, we have eight PV panels—the six Siemens SP75s and two, 75 watt Astropower modules for a total of 600 rated watts. These are controlled by an Ananda Power Manager PV60 charge controller. The panels are mounted over the rear exit on two I-beams set in concrete. A 2 inch galvanized pipe is bolted to the I-beams, and the PV rack is U-bolted to the pipe. Adjustable braces from the rack to the I-beams keep the whole thing stable, and allow for winter and summer orientation.

We used #4 (21 mm^2) wire for the 20 foot (6 m) distance from the PVs to the charge controller. I used a chart to find the correct wire size, then chose the next size larger.

Another Wind Generator

We also have a Whisper H900 wind generator. Our Whisper is mounted on a four-section, army surplus crane boom. Total height is 56 feet (17 m), which gets the genny adequately above surrounding trees. The wire run from the genny to the controller is 65 feet (20 m), using #00 (67 mm^2). The Whisper produces 60 amps peak output when winds are 28 mph.

We are still using the twelve Interstate L-16 batteries to store energy in our system. The 6 volt, 375 amp-hour batteries are wired in series and parallel for a rated 2,250 amp-hours at 12 VDC. I made my battery cables out of welding cable from a defunct portable welder.

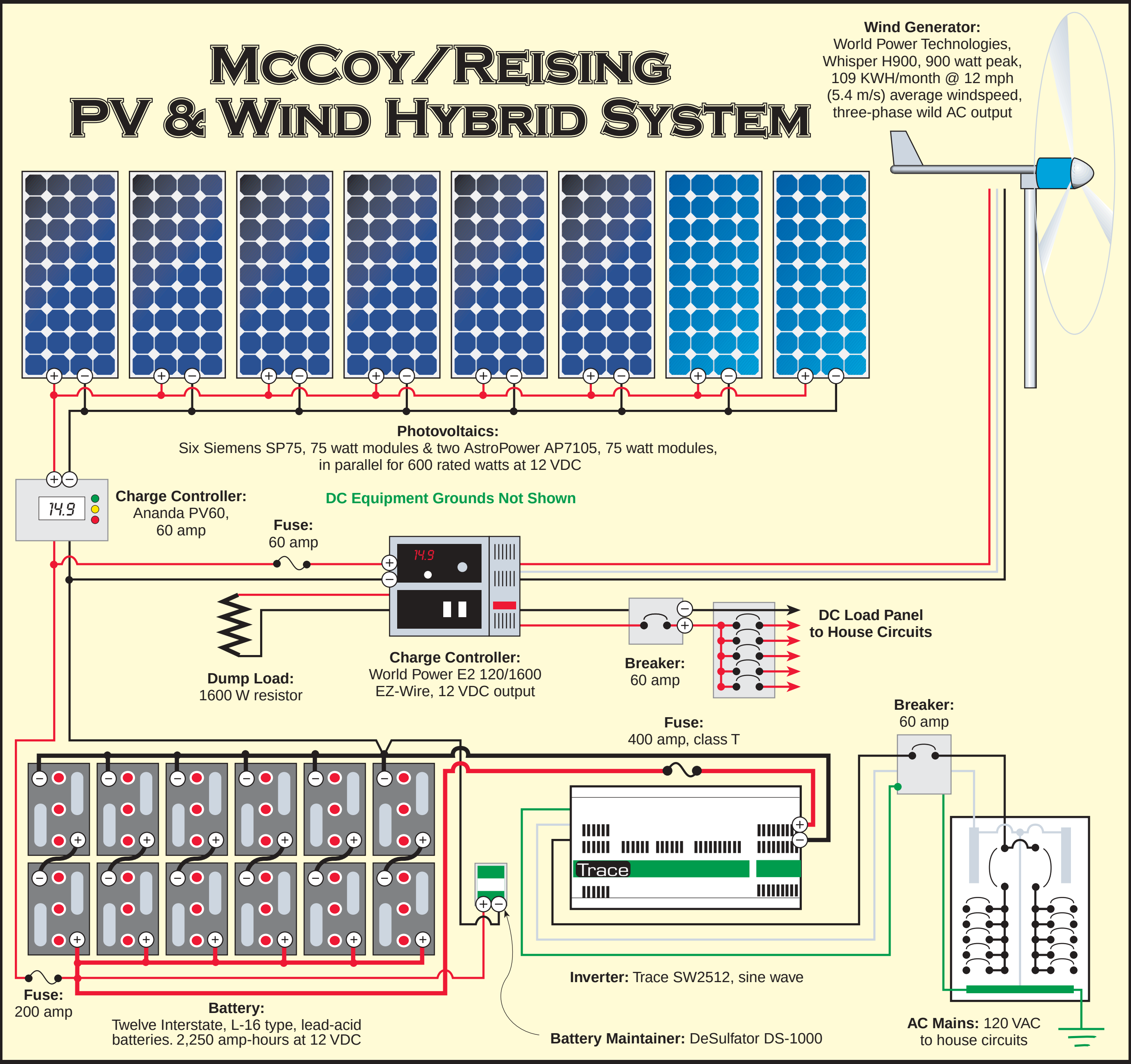
Since we are on a hilltop, we get plenty of wind. The hilltop is not large, so putting up the tower was not easy—no room for a tilt-up! We hired a crane with a 130 foot (40 m) boom. The crane operator set up out front and reached over the top of the house to set the tower in place. The tower only cost US$500 delivered, but the cost of the crane was nearly US$1,000. The tower is extremely sturdy and is guyed to three points. It is easy to climb and feels solid. It stands on a footing that is 5 by 5 foot by 1$^1/_2$ feet (1.5 x 1.5 x 0.5 m) deep. The guy wires are fastened to poured concrete footings.

We did have problems with the Whisper control unit. The circuitry that monitors the battery voltage failed. So once the batteries were fully charged, instead of shunting the wind generator output to the diversion load, the wind generator continued to charge the batteries. The unit got so hot during the failure that the solder was melted off the wire terminal connections.

We thought that two returns to the factory for repairs had fixed the problems. A third failure, while we were on vacation, proved too much for our batteries. After ten days of high winds with the diversion controller and dump load not working, our twelve storage batteries are now operating at about half their rated capacity. The factory finally sent us a new control unit, and it seems to be working properly. However, we do feel compelled to keep a constant watch on its operation.

The RE components are safely outside the house in insulated compartments, with the batteries in their own vented space.

The house's 120 VAC and 12 VDC wiring allows Colin and Christine to use either AC or DC loads.



Dual Wiring

Our electrical controls, master switches, metering, and inverter are housed in an insulated compartment that is attached to the north side of the house. Batteries are in a separate space below the other electrical equipment. The battery space is insulated with 4 inches of foam insulation on all sides. EPDM rubber sheets line the battery area. A 4 inch plastic pipe vents to the outside. A positive ventilation fan is in the future. Both spaces are well vented to prevent buildup of heat or gasses.

Originally, our AC power was from a Trace 2512 modified square wave inverter. We decided to upgrade to a sine wave inverter. Since we run some 12 VDC appliances, we wanted to keep our nominal system voltage at 12 VDC. Energy Outfitters found us a 12 VDC Trace SW2512 sine wave inverter, and we were good to go. Input from the batteries is through a 400 amp, fused disconnect.

The house is double wired for both 120 VAC and 12 VDC. The DC wiring is #12 (3 mm^2), and the AC wiring is #14 (2 mm^2). Most of our lights are 12 VDC. The circuits are wired through separate breaker panels. Both voltages are available in each receptacle box. Different plug patterns eliminate the possibility of plugging AC into DC, or vice versa.

As of now, we have no plans to increase our electrical generating capacity. We have never had to have any generator other than PVs and wind power. We have always lived within our energy generating capacity. Our motto is, “Keep it simple.” Complexity only adds more things to possibly fail.

Greenhouse Add-On

We decided to live in our underground solar house for a year or two before we built our attached greenhouse. Then, if we needed extra heat, we could vent it into the house. After a couple of cozy winters, we knew that the passive solar design features of the house were adequate, and no backup was needed. So we focused the design of our greenhouse primarily on the plants' needs, not ours.

We used the retaining wall at the west end of our house as the back wall of our 24 by 12 foot (7.3 x 3.6 m) greenhouse. Since this wall is concrete block, insulated away from the dirt, it also serves as a heat sink. We used 3 inch (7.6 cm) square aluminum for the framework since, in past greenhouses, we found that untreated wood tends to deteriorate over time. We garden organically, and did not want to use treated wood.

We used recycled 34 by 76 inch (86 x 193 cm) single pane, tempered glass for the south facing front and the single slope roof. The glass is held in place with glazing tape and 3 inch aluminum strips, screwed to the framework. An 8 foot (2.4 m) sliding glass door—also recycled—finishes the east end, while the west wall has three large windows. Both the east and the west ends have vents with automatic, heat-operated openers. Total cost was less than US$2,300.

Besides vegetables, citrus trees, and the seeds we start for our garden, the greenhouse also houses a hot tub. The tub is actually a 5 foot (1.5 m) oval, rubber-type stock tank. We plumbed the tub to a small stove that sits outside the greenhouse. Made to our specifications by a local shop, the steel stove is shaped like an inverted U, and has double walls that serve as a "water jacket." Water from the tub enters the stove at the bottom, and through natural convection, exits at the top.

It takes an arm load of wood and a few hours to get the tub to about 100°F (38°C)—about 10°F (5.6°C) per hour. We use a Magnum 350 aquarium pump and filter system, plus Baqua Spa products to keep the water clean. We opted for this water treatment system because it is both bromine and chlorine free, and doesn't take a lot of fussing.

During the summer months, we move most plants outdoors. A shade cloth covers the south side and roof to prevent overheating. Future plans call for a solar water heating system to provide hot water for an "outdoor" shower, as well as to heat the spa on sunny days.

McCoy/Reising Greenhouse Costs

Item	*Cost (US$)*
12 Aluminum box beams, 21 ft., 3 x 3 in.	$1,800
16 Aluminum straps, 16 ft., 3 x 1/4 in.	200
Sliding glass door, 8 ft. single pane, used	75
Tempered glass sheet, 5 x 2 ft.	60
Metal roofing	60
Concrete footings	50
Misc. bolts and screws	40
27 Tempered glass sheets, 34 x 76 in.	0
Total	$2,285

Just Say Yes

We were able to build this house using mostly our own labor. The cost, including septic system and our off-grid electrical system, was less than US$50 per square foot. We have learned through our various homes exactly what our needs are, and we were able to comfortably and easily accommodate them in this home.

We were saying yes to sunshine ten years ago (*HP24*), and we still are saying yes today. We have a large organic vegetable garden and extensive plantings of fruit and nut trees, berries, and grapes. Our garden and orchard, along with our natural house and new greenhouse, fit our desire to be self-sufficient and to live as lightly on the planet as we can.

This stove and its water jacket make the greenhouse's tub hot!

Proud owner/builders Colin and Christine in front of their home. It's the third earth-sheltered, passive solar, RE powered house that they've built.

Access

Colin McCoy and Christine Reising, 7401 South Fork Little Butte Creek Rd., Eagle Point, OR 97524

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Gaiam Real Goods, 13771 S. Hwy. 101, Hopland, CA 95449 • 800-919-2400 • Fax: 303-222-8702 techs@realgoods.com • www.realgoods.com PVs, wind generators, Ananda Power Center

Interstate Batteries, 12770 Merit Drive, Suite 400, Dallas, TX 75251 • Consumer Customer Service: 888-772-3600 • Fax: 972-392-1453 CustomerService@interstatebatteries.com www.interstatebatteries.com • Batteries

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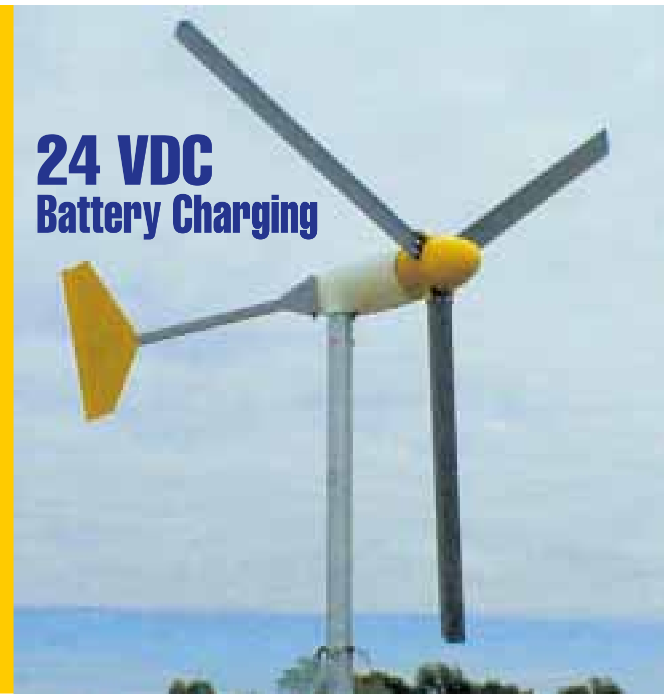

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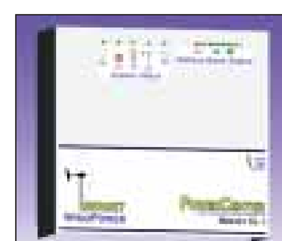

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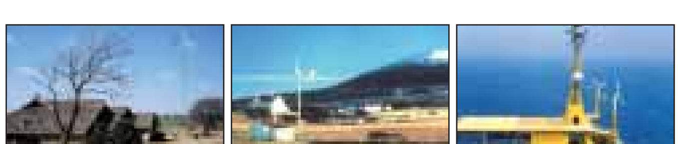

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Going Pro with Biodiesel

Emily Kolod

Tom Leue in front of his biodiesel truck and waste oil collection system.

Have you heard about biodiesel? Yes? Are you tired of hearing about it and want to *do* something with it? Here's a plan: start a small biodiesel business.

You can make biodiesel for yourself, friends, family, and any customer you can find (or who finds you). You can sell it at a price worthy of its value, and spread the good word that alternatives to petroleum can be as accessible as driving up to a pump. If you're especially well-positioned for this by living on a farm—well, you can probably see the benefits already.

Biodiesel 101

If you haven't heard about biodiesel, a good place to look first is *HP72,* pages 84 to 88, and then go on-line to the many great resources there, some of which are referenced at the end of this article. The book *From the Fryer to the Fuel Tank* by Joshua and Kaia Tickell (authors of the *HP72* article) is an indispensable reference.

Three main benefits of biodiesel are drastically reduced emissions, biodegradability, and low toxicity. The Health Effects Study approved by the EPA concluded that biodiesel in an unmodified diesel engine reduces soot and carcinogen emissions by up to 90 percent, sulfur by nearly 100 percent, and global warming gases by better than 90 percent.

Biodiesel is one-tenth as toxic as table salt if ingested, and as biodegradable as white sugar if spilled into the environment. It is also safer to store than petroleum diesel or gasoline, due to its higher flashpoint and low volatility. Its lubrication qualities reduce wear on engines, and even make them run quieter.

Biodiesel is also fairly inexpensive and easy to make. Prices vary by the manufacturer, but you will always pay a premium over standard, government-subsidized diesel fuel. Of course, diesel engines are more energy efficient than gasoline engines. The bottom line is that biodiesel is going to cost an additional 2 to 4 cents per mile driven, depending on the vehicle.

The technology is basic, allowing for a great degree of improvisation and creativity. The process is not overly complicated. It just requires patience, practice, and maybe a mentor. Depending on where you live, raw materials are accessible, and the main ingredient, used vegetable oil, is usually free.

Homestead, Inc. Biodiesel Production Cost (US$) for a 20 Gallon Batch

Item	*Quantity*	*Units*	*Invoice Cost*	*Cost / Unit*	*Units / Batch*	*Cost / Batch*	*Cost / Gallon*
Methanol	54	Gallons	$115.02	$2.13	3.750	$7.99	$0.40
Propane	100	Gallons	141.00	1.41	1.000	1.41	0.07
Sodium Hydroxide (NaOH)	50	Pounds	29.58	0.59	0.877	0.52	0.03
Filters	1	Each	0.50	0.50	1.000	0.50	0.03
Electricity	1	KWH	0.12	0.12	0.500	0.06	0.00
						Total	$0.52

Most of the published biodiesel research is focused on using new vegetable oil (mostly from soybeans), or improving oil extraction techniques from algae. Both of these oil sources are usually too expensive for small producers, but potentially useful for large businesses.

Used vegetable oil is abundant in the United States. The figure quoted most often is about 3.5 billion gallons a year, and usually restaurants pay to have it picked up and treated as a waste product. Diesel fuel use in the U.S. is about 275 billion gallons per year. Government figures state that biodiesel could yield up to 7 percent of national diesel use if this waste oil resource was fully used.

Doing It

Homestead, Inc. is a farm-scale business in western Massachusetts, and has been making biodiesel commercially since 1999 as Yellow Brand Premium Biodiesel. Homestead is steadily growing with the help of friends and the work of the founder, Tom Leue. As far as I know, Homestead is the first and only commercial biodiesel producer in the northeastern U.S. Last summer as an intern at Homestead, I obtained firsthand knowledge of biodiesel production. The internship was funded by the Chelsea Center for Recycling and Economic Development.

Massachusetts is a great place for biodiesel because there are an increasing number of small farms. Usually with farming comes stinking, health-impairing, petroleum-fed diesel equipment. An equally great site for biodiesel is near a body of water where there are diesel boats.

Biodiesel spills are less harmful than petroleum diesel spills, since they are nontoxic and degrade much faster. However, biodiesel can coat and potentially suffocate marine life, just like petroleum. The nontoxic exhaust is easier on fragile marine ecosystems. Few people realize the value of biodiesel in the marine market, and it's not being pushed nearly enough. But, no matter where you decide to manufacture biodiesel, here's a model from Homestead, Inc.

The Factory

Homestead has made a commitment to follow the basic rules of responsible resource management: reduce, reuse, recycle. True to the spirit of recycling, much of Homestead's equipment was previously used, and serves quite different purposes than in the past. Homestead's biodiesel factory is actually a converted maple sugar house.

A few of the parts from the maple syrup business were reused. The evaporator was made into a rendering pan to boil any water from the used vegetable oil before processing. The filter rig and storage tanks were also reused. Most of the remaining parts were salvaged from the junk pile in the back of the barn, or purchased from catalogs and local hardware stores as needed.

The space required is fairly modest—a heated garage, for example—and a small amount of land around it for storage. Making biodiesel might even fall between the cracks of local zoning rules. It is not easily put into any existing categories, so Homestead classifies it as a farming operation.

Keep in mind that there is no "correct" way to build a biodiesel factory. The description here will give you an idea of what can be done, and what works for Homestead. The processing system at Homestead has separate stages, as shown in the flow chart. Other small biodiesel producers do most of the work in a single drum processor, but are limited to one batch per day.

Finding the Raw Materials

Homestead, Inc. chooses to use recycled oil. In the northeastern U.S., virgin oils are hard to come by, while used fryer oil is abundant and very cheap. People who collect used oil are sometimes paid for collection services—up to US$1 per gallon in larger cities.

Homestead's biodiesel factory used to be home to a maple syrup business.

Depending on where you live, getting used vegetable oil may be the easiest part of the process. Homestead picks up used fryer oil in bulk from area restaurants, using a specially constructed tank. It is made from a salvaged pressure tank. The 250 gallon (950 l) tank uses a vacuum pump to create a strong vacuum in the tank. The tank's hose and suction wand have a filter to strain large food particles from the oil.

A standard 55 gallon (210 l) drum cannot support a strong vacuum, so a stronger steel container is needed. Homestead's tank and vacuum pump provide an effective suction system that sucks up hundreds of gallons of fryer oil in just a few minutes.

Homestead's biodiesel factory uses a lot of recycled equipment.

This suction rig can be easily rolled on and off the back of Homestead's pickup truck as needed. Bulk oil collection is much more efficient and easier than dealing with small, 5 gallon (19 l) containers of inevitably dirty fryer oil. Taking oil from the top of a bulk container (usually stored outside, behind a restaurant) avoids the water and other settled crud at the bottom.

Good oil is usually found at better restaurants—what you find out back of a restaurant tells you a lot about what's served inside. Fast food places often use palm oil, a naturally hydrogenated oil that is near solid at room temperature and difficult to work with. Best are family-owned restaurants that use canola or sunflower oils. Ask permission from the restaurant before taking their oil. Use the opportunity to tell them that you're going to make fuel from the stuff they're either throwing out or paying to have taken away.

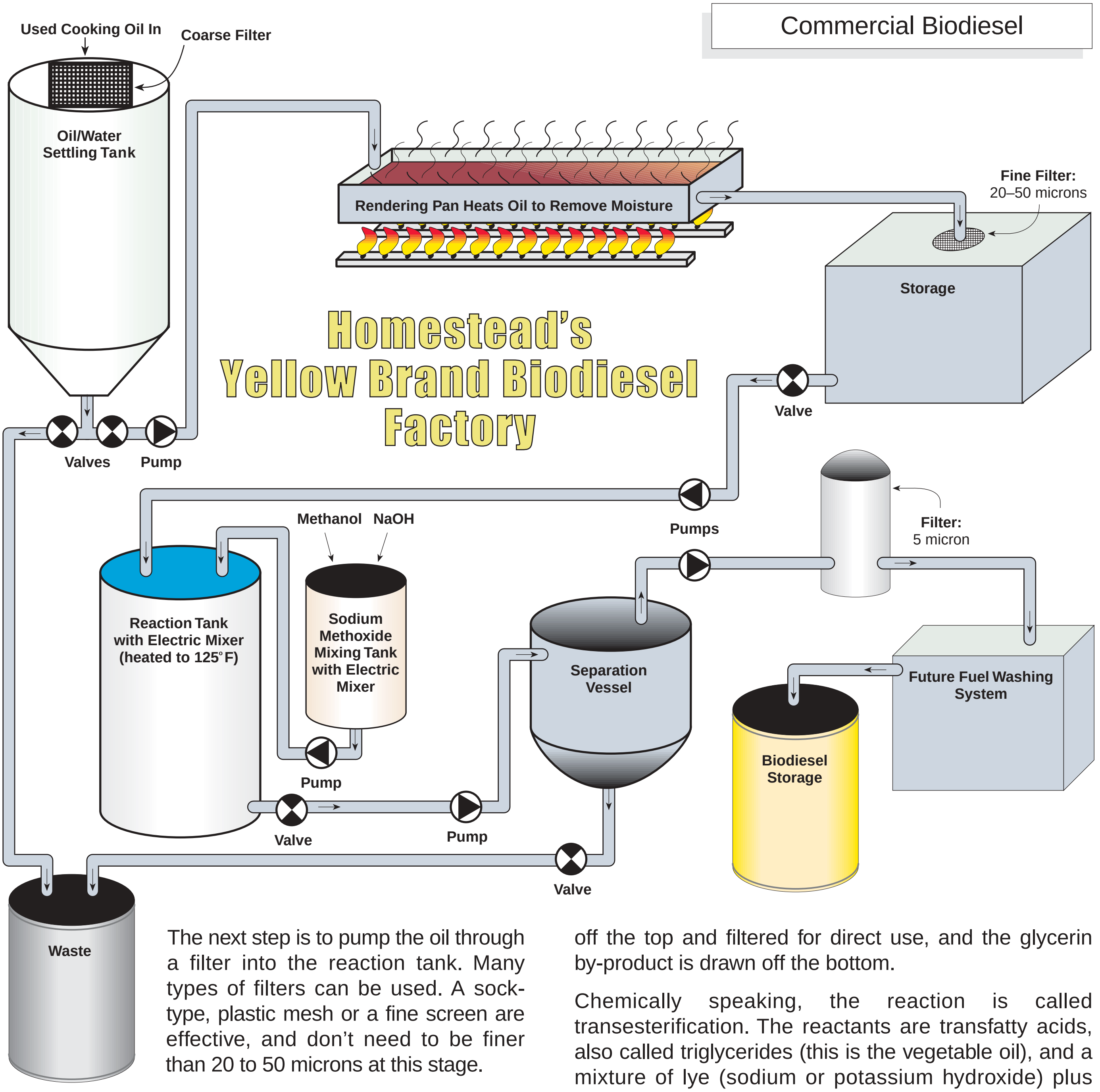
Besides vegetable oil, only two chemicals are necessary for the reaction: methyl alcohol (also called methanol) and 100 percent pure, undiluted lye. They're both very strong chemicals and need to be handled carefully. Before buying the chemicals, make sure that you have proper storage and personal safety equipment, and that you know how to use it.

Homestead gets chemicals from a chemical supply company, but there are other places to go. Methanol is a fuel for race cars, and is sold at racetracks and auto parts stores. Lye can be bought in a grocery or hardware store. Ethanol (which is created from renewable sources and is less toxic than methanol) can be substituted for methanol, but this decreases the reliability of the reaction and it is more difficult to obtain. Pay attention to biodiesel discussion groups on-line—new methods and ideas about raw materials are always coming up, and knowledgeable participants are willing to help.

Initial Filtration & Reaction

First you need a place to store the used vegetable oil. If the oil has been used heavily, it may be dirty and have a lot of water suspended in it (light brown and opaque appearance). A settling tank that allows dirty water to be drained from the bottom helps clear the oil over time. Or you can boil the water off in a flat rendering pan. If the vegetable oil is pretty clear and a decent, dark color, it can be used directly. The more storage capacity you have, the easier it is to deal with the various grades of oil you might pick up.

Nancy Leue stirs a new batch of veggie oil—soon to be biodiesel.



The next step is to pump the oil through a filter into the reaction tank. Many types of filters can be used. A sock-type, plastic mesh or a fine screen are effective, and don't need to be finer than 20 to 50 microns at this stage.

The reaction tank Homestead uses is a modified, open-top, propane water heater with a stirrer attached. A separate, small, deep tank for mixing the methanol and lye is necessary to produce the reactive chemical, sodium methoxide. A close-fitting cover for this tank is needed, along with a dedicated stirrer to avoid splashing. A chemical pump to transfer the chemicals will reduce potential exposure.

Compared to the insanely complex processes needed to refine petroleum into usable fuel, the chemistry of the reaction that makes biodiesel is very simple. The basic process involves mixing specific amounts of methanol and lye to make sodium methoxide. The sodium methoxide is added to the filtered oil, mixed for an hour, and allowed to settle overnight. Then, biodiesel is drawn off the top and filtered for direct use, and the glycerin by-product is drawn off the bottom.

Chemically speaking, the reaction is called transesterification. The reactants are transfatty acids, also called triglycerides (this is the vegetable oil), and a mixture of lye (sodium or potassium hydroxide) plus methanol, which forms methoxide. Methoxide is extremely reactive and dangerous—handle carefully! It breaks the transfatty acid/trigylceride molecule into two products—glycerin and methyl esters. Glycerin is the secondary product; the methyl esters are biodiesel.

The batch size is up to you. Homestead makes a relatively small batch (net 20 gallons; 76 l), and does two batches per day. The amount of chemicals used for the reaction is directly proportional to the batch size. The mathematical and chemical details are in *From the Fryer to the Fuel Tank.*

Ready for Sale

In Homestead's plant, the mix of glycerin and biodiesel goes into a commercial kettle, which is easy to clean and has a heating jacket to melt solidified glycerin in cold months. The last step is to transfer the top layer (biodiesel) to a dispensing tank for sale. Homestead pumps the biodiesel through a 5 micron filter and drains the glycerin from the bottom through a spigot.

Their tank is 275 gallons (1,040 l), with a dispensing pump like you'd find at a gas station—very convenient! If it has been properly filtered, biodiesel fuel straight out of the reactor can be used in a diesel engine. This fuel will not meet the standards for biodiesel, though; it still contains excess methyl alcohol and may also contain partially reacted oil.

A further refinement is a washing process to remove excess methanol and, to a lesser degree, other impurities. After the glycerin has been settled out, the biodiesel is moved to a tank that has a stratified layer of water at the bottom. Air is pumped through an aquarium stone in the bottom of the tank. The resulting very fine bubbles carry a thin layer of water on their outsides, which combines quite easily with methanol. Then as the bubbles reach the air at the top of the tank, they pop, leaving the water to work its way back to the bottom, picking up even more methanol on the way.

In addition to removing contaminants, washing also may reduce the energy value of the biodiesel slightly, but generally improves its overall quality. Homestead, Inc. expects to complete its fuel washing system in the summer of 2002, but so far has not had problems with the unwashed fuel.

You can use numerous pipes, valves, and pumps, depending on how mechanized you want to get or how much bucket-lugging you want to do. Homestead has tried several different types of pumps, but the gear pumps left over from the maple syrup business have

Government Support for Biodiesel?

Thomas Leue

By any measure, biodiesel fuel is the new kid on the block, as far as the government is concerned. Other types of fuels gather generous government support, from an oil depletion allowance that pays for resource exploitation to the liability limitations that the nuclear industry enjoys.

Biodiesel is starting to make a visible presence nationwide, and expected production is growing quickly with some government support. For instance, the USDA will provide substantial support for biodiesel production growth, up to almost US$1.50 per gallon last year, but only for established companies. Startup ventures need not apply.

Other agencies may offer help with particular development issues. The Department of Energy offers some support for new ideas to increase the use of renewable energy, and may support biodiesel production facilities if development plans are presented well. Put on your thinking caps and stay tuned to the Internet sites that will advertise these opportunities.

On a state level, government support is mixed, apparently based on proximity to the large, established companies. At least seventeen states have passed legislation in one form or another promoting biodiesel. You can see a complete list at the National Biodiesel Board (NBB) Web site. Other states, like Massachusetts, believe that there is "very limited potential for commercial application."

Private organizations are more likely to fund biodiesel startup ventures than governments are. An attractive presentation, mostly based on free Internet information and a good business plan, can catch people's attention and may spark the interest of potential investors. Homestead, Inc. is trying to raise funds to disseminate information on this new technology for free. See our first efforts at www.yellowbiodiesel.com.

Bureaucratic Setback

Shortly before press time, the EPA decided that the existing health effects study for biodiesel was privately owned by a nonprofit organization, the National Biodiesel Board, and could not be used by biodiesel production facilities without NBB permission. The NBB is a membership organization, but current rules require financial commitments beyond the meager resources of a bootstrap company like Homestead, Inc.

The EPA has stated that Homestead, Inc.'s fuel is OK for our own use, and can be used in off-road machines like tractors. But on-road commercial use is subject to fines up to US$25,000 per day. Needless to say, we are reevaluating our production and marketing plans.

An appeal has been made to the EPA to reconsider these rules in the light of the government's general encouragement of clean energy technologies. When new information becomes available, we'll post an update in *HP's* Letters section.

proven most satisfactory. Diaphragm pumps are good if they are not too expensive. Pumps intended to transfer petroleum oils are also available.

Avoid rubber, butyl, or neoprene compounds, as well as any styrene plastics, since these may degrade in the presence of some of the biodiesel ingredients. Be sure any pipes or hoses do not react with methanol, lye, or methoxide.

Building a biodiesel factory, especially with used parts, requires hard work, experimentation, and ingenuity. Another option is to have a brand new biodiesel refinery built for you. Pacific Biodiesel offers such a service, but only for large-scale operations (2,500 to 20,000 liters; 600 to 5,000 gallons per day) and prices range from US$375,000 to US$1,500,000. Better to save your money and start looking at want ads and sales.

Fueling with a Conscience

So who buys from Homestead? Their customers are conscientious people; they buy biodiesel to reduce their part in global warming, air pollution, and habitat loss, and to improve ambient air quality on their farms. Several local families have purchased diesel vehicles just because this fuel has become available. (I might join them some day if I ever buy a car.)

Many people who buy biodiesel from Homestead use it in tractors, since the area has a good amount of agriculture. Biodiesel is amazing for tractors in a large part because of the health benefits—no more breathing toxic diesel fumes for hours. Besides, both state and local taxes must be paid on every gallon sold for road use, and the paperwork can be difficult to figure out.

Homestead has an increasing number of regular customers, and receives many calls each day. Individuals and groups come by to see the process, and Homestead attends conferences and festivals to promote biodiesel.

Biodiesel is a great transitional fuel, and providing it to people with diesel engines to decrease petroleum use is definitely a good service. The price is up to you. Unfortunately, a price representing biodiesel's true value doesn't compete with tax-subsidized, environmentally damaging, and artificially low-priced petroleum.

The first question people unfamiliar with biodiesel usually ask is, "How much is it?" and scoff if it's "too much." They forget that technology is a privilege, not a right. Motor vehicles, motorized equipment, motor boats, and engine generators impact the environment, no matter what fuel they run on.

A fuel like biodiesel minimizes ecological damage and makes a healthier environment, while using a resource that's usually wasted. Until the day comes when living low-tech locally is the norm, biodiesel can take you where you want to go. And right now, its availability depends on the initiative of small businesses like Homestead.

Access

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Tom Leue, Homestead, Inc., 1664 Cape St., Williamsburg, MA 01096 • 800-285-4533 or 413-628-4533 • Fax: 413-628-3973 • Tilapia@aol.com www.yellowbiodiesel.com

From the Fryer to the Fuel Tank: The Complete Guide to Using Vegetable Oil as an Alternative Fuel, by Joshua Tickell, US$29.95 from BookMasters, PO Box 388, Ashland, OH 44805 • 800-266-5564 or 419-281-1802 tickell@veggievan.org • www.veggievan.org

National Biodiesel Board, 3337A Emerald Ln., Jefferson City, MO 65110 • 573-635-3893 • www.biodiesel.org

Biodiesel discussion groups:

www.biodiesel.infopop.net/2/OpenTopic

www.groups.yahoo.com/group/biofuels-biz

www.groups.yahoo.com/group/biodiesel

Good reference sources:

http://journeytoforever.org

www.mauibiodiesel.org

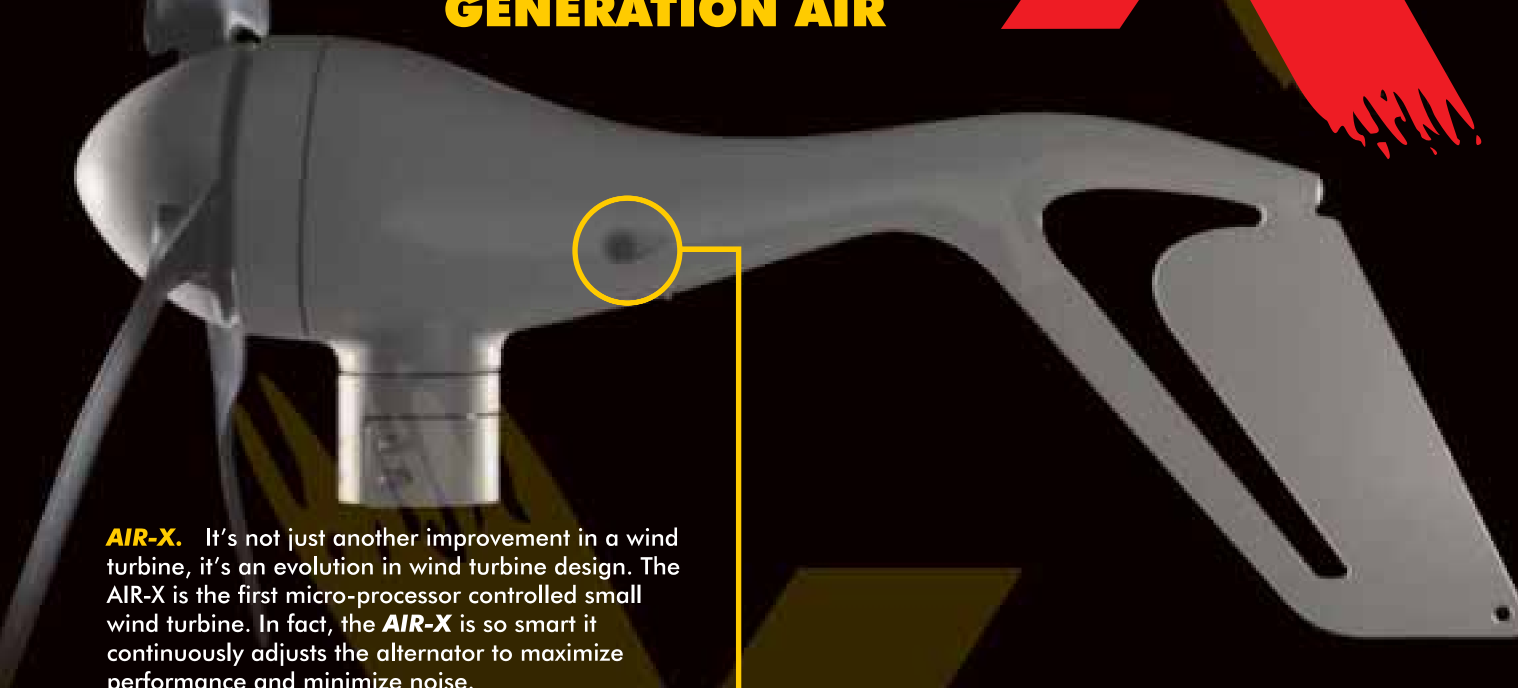
www.biodiesel.com

www.americanbiodiesel.org

www.webconx.com/biodiesel.htm

www.dancingrabbit.org

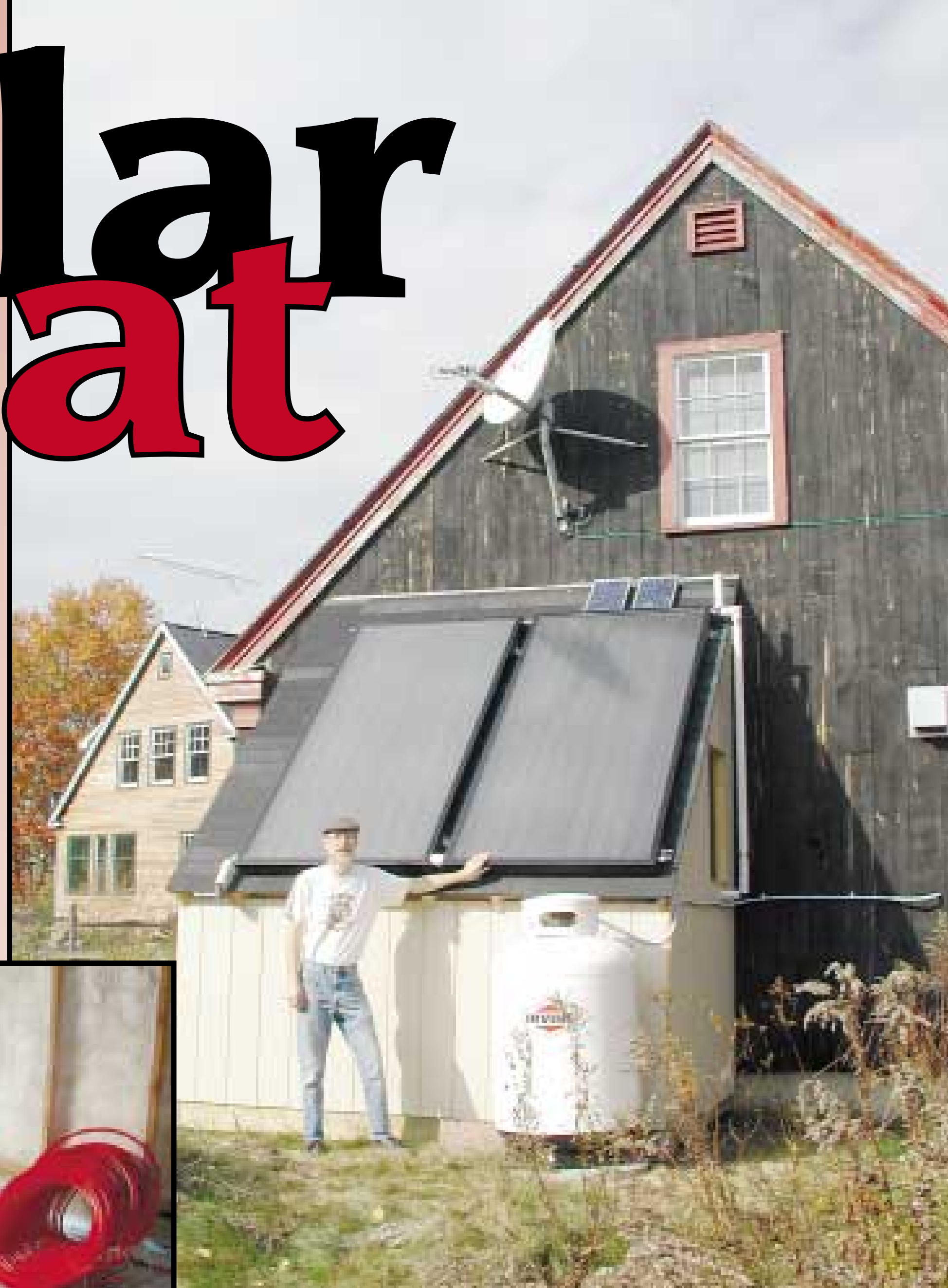
www.chelseacenter.org



Solar Heat

for My Maine Workshop

Guy Marsden



The author with the solar thermal panels that heat his workshop's floor.

Tubing within the concrete slab floor efficiently distributes solar heat, making a comfortable room.

My wife Rebekah and I decided to move from California to rural Maine for many reasons—mostly to live an affordable rural lifestyle in a beautiful environment. Having survived the California "energy crisis," we became even more energy conscious. Rebekah even started to refer to me as an energy nazi!

Using solar energy is something I have always wanted to do, ever since reading the *Whole Earth Catalog* in the late '60s. We were fortunate enough to make a significant profit on the sale of our suburban house in California, and used some of the proceeds for solar energy equipment and energy reduction in our new home in Maine.

We replaced all the incandescent lamps in the house with low wattage fluorescent lights, and purchased a Staber clothes washer. We plan to install a grid-intertied, solar-electric system for the house this year. Rebekah drives a 2001 Honda Insight and loves it! She gets an average of 61.2 mpg on most trips.

We both work at home, and wanted to be sure to have warm, comfortable, and well-lit work spaces. Rebekah's basement knitting studio is heated by a woodstove that heats most of the house. A propane backup heater fills in at night so we don't have to get up and stoke the stove. Our property includes a recently constructed barn that is perfect for my needs.

I make furniture and design electronics for a living. So I need two distinct work spaces. The barn has a full second floor for my electronics lab. That dish antenna you can see above the solar collectors is for a StarBand satellite modem. For my engineering work, I absolutely require high bandwidth. Due to our rural location, a satellite modem is the only viable high-bandwidth option. As soon as cable internet service is available, I will switch, since I find the slow speeds and long delays of the satellite to be much worse than advertised. Bad weather can knock it out entirely!

I suffer from migraine headaches that are triggered by cold temperatures, so heating in the Maine winters is crucial for my well-being. I decided to use a radiant heated floor, which is known for comfort. A particularly nice feature is that the heat rises up from the floor to warm my large, floor-mounted power tools. I had no intention of freezing my hands off in the Maine winters! The radiant floor is heated primarily by two, 4 by 8 foot (1.2 x 2.4 m) SunEarth Empire series solar collectors, augmented by an AquaStar (AQ125-BLP-S) propane on-demand water heater.

System Design

My first step was to have a heat load analysis done by Peter Talmage of Solar Market in Arundel, Maine. This helped to define my heating system design goals and insulation requirements. The barn was bare stud walls on a concrete foundation and rough concrete floor when we acquired it. It had been built to store the previous owner's lobster boat.

The floor plan is 24 by 28 feet (7 x 8.5 m), with a 10 foot (3 m) high ceiling on the ground floor and a full second floor. The ground floor is framed with 2 by 6 lumber, and the 45 degree roof (unfortunately facing east and west) is framed with 2 by 8 rafters. The barn had seven original windows, and I installed two, standard, well-insulated exterior doors.

Sometimes the Maine winter is relentless—an AquaStar tankless water heater fills in when the sun doesn't shine.

The heating system begins with the two SunEarth solar collectors that are connected in parallel. A PV powered pump circulates the heated glycol mixture through a heat exchanger. A second PV powered pump circulates heated water into the 80 gallon (300 l) storage tank. A thermostat controls the AC pump that feeds the two, 300 foot (90 m) loops of tubing in the concrete floor.

Guy's barn was oriented the wrong way to put his solar panels on the roof. The shed Guy built on the south end has a 45 degree roof pitch—perfect for the two, 4 by 8 foot solar hot water panels.

Corbond spray-on foam insulation has an R-value of about 7.3 per inch.

Insulating

The first task of any solar heating design is to get the best possible insulation for the walls, ceiling, and floors, and thoroughly seal any openings that would allow unwanted cold air into the building. I insulated the windows with removable Windo-Therm interior plastic double glazing that will be used only in the cold season (five months in Maine).

I insulated behind the original sliding barn doors by adding two in-swinging doors, which fit within the doorway when closed. Resembling hinged wall sections, the auxiliary doors are framed with 2 by 6s, filled with fiberglass, and finished with $^{3}/_{8}$ inch (10 mm) exterior plywood. They are thoroughly weather-stripped. These are huge (4 x 9 foot; 1.2 x 2.7 m) and imposing to open—I call them the “Doors of Doom!”

I contracted the installation of Corbond—a sprayed-in polyurethane foam insulation—throughout the structure. Corbond has an approximate R-value of 7.3 per inch. I had 3 inches (7.6 cm) installed in the walls on the ground floor, and 4 inches (10 cm) in the walls upstairs. A significant advantage of the foam is that it forms an airtight seal throughout the building. I left the building to air out all the urethane fumes for over four weeks before completing the interior work.

The exterior walls of my barn were 1 by 10 inch shiplap barn boards installed vertically over 1 by 2 inch horizontal battens. A layer of Tyvek housewrap is in between the battens and shiplap. As such, it was far from airtight. I added fiberglass inside (over the Corbond) to increase the R-value to about R-30 downstairs and about R-40 upstairs, and installed drywall over that. I estimate that I have approximately R-37 in the roof.

Radiant Floor

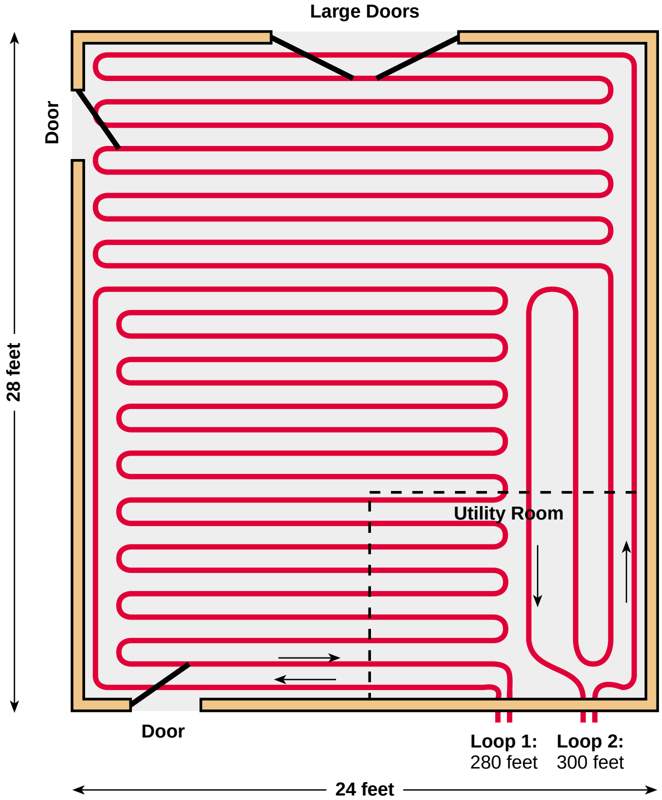
For the radiant floor, my first job was to install 1 inch (2.5 cm) polystyrene high density construction insulation over the existing concrete floor. I then laid 6 inch (15 cm) steel grid (commonly referred to as road wire) over that for securing the radiant tubing, using nylon cable ties. I laid out two loops of 300 feet (90 m) each of the tubing, which I connected to a manifold in the utility room.

A local contractor did a great job of pouring 3 inches (7.6 cm) of concrete over the tubing. I asked him to use a 4,000 psi fiberglass mix to give me a strong workshop floor. Naoto Inoue at Solar Market sourced the materials for this job and specified the details. He originally suggested 2 inches (5 cm) of concrete to create a very responsive system.

Laying 1 inch polystyrene insulation board over the old floor insulates the heated slab from the earth.

The 600 feet of hydronic tubing is held in place by road wire. Three inches of concrete will make the final layer.

Hydronic Loop Layout



Loops are 6 inches from outer walls and roughly 12 inches apart.

I felt that 2 inches would be too thin, and the concrete contractor refused to pour less than 3 inches due to the risk of damaging or exposing the tubing. The 3 inches still allows me to use a single household thermostat to control the heating, though it is less responsive. I'm still testing, but I believe that the system can raise the building temperature by about 3°F (1.6°C) per hour.

Building a Solar Roof

I needed a structure on the south side of the barn to put the solar collectors on, so I built a small shed with a steeply sloped roof. At this latitude, a 45 degree slope is recommended and is easy to build.

My neighbor John Rogers, who is a building contractor, helped me design the shed and gave me a hand for an hour or so to get the collectors mounted on the roof. I was lucky that the weather was still warm enough to sweat the exposed 3/4 inch copper pipe fittings in early October! Maine can be quite chilly at that time of year!

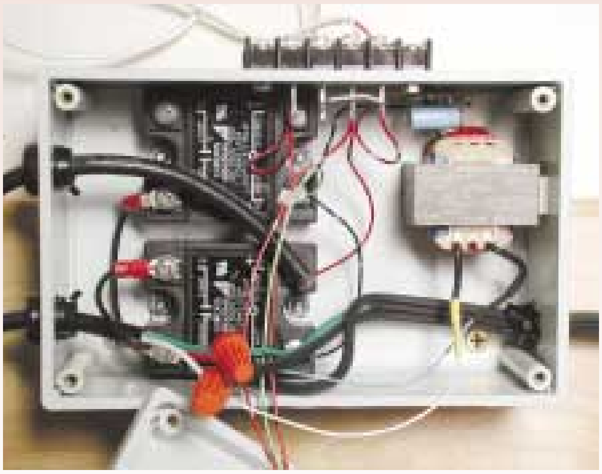
The collectors came with small L-brackets that did not seem to be big enough to raise the collectors more than 1/2 inch (13 mm) off the asphalt roof. Ken Olson suggested that an inch or so would be better, so I made up my own brackets from extruded, 3 inch (7.6 cm) angle aluminum with a 1/8 inch (3 mm) wall.

Thermostat Relay Box

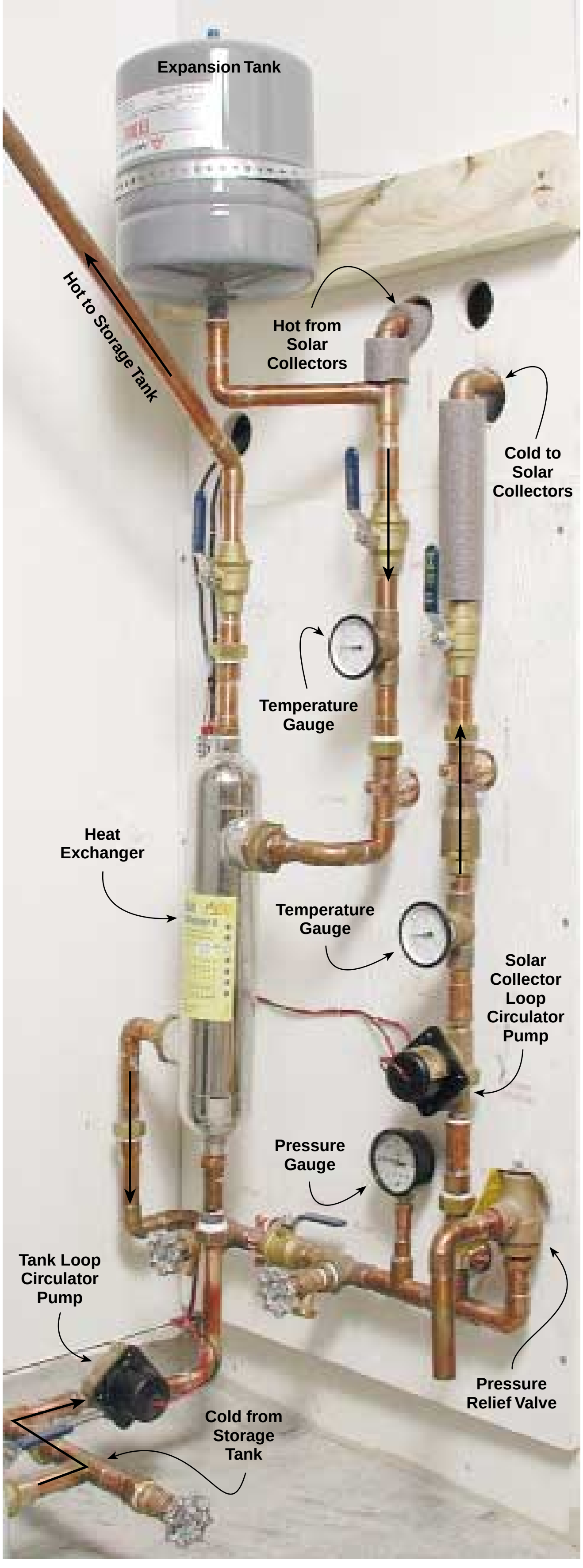
I built a relay box that allows my standard, centralized heating, digital thermostats to control the AC circulation pumps. To power the relays, I used a 12 VDC, "wall wart" plug (wall cube, or AC-to-DC converter), and wired it to solid state relays in a nice plastic box with two LEDs to indicate when each pump was running. I used solid state relays rather than mechanical ones, since they consume a fraction of the energy when activated.

The relay box is quite simple. All it contains is a 12 VDC power supply, pillaged from an old phone answering machine. I actually broke open the plastic housing of the wall wart, and extracted the transformer and electronic parts so I could silicone them into the box nicely. The dissected and reassembled wall wart sends power to the thermostat, which switches the solid state relays and turns an LED indicator on. The digital thermostat that I used runs on its own two AA batteries.

The control box LED requires a 1 K-ohm resistor in series with it for current limiting. I used relays that are rated at 10 amps at 240 volts. These can be found surplus for around US$7. When switching a motor with a relay, it is best to rate the relay at double the current and voltage of the load to allow for protection from the inductive surges that occur during switching.



A homebuilt, solid-state relay box allows standard thermostats to control the system's AC circulation pumps.



I used three, stainless steel, sheetmetal screws to attach each 3 inch long bracket to the collectors, and used a $^5/_{16}$ inch by 2 inch (8 x 50 mm) stainless lag screw with galvanized washers per bracket to secure them to the roof. I also put a bit of silicone around the lag screw heads to prevent ice from working down into the roof.

Lots of Plumbing

One thing that is rarely mentioned in articles about homebrew solar installations is the emotional ride. For me, it has ranged from excitement to total freak out at the daunting complexity and overwhelming amount of detail. Fortunately, I already had considerable experience in all the skills needed to accomplish my installation, so I was able to trust in my knowledge that I could complete the project almost single-handedly.

I am an experienced home and light industrial plumber from a previous life in photo processing. Nonetheless, it took many visits to the hardware store over a period of a couple of weeks to locate all the copper fittings for the system components. The plumbing assembly took more than a week to build. I sweated together each section of the various assemblies of valves, gauges, and pumps, which I then assembled into a complete system.

It was very helpful and timely that *HP85* came out as I began the plumbing phase. That issue contains Ken Olson's excellent article on closed loop antifreeze systems. I downloaded a copy and used it as a working reference on the job.

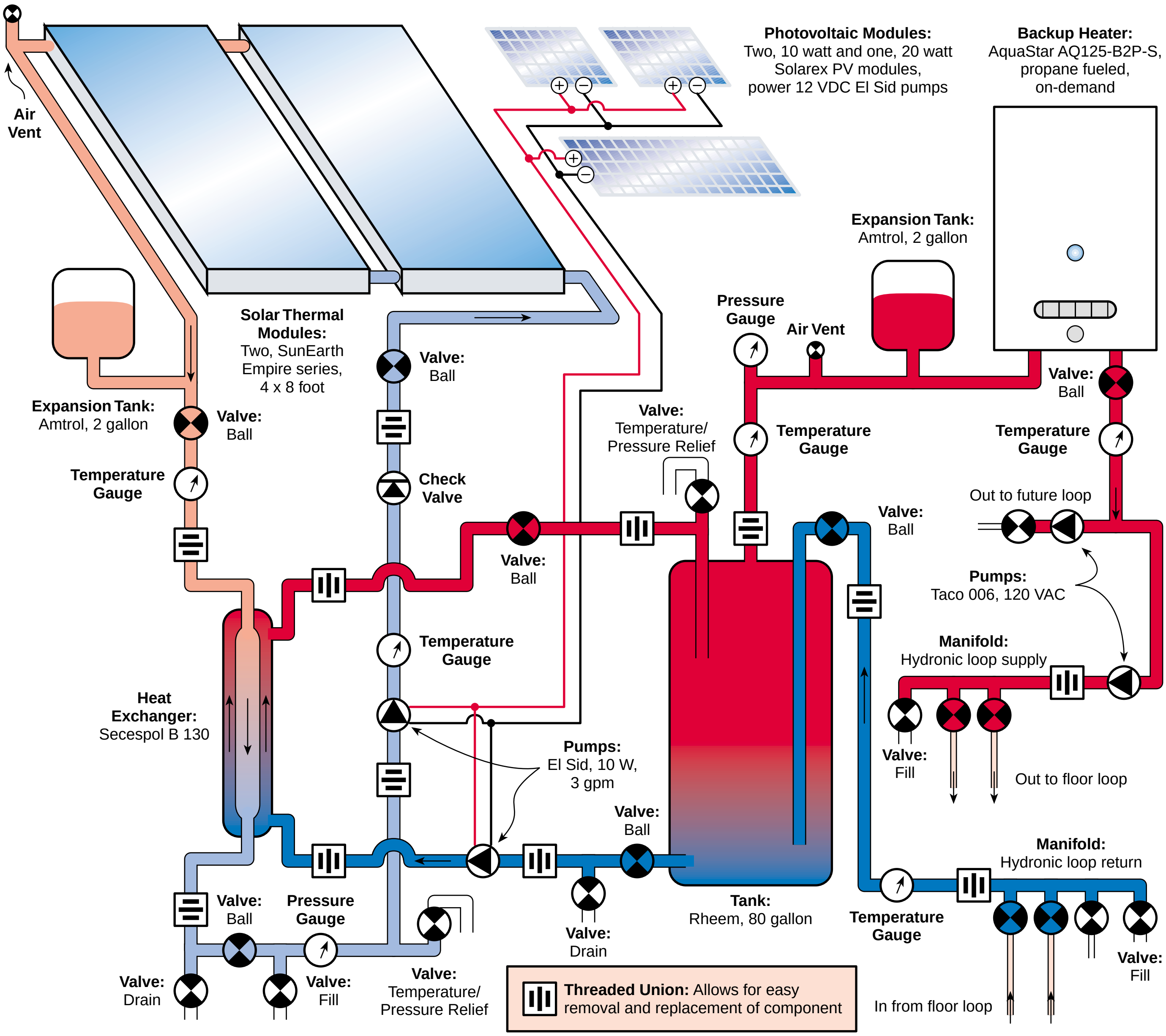
Some Plumbing Tricks

One neat plumbing solution that I found was a good way to mount thermometers into $^3/_4$ inch copper pipe. The thermometers that I used come standard with a $^1/_2$ inch pipe thread, and if you sweat a $^1/_2$ inch thread adapter onto a $^3/_4$ inch tee with a short length of $^3/_4$ inch pipe, the thermometer sensor stays out of the fluid flow. This can give inaccurate readings, especially if the tee is mounted so that air stays trapped in the stub tube.

A brass seat tee with reducer (right) keeps the thermometer sensor in the fluid's flow. Copper fittings (left) don't work as well.

The solar loop portion of the system's plumbing, showing the Amtrol 2 gallon expansion tank, Secespol heat exchanger, and 2 El Sid circulating pumps.

Guy Marsden's Solar Heating System



I used a brass sweat tee with 1 inch female threads instead. Then by putting in a $^1/_2$ inch reducer bushing, I found that the thermometer's $^1/_2$ inch thread would fit in snugly, allowing the thermometer sensor to protrude fully into the water flowing through the tee. I believe that this setup will guarantee accurate readings.

When plumbing the indoor section of the collector loop, I placed unions around the heat exchanger and pump sections. The sections can be removed easily for service or replacement, or to tighten the couplings. It turned out that I needed to make use of this feature, so it definitely paid off.

Another trick that I devised involves weatherizing the foam insulation on the exterior plumbing. I took some 2 inch PVC pipe and ripped it in half on my table saw and clamped it back around the insulated pipe using nylon cable ties.

The air vent needs to be located at the highest point in the system, which means at the top corner of the collectors for me. I ended up with a vent that is about 6 inches (15 cm) above the collectors. To insulate and protect it from the elements, I wrapped the pipe in foam, and put a length of PVC pipe with an end cap over it.

That's not Gatorade! Filling and pressurizing the solar collector loop with the propylene glycol solution.

Filling the System

My workshop has no running water, so I had to pull a garden hose over 70 feet (21 m) from the house to fill the system. I came up with a neat way to monitor the fluid and air bubbles entering and exiting the system. I made up two, 3 foot (0.9 m) lengths of 5/8 inch (16 mm) ID clear plastic hose and added garden hose fittings. One hose was connected to the fill pump outfeed, and the other to the system drain. This made it possible to monitor the fill process, and to clearly see when the air was purged from the system.

I let the fill pump continue to recirculate until the returning fluid stopped showing air bubbles. Air bubbles in a closed system can impede flow and limit the efficiency of the system, and should be carefully and thoroughly eliminated. When filling the water tank, I attached the clear plastic infeed hose directly to a garden hose, and let the overflow drain out the window!

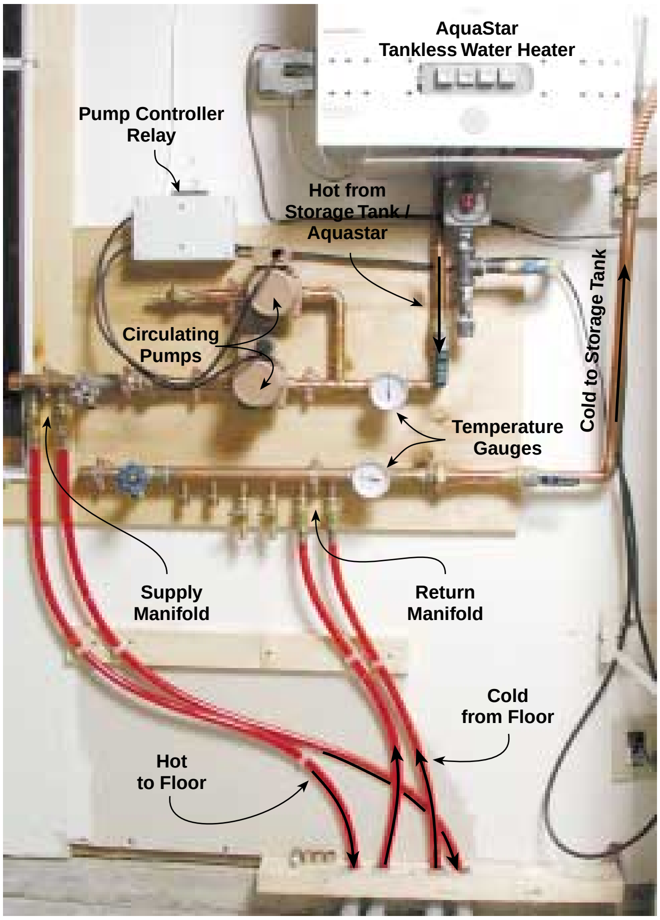
My solar collector loop holds approximately 3 gallons (11 l), so it was relatively easy to prepare a 50:50 glycol solution by mixing it in a 5 gallon (19 l) bucket. Use propylene, *not* ethylene, glycol. Ethylene glycol, as used in automobile radiators, is highly toxic. The propylene glycol that I used is formulated for the high temperatures that the collectors can generate.

Without fluid flowing during summer for space heating, the collectors could reach stagnant temperatures of over 300°F (149°C) in certain extreme conditions, although maybe not in Maine. Very high temperatures (over about 250°F; 121°C) will eventually cause normal propylene glycol to turn acidic, which can be harmful to the copper collectors. Even with the high temperature (325°F; 163°C) Dow Frost HD propylene glycol I used, stagnation should be avoided in closed loop systems.

The Break-In Period

After a late night of filling and checking the system, I was up with the sun the next morning to watch the solar powered El Sid circulating pump kick in and begin warming my system. I was disappointed at how long it seemed to take with the sun shining brightly, until I realized that I had installed the pump in the wrong direction. The pump was trying to suck against the check valve to no avail. Being quite dyslexic, this is something I have grown used to—getting things backwards!

The supply and return manifolds of the two hydronic floor loops. Notice the extra Taco 006 pump for a future heating loop in the barn's second floor.



The liberal use of threaded unions allows for easy removal of components for repair or replacement.

Fortunately, I had installed unions around the pump with serviceability in mind, so I simply closed some valves and removed the section. I unscrewed the fittings on each side of the pump, reversed it, and reinstalled it. The moment the pump began to run, I watched the incoming temperature gauge rise to over 220°F (104°C) from the stagnant hot water in the collectors. In a few minutes, it settled down to a nominal 155°F (68°C), which seemed to be the system's normal capacity (more on that later).

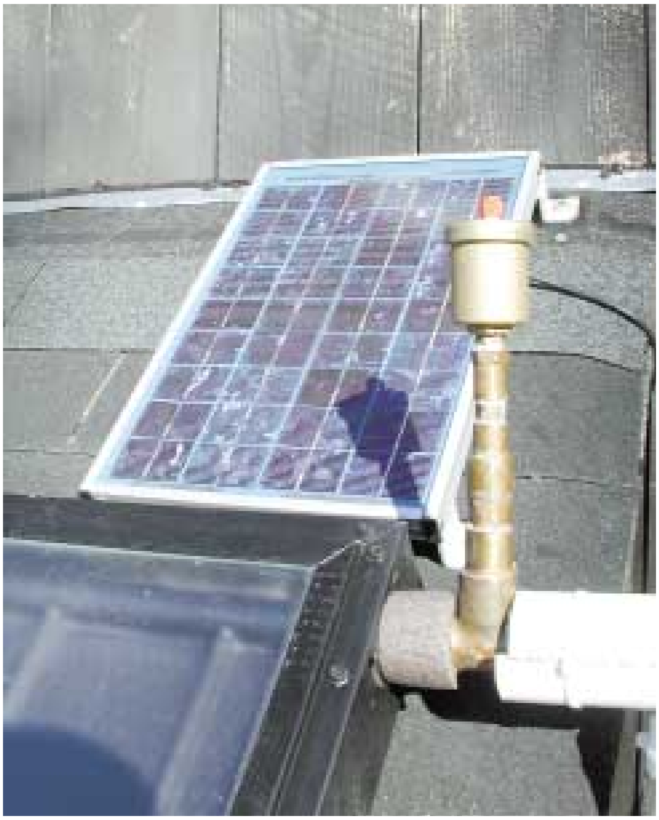
I wholeheartedly recommend that all systems have a liberal sprinkling of unions to allow for service disassembly. I also found some leaks around my heat exchanger, and rectified that by removing the whole assembly and tightening the fittings.

PV & Collector Problems

In the first few days of full sun, I noticed that the pump didn't kick in until after 10:30 AM. I first thought that the solar-electric panel that runs the circulation pump was underpowered. On the third sunny morning, I went out and looked at the PV panel. I saw that I had mounted it up slope from the air vent I had installed on a 6 inch (15 cm) extension above the collectors, and the air vent was shadowing the PV! So I moved it over by a foot and fixed that silly mistake!

When I mentioned to Naoto that my operating temperature was a nominal 155°F (68°C), he was surprised, since the design spec is closer to 180°F (82°C). He had been having trouble with other SunEarth Empire series units underperforming, and contacted the factory.

The SunEarth engineers were very responsive and soon learned that there was a manufacturing defect in the units. They arranged with Solar Market to replace



The air vent shaded the PV panels in the early morning, causing a delay in pump operation—Oops!

those units that were already installed. The first set of replacements I received was not packed properly and the panels were badly damaged in shipping. Almost four months later, I finally have the new units, and must now wait for a warm, dry day! Right now it's inches of mud and raining hard, with snow in the forecast! Check my Web site for details on the new panels and their performance.

Underpowered Floor Circulating Pumps

The next setback came when the propane supplier came to hook up the AquaStar heater. We couldn't get the heater to kick in, even though the circulating pump was running. I realized that mine is a closed system, and the AquaStar relies on a pressure difference of 10 psi to turn on.

This is fine in an open system. When you turn on a faucet, the outfeed pressure drops, turning the heater burner on to the degree needed to bring the water flowing through it to temperature. It looked like the pump (Taco 003 series) was underpowered. This was very distressing!

I called Naoto at Solar Market and he immediately drove over (a trip of more than an hour!) in his biodiesel

Marsden Heating System Costs

Item	*Cost (US$)*
2 SunEarth Empire series 4 x 8 foot collectors	952
AquaStar 125BS propane water heater	690
1,000 ft. Rehau radiant floor tube, 1/2 inch (600 ft. used)	616
Lumber for shed	580
Copper pipe, fittings, valves, etc., 3/4 inch	500
2 El Sid PV-driven circulating pumps, 3 GPM 10 W	420
Rheem storage tank, 80 gallons	369
2 Taco circulating pumps, model 006, 120 VAC	332
Secespol B 130 heat exchanger	256
2 Solarex SX-10M PV modules, 12 V, 10 W	212
Solarex SX-20M PV module, 12 V, 20 W	180
2 Manifolds, 6 outputs & 6 valves for floor tubes	138
Wayne PC2 utility pump, 60 gph at 40 feet of head	85
5 Temperature gauges	80
2 Amtrol 2 gal. expansion tanks, high temperature	76
Check valve, light-action spring	24
Amtrol air vent	9
Total	$5,519

powered Mercedes. He brought a larger pump. Naoto has been unfailingly supportive and helpful throughout the entire project. I simply couldn't have done it all without his help and advice. We were lucky that the larger pump (Taco 007 series) that he brought was the same brand and used the same size motor body as the underpowered unit.

The quick fix was to remove the motor from its housing and replace it with the larger motor and impeller. This saved a lot of work replumbing all the copper! The modified pump created enough draw to pull a pressure drop across the AquaStar and trigger it to fire up its burners.

After running this modified pump for several days, I noticed that it ran hot—too hot to touch comfortably. I decided to call the manufacturer, Taco, Inc. The application engineers there were very helpful and reviewed my design thoroughly. They asked me to take amp readings while the pump was running, and also ran a lab simulation of my system configuration.

Their conclusion was that I would be better served by a 006 series pump. It comes with 3/4 inch sweat fittings rather than the 1/2 inch sweat fittings that I had used with the original 003 series unit. This model is also more efficient electrically. The 007 model is rated at 0.7 amps, while the 006 model is rated at 0.52 amps. Both pumps operate at 120 VAC. I found that the rated amps are a rough value, and the actual draw varies with the operating temperature of the pump—cooler equals lower current. My pumps seem to run a bit lower than their rated specs even after running for hours.

The Taco engineers were kind enough to send me replacement pumps to solve my design issue. It required resweating a chunk of my manifold, and refilling my system, but it was worth it if only to reduce my electrical load!

When Naoto came by with the replacement pump, he reviewed the details of my system with me. He agreed with my assessment that the system efficiency could be improved by pumping heated water through the heat exchanger. In the original design, heat flowing up through the secondary side of the heat exchanger would create a thermosiphon effect to heat the water stored in the tank. My feeling is that this flow is insufficient to maximize the potential heat transfer capability of the heat exchanger. Heat rising through the heat exchanger does not flow as rapidly as it would if pumped.

We decided to add another PV panel with its own separate DC pump installed on the cold side of the heat exchanger. The neat thing about circulation pumps that are direct wired to PV panels is that they only operate when there is sufficient sun to heat the solar collectors. We also decided to add a temperature gauge before the AquaStar heater, at the storage tank exit. Previously, I had no way of monitoring the temperature of the solar heated water emerging from the storage tank.

Underpowered PV Circulating Pumps

Another issue arose when I noticed that the PV-driven circulation pumps didn't kick in until well after sunrise on sunny days. I e-mailed Dan Fieldman at Ivan Labs and asked what might be wrong. He explained that he recommends 20 watts of PV per pump when they are installed north of Jacksonville, Florida. He also corrected me on the orientation of my pump—the motor should be horizontal, not vertical.

Since the pumps are rated at 10 watts, Solar Market had sold me one 10 watt Solarex PV panel per pump. I have added another 20 watt Solarex unit for a total of 40 watts wired in parallel to run both my El Sid circulation pumps. This has dramatically increased my system efficiency.

Guy Marsden installed the whole solar hydronic heating system himself.

Learning How to Best Use Solar Heat

I bought a standard electronic thermostat for space heating systems that has four settings per day. It included a mode for radiant floor heating that makes it shut off as soon as the temperature is 1°F (0.56°C) above the setpoint. Originally, I set it to 60°F (16°C) at night, and 68°F (20°C) at 7 AM. I learned that this is the wrong thinking for a radiant floor, solar heating system.

My system has a very slow response time. So setting the temperature low at night appears to be a false economy, since it takes several hours to get back up to 68°F (20°C) in the morning. I experimented and learned to set the thermostat to 70°F (21°C) from 5 to 9 AM, and to 67°F (19°C) for the rest of the day.

The heat coasts up by several degrees during the two to four hours after the circulation pumps shut off. The building is so well insulated that when the heat shuts off between 9 and 11 AM (on days well below freezing outside), it does not come on again for over twelve hours. On days where the outside temps stay below 10°F (-12°C), the heat stays on all night, and cuts off midmorning when 67°F (19°C) has been reached. There is enough direct solar gain from windows that sunlight plays a big factor in daytime heating.

Many radiant floor solar heating systems suffer from an overproduction of heat in the summer, since there is little or no space heating load. My understanding is that the antifreeze in the Dow Frost HD propylene glycol mixture that I used is rated at 325°F (163°C) for one year. The lower the operating temperature, the longer it will last.

For the summer months, my inclination is to leave the system running, and see if the heat build-up in my utility room gets to be an issue. If it does, I'll either drain and flush the system or cover the collectors. Using custom canvas covers (available from boat outfitters) seems like the simplest solution for my needs now. I like the idea that I could uncover one collector at a time as needed.

You can see a detailed journal with many images of the whole process of building this system on my Web site. I am now enjoying building furniture in a warm work space. It is a very efficient system, and best of all—it's heated by the sun! Radiant heat makes a very comfortable work environment, and I have found that I am setting the thermostat lower than I had expected.

Access

Guy Marsden, Art Tec, 61 Delano Road, Woolwich, ME 04579 • 207-443-8942 • Fax: 207-443-8677
guy@arttec.net • www.arttec.net/Solar/BarnHeat.html

Solar Market/Talmage Solar Engineering, Inc., 25 Limerick Rd., Arundel, ME • 877-785-0088 or 207-985-0088 • Fax: 207-985-5577
naoto@solarmarket.com • www.solarmarket.com

Windo-Therm, 2746 NY 7, Valley Falls, NY 12185
800-819-9463 • Fax: 518-663-7678
windo@albany.net • www.windotherm.com

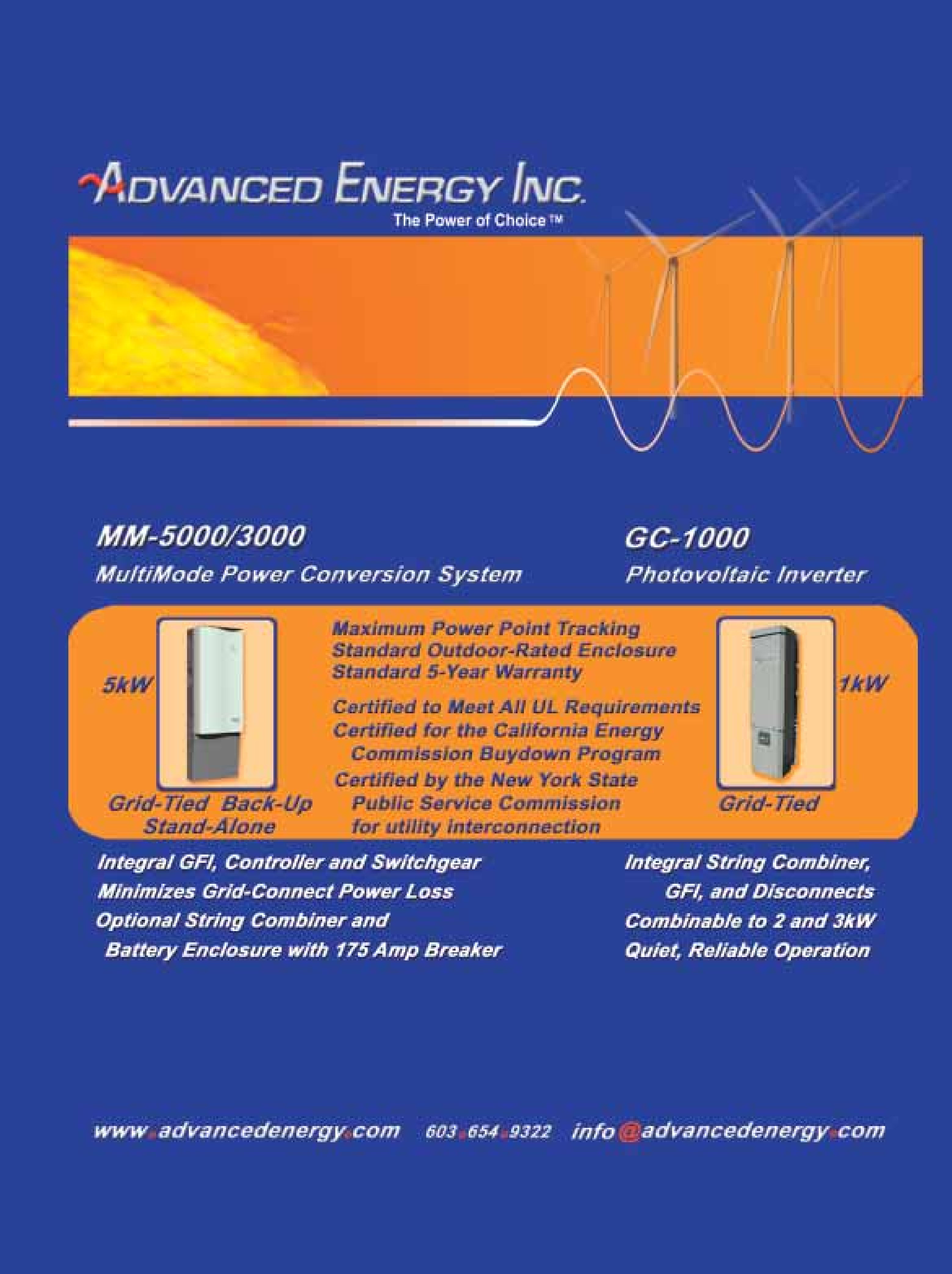
Corbond Corporation, 32404 Frontage Rd., Bozeman, MT 59715 • 888-949-9089 or 406-586-4585
corbond@corbond.com • www.corbond.com • Corbond insulation

Radiant Floor Company, PO Box 666, Barton, VT 05822 • 866-927-6863 or 802-525-1132
Fax: 802-525-3940 • info@radiantcompany.com
www.radiantcompany.com

Controlled Energy Corp., 340 Mad River Park, Waitsfield, VT 05673 • 800-642-3199 or 802-496-4357
Fax: 802-496-6924 • sales@controlledenergy.com
www.controlledenergy.com • AquaStar tankless water heater

Taco, Inc., 1160 Cranston St., Cranston, RI 02920
401-942-8000 • Fax: 401-942-2360
marcha@taco-hvac.com • www.taco-hvac.com

Ivan Labs, Inc., Dan I. Fieldman, 305 Circle West, Jupiter, FL 33458 • 561-747-5354 • Fax: 561-746-9760
ivandelsol@juno.com



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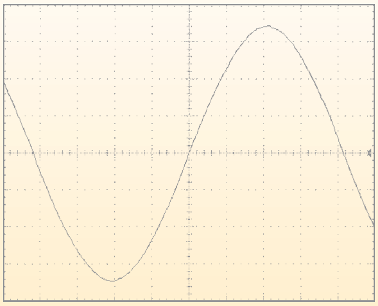

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Domestic Wastewater:

David Abazs

The Abazs farm in the Sawtooth Mountains of Minnesota uses a composting toilet and greywater irrigation

Over the last fourteen years on our homestead, my wife and I have worked at making our lives as cyclical as possible—turning all our lines into circles. When it comes to wastewater, after much trial and error, we feel that we have finally found a solution that works.

Being nestled in the Sawtooth Mountains in Minnesota, along the north shore of Lake Superior, has provided many challenges and opportunities for our family's homestead. The rocky and forest-covered Canadian shield makes for tough farming, but it also provides us with plentiful stones and timbers to build all our structures, fences, terraces, and whatever else we can think of. Being far away from power lines supports our commitment to living off the grid, but creates the additional challenge of prioritizing our energy needs.

In relation to our wastewater system, we tackled questions such as: How much energy do we need, or can we afford? What happens to the system when our batteries get low? How do we get water to our house, and how do we get rid of it? Pumps or gravity? The shallow soil, with less than two feet to bedrock, further limited our wastewater options—not to mention our farming. Creative solutions were needed.

At the time we were making these decisions, my job as the county water plan coordinator provided me with the opportunity to explore regional wastewater problems. During those years, I worked with an alternative wastewater technical committee, installing and evaluating alternative wastewater treatment systems throughout northern Minnesota. I couldn't have asked for a better chance to see the options available, and to help shape the trends in wastewater attitudes.

The first crop of apples irrigated with greywater.

A Circular Solution

to nourish and hydrate three different agricultural zones—orchard, greenhouses, and yard.

Our Farm's Solar & Wind Electrical System

In 1988, we set up a one-panel solar-electric system for lights and a radio in the hunting cabin we purchased on the land we now call Round River Farm. We then built a sauna, barn, and finally a new house in 1994, when we set up a full-service, 48 volt solar-electric system.

The system started with four, Solec 100 watt PV modules on a homebuilt PV frame; an Enermaxer shunt regulator and diversion load; a main breaker; a Trace 4,000 watt inverter; sixteen, 220 amp-hour, deep-cycle Interstate batteries; and AC and DC breaker panels. The DC panel uses a Vicor Mega Module DC-to-DC converter to step the 48 volts down to a more usable 12 volts to run an answering machine and the composting toilet fan.

In 1996, we installed a Whisper 1500 wind generator on an 80 foot (24 m) guyed tower (a challenging installation to say the least). This was soon struck by lightning, which despite proper grounding and lightning arrestors, fried our Trace inverter. After the repairs, we installed welding cable quick connectors so that we could disconnect the inverter during lightning storms.

After another lightning strike fried the regulator, we added a new switch that allows us to disconnect the wind generator from the rest of the system.

In 1997, we added four new BP590 PV modules to help compensate for the less than reliable wind machine. (The Whisper 1500 wind generator is no longer available.) In 1999, we added additional breakers, a DC disconnect unit—the "terminator switch" for the wind machine—and replaced our 5-year-old batteries with sixteen, 350 amp-hour, deep-cycle Interstate batteries.

Tremayne checks out the lush, greywater-irrigated tomato plants in one of the greenhouses, one of three irrigation zones on the farm.

Tremayne shows off the Sun-Mar toilet, which is raised above a custom-built, 64 cubic foot composting bin.

With this system, we can run our entire farm and home without a fossil fuel backup generator. This includes all of the needed creature comforts, along with irrigation, electric chainsaw, lawn mower, and other farm needs. It also provides the electricity for our water and wastewater systems.

Our Toilet Evolution

In our early homesteading years, we actually liked the outhouse. It had the best view on the farm, overlooking the garden and the towering cliffs, and the nightly trips meant we never missed the dazzling northern lights or meteor showers. But along came children, or maybe we just got wimpy, and those subzero midnight trips weren't quite as appealing as they used to be. When we built the new house, an indoor toilet was put high on the priority list.

Many composting toilets require heaters and fans that use electricity. In situations where water must be pumped, electricity is used to move water to and from the toilet and septic tank. Because of our energy restrictions, we chose to use the Sun-Mar nonelectric, self-contained composting toilet, with the addition of an electric vent fan.

After this toilet failed to perform adequately—my wife and kids fled the house whenever I emptied the bin—I retrofitted it to help it meet our needs. The Sun-Mar composting toilet is designed with a circular, tumbling bin that captures the waste. The toilet can continue to be used as the waste is periodically tumbled for about a month. The waste is then dumped through an opening to a lower bin that operates as a slide-out drawer for emptying.

I built a 15 by 10 foot (4.6 x 3 m) bathroom addition to our house so I could build a 4 by 4 by 4 foot (1.2 m) composting bin that could be accessed from outside the house. This bin was built with treated plywood that extends three feet below the floor of the addition. With the 8 inch (20 cm) floor joists, this gave me 28 inches (71 cm) of space to place an outside access door for removal of the finished compost. After sealing all the joints on the plywood box, I lined the inside with exterior styrofoam insulation, and built the bathroom floor over the whole thing.

I cut out the fiberglass bottom of the toilet's lower bin unit and reinstalled the toilet over the top of my new bin. We use the tumbler part of the unit as it was designed, rotating the contents for a month before dumping it into the new and much larger bin below. The material then has up to two years to continue decomposing, resulting in a finished compost far more acceptable than what we had gotten before. Every two years, we empty the bin and put the composted material in our orchard.

The vent fan draws 0.07 amps at 12 volts DC—just over 20 watt-hours per day. We run the fan on DC, even though the rest of our house is on AC, to avoid the inverter being on 24 hours a day. We also keep an extra replacement fan on hand, since we would not want to go long without a working fan on the ventilation pipe.

Not everyone has to go through the toilet evolution we did. Several family-sized composting toilets are commercially available that could have worked for us, probably for a bit more money than we had at the time. With all these toilets, however, an off-grid home still has to consider the units' energy needs. Heating elements, required by several commercial designs, do not work in a reasonably sized, off-grid electrical system. Some of these heating elements use more electricity than we use to power our entire farm and home.

Even when a home is connected to the utility grid, reducing household energy consumption is a choice that will reduce the environmental damage created by most electrical power generation. Phoenix, Carousel, and Clivus Multrum composting toilet systems are all designed to be used without heating elements. Biolet and Sun-Mar nonelectric units work in seasonal or cabin situations, but it was a mistake for us to use this type of toilet for a full-time household.

A less expensive option is to build your own unit. Many designs can work very well. The basic design elements to keep in mind when building your own composting toilet are providing the right combination of air, warmth, moisture, and time, and the correct carbon/nitrogen ratio. Homebuilt composting toilet designs can be found in the old *Mother Earth News* (January/February 1984), and in books such as *The Humanure Handbook: A Guide to Composting Human Manure* and *The Composting Toilet System Book: A Practical Guide to Choosing, Planning, and Maintaining Composting Toilet Systems.*

What about the Greywater?
Once we were set up with our composting toilet, we still had to deal with the greywater flowing from our sinks, showers, bath, and laundry. While greywater usage provides many advantages, it still needs to be treated. When the toilet outflow, or blackwater, is excluded from the rest of the wastewater, the remaining greywater contains:

- 40 percent less water
- 50–90 percent less nitrogen
- 40–60 percent less phosphorus
- less bacteria and fewer solids

Greywater treatment seems to be even harder for regulatory agencies to accept than composting toilets, although I am not sure why. What comes out of a typical household as greywater actually contains fewer “problem” nutrients than the treated effluent that comes out of a typical mound septic system. A homeowner has little problem getting a mound system approved, while someone wanting to try a greywater system will probably be pushed into the “experimental” category with all its hoops to jump through.

The biggest obstacle is that the regulatory community has figured out how to do a few systems (mounds and trenches, in our area), and does not want to spend the time and effort to investigate other options. They feel that their systems work, which in itself is arguable, considering the many studies revealing failing “approved” septic systems. Nonetheless, they have the tendency to reject any other suggestions.

In Minnesota, there are septic regulations (Minnesota Individual Sewage Treatment Systems Standards Chapter 7080), and all systems have to fit within these specs. Each state has different regulations. Here are three recommended steps for successfully getting your greywater system approved.

Growing Safe Vegetables with Greywater

Some concerns about irrigating veggies with greywater are very real. Greywater contains various plant nutrients, but can also carry harmful bacteria and viruses that could pose a human health risk. To make sure our vegetables would be safe to eat, we placed our drip irrigation lines so that all of the wastewater is delivered to the plants underground. Soil is a very hostile environment for bacteria and viruses, and provides effective treatment in breaking down these dangerous pathogens.

One guideline we use for irrigating our vegetables with greywater is that we only irrigate aboveground crops. Irrigating root crops with greywater is ill-advised (pardon the pun), because you would be handling and eating food that has been in direct contact with the greywater. We have grown squash, tomatoes, peppers, herbs, broccoli, kale, lettuce, beans, apples, grapes, and flowers with our greywater.

1. Find out how an alternative system fits into the existing regulatory guidelines, and address these regulations in any design you propose. In our case, we knew that the wastewater had to remain subsurface, and a 500 gallon (1,900 l) septic tank was required, so we used these parameters in finalizing our design.
2. Show that your system will treat the waste as well or better than approved systems. Make sure you know more than the officials do about greywater.
3. Go to meetings, talk directly with all the individuals involved in granting your permit request, and find influential people, like county commissioners, to support your efforts.

I followed all of these steps, plus I had the added advantage of having worked at the county level in the research of alternative waste water systems and was considered an expert in the field.

For some time, we have been working on an ecological way to not only treat, but also use this nutrient-rich water source safely and efficiently. Through the evolution of our system, we’ve learned plenty about how to approach designing, permitting, building, and using a greywater system.

Two Norwesco plastic sphere tanks help settle and filter greywater before irrigation.

The buried tanks are unobtrusive, with only the access covers showing.

Our First Try

We first started with a purchased system that used a barrel, pool sand filter, screen filter, and drip irrigation tubing. The design idea was to filter the greywater and disperse it through little holes (emitters) in the irrigation tubing. In our situation, we found there were too many flaws with this particular system. (The company, Agwa Systems, has since gone out of business.)

The pump was an energy hog and ran for much too long at a time. The sand filter kept getting clogged, and the screen filter required hand-cleaning after every load of clothes we washed. In addition, the drip tube emitters were plugged after the first few months of use. We didn't like them in the first place because the plastic was injected with an herbicide to inhibit root infiltration.

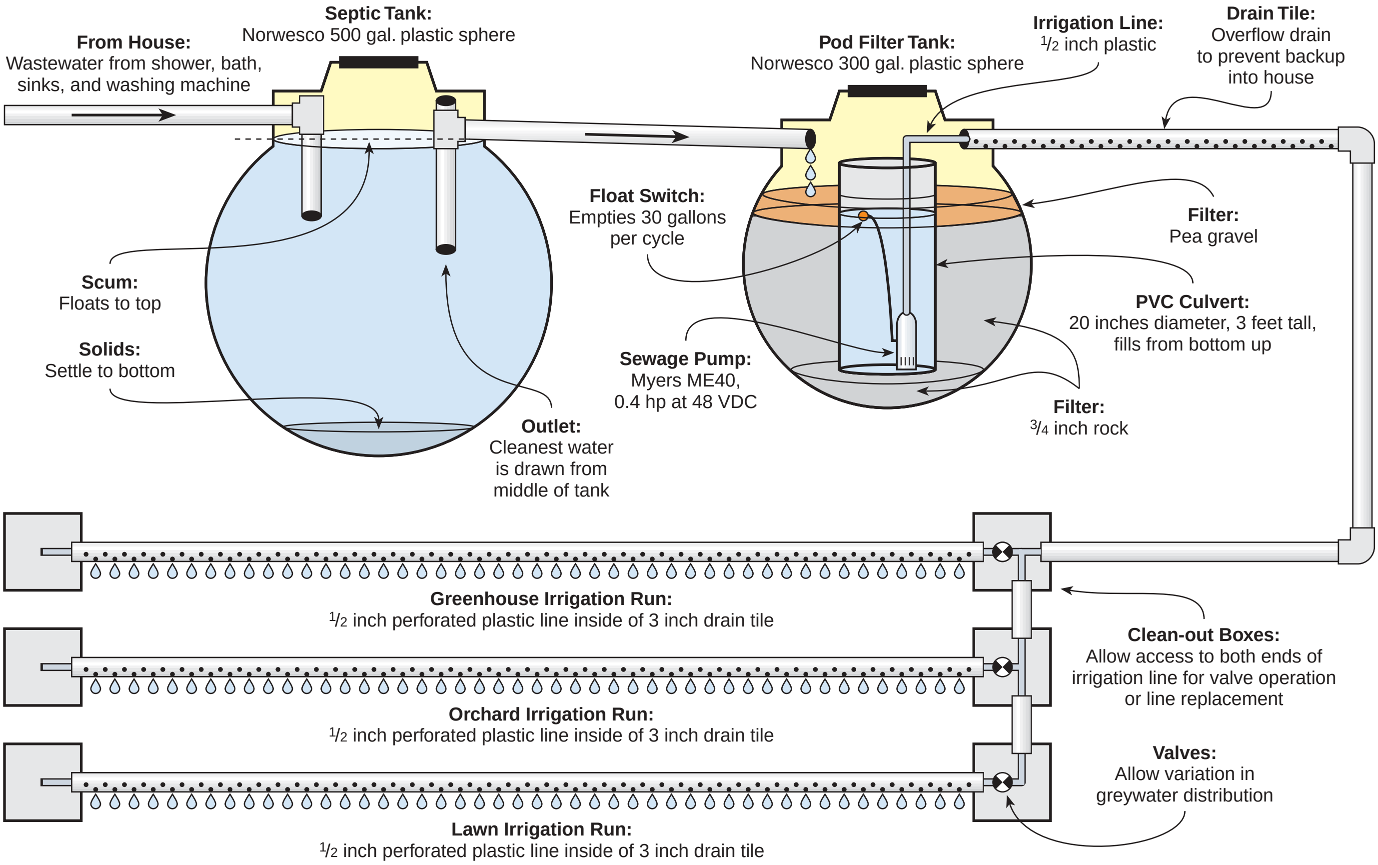
Finally, because we had installed the system in the greenhouse adjacent to our basement, we had the unpleasant side effect of a vague, sweet (my wife called it sour), greywater smell in the house whenever the pump cycled. We did all we could to avoid the pump cycling when we had visitors. Not even counting the problems we had with freezing in winter, we were far from satisfied.

Deciding to start from scratch, I took all we had learned that didn't work and managed to create something that did work. I had to start with all new equipment. The major parts of the new system are a 500 gallon (1,900 l) Norwesco plastic sphere for the septic tank; a 300 gallon (1,100 l) Norwesco plastic sphere for the pod filter; a 20 inch diameter, 3 foot section of PVC culvert; a ME 40 Meyers pump; $^1/_2$ inch irrigation tubing; and 3 inch plastic corrugated drain tile.

We now have an outside, buried system that doesn't freeze. It drip-irrigates 30 gallons (114 l) at a time into selected areas (zones) within 3 minutes, with no clogging and no smell. With only two cycles a day, even though the pump is a high-energy load, the system uses very little energy because of its short duration of just 6 minutes total per day.

The new pump draws 9 amps at 48 VDC for 6 minutes on an average day. This gives us a daily consumption of 43.2 watt-hours. Of course, it has a surge spike at the

Abazs Greywater System



beginning of each cycle. The old system had a similar pump, but ran for an hour plus, using 432 watt-hours per day. The current system uses a tenth of the energy of the older system. If there is a power failure (due to lightning, for instance), the system is designed to overflow into a wastewater drain tile.

I have installed several systems of this type around the region over the last few years, and I've learned a lot and made a few adjustments for individual situations. I've put together a detailed manual on my "Symbiosystem" greywater treatment system (see Access).

I had to spend a lot more time dealing with the regulatory bureaucracy than I did actually putting the system in the ground. It feels like a worthwhile cause, however, to be opening the way for people to use an environmentally friendly alternative to typical septic systems.

How Does It Work?

In a typical conserving home such as ours, greywater volume runs under 100 gallons (379 l) per day. We are careful to avoid using household chemicals that can harm the system and the plants we are feeding. Our greywater flows from the kitchen and bathroom sinks, shower, bath, and laundry into the septic tank. Our tank is buried to keep it from freezing, but it could be above ground in warmer climates. Because the tank I use is plastic, it is allowed to be placed closer to houses and bodies of water than a cement tank would be, since cement tanks are born to leak.

The septic tank performs minor biological treatment. But it mostly serves to separate the solids to the bottom and

The plastic culvert and pump inside the pod filter tank. The sand was later replaced with pea gravel.

Clean-out boxes help with distribution of irrigation water, as well as system maintenance.

the soaps and scum to the top of the tank, which keeps the inlet and the outlet free from clogging. The septic tank PVC pipe inlet extends 11 inches (28 cm) below the wastewater level in the septic tank. The outlet extends 17 inches (43 cm) below the wastewater level (depths vary based on septic tank size.) This setup results in clearer water leaving the tank before it flows into the pod filter.

The pod filter increases water clarity, while providing a pump chamber so we can pressurize the drip irrigation zones. My pod filter is a small septic tank with an upright culvert in the center, resting on a 3 inch (8 cm) bed of clean 3/4 inch (19 mm) rock. The area around the culvert is also filled in with clean 3/4 inch rock, 2 feet (0.6 m) deep, topped off with 8 inches (20 cm) of clean pea gravel.

Originally I used clean sand, but it restricted the water flow more than necessary. With any filter material used, a "clean" product is the key to success, and the pea gravel, instead of sand, was a good enough filter to achieve clean water. The pipe from the septic tank is placed so that the water entering the pod tank filters through the pea gravel and rock before it fills the culvert from the bottom up. The only moving part in the system is a high-quality sewage pump placed in the pump chamber formed by the culvert.

The pump sends the greywater into 1/2 inch plastic irrigation lines laid inside 3 or 4 inch plastic drain tiles. No herbicide is needed because of the air space between the drip lines and any invading roots. The irrigation lines have 1/8 inch (3 mm) holes to disperse the water in the areas we want irrigated. The soil directly around the irrigation lines is where the major treatment of the wastewater takes place. Many types of plants can take advantage of the nutrients in greywater. By using hand valves, I can send our greywater to zones in the greenhouses, orchard, or yard.

This system meets all the conditions necessary for a successful soil treatment system based on Minnesota's strict regulations:

- The wastewater never surfaces.
- Enough area is used to fully treat the water.
- The drip zones are designed to avoid freezing.
- The filter is designed to limit clogging.

We have always tried to live a self-sufficient, natural lifestyle. Living off the grid, we had to solve the issue of energy use and our wastewater options. With this new system, we use less energy, while providing nutrients and water to our greenhouse crops and orchards. Our

Greywater crazy— Halloween costumes.

Abazs Greywater System Costs

Item	Cost (US$)
Norwesco 500 gallon sphere	$320
Norwesco 300 gallon sphere	220
Misc pipe fittings, glue, roll of Mainline tubing (1/2 inch), 1/4 inch punch, compression fittings	175
Myers ME40 pump 0.4 hp	159
3 Norwesco access hole extensions	150
Culvert, 20 inches D x 36 inches H	55
Norwesco tees & gaskets	30
Perforated plastic pipe, 3 or 4 inch	25
Drop boxes, for end of drip lines	24
Silica tube,100%	2
Exterior foam insulation (surplus)	0
Total	$1,160

system has been evolving over the years to a point where it now practically takes care of itself!

Recycling greywater and putting it to productive use has always made sense to us. This circular solution has provided our homestead with a "resource," created from what was considered "waste."

Access

David Abazs, Round River Alternatives, 5879 Nikolai Rd., Finland, MN 55603 • 218-353-7736
abazs@lakenet.com • www.round-river.com
Symbiosystem: Installation, Operation and Maintenance Manual, by David Abazs, 24 pgs., US$59.50 (includes shipping and one hour of consultation)

The Composting Toilet System Book, by David Del Porto, US$29.95, plus US$3.20 S&H (US$12 outside U.S.) from Center for Ecological Pollution Prevention, PO Box 1330, Concord, MA 01742 • 978-318-7033
ecop2@hotmail.com • www.ecological-engineering.com

The Humanure Handbook: A Guide to Composting Human Manure, Second Edition, 1999, 302 pgs., ISBN 0-90644258-9-0 • US$19 (plus US$5 S&H) from Jenkins Publishing, 324 Old Beech Rd., Grove City, PA 16127 • 800-689-3233 or 814-786-9085
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Make Your Own Battery & Inverter Cables

Richard Perez

Distributing low voltage electricity around renewable energy systems has always been a problem. Every element in every circuit, especially in wiring and connectors, is a potential source of voltage drop. And in 12 or 24 volt systems, we need all the voltage we can get.

Nowhere are low resistance wiring and connections more important than within the battery pack and between the battery and the inverter. These wires may have to carry more than 500 amperes. Even small amounts of resistance in the connections can lead to unacceptable voltage losses at high rates of current. Here's how you can make your own very low loss, long-lived battery and inverter cables.

Connectors

The method of attaching the connectors to the cable's ends is very important. Connectors that are merely mechanically crimped to the wires' ends are unacceptable. These mechanical connections oxidize over time. Copper oxide is a very poor conductor of electricity. Mechanical connections may have relatively low resistance when they are first made, but after several months, their resistance increases as they oxidize.

Step 6: Flattening the tubing in a vise.

The decay of mechanical connectors is accelerated when the connectors are attached to the poles of lead-acid batteries. Lead-acid batteries always collect some sulfuric acid on their surfaces and on their wiring and connectors. This acid rapidly attacks mechanical connections, and quickly results in unacceptable voltage losses.

So it is not enough for us to use large diameter, low resistance cables on our batteries and inverters. We must also have low resistance, durable connectors. Soldering the connector to the cable is really the only way to keep the battery's acid electrolyte from attacking the connectors.

Steps 1–3: Strip insulation from cable and cut copper tubing to length.

Step 7: The end of the tubing without cable gets pounded flat.

Step 8: Fold the end over in a vise, shown half completed.

A soldered connector is permanently sealed—there is no way the acid can destroy the connection between the cable and the connector. Most commercially available connectors are the crimp-on type. These lugs can be soldered from the cable side of the connector if the wire insulation is cut back $^1/_8$ inch from the lug. Some lugs have an open end on the terminal side of the connector to flow solder into.

Make Our Own Connectors

One type of homemade connector is made from copper tubing sleeved over the copper cable. Use only clean, thick-walled (type L), soft copper tubing. Don't use hardened copper tubing, or oxidized, dirty tubing. The proper copper tubing is available at almost any hardware store, and is sold by the foot.

Use the appropriate gauge, stranded copper cable for your application. Battery cables should be sized to match the inverter capacity and load. To figure out exactly what size cable to use in your application, see the wire sizing spreadsheet posted on *Home Power's* Web site.

Measure the length of cable you require very carefully. Depending on what wire type you use (number of strands), these cables can be very stiff, and you may need to allow for a bending radius. What follows are step-by-step instructions for making and attaching soldered connectors to your cable's ends.

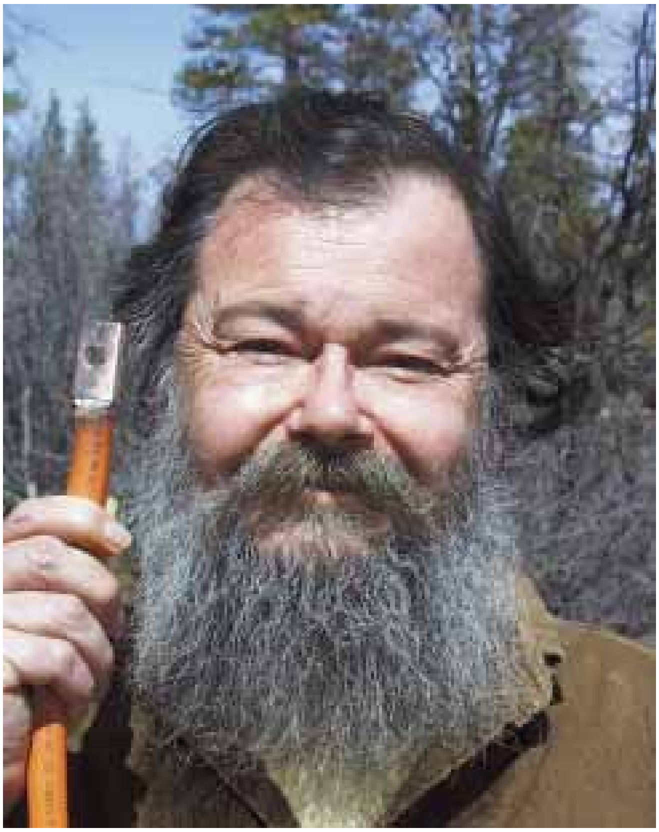
1. Strip 1$^3/_4$ inches (45 mm) of the insulation from each end of the cable.
2. Take the twist out of the individual wires that make up the cable. The wire strands should be fanned out until they are all parallel and not twisted around each other. This makes flattening the finished connector much easier. A set of pliers aids in this process.
3. Cut 2$^1/_2$ inch (64 mm) lengths of the copper tubing. Use $^5/_8$ inch (16 mm) diameter tubing for #0 (53 mm^2) cable, $^3/_4$ inch (19 mm) tubing for #00 and #000 (67 and 85 mm^2) cable, and 1 inch (25 mm) tubing for #0000 (107 mm^2) copper cable.

Steps 9 & 10: Gently secure the cable in a vise and flow solder into the tubing until full. Let cool before handling!

Step 12: Locate and drill the bolt hole.

Step 13: Trim off the excess part of tubing that contains no cable.

Step 14: Polish and brighten the connector for good contact.



Be proud of making a quality, lasting component that is essential for good system performance.

4. Lightly coat the stripped, untwisted ends of the cable and the interior of the copper tubing with solder flux. I use No-Corrode flux, but use whatever you wish, as long it is noncorrosive and not acid based.

5. Slide the copper tubing over the stripped end of the cable. Leave about 1/4 inch (6 mm) gap between the cable insulation and the copper tubing.

6. Flatten the tubing, with the wire inside, in a vise.

7. Position the entire assembly on a flat surface. Use a hammer to compress the connector until is flat and even. Note that the copper wire doesn't extend all the way into the tubing. There is about 3/4 of an inch (19 mm) of tubing that has no wire within it. Pound this area flat.

8. Put the portion of the tubing with no wire inside into the vise and roll it back on itself. This makes a sealed bottom to the connector so that the solder will not run out the bottom during soldering.

9. Clamp the cable into a vise with the cable up and the sealed bottom down. Heat the outside of the copper tubing with a propane torch until the flux begins to boil out of the open end of the tubing.

10. Flow solder into the open tubing end gradually, until the tubing is full. When the tubing is full, the solder will overflow the open end of the tubing. Use a good grade of solder. I like Kester 44, 60 percent tin and 40 percent lead.

11. Allow the connector to cool before removing it from the vise.

12. Locate the hole to be drilled in the connector with a center punch. Then drill the appropriately sized bolt hole.

13. Trim off the end of the connector that doesn't contain any wire.

14. Polish and brighten the connector with a wire brush.

The result is a soldered connector that actually has less resistance than the cable itself. The strands of wire that make up the cable extend *all* the way through the connector. Compare this with commercial soldered lugs where the wire is only in contact with half of the connector.

These homemade connectors not only have less resistance than the cable, but are actually mechanically stronger than the cable itself. And they are totally sealed, so there is no way for the connection to corrode internally. If the connector becomes corroded on the outside, simply remove it from the battery, and polish it with the wire brush until it's bright and clean.

It's a lot of work to make these cables, but once you have done it, the job is done for the long haul. So dust off the propane torch and make something that really works and lasts.

Access

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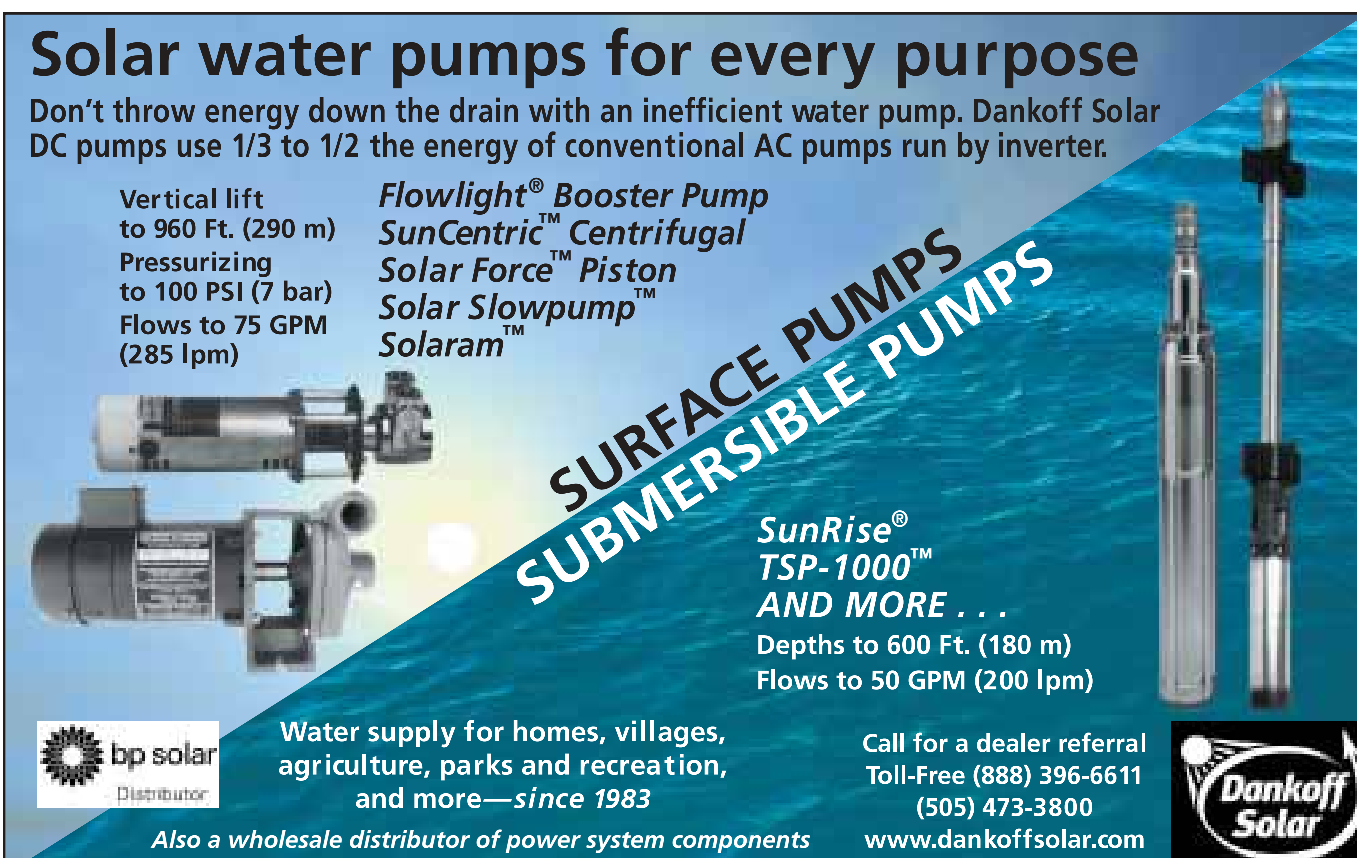
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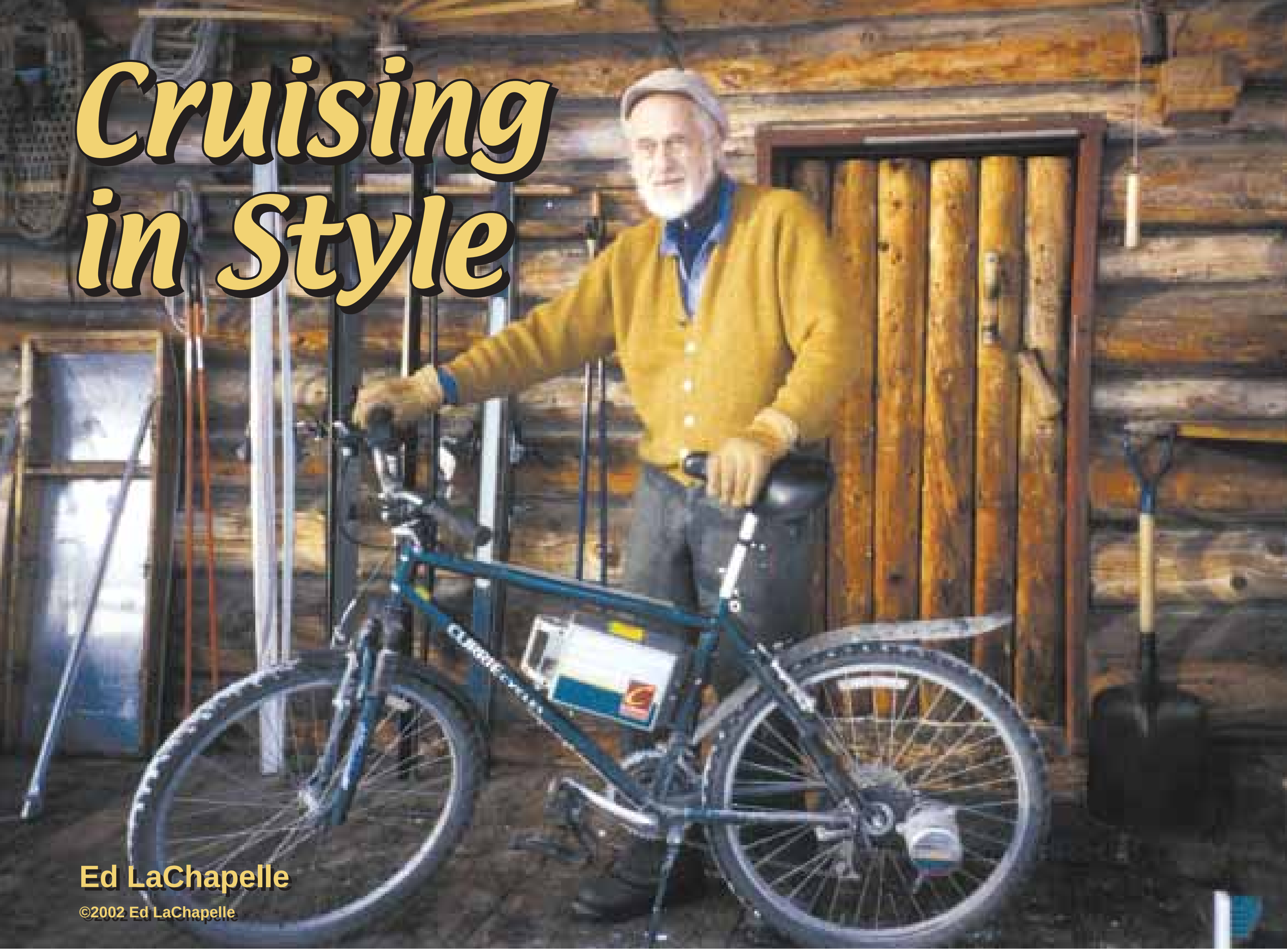

Ed LaChapelle and his trusty steed, a Currie USPD electric bike.

I had often dreamed of cruising around the local landscape on an electric bike—solar powered, of course! I looked at various models, including some shown in *Home Power* articles, but none seemed like a really good design.

My survey of other bikes was not complete. But it included front wheel drive, motor mounted to bike frame, and friction drive on tire styles. Each of these had limitations, such as regenerative braking (you have to apply leg power against it), poor drive mechanism, etc. Then I saw an article in *HP78* about solar charging stations on the streets of Grants Pass, Oregon. The article mentioned "a zippy new generation of electric bikes." Could this be my dream finally come true?

I contacted one of the authors, Gary Thomas of Solar Man Company, for more information. Gary recommended the Currie Model USPD electric bicycle, and sent details. This looked like the answer—a well-engineered, compact drive mechanism, attached to the rear wheel hub and powered by a 24 volt, 12 amp-hour, sealed lead-acid battery hung from the bike frame. So I ordered one at US$900 plus shipping from Solar Man, sent by mail to my remote village in Alaska. (See *HP17* and *HP69* for articles on my PV and EV systems.) These days, you can pay twice that for a mountain bike without electric drive.

Assemble & Go

The bike arrived in good condition, with a modest amount of assembly and adjustment required. Soon it was ready to go, with battery switched on and my thumb on the throttle lever. Nothing happened, zilch, no power. Digging into the power wiring revealed a broken connection to the speed control potentiometer caused by careless assembly at the factory. After a phone discussion with Gary, the Currie factory soon had a replacement on the way. Once installed, the new throttle brought the bike to life...and this thing really goes!

For the six snow-free months this past year, I cruised all over the local dirt roads with a whole new sense of freedom. The acceleration is lively, even uphill. Combine motor power with leg power on a hill and you can really fly, impressing spectators with what they believe to be your legs of steel. Using the motor for acceleration and my leg power for cruising takes so much effort out of bicycling that it becomes habit-forming.

When I offer my neighbors a chance to ride it, they universally come back with big grins on their faces. At full throttle, the acceleration quickly boosts the speed to faster than I care to ride a bike, at least on a dirt road, where I stick to 10 mph (16 kph) or so. The manual says maximum speed is 17 to 18 mph (27–29 kph).

After being put away for the winter, the Currie bike needs only some cleaning and adjusting for the summer. The manual says it is not designed for off-road or unpaved roads, but I find it works fine if you use some common sense. It has stood up to far rougher use than it was designed for.

Bike Details

The drive unit is an enclosed motor, gear box, and pulse width modulated (PWM) speed controller with chain connection to the rear bike wheel. It is entirely freewheeling: with motor turned off, it is just a regular 21-speed mountain bike. The electric drive, including battery (which can easily be detached and carried separately) adds 24 pounds (11 kg) of extra weight. Total weight comes to 67 pounds. In operation, the extra weight is offset by using the motor.

The Currie's lead-acid battery mounts inside the bike frame's main triangle. The electric drive system including battery adds 24 pounds to the bike.

The motor and drive train mount to the bike's rear hub.

Leg and motor power can be applied at the same time. This bike freewheels, so there is no regenerative braking. Battery charging with the standard 120 VAC charger provided with the bike takes about 8 hours. I also bought the high-speed charger, which does the job in 3 hours. The 5 amp charger retails for US$119.99. Plugging the charger into my solar-electric system's inverter lets me ride with the sun.

The owner's manual says that the bike will have up to a 20 mile (32 km) range under ideal conditions (level ground, on pavement, light-weight rider) before the batteries need to be recharged. My maximum run is 4.5 miles (7.3 km) up a grade gaining 800 feet (244 m) elevation, with mixed battery and leg power, which leaves some charge still in the battery. I have never run it all the way down, which is the best treatment of a battery, as *HP* always advocates.

Depending on use, you can expect to get 300 to 400 recharge cycles if you use 80 percent of the battery capacity. This will increase to 700 or 800 charge cycles if you use only half of the available charge. Since it is a lead-acid battery, it doesn't have a memory problem like cell phone batteries, and can be recharged at any time without harm. A replacement battery pack is only US$155, and is very easy to exchange. I know this because I remove the battery whenever I take it inside so I can charge it at room temperature.

Even the long Alaskan winter can't stop the Currie electric bike.

The motor has a high-temperature cutout. If you run it at full throttle up a long, steady grade, the electric assist stops until the motor cools down. Periodic bursts of acceleration, interspersed with leg power, beat this inconvenience. For servicing the bike, or tire repair, the whole motor unit easily detaches along with the wheel. Currie offers a Fitness Adapter, an extra attachment (US$59.99) that limits motor power and forces the rider who can't resist pushing on the throttle to do more of the work.

Downsides

I found a couple of minor downsides. The throttle and thumb-lever unit uses a tiny potentiometer with even tinier terminals designed to solder to a printed circuit board. Instead, the terminals are soldered to some loose wires running along the bike's handlebar, and hence are easily damaged. Currie is fully aware of this problem—twice the owner's manual warns of fragile wires in the throttle, and states in capital letters not to tamper with them.

In addition, the removable bolt anchoring the battery case is underdesigned, and predictably failed early. I replaced it with a heavier nut and bolt. The other end of the battery case needs a shim to keep it from bouncing up and down on rough roads.

A Good Ride

The USPD model I purchased has since been superceded by the new e-Ride model, with a new frame, upgraded components, newer generation motor, and all for a new lower price of US$599. A representative from Currie Technologies has assured me that this newest model includes changes to the throttle and corrections for the other design flaws I found.

I really appreciate the good engineering aspects of the Currie bike, and the maximum flexibility it offers for use and service. These, I think, speak for themselves. This bike has attracted so much favorable attention here that neighbors are now talking about ordering their own for this summer.

Access

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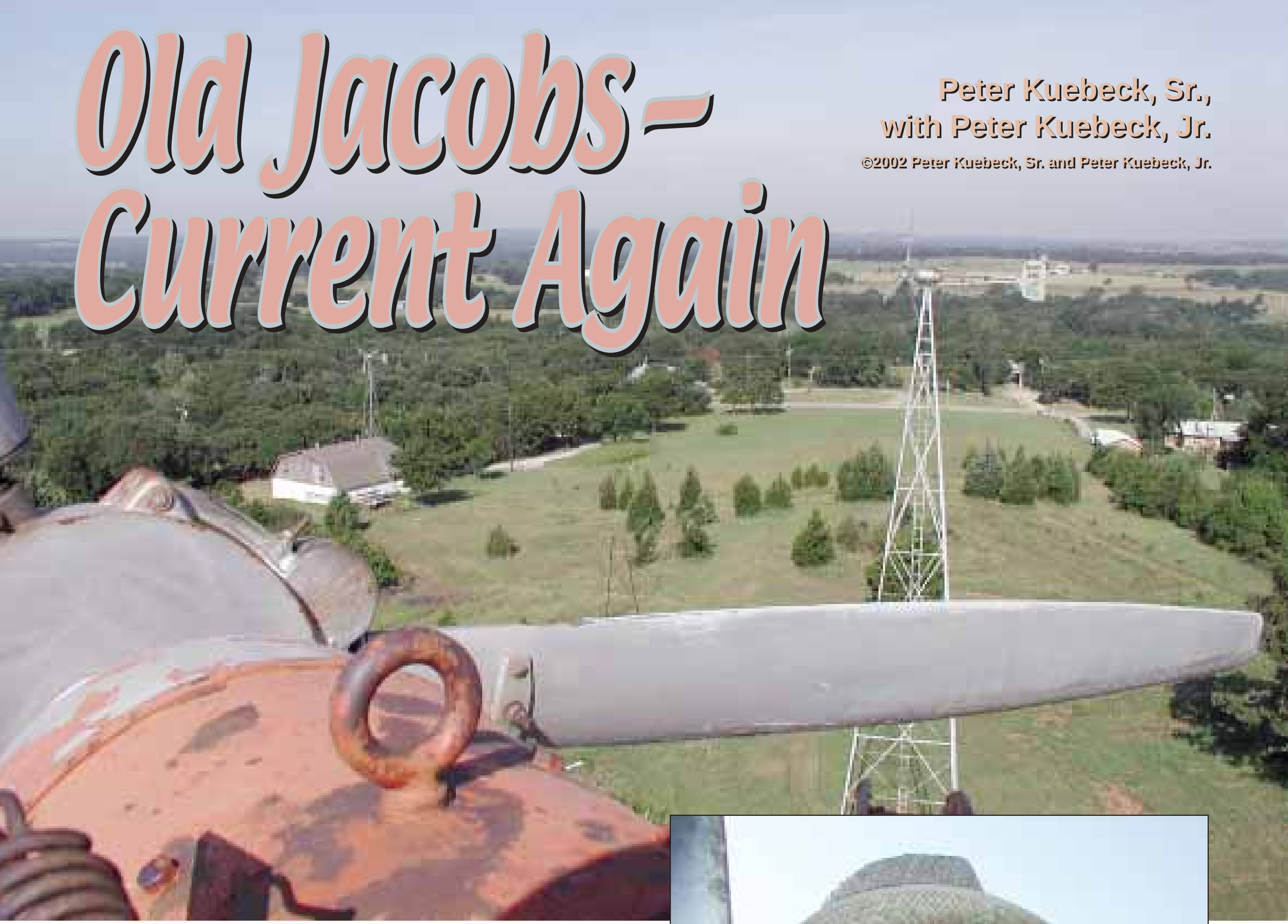
Old Jacobs– Current Again

Peter Kuebeck, Sr.,
with Peter Kuebeck, Jr.



High in the saddle—two classic Jacobs wind generators are visible from atop the third.

I have always been intrigued by difficult challenges. When my family took vacations, we admired the wind generators on the farms and in the pastures. They seemed to hold their own stories—some very antiquated and idle, and others still turning in the wind. One particular trip through South Dakota in our pickup became the fire of a new passion.

But first some background. I came to America in 1956. I was raised in Germany and always had a strong desire to come to the U.S. I met the girl who would be my wife, Louise, soon after my arrival. We have two sons, Peter, Jr. and Thomas. New Jersey was our home for many

Peter Kuebeck, Sr. surveys his wind powered farm from a lofty perch.

years. In 1977, we decided to “go west,” and we relocated in Prague, Oklahoma. I had been hired by Mobil Chemical Company in 1977, and was employed there as a maintenance mechanic until my retirement three years ago. Peter Jr. is an electrical engineer working in power distribution.

From Hobby to Passion

Our trip to South Dakota was in the summer of 1989. After checking into our motel in Murdo, we took a short drive through the small town. We spotted a Jacobs wind generator on a 45 foot (14 m) tower beside a small home. The owner was in the yard, so I stopped and went over to speak with him.

Ten minutes later, I returned to our truck and informed my wife that “we would be staying another day or two,” because I had purchased the wind generator. We hired a cherry picker to make it simpler to disassemble, and three days later we were driving into our yard with the first wind generator in our collection.

Over the years, my objectives and interests in wind energy have evolved from a hobby to a serious mission. While it has been a lot of work, there has also been plenty of help on weekends and evenings from my son, Peter, Jr. and former coworkers Travis Sweet, Bill Rigny, and Jim Bratcher. These men must be thanked, for it is their project as well.

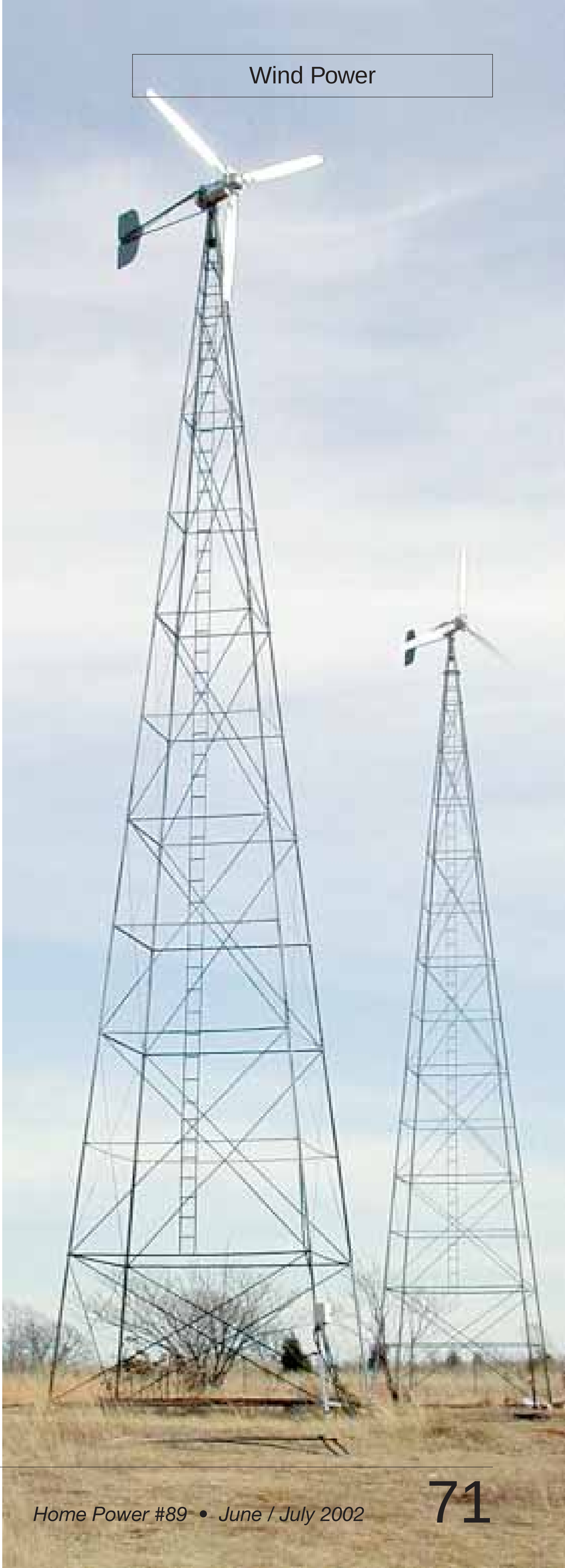
I’ve taken quite a few reconnaissance missions into the central plains. Seven of those trips were successful since we were able to bring home either 110 VDC or 32 VDC Jacobs wind generators. That’s the foundation of this story.

Economics

Generating electricity is a capital-intensive business, whether in central stations, transmission and distribution, or in residential systems. An effective project has to have low cost to get value for the effort. In an economic evaluation, the project is good if the cost is less than the present value.

We began this effort by reviewing all the alternative energy solutions. Our area of the country, Oklahoma, is a good location for either solar or wind projects. For us, PV was attractive for safety, ease of installation, and low failure rates. But after we looked at the economics, we decided not to pursue a PV system.

Examining the present value of a 100 W PV panel, with a production of 10 hours per day for 30 years at a rate of return of 7 percent and a US$0.10 KWH energy cost, yields a value of US$453. The present worth of the panel is just over the cost of US$399. High electricity prices are the major factor in making such a project cost effective, when grid electricity is available.



Heavy-Metal Wind Generators

Mick Sagrillo

The Kuebecks are running direct drive Jacobs wind generators. These "Jakes" were manufactured from 1930 to about 1956 by the Jacobs Wind Electric Company, in Minneapolis. During that time, over 50 megawatts of wind generators were manufactured and installed on six continents, according to the manufacturer.

All of the Jakes had a 13.5 foot (4.1 m) rotor diameter. The peak output ranged from an early 1,500 watt version, to 1,800 watt (at about 18 mph; 8 m/s) and 2,500 watt (at 25 mph; 11 m/s) models. A later model peaked at 3,000 watts (at 28 mph; 12.5 m/s). With an average peak output of 2,000 watts, 50 MW means there were about 25,000 of these wind-electric systems.

Wind generators were a primary mode of electricity generation on farms, from the Ohio River Valley to the Rockies, and from Canada's Red River Valley to Sonora, Mexico. The Jakes were the expensive option in a field of dozens of wind generators made during the pre-rural electrification era of the 1930s and '40s. When you consider that this was during the Great Depression in the United States, the success of this product speaks volumes about its reputation.

All of the pre-Rural Electrification Administration (REA) Jakes were DC generators, and were used to charge 32 VDC or 110 VDC battery banks. The batteries powered a variety of 32 and 110 VDC appliances and tools, from radios, fans, and toasters to vacuum cleaners, refrigerators, and drills.

The Jakes were considered the "Cadillac" of wind generators. They have been, and still are, highly sought after by rebuilders for remanufacture and sale. Weighing in at 450 to 550 pounds (200–250 kg) and peaking out at 225 to 325 rpm, they were the "heavy-metal," low wind speed design that others emulated then, and still try to match in durability and performance today.

The hub of an old Jake showing the unique flyball governor that controls blade pitch.

Kuebeck Wind System Costs

Item	*Cost (US$)*
3 Jacobs wind gennies	$1,050
144 C&D batteries, 450 and 480 AH	720
Tripp Lite PV2400 inverter	465
3 Towers	450
Concrete, 12 cubic yards	360
12 C&D batteries 2,016 AH	60
Breakers, meters, & panels	0
Total	$3,105

Salvaged Jacobs wind-electric units, with an estimated output of 2,500 W under the same analysis with 4,000 production hours in a year, have a present value of US$12,712. The cost of the three units we are running now was only US$1,050. Our batteries were also salvaged from microwave installations. These bargains made generating electricity with the wind economically appealing.

Over time, we have recovered various wind generators—Paris-Dunn, Wincharger, and Jacobs. The units were recovered from Kansas, the Dakotas, and Montana over a period of ten years. Most were lifted from towers, though several were off the tower and inside garages and barns. The preferred unit for our system is the 2,500 watt, 32 and 110 VDC, long case Jacobs. We now own four, 110 VDC and three, 32 VDC Jacobs units. Initially, we had three, 110 VDC units in the air, but we've recently converted two to 32 VDC.

Battery & Power Conversion—Take One

Our initial battery bank was 120 VDC, with sixty C&D LS-600 cells (regulated valve type) connected in series. A major design consideration in this arrangement was safety and maintenance. These cells are popular in large uninterruptible power supply systems. They did not

A DC motor / AC generator combination provided 120 VAC initially.

The DC power panel with breakers and meters, kilowatt-hour meter, and Tripp Lite 2,400 watt inverter.

Individual 30 amp fuses for each series string of lead-calcium batteries.

have the deep-cycle capability of the lead-calcium or antimony type cells, though they required minimum maintenance. But these batteries proved too delicate for wind charging and even modest discharge.

The wind gennies powered a 500 W Exide inverter, a 5,000 W motor-generator set, and 1,500 W of incandescent yard lighting. The Exide inverter has a 120 VDC input with a six-pole sine wave output. The unit is an early ’80s inverter, and has the critical features such as low voltage shutoff and overcurrent protection. The unit was used for fluorescent lighting in a high-bay garage area.

The motor-generator set used a large, compound-wound DC motor, coupled to a 5 KVA, permanent magnet, 1,800 rpm alternator. The compound-wound motor manages frequency control, which can vary from 55 to 65 Hz. This unit can be run directly from two or more Jacobs units, or from the 120 VDC batteries. Idle wattage was about 650 W. With all three Jacobs machines on-line, we can use the motor-generator without the battery.

At first, the motor-generator set was the preferred DC to AC converter. The energy conversion was not as efficient as the inverter, but inverters tend to be sensitive to momentary overloads and lightning. Also, many inverters are hard on the batteries and wind generator brushes, since they tend to draw high current in millisecond periods. It’s difficult to filter these impulses, especially with long wire runs (several hundred feet) between the wind generators, batteries, and inverters.

Our motor-generator set weighs around 600 pounds (270 kg). The heavy motor and permanent magnet generator store a lot of energy as inertia in the rotors. This smooths the output of the wind generators, so that frequency varies from 55 to 65 hertz on windy days under load. This stored inertia allows loads of all types—refrigerators, electronics, and well pumps—to coexist.

Battery & Power Conversion—Take Two

In the fall of 2001, we obtained a contract to remove all the lead-calcium cells from a 6 GHz industrial microwave system that was being taken out of service. We recovered five dozen, 450 amp-hour; seven dozen, 480 amp-hour; and one dozen, 2,016 amp-hour lead-calcium cells, complete with cables. The estimated cost for travel and meals was about US$5 per cell.

We made the painful decision to convert our battery bank from 120 VDC to 24 VDC. This was done so we could take advantage of the availability of high powered but inexpensive inverters. It was painful because the 120 V required less ampacity and could power lamps and some heaters directly. But we had grown beyond simple uses, and needed to power standard AC appliances.

Peter's packed battery room holds over 5,000 amp-hours of lead calcium-batteries at 24 volts DC.

Twelve huge 2,016 AH batteries make up a single series string at 24 volts DC.

Our 24 VDC battery banks add up to a capacity of 7,626 amp-hours. The battery cabinet has three tiers on each side, with ten series strings of the 450 and 480 amp-hour C&D cells. (Two of the 450 and 480 AH strings are inside the garage with the big 2,016 AH batteries.) An aisle provides access to all cells, buses, and conductors. The electrolyte levels are easily viewed, and there are good working clearances, which makes filling the batteries easy.

We are especially proud of the massive C&D DCU 2,016 amp-hour batteries. As can be observed from the photo, these units are about as big as they get. Each cell weighs 400 pounds (180 kg). Basically, they are a plastic case with 5 gallons (19 l) of electrolyte and 300 pounds (136 kg) of lead. We used hoists, slings, and lots of luck to get them into the building. Only one small puncture of a case was sustained, and that was later repaired permanently.

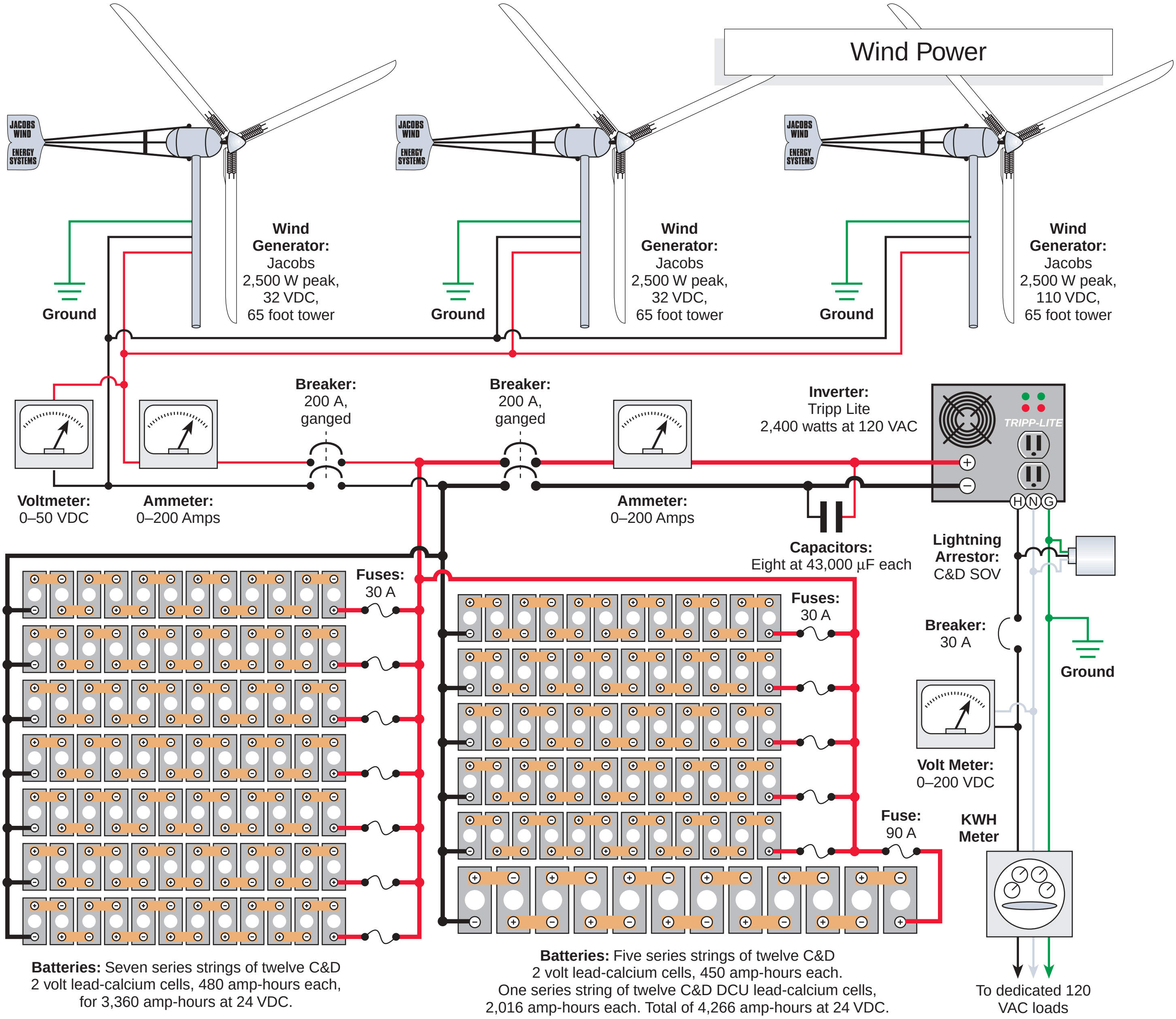
A large 24 VDC battery bank such as this, with its low impedance batteries, needs adequate fusing and grounding. Fault current is in excess of 100,000 amperes. Positive leads have fuses, and copper conductor is used to and from positive and negative buses. Ground conductors are #6 (13 mm^2) copper. They are sized as power conductors, and are connected to the negative bus.

A major effort was made to arrange breakers in the main panel so that lightning can be isolated from delicate inverters and loads. Our practice is to shut down the wind generators and open the breaker between them and the rest of the system wiring whenever even a hint of lightning is about. This helps isolate the battery and inverter from possible lightning damage caused by a strike on the towers. Lightning protection is also provided between the inverter and house loads.

Wind Generators

The wind generators we use are 2,500 W, long case Jacobs units. Two of the units are single commutator, 32 VDC units, connected in parallel with diodes. The 110 VDC unit has the front and rear commutator arrangement.

These wind generators are low rpm, upwind, direct drive machines with 13 foot (4 m) rotors. Their centrifugal overspeed control is the original Jacobs flyball governor. We have the blades set to feather out and govern the machine at 200 to 225 rpm.



Spring-loaded tail sections are operated with a hand crank, and direct the units out of the wind when not in use. The units are mounted on self-supporting, original Jacobs towers. The galvanized, four-legged towers are constructed with 2 inch (5 cm) face angle steel.

Towers

The three, 65 foot (20 m) towers are sited within a 16 acre lot. The elevation of two units on a hill is 1,003 feet (306 m), while the other is about 975 feet (297 m). The surrounding area is an elevation of 946 feet (288 m) above sea level. Average wind speed at the site is about 13 mph (6 m/s). The site is 2 miles (3 km) from the nearest airport and has no restrictions on tower height due to ordinances or flight paths.

Top wind gusts are in the 50 to 60 mph (22–27 m/s) range, though tornados can rage through the area during spring and fall. A key to safe construction and operation is the design of the tower footings, with consideration of the soil type in analyzing the "upturn" potential. The soil type where the towers are sited is clay, which is about the best for permanent anchoring.

The structural analysis of the tower needs to take into account the surface area of the tower face and an estimate of the swept area of the blades. The resulting moment or force against the tower above the ground results in an overturning force that can pull the piers out of the ground. Usually structures are overdesigned so that conditions such as rain softened soil don't result in catastrophic problems.

Placement of the tower is also critical. For example, we have three towers, all 65 feet in height. The first tower is in a location where the wind "wanders" when northerly winds prevail. The second and third towers are in an area where the prevailing southerly winds get a "boost" as they ride up the the face of a hill, free of obstacles.

At 65 feet, that tractor looks pretty small—
we're glad Peter Kuebeck, Jr. is wearing a harness.

Kuebeck System Loads

Item	Rated Watts	Avg. Hours Per Day	Avg. WH Per Day*
Electric heat	1,500	6	6,429
Microwave	750	10	5,357
Refrigerator	600	10	4,286
Six-lamp fixture	240	10	1,714
TV	240	10	1,714
Two-lamp fixture	120	10	857
Coffee pot	1,025	1	732
TV	100	10	714
TV	100	10	714
Lamp	100	10	714
Lamp	100	10	714
Lamp	100	10	714
Lamp	60	10	429
Lamp	60	10	429
Fluorescent lamp	40	10	286
Propane stove	25	10	179
		Total	25,982

** All appliances used an average of 5 days per week.*

Consistent wind is needed for the best performance. Positioning the towers so that they have a clear shot at the prevailing winds results in good generator output. For instance, in Oklahoma, the winds come from the north and south 77 percent of the time. At least 85 percent of the energy from the wind occurs from these directions. We tried to take this into account when siting our towers, and then hoped for the best.

The towers use piers that are 3 feet (0.9 m) in diameter and extend 5 feet (1.5 m) below grade. The upturn moment in clay soil at 52 mph (23 m/s) of wind is strong enough that the force of wind against the blades and tower would pull the piers out of the ground. With the blades out of the wind or stalled due to the overspeed control, the tower is adequate for 100 mph (45 m/s) winds. The blades stall at around 225 rpm, which should leave some 30 tons of margin of upturn at 23 mph (10 m/s). Tower and anchor design and siting are complex design and engineering efforts, and vary greatly depending on soil type. Consult a professional prior to construction.

Expertise is essential. Installing a tower and turbine is not a "cookbook operation." It's a two-person job, and you need good, dependable tools. It would take too much space to properly illustrate the process for rigging the tower and the turbine. My advice in this area is to try to locate an out-of-print manual, published by The Jacobs Wind Electric Company, Inc., titled *Instruction Book; 110 & 32 Volt Direct Drive Jacobs Wind Electric.*

System Loads

Since the conversion to 24 VDC was done, we have gone the inverter route instead of using the motor-generator. This improves the efficiency of the system immensely. We selected a modified square wave Tripp Lite PowerVerter. The unit starts motors up to 2.25 hp, and the peak rating of the unit is 4,800 watts. We are very pleased with the robust nature of the unit.

The Tripp Lite inverter is a compact unit with a maximum input of 200 amps at 30 VDC. The unit powers up with a simple on/off switch on the front panel, and requires about a ten second startup. We have DC-rated input breaker protection for 200 amps and output protection for 30 amps on the 120 VAC side.

The unit has simple LEDs to indicate low, medium, and high loading. Idle current at no load is about one ampere, for about 25 watts. Full load efficiency is rated at 90 percent. We mail ordered the unit from buy.com for US$465, including shipping. The inverter can be seen in the bottom right of the control panel with input amps and voltage instrumentation.

The inverter has been in use for only a couple of months. At this point, I am not using the system to its full capacity. I am alternating usage in a variety of ways to evaluate where the best performance will be. I will eventually have to separate some circuits and make changes in the house wiring.

We are using an auxiliary heater of 1,500 W to offset the cost of the central heating system, and 800 W for exterior lighting. I have one wind powered circuit in the house, and alternate the appliances to test the capacity and reliability.

Well-planned systems may use two inverters, which allows for separation of sensitive loads from the heavy surges of motors. We will go that route as the system capability improves. We plan to add an additional 32 VDC wind generator to the ones that are already up and running.

System Performance

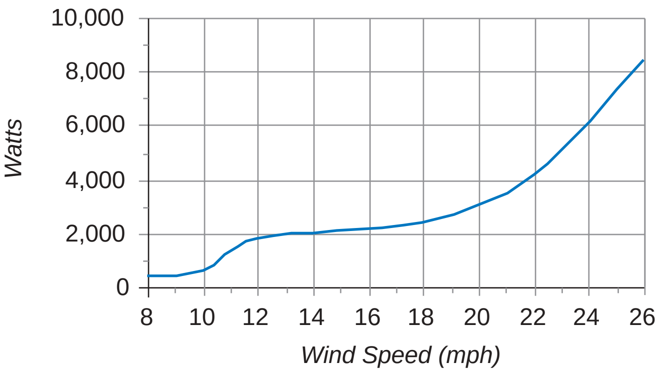
Oklahoma wind is fairly consistent, except in the dead of summer. Prevailing winds are from the south, and typically 10 to 22 mph (4.5–10 m/s). When fronts move through, north winds can average 20 to 30 mph (9–13 m/s) for a day. Because we don't have a dump load and can't use all the electricity we can produce, we typically run only one or two of the machines to limit charging. The units have governors for limiting overspeed problems, but we are careful to avoid having all three units on-line in a windy day to reduce the risk of overcharging.

At this point, we regulate wind turbine charge amps to the batteries by manually furling the machines out of the wind when the batteries are fully charged. This approach is not recommended. The addition of a shunt type regulator, an Enermaxer or Trace C40, for example, used in conjunction with a resistive dump load, would fully automate the battery regulation process. This would make the system more convenient, as well as safer.

The arrangement of generators has changed over the years, and in the past we have seen 120 amps into a 120 VDC bus. This seriously overcharged the small 600 amp-hour batteries that made up the bank. (Ultimately, it was dangerous!) Generator output is dependent on the wind speed. We don't meter the units separately, so the graph demonstrates output of the three units' ganged output.

One of the keys in converting to 24 VDC was that with the salvaged batteries, we have enough capacity to handle the charging during windy periods without overcharging. The eight hour charging rate for the battery bank (C8) is 930 amps. The battery manufacturer recommends discharging and charging the bank below the C8 rate for good battery life. Our charging rate with two units is typically 50 amps. In blustery weather, 75 to 100 amps is common. A front will result in a 150 amp charge. Battery voltage normally is around 26 volts, while with several days of gusty weather, we can see 30 volts.

Three Generators' Combined Output



One of the advantages of using the 32 VDC generators compared to 110 VDC units is that the output begins at lower wind speed. This is because 32 VDC units require only 60 percent of the blade speed to begin output. We get 25 amps of charging in less than 10 mph (4.5 m/s) wind speed.

A System in Transition

The system is currently a stand-alone, experimental system for two main reasons. The cost of a system reliable enough for home use would be high. For instance, we would need at least two inverters for operation, and a spare so that a failure would not render the residence uninhabitable during the failure.

Another option would be to install an AC bypass switch that would power dedicated household circuits directly from the grid in the event of an inverter failure. Although we have a motor-generator set that would be robust enough for nearly any short-term needs, efficiency is poor.

It takes time to maintain the system. Batteries, towers, and wind generators have high maintenance requirements, and you need to be careful that you don't get overextended on a hobby.

The wind generators are visible for miles around. We get visits and calls regularly from all over Oklahoma and a variety of other states to see just what is involved and how it works. Every visit has been positive and cordial, punctuated with lots of curiosity. You never know what they will ask. Good ideas have come from some of these discussions. Steve Hicks from Mountain Pass

Wind in White Sulphur Springs, Montana, has become a good friend. We visit on the phone periodically, and he is a good source for wind and solar-electric information.

We are looking forward to improving the system. At some point, we will swap out a 110 VDC machine for a 32 VDC unit to allow us to have a spare. We will add another unit on our site for a total of three, 32 VDC machines and one 110 VDC machine. We may eventually decide to go off the grid when we gain more experience in operating the system.

Access

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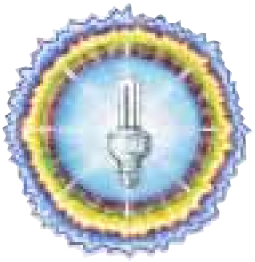

"The man who on his trade relies, Must either bust or advertise."
Sir Thomas Lipton — 1870

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TOP SECRET

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

PROFILE: 0020

DATE: April 2002
LOCATION: Northern Hemisphere
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 100 watts of PV
PERCENT OF ANNUAL LOAD: 4%
TIME IN SERVICE: 2 months

I am just an average, ordinary guy. I am not a handyman, nor an electrician. I'm writing this to show that you do not have to be a genius to start your own solar-electric project.

I have been slowly changing out incandescent lightbulbs for compact fluorescents in my home. I never really paid attention to how many kilowatt-hours I was using on a monthly basis. That all changed in April 2001, when I read my first issue of Home Power magazine.

I read about a guy who was using a single, 10 watt solar-electric panel and a wind generator that he built himself. I didn't understand much of the technical jargon of the article at first, but I did know that I wanted to try it myself.

I bought a used, 10 watt solar-electric panel on eBay's auction Web site. I found a deep-cycle battery, on the curb that the garbage collector refused. With a 300 watt inverter, I was able to run an 11 watt compact fluorescent light. Every night, I could sit in my chair and be bathed in the warm glow of solar powered light. I was so pleased, but I wanted more. I contacted the local electric company to purchase green power, but was told that the service would not be available in my town. That's when I decided to go guerrilla.

A recent Home Power article gave step-by-step instructions on how to build a small, relatively inexpensive guerrilla system (HP86, page 84). I went to eBay and purchased a Trace MicroSine inverter for US$209 shipped. I purchased 50 watt panels from solarseller.com for US$335 shipped. I got a pretty good deal on the panels because they are from different manufacturers; one is made by BP Solar and the other by Siemens. I purchased the rest of the materials from my local hardware store for under US$100. I made an adjustable mounting frame out of angle iron.

On February 1, 2002, I plugged my panels in for the first time. I immediately looked at my utility meter, but it wasn't running backwards. I switched off all the breakers in my house except for the one my PV system was plugged into. The meter went backwards very slowly. I adjusted the array to the proper angle for our location. Then I watched the meter spin backwards at a much more satisfying rate. Since I started conserving electricity, my utility bills have decreased by an average of 17.3 percent from last year. My PV system should also lower my energy consumption by another 4 percent.

What have I learned from my experimentation? I've learned that it is more cost effective to save electricity than it is to generate it. I also learned that this isn't rocket science--anybody can generate their own electricity.

Guerrilla Solar Defined

Energy is freely and democratically provided by Nature. This century's monopolization of energy by utilities both public and private threatens the health of our environment. Solar guerrillas believe that clean renewable energy should be welcomed by utilities. But utilities and governments continue to put up unreasonable barriers to interconnection, pushing common citizens to solar civil disobedience. Guerrilla systems do not endanger utility line workers (see *HP71*, page 58). They share clean, renewable energy with others on the utility grid, and reduce the need for polluting generation plants. When interconnection for small-scale renewables becomes fair, simple, and easily accessible to all, there will be no more need for guerrilla action.


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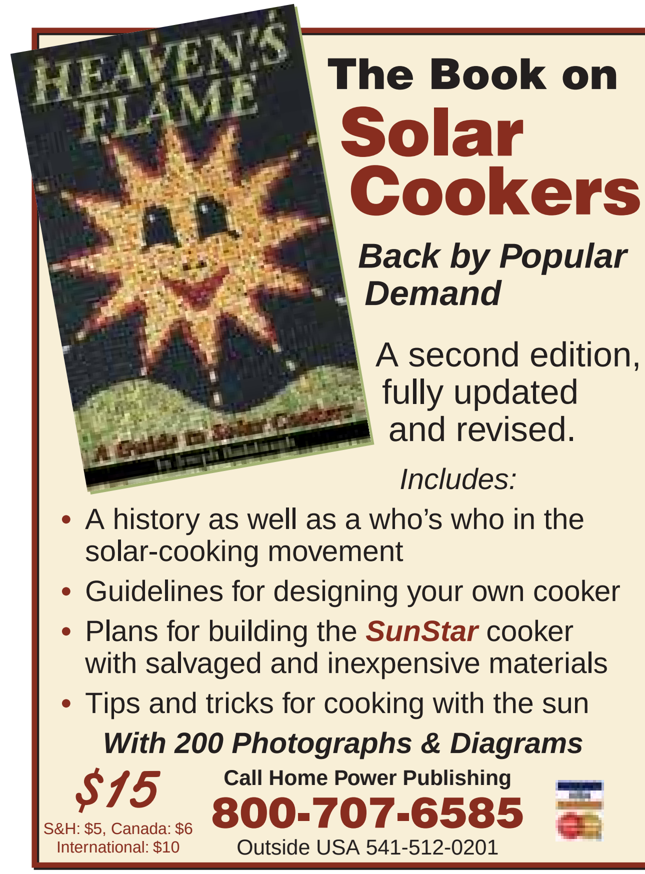
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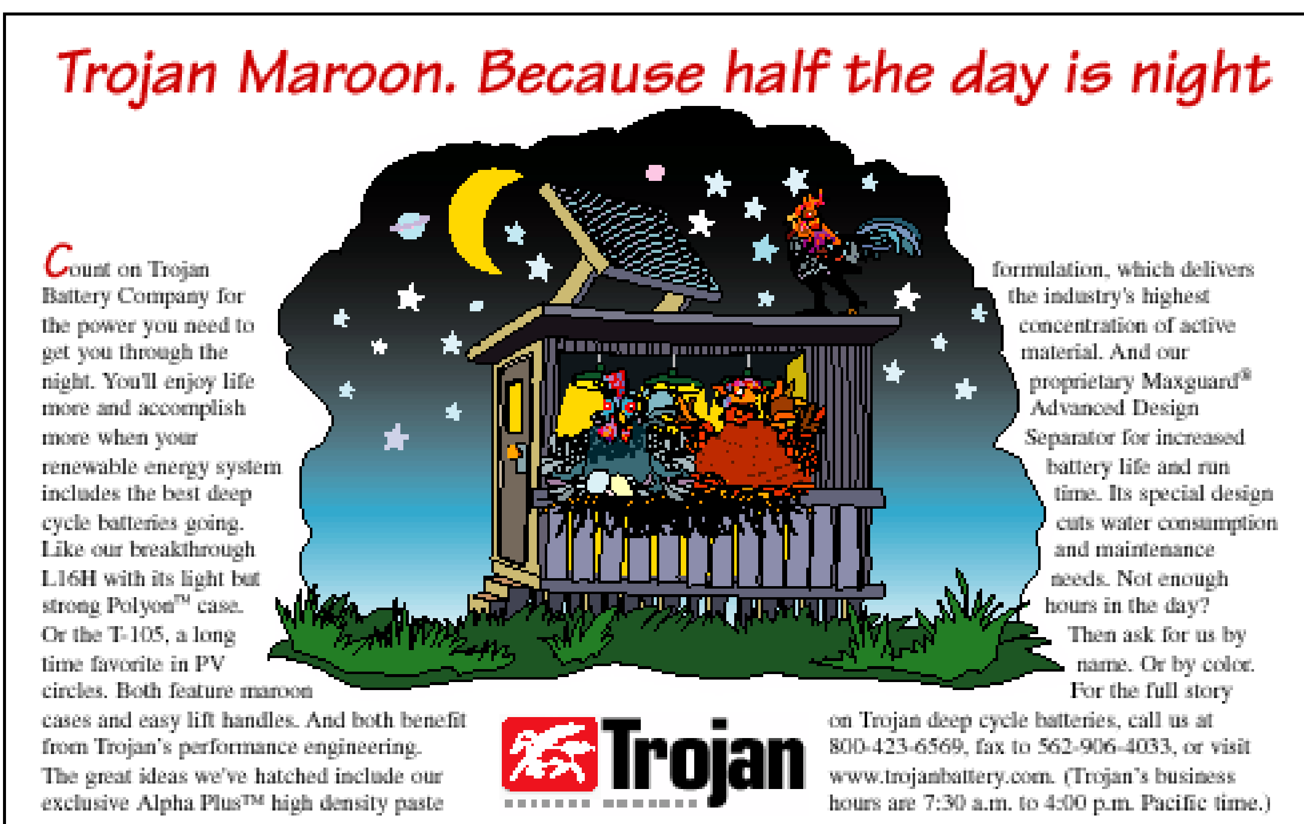
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Things That Work!

Tested by Home Power

Fax Timer

From Backwoods Solar

Ian Woofenden

Need a fax machine, but don't want an always-on load keeping your inverter awake? Backwoods Solar's fax timer was the answer for me.

When I started my telecommuting job as text editor for *Home Power,* I had to get a fax machine. I need to receive schematics and other things that aren't always available via e-mail. But our wind and solar-electric system didn't have much surplus energy. And since our home is run largely on DC (we started in the old days), our Trace SW4024 inverter is usually asleep.

The inverter only wakes up when it finds a load during its "search" mode. The rest of the time, it sends out a pulse to detect any loads, using very little energy. For smaller systems, and systems on a tight energy budget, not having the inverter "on" all the time can yield significant energy savings.

I did not want to add the always-on load of a fax machine to our system. In addition to the significant load of the fax machine itself, it would also add the inverter's hefty idle load. And the conversion efficiency of the inverter at that low wattage level is only about 50 percent, causing an even bigger drain of resources. Having even one always-on load would also make it harder for us to notice other AC loads inadvertently left on and using up our precious renewable energy.

Fax Machine & Timer

I called Steve Willey at Backwoods Solar, and asked him about the fax timer I'd seen in his catalog. Backwoods started manufacturing this timer after hearing from customers who wanted to run fax machines off-grid. Steve explained that it works only with fax machines that warm up quickly enough after being plugged in to answer on the 4th or 5th ring. He recommended Canon's B640 model. I purchased this fax machine from a mail order firm, and the fax timer from Backwoods.

The timer arrived via UPS, well packed, and with a one-page explanation sheet. I like doing business with small RE outfits that give good and personal service. Backwoods is one state away from me, and ships very promptly.

The timer is simple and functional. It uses a Radio Shack "Fone Flasher," which is made to flash a light when the phone rings (typically used by deaf people or in noisy places). The flasher is hooked up to a relay and timer inside a double-gang electrical box. The box has two outlets that are controlled by the timer. A switch on top allows you to manually energize the outlets, as well. This feature lets you turn the fax machine on when you want to send a fax.

The box is plugged into an AC receptacle in your home or office with a standard AC cord. Both the flasher and the fax machine phone cables plug into the same phone

The Backwoods fax timer with included Fone Flasher.

line jack. When the fax line rings, the flasher turns on the timer and relay, which energizes the outlets.

One outlet powers the fax machine. The other outlet can flash a small lightbulb when the phone rings, in case the fax machine by itself will not pull your inverter out of search mode. (If the fax machine is too small a load to *hold* the inverter on, you can add another small light to the same outlet the fax is plugged into, using a splitter.) My inverter's search mode is set at 16 watts, so I had to add a 20 W lamp to the unit's second outlet. It flashes on when the phone rings, and adds enough load to wake up the inverter.

If another fax comes in after the first call, but before the timer turns the machine off, the timer is advanced another full cycle so the incoming fax is not interrupted. The cycle is factory set at about 15 minutes, but can be adjusted between 1 and 100 minutes by the user if needed. I've never had any problem with the factory default.

Steve says that this unit can work with some answering machines, too. You need to test the machine to find out, and it sounds like there's some tweaking to be done. I've never tried this, since voice mail handles our phone answering needs.

"Only" 7 Watts?
My fax machine draws about 7 watts once it has gone through its warm-up cycle (measured downstream from the inverter). That doesn't sound like much. But if I left the fax machine on 24 hours a day, it would burn 168 watt-hours (WH) per day. But the inverter's idle power consumption results in low power conversion efficiency when powering small loads. The SW4024 has an idle load of 18 watts. If the inverter stays in idle mode all day, it will consume 432 WH of energy. So leaving the fax machine on all the time would gobble 600 WH per day (168+ 432) from our battery bank!

We get about 4 peak sun hours per day on average, and you have to figure in the inefficiency of the battery bank and the inverter. So leaving the fax machine on 'round the clock would use the output of more than four of our Siemens M75, 48 watt PV modules.

The fax timer and fax machine together draw about 9 watts. With the inverter inefficiency, this means that every time the phone rings, it uses about 4 watt-hours over the 15 minute cycle. I don't get very many faxes, so the load is a negligible one in our system. And yet I have a fax machine that is always available, 24 hours a day.

Simple Energy Saver
At US$125 plus $3 shipping, the Backwoods Solar fax timer is a great value for the energy saved and the convenience it offers. The timer has worked well for me for three years. It's not slick or pretty, but there's something beautiful about a simple device that lets me keep communication lines open without using much energy.

Fax timer, Canon fax machine, and the inverter trigger light plugged in.

Access
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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.


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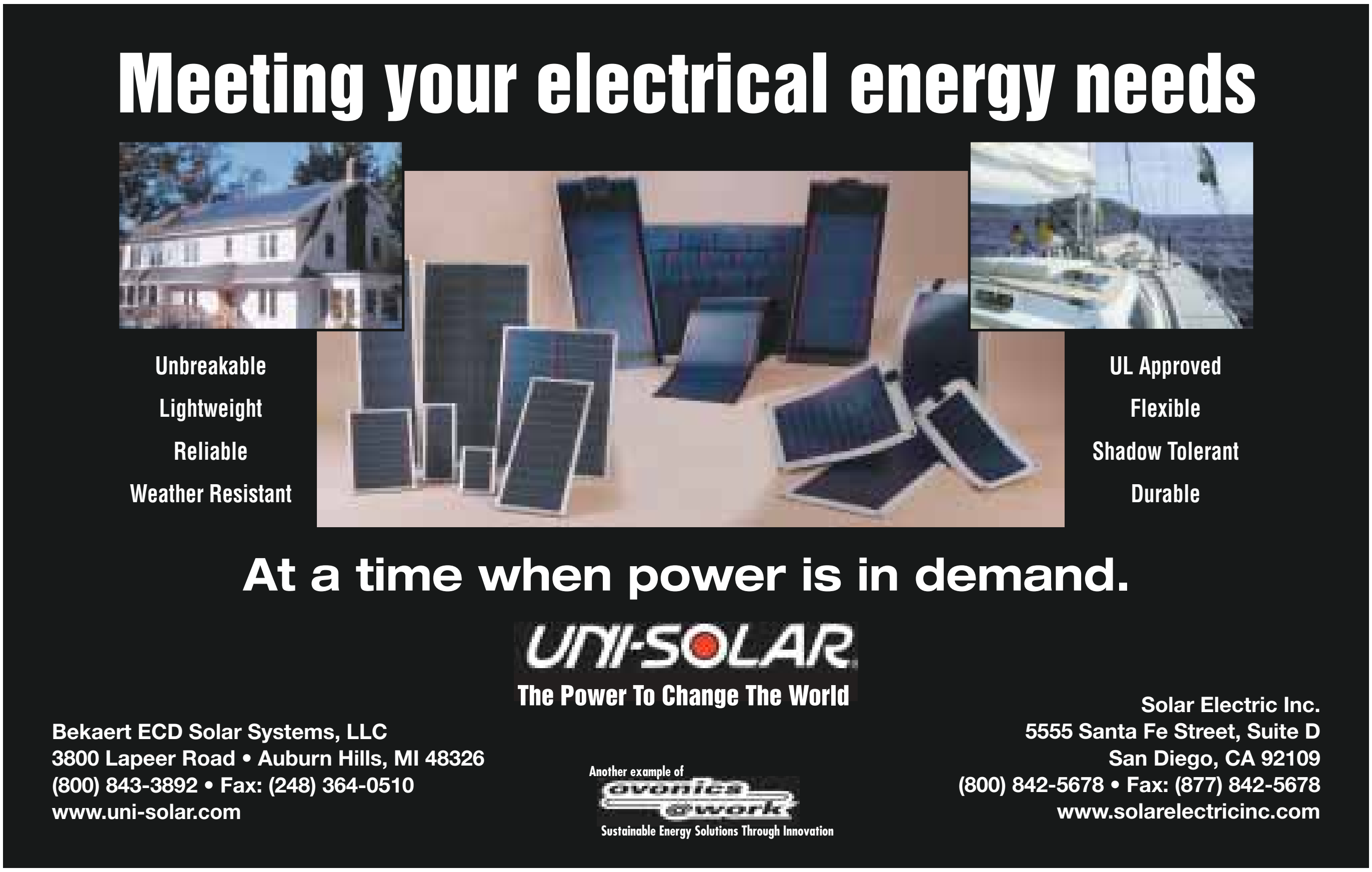
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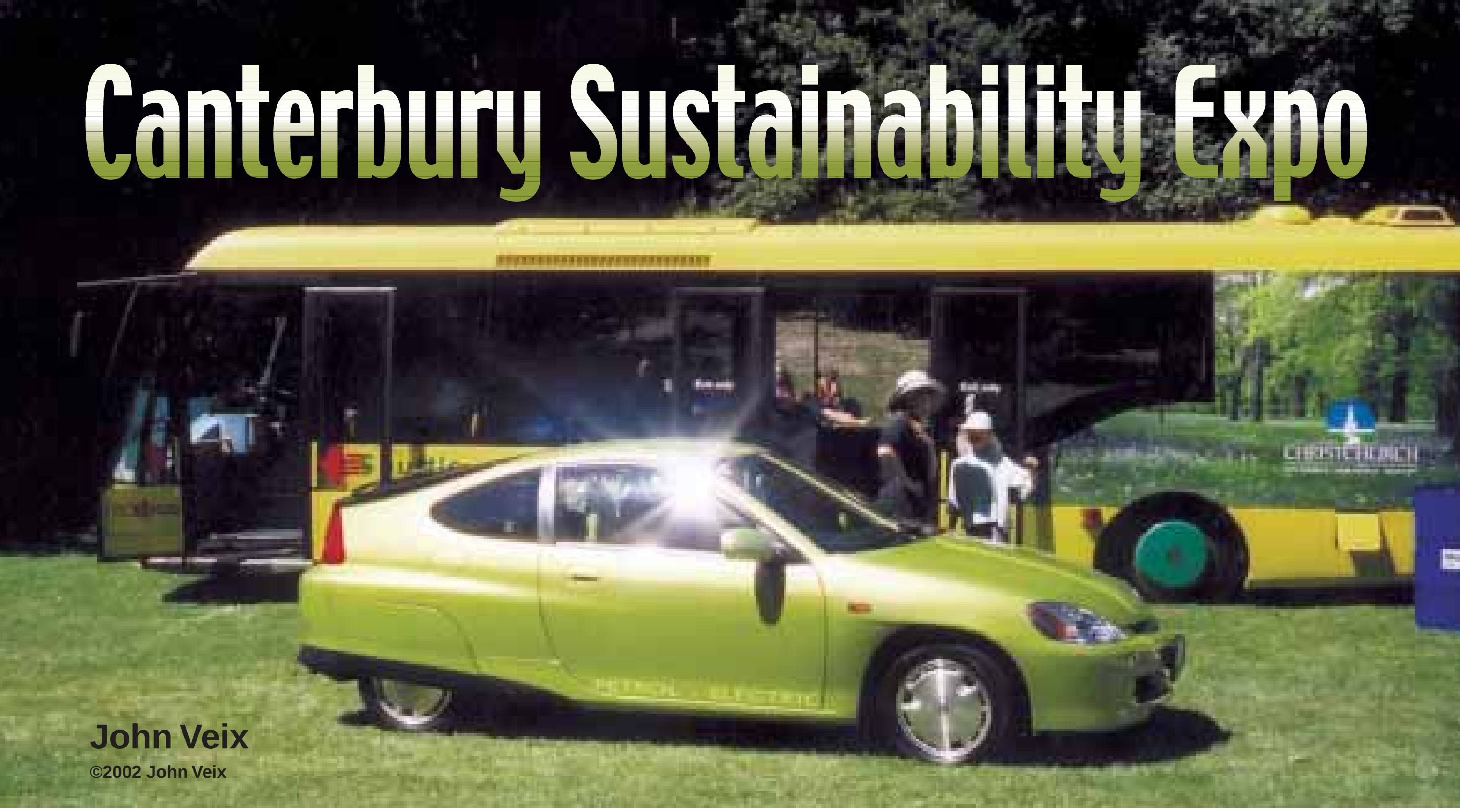
Canterbury Sustainability Expo

John Veix



Two hybrid electric vehicles—the Honda Insight and the Designline bus.

After last year's successful renewable energy fair, we decided to add a new twist. This year, we opened up the Canterbury Sustainability Expo to nearly all topics related to sustainable living. When people are interested in one aspect of sustainability, they tend to want to find out more about related aspects. People who are deciding which solar hot water system is best for them may also consider worm farming or net metering.

The Canterbury Sustainability Expo was held February 2–3, 2002 at the Girl Guides Cracroft premises. This tree-surrounded property is at the foot of the Cashmere Hills in Christchurch, in the Canterbury region of New Zealand's South Island. It was decided after the last event that we would hold an indoor/outdoor Expo. Indoor talks are better received due to greater control of background noise and lighting.

Discerning & Interested Attendees

Attendance was estimated at 700 to 800 people. We had about 16 presenters at the talks, discussing various aspects of sustainability. There were 25 exhibitors, plus over 20 displays and 4 good examples of electric vehicles, both new and vintage. We also had a video made by an M.P. (member of Parliament—an elected politician) who is living off-grid. How many high government officials live off-grid in the U.S.?

This year we had more sponsors and many more exhibitors and displays. They covered a diverse range of interests from permaculture to fuel cells and from worm farming to electric vehicles. The electric vehicles included the Honda Insight, a high economy petrol-electric; the Designline bus, an electric hybrid used in the streets of Christchurch as a shuttle bus; and a 1919 Walker electric truck with solid rubber tyres. Of course, the usual RE equipment was present—solar-electric (photovoltaics), solar thermal (hot water), and small-scale wind systems.

Model of an energy efficient home by Environment Canterbury.

Benefits of the Expo

Education is the focus of the Expo, and a great deal of educational literature is distributed. The talks are also a key feature in spreading the word about sustainable living. This year's talks included Permaculture Basics, Greywater/Wastewater, Rainwater Catchment Systems, Fuel Cells, Alternative Housing, Home Energy Efficiency, Large-Scale Hydro Power Projects, and all the other usual RE subjects.

The video made by the co-leader of the New Zealand Green Party, Jeanette Fitzsimons, talked about sustainability, using her off-grid home and farm as the example. The video was especially interesting for those who do not live in an off-grid environment.

Educational material was provided by a range of interests. The Energy Efficiency and Conservation Authority (EECA) furnished helpful advice, especially on saving electricity. A regional authority, Environment Canterbury, had their energy efficient home model on display, showing where savings can be made throughout the home. Throughout the area, the Ministry for the Environment had many useful posters that explained the repercussions of climate change. The Centre for Advanced Engineering (CAE) had a number of very good and helpful pamphlets and books available to the public.

A locally produced Solar Education Kit was partially sponsored by Shell Renewables. There were also many displays and other good information on recycling and reusing materials. Some promotional material was available on the newly formed New Zealand Photovoltaic Association, an industry association. Another interesting display was of disposable trays and plates manufactured from potato starch. After use, these plates decompose naturally.

Elizabeth Veix at the Solar Electric Specialists booth.

Burning wood to show the power of a parabolic solar cooker.

2002 Energy Fairs—Be There!

As New Zealanders are talking over the success of their annual renewable energy fair, folks here in the states are gearing up for the summer RE fairs. *Home Power* plans to attend the fairs listed below. If you want to get filled up with RE information, buy some RE gear, and rub elbows with lots of like-minded folks, see www.homepower.com/happs.htm for fair details.

Renewable Energy & Sustainable Living Fair
Custer, Wisconsin — June 21–23

SolarFest
Middletown Springs, Vermont — July 13–14

SolWest Renewable Energy Fair
John Day, Oregon — July 26–28

Southwest Renewable Energy Fair
Flagstaff, Arizona — August 9–11

SolFest
Hopland, California — August 24–25

IRENEW Energy Expo
Hiawatha, Iowa — September 7–8

Texas Renewable Energy Roundup
Fredricksburg, Texas — September 20–22

Prototype hydrogen fuel cell from Industrial Research, Ltd., a New Zealand company.

The official opening of the Expo was made by the Mayor of Christchurch, Garry Moore. The featured keynote speaker was Associate Professor Ralph Sims of Massey University, who spoke on “Climate Change and RE,” a popular and timely topic. The Girl Guides provided refreshments, as well as a sausage sizzle for those wanting to make a day of it.

Hard Work, But Worth It

I am grateful for the volunteer help from people giving the talks, and those who helped me set up and run the Expo. Also, I could not have organised such an event without the full cooperation of sponsors, exhibitors, and display people.

In his official opening, Garry Moore indicated that he would like to see a much larger event next year, so I will have to plan accordingly. This will require the help and support of even more people.

The Expo was highly successful. We had a tremendous response to our questionnaire proposing a monthly newsletter. The people who came to the Expo stayed a long time and went away very happy, according to an informal poll. And the exhibitors were pleased to note that the attendees were serious to talk business, and were not the “tyre-kicker” or time-waster type of person. With all the serious interest expressed, I expect to see sustainability and renewable energy soon become part of everyday life here in New Zealand.

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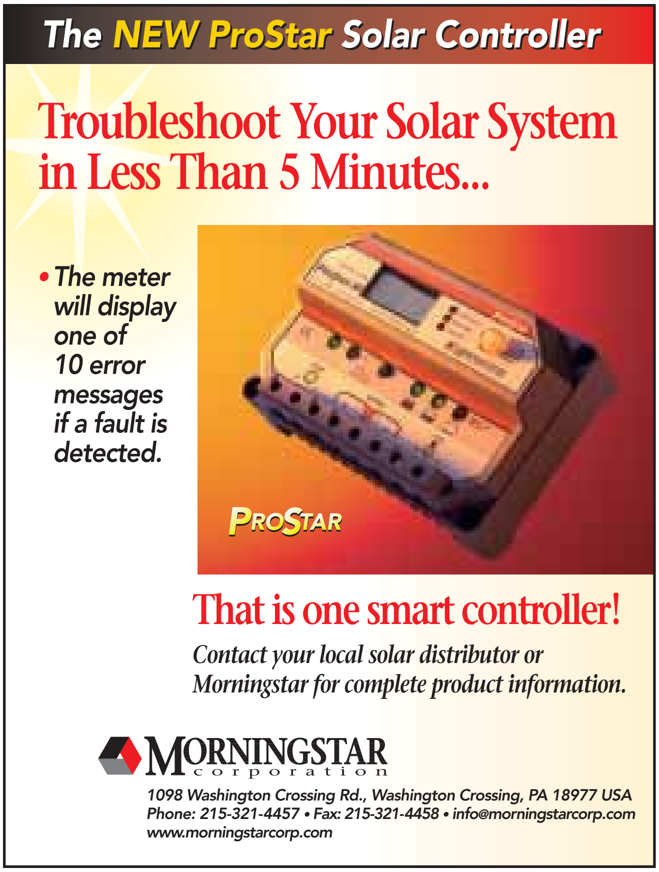
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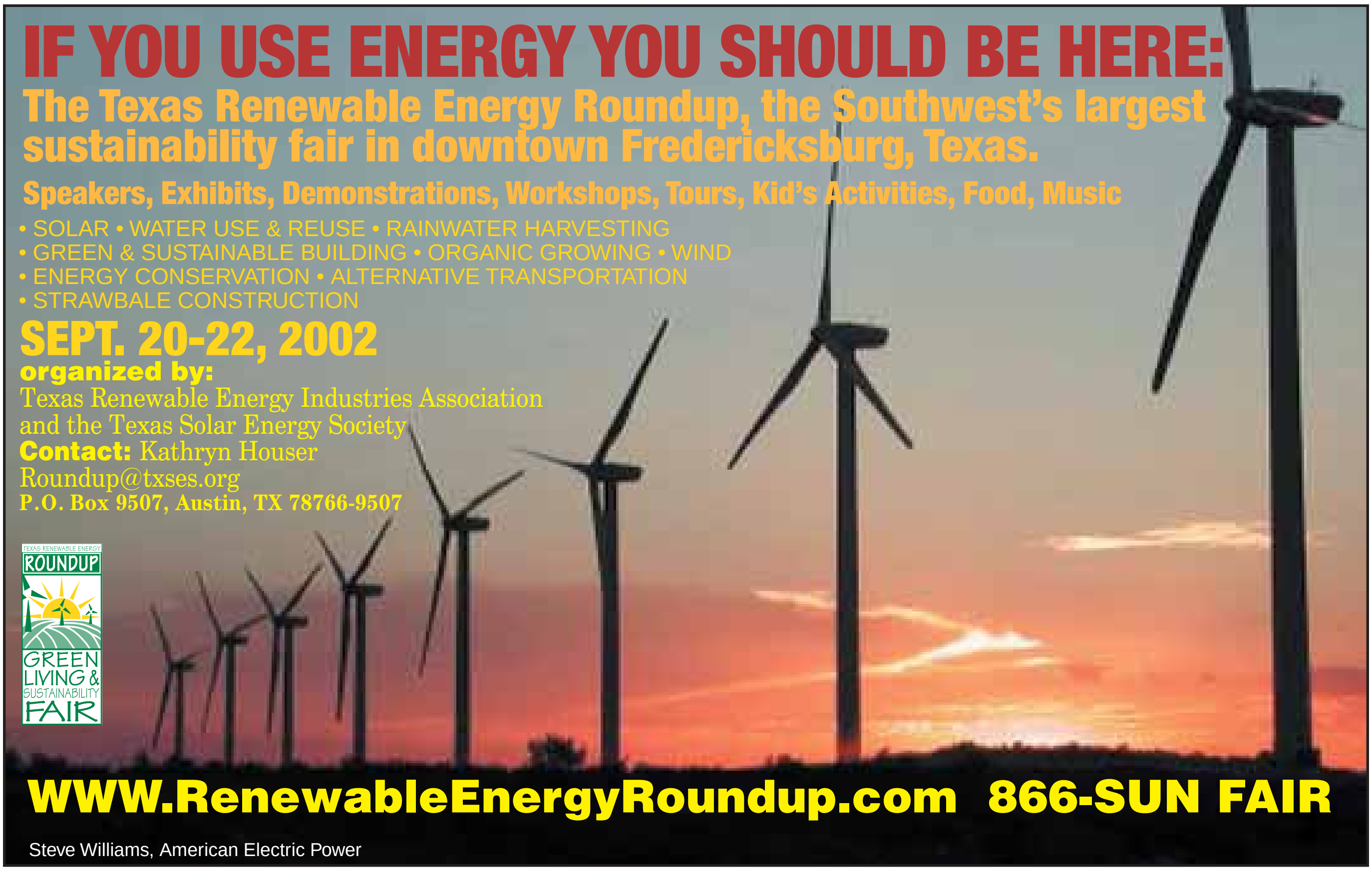
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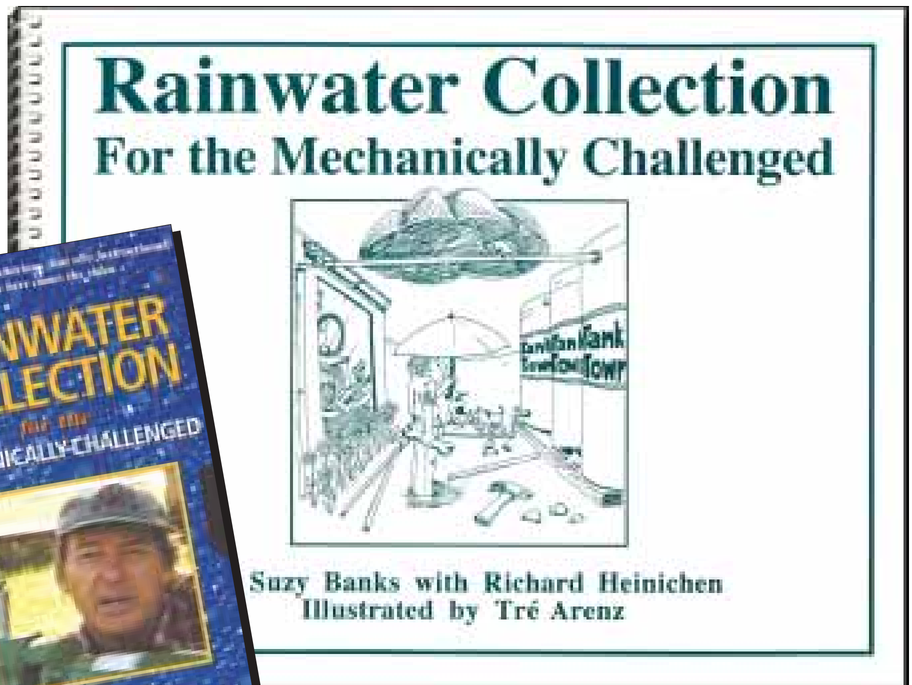


Rainwater Collection For the Mechanically Challenged, book and video

By Suzy Banks and Richard Heinichen
Reviewed by Andy Gladish

A year ago, the side of my plywood cistern blew out in a brief but spectacular cascade of precious rainwater. I went back to trying to keep five plastic barrels full enough to keep our family of five in showers and clean laundry. That's obviously a hopeless task, even in the rainy Pacific Northwest. But every option I could think of involved either too much money or too much time and material. To be honest, I had no idea what to do next, except another rain dance.

But once in a while, a resource comes along that clarifies the problems, and presents solutions in such a way that you find yourself saying, "Even I can make this work!" *Rainwater Collection for the Mechanically Challenged,* and its companion video, did it for me.

Suzy Banks and Richard Heinichen started their journey living on a farm crippled by a bad well. They ended up with a dependable rainwater collection, storage, and distribution system that supplies plenty of clean water for all the needs of a busy homestead. In both book and video, the authors show that you don't have to have training in plumbing, electricity, or fluid engineering to build a working rainwater system.

Since this book is dedicated to problem solving and building confidence, by the second page you're already into logistics. It covers what kind of roof material is best; how much water you can expect to harvest from a roof in your climate; storage tank selection, sizing, and placement; gutter types and installation; basic planning; and assembly of plastic pipe.

Many of us have a desire to conserve water and use a plentiful, renewable resource. We also have concerns about contamination and safety of rainwater, especially if we plan to drink it. This is amply addressed in Chapter 5, including what gets into rainwater, how it affects us, how to get it out, and how much each method of purification costs.

The section comparing contaminants in well, rain, and municipal water was a real eye opener. I concluded that properly treated rainwater is superior to other common sources in many respects, even for drinking.

The book also addresses the practical limitations of rainwater systems. If you have a big enough roof and enough storage, you can irrigate a lawn through the dry season. But it's best to plan in advance where you're going to "spend" your water. The authors share many tips on how to look realistically at your needs and what it will take to supply them.

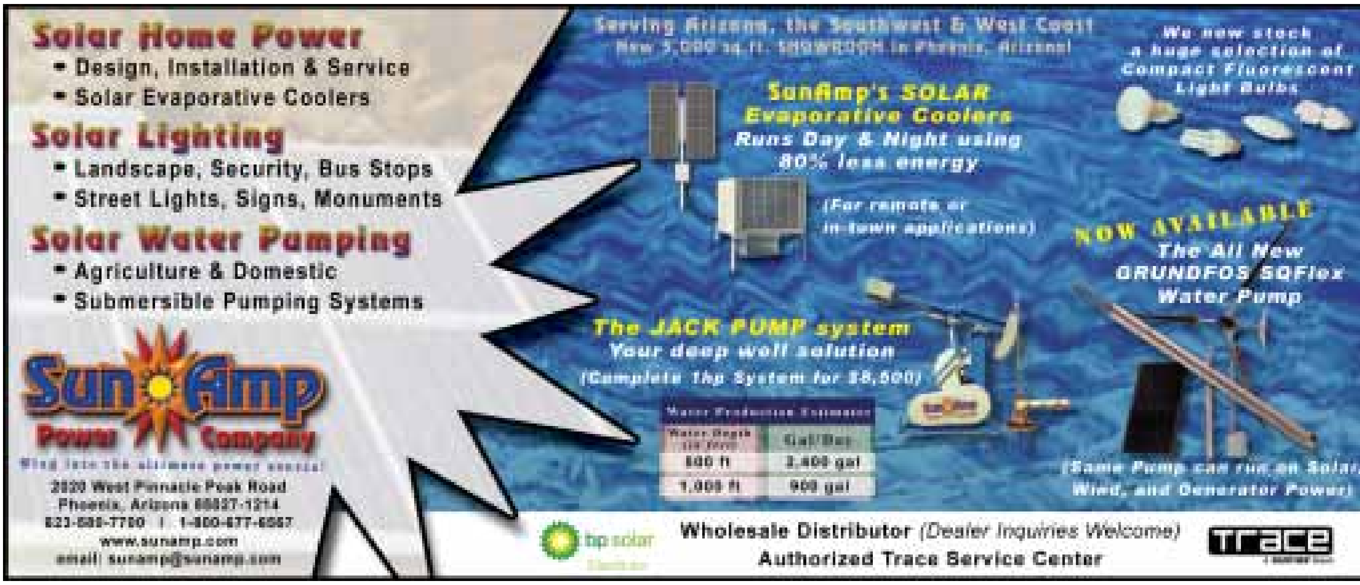
The video, true to its title, is a really fun look at how "mechanically challenged" folks can approach what looks like a dauntingly complicated job, and actually enjoy it. While developing my own system, I had very few questions that weren't quickly answered by reviewing the book and video.

If you've ever considered collecting rainwater, even for an occasional shower, you'll be excited to find out just how practical a whole-house system really is. I now have a (full!) 2,500 gallon (9,500 l) cistern, and smoothly working transfer and pressure pumps that supply my family with clean, mineral-free water—thanks largely to the information and encouragement in this book.

Access

Reviewer: Andy Gladish • gladish@cnw.com

Rainwater Collection for the Mechanically Challenged, by Suzy Banks with Richard Heinichen, ISBN 0-9664170-03, 1997, 48 pages, US$15 plus US$3 shipping • *Rainwater Collection for the Mechanically Challenged* video, by Richard Heinichen, ©1999, 37 minutes, US$19 plus US$3 shipping. Book and video together, US$30 ppd. from Tank Town, 2770 Hwy 290 West, Dripping Springs, Texas 78620 • 512-894-0861 Fax: 512-858-2321 • tanktown@aol.com www.rainwatercollection.com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Charge Your EV PART 1

Shari Prange

Most conversions carry 120 V onboard chargers that can plug into common outlets almost anywhere.

Driving an EV (electric vehicle) means never having to say, "Fill 'er up." Sailing past gas stations is one of the pleasures of owning an EV. You never have to make the time to go to the gas station, jockey into position, wrestle a smelly and recalcitrant pump, and hand over a shocking amount of money for the privilege. Instead, when you get home at night, you take thirty seconds to plug in the charger. In the morning, the car is "full" again, just like magic.

In fact, if you drive an EV regularly and switch back to a gas car, you may discover that you have been spoiled by the convenience of charging. You lose the habit of thinking about gas—right up to the point where the gas car suddenly coughs and dies with the fuel needle at "empty."

Frankly, though, sometimes it would be handy to "top off" your EV away from home. If you live off-grid, you may be budgeting your kilowatt-hours, and have to choose between charging the car or doing the laundry. If you are on the grid, being able to charge off-site might make it possible to go out for a night on the town after work instead of going straight home.

The early days of gas cars were very similar to the state of EVs today. Back then, you had to buy your gasoline at the hardware store in a can, and take it home to pour into the car with a funnel. Gas stations weren't on every corner, just as there aren't electric filling stations on every corner now. But maybe they are if you know where to look for them. In this article, I'll talk about off-site charging for homebuilt conversions. Next time, I'll cover charging stations for factory electric cars.

Know Your Needs

When you drive into a gas station, you need to have specific information available. Does your car take regular, premium, or super? Is the fill cap on the right side of the car or the left? Similarly, you need to know some things about your EV before heading out in search of a charging station.

What kind of connection and what kind of electricity does your car require? Most converted electric cars have onboard chargers that use 120 VAC. Somewhere on the car (usually in the rear, and often emerging from the former gas fill door) there is a normal household three-prong (grounded) cord cap or plug for a standard 15 or 20 amp receptacle.

The downside of this setup is that 120 V typically provides slower charging than 240 V. The upside is that this is the most common type of electrical outlet, and you will find them all over if you simply start looking for them. All you need is the space to get your car close enough for the cord to reach.

A few conversions use 240 V input. The advantage to this is faster charging. However, many of these chargers are bulky, and are housed permanently in the garage, not in the car, so that doesn't do much good away from home. Some conversions are "bi-voltual," so to speak. They can charge from an offboard 240 V charger when at home. But they are also equipped with a 120 V onboard charger for what is known as "opportunity charging," as in, "If you have the opportunity, charge it!"

For those that do have 240 V onboard chargers, pickings are a lot skinnier than for 120 V. High voltage outlets are much less common, and they come in several different plug configurations. People with onboard 240 V chargers usually carry a collection of short adapter cords for any available outlet.

Conversions with 240 V input can use a special adapter to take advantage of some charging stations for factory EVs that use the Avcon connection. This adapter plugs into a standard NEMA 14-50 connection (a common RV-type, 240 V connector) on the car on one end, and into the Avcon charger connection on the other end. They are available from the Electric Auto Association.

You should also know the maximum amperage your charger draws. Battery chargers draw the highest current at the beginning of the charge cycle, when the batteries are most deeply discharged. Current then automatically tapers as the batteries fill up. Most chargers allow you to reduce the current draw to keep from tripping a circuit breaker.

If you know your charger's highest current draw, you can judge when it might be prudent to decrease the charge rate while charging from a source that may have less available capacity than your usual electricity source at home. You can also convert this information into kilowatt-hours and multiply it by your local electricity price to attach a dollar amount to your charge. This can be useful information in any bargaining effort, as we'll discuss later.

Seek and Ye Shall Find

Now that you know what you need, start looking for it. Don't wait until you need a charge. Plan ahead, scout out your neighborhood, and locate possible watering holes.

If you use a 120 V charger, you have a lot of choices. Many public buildings and businesses have outdoor 120 V outlets. Even some gas stations are friendly about lending a charge. Parking garages often have 120 V outlets for various equipment they might use. In cold climates, many places have outlets available for block heaters on gas or diesel vehicles.

Public charging stations for factory EVs sometimes have ordinary outlets for charging conversions, as well. Look for places where other electric vehicles collect to charge. Facilities with fleets of golf carts or industrial carts may allow a civilian an occasional sip of juice

As mentioned before, 240 V is harder to find. If you have friends with clothes dryers in their garages, they may be willing to let you charge when you visit. Otherwise, you need to look for accessible places where heavy electrical equipment is used, such as small industrial shops. Places with electric forklifts will have 240 V service you may be able to use.

Check It Out

OK, you've located possible places to charge. What's the next step? First, don't assume that every outlet or charging station is actually functional and available. Carry a 120 V electrical outlet tester from a local hardware store to plug in and check for function. This will also tell you whether the outlet is properly grounded. If it isn't, some chargers will not operate, even though the outlet is "live."

The other aspect to research in advance is availability. Whenever you are in the area, check to see whether the charging outlet is open for business. Is there available parking close enough for your cord to reach, or is the outlet often blocked by parked cars? Are some times of day better than others? Also check for any time limits on parking there. You don't want to rely on getting a full day's charge from an outlet that's limited to 2 hours parking.

Getting Permission

If everything appears to be functional and available, there still are etiquette rules to follow. If it is a public charging station, no permission is necessary. For a normal electrical outlet in an unattended public parking garage, you might as well just plug in, since it will probably prove difficult or impossible to locate anyone with the authority to give you permission.

For charging stations intended for private fleets, or for any ordinary outlets on businesses or public buildings, you should get permission in advance. One of our customers once drove his converted Porsche 914 to the office to do some extra work during the Christmas shutdown. He parked outside his office, ran a cord in through the window, and plugged in. Unfortunately, he wasn't the only one working during the holiday break, and his car wasn't the only load on that circuit. He tripped a main circuit breaker and crashed several computers. Luckily, all parties involved took it well, and he was promptly given a dedicated charging outlet of his very own, but it could have turned out nasty. This is not the way to win converts to EVs.

Who you choose to ask can be critical, and you may have to use your instincts here. If you are approaching a small business, you probably want to go to the top and talk to the manager or owner. For a large business or public building, someone closer to the action may be more effective. This might be the facilities manager, yard foreman, or public relations manager. If you want to plug in at a public building or facility, you might try to get a city council member to smooth the way for you. Look for someone who has the authority to say yes, and no compelling reason to say no.

Your approach is very important. Be friendly, polite, and low-key. Many people are fascinated by EVs. If you give them the grand tour of the car and take them for a ride, they will be delighted to have you charging at their very own outlet, and they'll tell all their friends.

Reservations about letting you charge usually fall into three categories. The first is inconvenience or obstruction. Allowing you to charge your car must not impede people from going about their normal business. This means parking so that your car and cord are not in the way, not hogging an outlet that is needed for other things, and turning down your current draw if other loads are on the circuit.

The second issue is cost, since people may have visions of their electric bills skyrocketing while you enjoy a free charge. This is where the numbers you collected earlier come in. You will probably find that, even worst case, your car is only sucking up about US$0.10–0.20 per hour. Offer to pay for the electricity. Your offer will almost always be turned down.

The third issue is safety. You need to be familiar with the safety features of your car, so you can reassure people that the car won't catch fire, explode, or electrocute anyone. (If it's any consolation, early gas cars faced similar fears.)

Once you get permission to charge, it wouldn't hurt to thank the person with a letter, a small gift certificate, a box of donuts, or a case of beer, whichever seems most appropriate.

Ask and Ye Shall Receive

What if you just can't find any potential charging locations that are useful to you? Maybe you can make one happen. Many EV owners have successfully lobbied for EV charging outlets and parking spaces at their places of employment. Some employers eagerly embrace the opportunity, and get maximum public relations mileage out of their forward-thinking, environmentally friendly action.

Others who are less enthusiastic already offer transit passes or carpool benefits to employees, and can be persuaded that EV charging is comparable. To dispel charges of special treatment, you can offer to buy a special parking permit from the company, thereby paying for the electricity.

The final argument always comes down to money for installing the charging station. If you have a conversion that uses a normal 120 V outlet, that's cheap and easy to install. You might want to volunteer to cover the cost, if it seems like this will make the difference.

Ready, Set...Charge!

For the foreseeable future, most EVs will get the bulk of their charge at their home base overnight, but off-site opportunity charging can extend their usefulness. EV drivers are pioneers in uncharted territory here. They need to be "action figures" and seek out—or create—their own infrastructure. All it takes is a little preparation, creative thinking, and the willingness to look for or ask for what you need.

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Switched Outlets

Joel Chinkes

When folks ask me about solar electricity, I tell them that there are two simple steps: First, generate and store your own energy. Second, don't use it. In this article, you will learn a way to be absolutely sure you are not consuming energy when you don't intend to. You can call it the "Switch and Save" method.

The mainstream media is now running stories about the amazing fact that some household appliances use electricity when they are switched off and supposedly not in use. In total, we are talking megawatts! This news breakthrough will take several decades to penetrate the general social consciousness. Meanwhile, as a *Home Power* reader, you are ahead of the curve. You're constantly alert, searching for ways to cut back on waste, whether you are on or off the grid.

Switch & Indicator Light

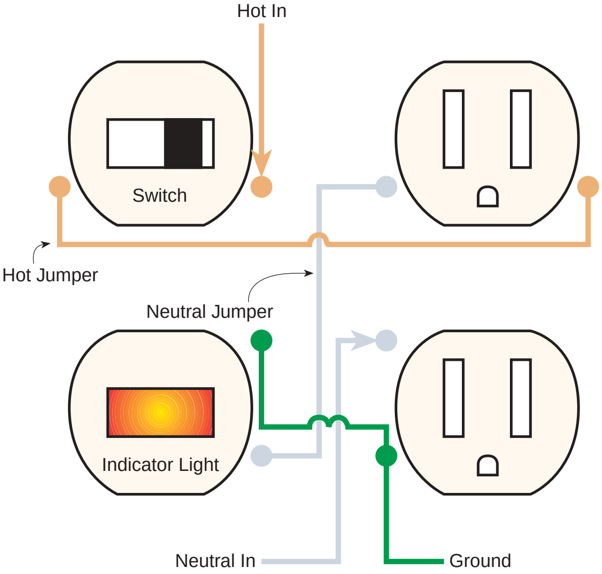
Recently, I had the opportunity to wire up a new building for 120 VAC inverter service. The building is the solar power plant and utility structure at a New Mexico ranch. I specified that each outlet be switched at the point of use.

I used Eagle Electric's model #277V (the "V" stands for ivory) Single Pole Quiet Switch & Neon Pilot Light, rated at 15 amperes. The Leviton #5226-I, and Slater #692-B are similar switches. These are easy to find in any hardware store or supply house.

This device is really a combination switch and indicator light. It fits in the same space as a duplex outlet. Box covers made for an outlet will also fit the switch and light combo. When you wire it, you decide whether the indicator light will come on when the switch is on, or come on when the switch is off. For inverter users, it's better not to have any loads running when not needed, so I chose to have the light off when the switch is off.

By actual measurement, the indicator light registered zero watts on a digital power meter. This is an approximation, but I consider the load negligible—probably less than one-seventh of a watt per lamp.

Switched Outlet Diagram



Wire It Up

The wiring diagram packaged with the switch was hard for me to read, so I made up my own (see diagram). The hot/black, neutral/white, and ground/green/bare wires are configured as shown. You will also need to cut two short jumper wires, one black and one white, to connect the switch and the outlet to one another. Check the wiring diagram that comes packaged with your switch to be sure no design changes have occurred.

The #277V switch is on the left in the diagram, and an ordinary 15 or 20 amp duplex outlet is on the right. You will need a two-gang box, instead of a single-gang box, for each switched outlet.

Inverter AC power presents itself first at the switch. If the switch is off, there's no current, and both outlets are dead. If the switch is on, the red neon indicator light comes on, and the outlets are energized.

Waste Not, Want Not

This setup has three advantages. First, when you glance about the room, you can see right away what is getting power, because a bright red indicator light is glowing. Second, when the outlet is switched off, you can be sure there are absolutely zero phantom loads. Finally, you have reduced shock and fire risk from runaway appliances. This is notably helpful in the case of toasters and clothes irons, which seldom have indicator lights of their own.

This switched outlet conveniently manages phantom loads.

One switched outlet is pictured in this photo. Each outlet box, all the way around every room, is set at a convenient height, so it can easily be seen and readily turned on or off as needed.

To reduce fumbling, I standardized the layout. Every box has the switch on the upper left, the indicator light on the lower left, and the two controlled outlets on the right. The ground terminal is down in every case.

If you are using single, rather than double boxes, you can use Eagle Electric's model #274V Combination Single Pole Switch & Grounding Receptacle, or equivalent, rated at 15 amperes. This device has a tiny indicator light, and will replace two outlets with one outlet and a switch, using the same cover plate.

Whether you are on or off the grid, you should consider installing a switch and indicator light at each outlet. This will give you an easy way to be sure that you are not using energy when you don't want to. You reduce waste and improve safety at little expense, without the bother of plugging and unplugging power cords or using numerous switched plug strips.

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Further Reading: "Hunting Phantom Loads" by Dan Chiras, *HP82,* pages 40–44

"Doing a Load Analysis" by Benjamin Root, *HP58,* pages 38–44

"Phantom Loads Update" by Michael P. Lamb, *HP55,* pages 36–38

"A Beginner's AC Ammeter Project" by Joel Chinkes, *HP33,* 82–83

Buying A Used EV, Part 1

Mike Brown

"I want an electric car and I have found a conversion for sale. How can I be sure I am getting a good EV that will fit my needs?"

This question has come up several times recently. Most of the major manufacturers are discontinuing their EV programs in favor of hybrid electric cars. People who had leased factory EVs now have to give them back, and the people who didn't get a factory car still want one.

Fortunately, some of the conversions built in the nineties are coming onto the market. These cars are being sold for a number of reasons. Changes in jobs or lifestyle may make the EV no longer suitable as a means of transportation. Or a conversion may be sold because the owner wants to build a new EV, and the old one has to go. Let's talk about what to check for in a used conversion to make sure that your dream car doesn't become a nightmare.

Make, Model, & Age

The buying process starts with the donor car that was converted. When you are buying a gas car, you usually look for a particular make and model, and probably have quite a few cars to choose from. Buying an EV is different because there are only a few to look at, and makes are limited to those cars and light trucks that were suitable for conversion.

The make of car that was converted is important. You want a make that is represented by a dealership in your area and was a good seller as a gas car. This is so you have a better supply of parts for the areas of the car that were not changed by the conversion, such as the chassis, brake system, and suspension. Parts are readily available in independent parts houses for popular cars or trucks.

This is also true in dealership parts departments. I was once looking for two transmission-to-engine locating dowels for a Pontiac Fiero adapter design I was doing. I was told by the dealer that they had no listing for that part anymore. When I asked for the same parts for a Chevy S-10 pickup truck, which had the same engine as the Fiero, they had a listing for it and I had them the next day. GM sold a lot more S-10s than Fieros.

So if you must have that converted Fiat or Renault, be prepared to hunt for the parts you need and pay a high price for them. Parts availability is also a good reason for buying the newest conversion you can find. Even the best selling cars fall off the parts books eventually.

Body & Interior

After you find a conversion that passes the make and age criteria discussed above, look at your specific prospect. The first thing you notice about a car is its appearance. Body condition as a part of the buying decision can be a minor or major point. If a faded paint job and small dings are all that is visible, you at least have a bargaining chip in the price negotiations.

However, if there is major body damage or signs of damage that has been badly repaired, this could be a reason to pass on this particular car. Repairing damage is an expense that you will incur if you want to restore the car to something you'd be proud to drive. The damage might prove to be very expensive or impossible to repair.

Repaired damage, if not done correctly, could conceal weakness in the chassis of the car that might lead to failure under the increased weight of the battery pack. A bad repair job could also cause wheel alignment problems, reducing the range due to increased rolling resistance.

Any body rust is a deal breaker. Rust is very difficult and expensive to remove, sometimes requiring the removal and replacement of whole sections of the body. Most of the time, any rust repair that is done is only a temporary fix because the rust will pop up somewhere else on the body. As singer Neil Young said, "Rust never sleeps."

The interior of the car is a similar issue. Worn seat covers or carpets are small items that are to be expected in a used car. However, badly torn seats, broken seat back mechanisms, or carpets that are worn to the metal floorboards are more serious. Replacements for broken or missing plastic trim pieces are almost impossible to find new, and don't exist used because they all wear out at about the same rate.

If the most expensive parts of the interior—the headliner and padded dashboard—are torn or cracked, you might consider looking elsewhere for your EV. The bottom line on body and interior condition is how much time and money you want to spend to restore it to a condition that is acceptable to you.

Mechanical Condition
While assessing the condition of the body and interior is something the average person can do, the evaluation of the mechanical condition of the car or truck is best left to a professional mechanic. So unless you are an advanced home mechanic or a professional mechanic yourself, it's time, if the car can be driven, to take your potential EV purchase to a shop for a checkout.

Try to find an independent repair shop that specializes in or is familiar with the make that was the donor car for the conversion. Explain to the mechanic that, while you realize the car has been converted to electric power, you want him to check out the other parts of the car.

The brakes should be checked for the amount of lining on the brake shoes in a drum brake system or how thick the friction material on the brake pads is on a disc brake system. If the car's brakes are worn and the drums and discs are close to their wear limits, they should be replaced.

The hydraulic parts of the brake system (the wheel cylinders and brake calipers) should not be leaking. In addition, the calipers should be pressing the pads on each side of the disc with equal force. A pad on one side of the disc that is noticeably thinner than the pad on the other side is an indication of a sticking caliper, which should be replaced. The rubber hoses that carry the brake fluid from the steel brake lines on the body to the wheels should not be cracked or show signs of rubbing against the body or the wheel.

Since the brake system is stopping a lot more weight due to the battery pack, it should be in top condition. Get estimates for any needed repairs, and try to get the seller of the EV to deduct that amount from the price of the car.

The steering should be checked for excessive play in the steering box or steering rack. The tie rod ends that connect the steering mechanism to the front wheel spindles and the ball joints that the spindles turn on should be checked. Look for looseness, wear, and torn rubber covers that let lubricant out and let dirt in.

If the EV motor is in the front and driving the rear wheels, check the universal joints at each end for wear and looseness. If the car is front motor/front wheel drive, check the constant velocity joints for looseness and torn boots. Like the brake system, all of these parts are subjected to greater loads due to the weight of the batteries, and should be in good condition.

A thorough road test should be included in the checkout. Clutch operation, how the transmission sounds and shifts up and down between the gears, and how the EV drives down the road are items to check out.

If the EV can't be driven to a shop to be checked out, see if there is a mobile mechanic that can come to the car's location to do a check. Another option is having the conversion towed to a shop for inspection. If you can't have an inspection done and the owner can't provide documentation showing repair or replacement of the parts in question, you are buying a pig in a poke, and the price should reflect that fact.

Electric Drive Components
If the car's body and interior are acceptable and the mechanical inspection shows no major problems, the next thing to check out is the conversion itself. Two areas are of concern here. The first is the components used in the conversion. The second is how they were installed.

Even if the best components available were used, if they weren't installed in a competent manner, the usability of the EV as a daily driver is questionable. The quality and type of the electric drive components that are installed in a conversion are critical if you're looking for a reliable means of transportation.

Motors
At the very heart of the conversion is the motor. Some motors are suitable for electric vehicle conversions and other motors are not.

Let's get the unsuitable ones out of the way first. The absolutely least suitable motor for an EV is an aircraft starter or generator. When used as a car motor, they have to be run at voltages beyond their nominal 24 volt rating. They must also run at very high amperage draws to give enough speed and torque to produce marginal performance in a conversion. As a result, they are very short-lived in this application. If you are offered an EV powered by one of these gems, decline the offer politely, get a firm grip on your wallet and checkbook, and run.

Another unsuitable motor is a forklift truck motor. These motors were designed to produce a large amount of torque at low speeds from a low voltage pack. In addition, due to their application, they are very large and heavy. If the conversion you are looking at is an older conversion done in the late '70s, it might have a Baldor motor. These motors were suitable for an EV as far as voltage, amperage, and horsepower ratings, but didn't like high rpm, which resulted in armature failures.

The three common brands of motors that are suitable for conversions are Prestolite, General Electric (GE), and Advanced D.C. (ADC). The Prestolite and GE motors are no longer in production, but there are quite a few still running around in cars. There is also the huge, 11 inch (28 cm) diameter, Kostov motor that has been sold in limited numbers. This motor is used mainly by the drag racing crowd, and probably won't show up in the used EV arena very often.

ADC came on the EV scene in 1990, and has pretty much dominated the conversion market. They make three sizes of motors suitable for conversions: the 7 inch (18 cm) diameter, equivalent to the Prestolite; the 8 inch (20 cm); and the 9 inch (23 cm), which is equivalent to the GE.

The only problems we've seen were caused by mistreatment, or using the wrong motor size for the application—usually too small a motor in too heavy a vehicle. So be wary of a pickup truck with a Prestolite or a 7 inch or 8 inch ADC motor in it. Pickups and heavier cars, like the Ford Escort, should have GE or 9 inch ADC motors.

Controllers

The next component to consider is the speed controller, which is the EV component that feeds battery pack voltage to the motor, controlled by how far the accelerator pedal is pressed. Since the late 1970s, all controllers have been pulse-width-modulated, solid-state devices.

There are still some GE-100 controllers (which were modified forklift controllers) around, but they are no longer in production and are not supported. If you find an EV with one of these controllers, be aware that when it fails, replacement is the only option. The bright side of this is that you will be replacing it with a much better controller.

One company, Curtis/PMC, builds the controllers you will find in most conversions. The early PMC-21 and PMC-25 are fine controllers, and I wouldn't hesitate to buy a car with one of them in it. However, since they are no longer in production or repaired by the factory, they can only be replaced if they fail.

The current production Curtis/PMC 1221 and 1231 are good controllers with a good reliability record. Most failures have been due to improper installation or being used in applications or conditions that cause the controller to operate in the higher end of its duty cycle for too long. An example of this is a 1221 in a pickup truck with an ADC 9 inch motor being used in hilly terrain. This truck and those conditions require a 1231 with a higher duty cycle. If quick acceleration is important to you, a 1231 is the controller of choice.

In the event of a failure, Curtis/PMC has a low cost, quick turnaround exchange service. If the failure of a 1221 was caused by the extreme conditions discussed above, have it repaired, sell it as a never-used rebuilt, and use the money from the sale toward a new 1231. New ones cost US$1,100–1,700, depending on model. If you turn in a completely toasted one, you can get a rebuilt exchange, with a one-year, like-new warranty, for for about half the cost of a new unit.

Other small companies—such as Auburn Scientific and Dax Controllers—have built specialty, high performance controllers, but these controllers are rare and not likely to be seen in daily driver conversions. If an EV you are looking at has one of these controllers, find out if the company is still in business, and whether they still support the controller.

Adapter & Clutch

The car's adapter (the part that attaches the electric motor to the car's standard transmission) could be professionally built or homebuilt. If the adapter that is in the EV is working, there are no strange noises or vibrations, and the transmission shifts easily, it's probably OK. The more miles on the conversion without trouble from the adapter, the less likely that there is anything wrong with it.

In my opinion, if the used EV you are looking at has a manual transmission but no clutch, you should not buy it. What we have heard from people who have done a conversion without a clutch is mostly that they would not do it that way again. One reason they give is difficult gear shifting, even after they have driven the car long enough to learn how to shift without a clutch. This learning curve, which depends on seat time, makes the clutchless EV a one-driver car, limiting the vehicle's usability.

Abnormal transmission wear is another effect of clutchless cars. But the biggest concern people have is safety. Missing a shift in rush hour traffic or while doing an evasive maneuver to avoid a potential accident could be dangerous to both car and driver.

So Far, So Good

In this article, I've talked about what to look for in a conversion EV's appearance and mechanical condition. We also looked at most of the major components of a conversion, and gave you some idea of what to look for and what to avoid.

In the next issue of *Home Power,* I'll discuss chargers, gauges, batteries, and what to look for when the car and the EV components are brought together and made into a running EV conversion. In the meantime, feel free to contact me with any EV questions you might have.

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Renewable Energy Terms

Horsepower—Rate of Energy Flow

Ian Woofenden

Derivation: Horse *is from Old English* hors *and Old High German* hros, *literally* a runner. Power *is from Vulgar Latin,* potere, *meaning* to be able.

With so many technical terms like joule, amp, and watt, it's a bit surprising to see "horsepower." Why do we still use a term like this when talking about a technical subject? Where did it come from? What does it mean?

Eighteenth century Scottish inventor James Watt came up with the term to quantify the power of his improved steam engine. He estimated that a strong pony, working for eight hours, averaged 22,000 foot-pounds per minute. Watt increased this figure by 50 percent (upgrading from pony to horse), and the accepted meaning of 1 horsepower (hp) became 33,000 foot-pounds per minute.

A foot-pound is the amount of work done when lifting one pound, one foot. So 33,000 foot-pounds per minute could mean that Watt's theoretical horse could lift 33,000 pounds to a distance of 1 foot—or 11,000 pounds to 3 feet, or 1,000 pounds to 33 feet, or 1 pound to 33,000 feet—in a minute.

"Power" is the rate work is done. "Horsepower" is a unit of power and also a rate—notice the "per minute" in the definition. In the United States, we generally talk about electrical power in terms of watts—another unit of power. Electric motors are rated in horsepower, and with internal combustion engines (ICE), we always use horsepower. In other parts of the world, watts are often used for both. As Scottish electrical nerd Hugh Piggott says, "A lot of people do not realize that mechanical power and electrical power are basically the same thing—the rate of energy flow from one place to another by different means."

It is possible to convert horsepower to watts. The theoretical definition of 1 horsepower is 746 watts. But it's not really that simple where the rubber meets the road. Manufacturers of engines and motors are often enthusiastic about rating their products. Solar pumping guru Windy Dankoff says that in practical terms, 1 horsepower in electric motors is equal to about 1,000 watts, once you factor in the losses.

When you're looking at a motor, it's not always clear what the manufacturer means by "horsepower." Some labels for horsepower—such as peak, developed, no load, brake, stall, or market rated—do not indicate the continuous duty output you'll get in real life.

Rated and measured amperage can help you get some sense of the horsepower. But different motor types have different levels of efficiency, so their current draws will vary somewhat. And each motor has different torque (turning force) and rpm characteristics, which can affect the delivered horsepower significantly. DC motors have a higher overload torque that doesn't fall off as much at lower rpm as in AC motors. So a 1 hp DC motor is not equal to a 1 hp AC motor.

Short of using a dynamometer (a device that measures horsepower), you have to rely on the best specs you can get from the manufacturer. Try to get "true horsepower" ratings so you can compare apples and apples. Industrial electric motors (as opposed to consumer goods) tend to use true horsepower ratings.

When it comes to internal combustion engines, you have to adjust your thinking again. Because of differences in rating methods, and differences in how engines and motors develop torque and horsepower, a typical 1 hp engine is not equal to a typical 1 hp electric motor. Generally, you can assume that a 1 hp electric motor will do the work of a 2 to 3 hp ICE.

How about coupling engines with alternators to make homebrew battery chargers? You have to deal with electric motor/alternator horsepower and ICE horsepower again. In *HP42,* page 28, Richard Perez recommends a 5 hp engine for a 1.6 KW car alternator (100 amps at 16 VDC) because a smaller engine may not be able to push the alternator to full output.

I wonder if James Watt would be surprised that his down-to-earth measure of work has lasted for more than 200 years. In our increasingly complicated and technical world, it's refreshing to have a measure grounded in traditional farm and transportation life. And it makes it easier to remember that "power" is the capacity to do work at a certain rate, whether it's a horse, an engine, or a motor that's working for you.

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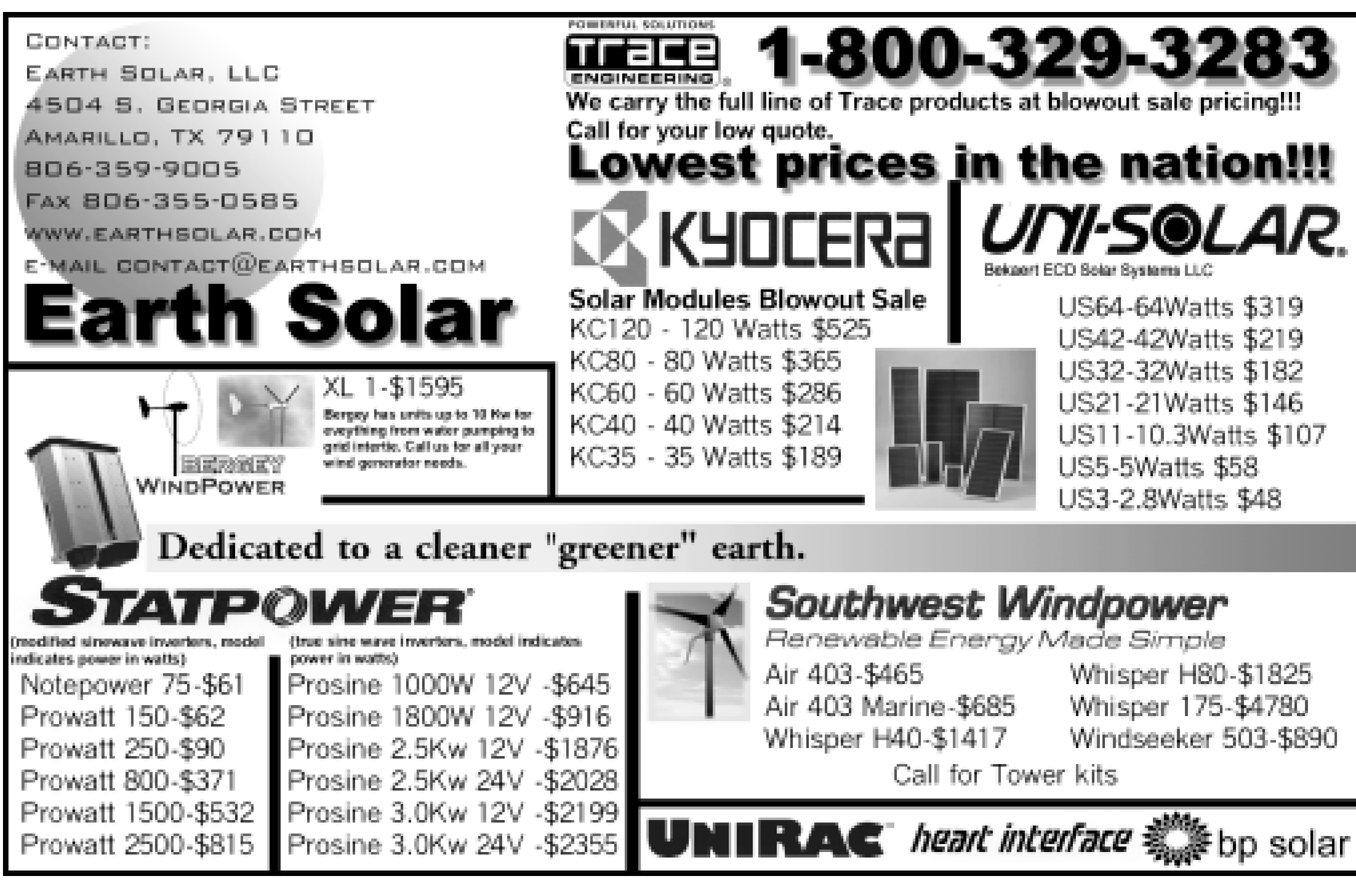
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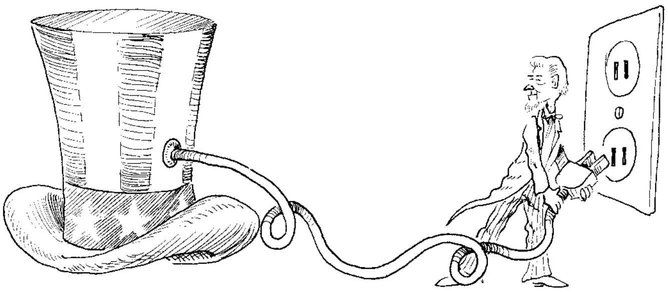

Vampires Rising from the Dead

Michael Welch

I have been thinking a lot lately about our energy future. So much of it is out of our control, and it doesn't seem to be getting better. This is doubly so in the case of nuclear energy's future.

If we had talked ten years ago, I would have told you that a resurgence in nuclear energy in the U.S. was not possible, that it was dead. I thought that we could hold a requiem for future nuclear energy and truly mean "may it rest in peace" for all time—while still crossing our fingers that existing plants would also rest peacefully. I would have said the same for the possibility of a permanent, high-level, nuclear waste dump in the U.S.

In 1993, President Clinton told a joint session of Congress that our country would be eliminating research and development funding for nuclear energy. This was one indication that the possibility of new nukes was in the coffin, and in fact provided one nail for the coffin's lid. Other nails included the WPPS nuclear plant financial fiasco, the huge cost of plant construction, Three Mile Island, Chernobyl, the high cost of decommissioning worn out plants, widespread local opposition to siting low-level nuclear waste dumps, and not having any place to put the dangerously irradiated fuel (high-level waste) from operating nuke plants.

But it turns out that the nuclear industry is not really dead yet. Like a zombie, it is ready to walk the earth again. Maybe more like a vampire with superhuman strength, it has been resting quietly until that dark hour is with us again. Mere individual mortals are no match for the strength of the bloodsucking nuclear corporations that have only been biding their time, waiting for darkness to arrive.

I could go a lot further with this metaphor. It never hurts to keep some humor and playfulness in the face of such daunting adversity. And I do mean daunting. Things have not looked this bad for the antinuclear and pro-RE public since the days of the Reagan administration.

Nuclear Future

"George W. Bush has lately become accustomed to a certain amount of deference. Since September 11, it is politically incorrect to speak to or about him without a glowing tribute to his war leadership." So says correspondent Mary McGrory in her recent *Washington Post* article. The President is incredibly popular since he has gone to war. (I find it hard to grok that they become *more* popular when they go to war.) He pretty easily gets his way with Congress and the public. That increases the possibility that he will get his way with energy legislation, which seems to include more and more concessions to pro-nuke and pro-oil interests. The coffin's lid is bulging from strain, threatening to pop the few nails left holding it down.

The U.S. House of Representatives passed their radically pro-corporate energy bill last fall. Recently, the Senate has been toying with their version. And despite a supposedly more "liberal" membership, it isn't that much better than the House version. Included in amendments to the Senate's version of the energy bill are several pro-nuke provisions. The bill:

- Extends authorization for the "Fusion Energy Sciences Program" by three additional years beyond the period stipulated in the original bill, and authorizes US$1.4 billion for years 2003 to 2006.
- Directs the DOE to carry out the "Nuclear Power 2010 Program," an aggressive program to facilitate the construction and start-up of new nuclear plants by 2010.
- Reauthorizes the Price-Anderson nuclear liability subsidy for commercial reactors until 2012, and treats any group of modular reactors totaling under 1,300 KW as one reactor for the purposes of this subsidy.
- Establishes the Office of Spent Nuclear Fuel Research to carry out research, development, and demonstration programs on technologies for treatment, recycling, and disposal of high-level nuclear waste and irradiated fuel.
- Directs the Secretary of Energy to study designs for a high-temperature nuclear reactor capable of producing large-scale quantities of hydrogen using thermochemical processes.

Yucca Mt. "Designated"
Early in January, Energy Secretary Spencer Abraham recommended the Yucca Mountain site in Nevada as our nation's high-level nuclear waste repository. Then it was up to the President to officially designate Yucca Mountain as the dump site, which he did on February 15th. Neither Clinton nor Bush 1 had been willing to take that step, since the science behind the site choice clearly shows it is not geologically stable enough for such an undertaking.

With Bush 2's designation, it is steps closer, but there is still some hope. Written into the Nuclear Waste Policy Act is the ability to veto the choice by the participating state's governor. It is assumed that with Nevada's vehement official opposition to the dump, Governor Kenny Guinn will exercise that veto, which is expected by mid-April.

Then it becomes up to Congress to override the governor's veto. An override happens with a simple majority of both the House and the Senate, and must happen within 90 days of the gubernatorial veto. (Some people call this act the "Screw Nevada Bill," since Nevada was the only considered state without enough political clout to become excluded. See *HP46,* page 89.)

Last May, Senate Majority Leader Tom Daschle promised that as long as there was a Democratic Senate majority, the veto would not be overridden. But this March, he changed his tune a bit. He now says that he will continue to work on this issue with Nevada Senator Reid, but when asked if Yucca Mt. legislation could be killed in a Senate vote, he said, "I have no idea."

Another strategy to watch for in coming months is that pro-nuke members of Congress are considering a court challenge to the constitutionality of a state governor being able to veto federal legislation. But Nevada does not take this lightly. The state is pouring millions in government and Las Vegas casino money (the casinos are afraid of harm to the tourist industry) into research and action to head off a veto override.

Other Energy Disappointments
The U.S. Senate's energy bill (S. 517) would authorize the opening of the Arctic National Wildlife Refuge to gas and oil exploration and development (see *HP83,* page 90). This one issue is the only serious sticking point for the bill as it now stands. It looks like the Democrat-controlled Senate will be willing to accept the rest of the energy bill, as horrible as it is, if the refuge is left untouched. It really ticks me off that our legislators choose to ignore other important environmental issues. It really ticks me off how the President has parlayed his war-time popularity into further benefits for energy corporations.

Another fight is about the amount of RE resources that the energy bill would help create. A proposed amendment would have required that by 2020, twenty percent of utility energy would come from RE sources. Through intense lobbying by utilities and major consumers of energy, the amendment was soundly defeated in mid-March.

Environmental activists were hopeful that another, less stringent amendment would be offered. A new amendment, calling for 10 percent by 2020, has been approved. But current thought is that it will be pretty much gutted through the use of exemptions, loopholes, and phony definitions of the word "renewables."

The Senate energy bill also includes these interesting details:

- The bill makes Enron-like situations (see *HP88,* page 108) more likely by repealing the Public Utility Holding Company Act (PUHCA), the federal government's most important electricity consumer protection.
- The Senate caved to industry and turned its back on improving vehicle fuel economy. A proposal to raise corporate average fuel economy standards to 36 miles per gallon by 2015 was defeated. The Senate opted instead for the inaction of a study.
- The bill doles out US$1.8 billion to subsidize the coal industry, and more than US$2 billion to promote oil and gas production and other "core fossil research and development." The oil and gas industries would get US$3.2 billion in tax breaks.

Soon after the Senate bill passes, it will need to be reconciled with the House version. This could take months, so there is plenty of time to keep bugging your legislators to help them see the errors of their ways.

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Batteries and PV Systems

Don Loweburg

Battery management and maintenance are significant concerns in off-grid PV systems. Many of the user problems associated with these systems can be traced to improper treatment and misunderstanding of battery performance.

Modern battery chargers use three charging stages—bulk, finish (absorption), and float. Bulk brings the batteries up to the high voltage regulation point; finish holds it at this high voltage regulation point based on time. In the absorption stage, the voltage is constant, and the current tapers off as the batteries are filled. Float trickle charges the battery to a lower, user-determined voltage to keep it full.

From my experience, the most common battery problem is undercharging, leading to sulfation, loss of storage capacity, and shortened service life. Sandia National Laboratories recently published "PV Hybrid Battery Tests on L-16 Batteries" (see Access). Their tests represent several years of systematic testing of a PV-generator (hybrid) system.

The Sandia report is very thorough. Four different brands of batteries were tested. They were all flooded, L-16 type batteries, the most common battery used in residential-scale RE systems. Tests were repeated so that the data represents good averages, and the conclusions are based on good data and methodology. The study has four conclusions:

1. The finish voltage (sometimes called the absorption voltage) for a flooded lead-acid battery operating at 12 VDC nominal should be about 15.3 volts (2.55 per cell) rather than the customary 14.4 volts.
2. Finish charge time should be at least 3 hours and often longer.
3. The maximum interval between finish charges should be about five days.
4. Not all brands of L-16s are the same (though the report names no names).

The general conclusions of the Sandia report are consistent with the number one problem experienced in off-grid PV systems—undercharged batteries. Richard Perez has for many years advocated higher finish voltages for PV-engine generator systems. As he says, "I like to run them hot."

Home Power technical editor Joe Schwartz adds some good advice regarding flooded lead-acid batteries:

- Higher finish charge rates result in significantly more gassing and potential for hydrogen buildup. Before you crank up the finish voltage to 15.3 VDC (for a nominal 12 volt system), make sure that the battery containment is well ventilated. The use of powered battery vents is recommended.
- Batteries charged to a high finish voltage produce a significant amount of waste heat. Depending on the type and location of the battery containment, in warm climates or seasons active ventilation may be required to keep battery temperature in check. Optimal operating temperature for lead-acid batteries is 78°F (25°C). Higher battery temperatures (90°F plus; 32°C) result in increased self-discharge. Temperatures over 120°F (49°C) can damage lead-acid batteries.
- Batteries charged to a high finish voltage consume a lot of water. Compared to charging at the traditional 14.4 VDC finish voltage, the time period between battery watering can easily be cut in half. Automatic battery watering systems greatly simplify the process.
- Use temperature compensation on all charge controllers and inverter/chargers.

Finish Charging Is Inefficient

There is one significant downside to the battery management strategy presented in the Sandia report. Due to battery charging characteristics, efficiency is very low during the finish charge phase. Very long engine generator run times were reported, sometimes from 6 to 20 hours. These long run times were required to completely refill the batteries to the manufacturers' stated ampere-hour capacity.

The state of charge (SOC) of a battery is most accurately measured with a hydrometer, and is indicated as specific gravity (SG). Most RE users rely on amp-hour meters to provide convenient (although slightly less accurate) battery SOC information. During the Sandia tests, full batteries had a SG in the range of 1.290. The long, engine generator run times needed to achieve this SG translate into dollars and pollution (both audio and atmospheric). Perhaps there is a "middle way" that preserves the lifetime of the batteries while reducing the time and cost of engine generator finish charging.

Revisit the Assumptions

The batteries tested at Sandia were discharged by 60 percent of capacity (to 40% SOC) and then charged back to rated capacity. In these tests, the rated capacities were determined empirically, and in most cases were close to the manufacturer's stated value (in the range of 350 AH for an L-16).

These two points require comment. First, this depth of discharge is not typical of most well-designed, stand-alone PV systems. This point is clearly stated by the author of the study. Most stand-alone PV systems, by design, cycle batteries by about 25 percent daily, not 60 percent.

Second, the manufacturer's rated battery capacity and the way it is determined should be understood. All manufacturers recharge batteries on the grid. Using the grid, they can finish charge the batteries for long periods (on the order of 8 to 12 hours), cramming maximum ampere-hours into them. For a manufacturer, this method makes sense because it results in greater AH capacity figures for their product.

The long engine generator run times required by PV hybrid systems must mimic the finish charge conditions the manufacturers use to rate the battery's capacity. Perhaps batteries should be rated based on their application. For instance, a battery used in a standby application (such as utility backup system with grid recharging) might specify a full charge SG of 1.290. The same battery used in an application that regularly cycles the batteries (such as a PV system with engine generator backup) might have a recommended SG of 1.250 to be considered full.

It is true that a battery with a SG of 1.290 holds more charge than the same battery with a SG of 1.250. However, the shorter finish charge time required to achieve the lower SG reduces the engine generator run-time. Keep in mind that most of the fuel consumed by the engine generator is wasted during the late stages of finish charging.

A Comparison

Consider two systems. System A is designed and operated along the lines of Sandia's test. It might be characterized as an undersized PV array with batteries that are cycled deeply (50 percent) and recharged to the manufacturer's recommended SG of 1.290. System B is designed to provide the same functional capacity (daily AH consumed, in this case 350 AH), but the batteries are only cycled by 25 percent, and the engine generator finish charging takes the batteries to a SG of 1.250.

According to Sandia's findings, system A would need about six hours of finish charge every five days, due primarily to the deeper cycling. Because system B is only discharged by 25 percent and the target SG is lower, it would require less finish charge time of about three hours every five days. Over a ten-year period, the difference between the two engine generator run times is about 2,160 hours.

A conservative assumption is that it costs US$1 per hour to operate an engine generator. The ten-year savings of system B over system A (US$2,160) is reduced, however, by the fact that B's battery bank is twice as expensive. If both systems used L-16 batteries, the respective capacities in this comparison would be 700 AH (A) and 1,400 AH (B). System B would have an initial battery cost of about US$800 more than system A (based on US$200 per L-16). Subtracting the increased battery cost from the engine generator savings (US$2,160 - US$800) gives a net savings by system B of US$1,360. System B also realizes further savings because of longer battery life due to the lower depth of discharge.

Modified Conclusion

Finish (absorption) voltage needs to be about 15.3 volts (for a nominal 12 volt system). Batteries need to be fully charged (finished) about once a week. If the depth of discharge is moderate, and a modest SG of 1.250 is chosen, the finish charge time can be reduced from six hours to three hours.

These choices will reduce the engine generator run costs. On a life cycle cost basis, the reduced engine generator run time more than pays for the larger battery bank. Other benefits include reduced local air pollution, longer engine generator life, and reduced noise pollution, battery watering, and maintenance.

Don't Undersize the Array

Though Sandia's tests were specifically done on L-16 batteries, based on my field experience, the results are generally true for all lead-antimony flooded cell batteries. In very general terms, we can say that the finish charge time is inversely related to the average state of charge.

Finally, one of the easiest ways to increase battery life, in addition to limiting the depth of battery discharge, is to add more PV to an existing array. Doing so increases the average state of charge and reduces the need for long engine generator assisted finish charges.

UL vs. Xantrex—The Aftermath

Last November, Underwriters Laboratories (UL) withdrew its listing for the Xantrex SW series inverters and posted a public safety alert and press release on its Web site. Though the SW inverters have been relisted by the Canadian Standards Association (CSA), and Xantrex is taking measures to upgrade all affected units, UL's unprecedented, heavy handed, and punitive behavior leaves many questions.

No one has ever been hurt by an "islanding" inverter. Other well-publicized, UL-approved products that actually killed people were not treated in the same manner. For instance, I saw no mention on the UL Web site of the UL-listed halogen lamps that started several house fires.

Why would a company (UL) treat one of its clients (Xantrex) so poorly? Was there ever a real safety issue involved? Was this public "shaming" of Xantrex and the damage to their reputation commensurate with the severity of the problem?

I do not have detailed answers to these questions. However, UL's pattern of behavior, and anecdotal comments from those who have worked closely with UL, suggest an attitude of arrogance and tyranny.

A Short History

UL is not the only U.S. electrical product testing agency, though it is the oldest. Founded in 1894, UL touts itself as holding "the undisputed reputation as the leader in U.S. product safety and certification." UL was able to attain that reputation, in large part, by maintaining a near monopoly on the certification business.

Prior to 1983, only two testing organizations were authorized by the Occupational Safety and Health Administration (OSHA) to certify electrical products nationally for safety. They were UL and Factory Mutual Research Corporation (FMRC). In 1983, a private testing company, Electrical Testing Laboratories (ETL, now ETL Semko) sued OSHA, since under federal law OSHA enforced safety regulations and technical standards. As a key element of that lawsuit's settlement, OSHA set up the Nationally Recognized Testing Laboratory (NRTL) program, breaking UL's nearly century long monopoly.

Since 1988 (it apparently took five years to establish NRTL), more than twenty companies have been "recognized." OSHA recognizes a company based on an evaluation of the company's ability to perform a specific test. OSHA does not set the standards for testing. Rather, OSHA determines whether or not a company has the technical, staffing, and administrative resources to conduct a specific test. If this is the case, that company becomes an NRTL for that test.

Quoting from OSHA's Web site, "The NRTL determines that specific equipment and materials ('products') meet consensus-based standards of safety to provide the assurance, required by OSHA, that these products are safe for use in the U.S. workplace. Given that each NRTL has met the same requirements for recognition, OSHA considers NRTLs recognized for the same product safety test standard to be equivalent in their capability to certify to that standard."

Choices Are Available

Today OSHA recognizes several electrical testing organizations, including the well-known UL, ETL, and the Canadian Standards Association (CSA). All three are NRTLs, and are legally equivalent. In large part, UL's continued dominance of the testing market today is based on almost a century's momentum gained from their near monopoly. Consumers have grown to accept UL almost as a quasi-governmental agency.

This consumer expectation that UL is the only "official" certification mark, influences many manufacturers to go with UL rather than ETL or CSA. Engineers working in RE have indicated to me that they prefer working with ETL and CSA. They end up working with UL only because their marketing departments fear consumer rejection if a lesser known but legally equivalent testing agency was used.

Clearly, customer attitude (or at least perceived attitude) is key here. Once customers understand and accept that other testing agencies exist and that they can provide legally equivalent testing services, manufacturers may choose to have their testing done by an agency other than UL.

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Quarterly Highlights of Sandia's Photovoltaics Program, "PV Hybrid Battery Tests on L-16 Batteries," Photovoltaic Systems Assistance Center MS0753,

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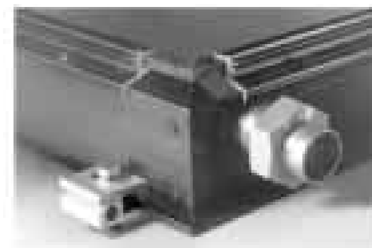

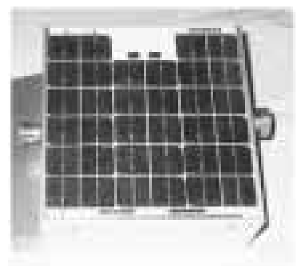

Making the Grid Connection

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

You are planning to install a utility-interactive PV system. You have sized the system, selected the modules and the inverter, and made all the DC wiring decisions. You now have to decide how to connect the AC output of the inverter to the grid.

A number of areas must be considered in connecting to the grid safely. The utility company should be notified and their technical and administrative requirements addressed. These requirements will vary widely from utility to utility. Permits and electrical inspections may be required. In harmony with the utility requirements, the *National Electrical Code (NEC)*, and any local code and inspection requirements, you will have to plan, select, and install the hardware that will be used to get from the inverter to the point where the AC power interfaces with the existing wiring in the building.

The Utility Disconnect

In most locations, the connection to the existing wiring will be through a backfed circuit breaker in an existing load center. However, some utilities, but not all, require a disconnect switch that is accessible to utility personnel between the output of the utility-interactive inverter and the connection to the existing wiring. If the inverter is to be mounted inside the building, the wiring from the inverter to that backfed circuit breaker must be routed outside the building, through this disconnect, and then back inside the building to the load center.

Utilities usually require that a switch-type disconnect with visible blades (so they can verify when it is open) be used, and that the disconnect can be locked in the "off" or "open circuit" position. The idea is to enable a utility lineman working on the distribution system to lock this switch in the "open" position. This ensures that the disconnected line or feeder cannot possibly be energized by any connected power generation source. The location of the switch also allows the rest of the house to receive grid electricity while the PV system is disconnected. This external AC disconnect, under utility control, is sometimes used to prevent the PV system from being connected to the grid until all of the contractual, technical, and billing details are resolved.

Some people have suggested that when the utility lines are being serviced, the meter be removed from the meter socket or base instead. But this is prohibited by utility regulations in some states, and may cause billing errors if a meter is inadvertently switched around. Usually only the utility metering departments are allowed to remove or change meters. Fire departments are also allowed to remove meters, but only in emergency situations when the main disconnects cannot be located.

Inverter Size vs. the Load Center

NEC Section 690.64(B)(2) is written to prevent unintentional overloading of circuits that may carry both grid power and power from a PV source. These circuits include feeders, branch circuits, load centers, and any other circuit that may be connected to multiple sources of power. Let's look at a load center in a commercial building first to see why this requirement (paraphrased below) exists. Then we'll examine the exception that applies to dwellings.

Suppose, for example, a load center in a commercial building is rated at 400 amps and has a 400 amp main breaker or a 400 amp breaker on the feeder supplying the load center. Since the load center is rated at 400 amps, this is also the rating of the bus bars in it. The *NEC* allows high loading of load centers in commercial buildings, and this particular load center is loaded to about 320 amps when the building is occupied—mostly during the normal daytime working hours. Like a residential load center, the ratings of the individual branch circuit breakers may total far more than the 400 amp rating of the load center, but the load design calculations used for the installation allow for up to 320 amps being drawn.

Now let's install an 80 amp, AC output, utility-interactive PV system on this commercial building, and backfeed a 100 amp breaker in the 400 amp load center. When the PV system is delivering the full 80 amps, some of the 320 amps of daytime load are being supplied by the PV system, while the grid supplies the remaining 240 amps. All circuits are properly loaded, no circuit is overloaded, and no circuit breakers trip. At night, the PV energy goes to zero. The grid, through the 400 amp main breaker, supplies any building load.

The PV system performs well and is "out of sight and out of mind." Sometime later, management decides to renovate the office space, and installs numerous computers that will be used by the office staff during the day. No one brings in an electrician or an engineer to reassess the new load. If the PV system had not been installed, the main 400 amp breaker would sense any overloading of the 400 amp load center. It would trip, protecting the load center. But now, let's see what happens when 100 amps of additional daytime load are added to the various branch circuits connected to the load center.

During sunny days, the PV system supplies 80 amps of the greater 420 amp load, and the grid supplies 340 amps. No circuit breakers trip, although the main breaker is being operated at more than 80 percent of rating. Everything appears normal until we look at the bus bars, rated at 400 amps, in the load center. They are now overloaded when carrying 420 amps, and that may cause them to generate excess heat and possibly, over the long term, cause nuisance tripping or shorten the life of the circuit breakers. At night, when the PV system is not producing, the load is also reduced and nothing is amiss. On cloudy days, the main breaker may trip, depending on the output of the PV system and the actual load.

This additional load, of course, has been applied improperly without a reassessment of the total load on the panel. However, these things do happen in many office complexes. The *NEC* recognizes this problem and hence the following requirement in *NEC* Section 690.64(B)(2) [paraphrased]: *The sum of the ampere ratings of all overcurrent devices supplying power to a circuit, feeder, bus bar, or the like shall not exceed the rating of that circuit, etc.*

Generally, in a commercial building, it is not possible to use a backfed circuit breaker in an existing load center to connect a utility-interactive PV system to the grid. There are a couple of proper ways that this connection can be made. The load center could be increased to say 600 amps (with 600 amp bus bars) and equipped with a 400 amp main breaker (or better yet, a 450 amp main breaker). Or a separate 100 amp fused disconnect or single breaker disconnect could be connected in parallel with the existing 400 amp load center (or the replacement load center installed to handle the increased load).

Residential Installations and *NEC* 690.64(B)(2)

Now that we have seen the problems and solutions with a commercial installation, what about a residential installation? Since residential load centers are more lightly loaded (by design and code), Section 690.64(B)(2) allows an exception to the general rule.

The exception allows the sum of all overcurrent devices connected to a circuit, load center, or feeder to exceed the rating of that circuit by 20 percent. For a 100 amp residential load center, 20 amps of backfed breakers (one on each side of the 120/240 volt line) may be connected. This represents about 4,800 watts with either two, 120 volt, 2,400 watt inverters or one, 4,800 watt, 240 volt inverter.

Since most of these breakers are limited to continuous currents at 80 percent of rating, the actual inverter power levels would be limited to 1,920 watts and 3,840 watts. For a 200 amp load center, two, 120 volt inverters of 3,840 watts each or a 7,680 watt, 240 volt inverter may be connected.

For larger PV systems using larger inverters with only 100 or 200 amp load centers, an external disconnect needs to be paralleled with the existing load center. This external disconnect must be rated as service entrance equipment because the connection amounts to a second service entrance on the house.

These limits are troublesome for those wanting to connect battery backup systems using the larger inverters that have 60 amps of grid feed-through, and lesser amounts of inverter output in the utility interactive mode. The desire is to install a 60 amp, backfed breaker to take full advantage of the grid feed-through. But as can be seen from the *NEC* limitations, the 60 amp breaker is not compatible with either of the common 100 amp or 200 amp load centers. To meet *NEC* requirements, the load center would have to be rated at 300 amps or larger (20 percent of 300 is 60 amps). These installations will normally require a parallel disconnect/overcurrent connection as described previously.

Dedicated Circuit

NEC Section 690.64(B)(1) requires that each utility-interactive inverter be connected to a dedicated circuit breaker or fused disconnect. The dedicated circuit requirement (up to the first disconnect device) is to minimize the possibility of creating an island within the building where a constant load on the same circuit matches the inverter output and allows the inverter to run after the disconnect is opened.

If a dedicated circuit is not used, there is also the possibility of connecting the inverter to a circuit that might have devices that could be damaged by the inverter. For example, the code requires that all utility-interactive inverters be connected on the line (grid) side of any ground-fault circuit equipment. When an inverter shuts down through loss of the grid signal, it does not shut down instantaneously.

The decaying voltage output of the inverter may be sufficient to destroy the trip coils in the antishock GFCI devices where the inverter is connected to the load side of the device. With burned out trip coils, the GFCI will no longer provide the antishock protection it was intended to provide. It will continue to carry power, but will not trip open when a 6 milliamp or greater ground-fault current is in the circuit.

In many commercial buildings with very large service entrance equipment, a 1,200 amp, equipment-protection, ground-fault device may be installed. It is important that any PV system be connected on the line (grid) side of this device to meet general safety and code requirements.

Circuit Ratings
The conductors between the inverter and the grid connection should have a temperature-derated ampacity of at least 125 percent of the continuous rated output current of the inverter. This current rating is determined from the manufacturer's specifications or by taking the rated inverter power output and dividing it by the line voltage.

Overcurrent devices in this circuit should also be rated at 125 percent of the continuous inverter output current, and be less than or equal to the conductor ampacity. These 125 percent factors are used to ensure that neither the overcurrent devices nor the conductors are used at more than 80 percent of their ratings.

For example, a 2,500 watt, 240 volt inverter has a continuous output current of 10.4 amps. This current must be multiplied by 125 percent to get 13 amps to determine the ampacity of the conductor and the rating of the overcurrent device. The next larger standard overcurrent device would be rated at 15 amps and a #14 (2 mm^2) or larger conductor could normally be used since it has an ampacity of at least 15 amps under typical residential use conditions.

Continuing the example, a 15 amp, double-pole, 240 volt circuit breaker could be used to connect one of these inverters to a 100 amp load center and meet the requirements of *NEC* Section 690.64(B)(2). With a 200 amp load center, it would be possible to connect three of these inverters if they were first connected to a subpanel. Three, 15 amp circuit breakers (one for each inverter) would feed a 100 amp subpanel, containing a 40 amp main breaker. The subpanel would meet 690.64(B)(2) requirements, since the total of all breakers feeding the 100 amp panel would be 85 amps (3 x 15 + 40).

This subpanel would then be connected to the main 200 amp load center through a backfed 40 amp breaker. The panel would meet 690.64(B)(2) requirements (20 percent of 200 is 40). Each of the 40 amp breakers would be appropriately rated (1.25 x 10.4 x 3 = 39), and each inverter would be on a dedicated circuit.

Conductors & Wiring Methods
Any wiring method found in Chapter 3 of the *NEC* is acceptable for connecting the inverter to the load center. Indoor wiring might include non-metallic sheathed cable (Type NM) or conductors (Types THWN or RHW) in conduit (either PVC or metallic). Outdoor inverter installations might also use conduit or possibly Type UF (Underground Feeder) cable marked "sunlight resistant." Wiring methods using conduit might be required on commercial buildings due to local codes.

Disconnects
If the inverter is within 5 feet (1.5 m) of the main load center, the backfed breaker could serve as the inverter AC disconnect for inverters not having an internal disconnect device that meets code requirements. If the inverter is more than 4 to 5 feet away from the main load center or the subpanel, and the inverter has no internal AC disconnect, an external disconnect device should be connected in the circuit near the inverter. Even though the inverter is usually power (and current) limited, some inspectors may require an overcurrent device at the inverter location. So using a circuit breaker makes sense for the disconnect.

Grounding
Each inverter will have a unique method of grounding the AC output, and the manufacturer's instructions should be followed. In most cases, for inverters less than about 15 KW, there is no internal bond between the AC neutral and the grounding system. This bond is made in the load center/mains panel to which the inverter is connected.

Inverters with external transformers may require special grounding considerations. In nearly all cases, the AC equipment-grounding conductor should be run with the circuit conductors (same conduit or cable) from the inverter to any connected equipment (switchgear, overcurrent devices), and then to the equipment-grounding system associated with the building.

Marking Requirements & Plaques
Part VI of Article 690 establishes the *NEC* requirements for marking the utility-interactive PV system. Section 690.53 requires a marking at the DC disconnect showing the operating and short-circuit current, operating voltage, and maximum system voltage. Section 690.54 requires that all points of interconnection with the grid be marked with the maximum AC output operating current and the operating voltage. This means marking each subpanel and the final load center or switchgear that have AC current from the inverter through them.

Additional marking requirements apply if the system has batteries or other sources of power. Section 690.55

specifies that if the system has energy storage devices, the maximum voltage (including any equalizing voltage for batteries) and the polarity of the system ground must be displayed.

Section 690.56 further requires that permanent directories or plaques showing all sources of power and disconnect locations be mounted on the outside of the building in a readily accessible location.

Summary
Connecting a utility-interactive PV system to the grid can be done in a way that is safe and meets utility and *NEC* requirements. By following the guidelines above and the details in the *NEC,* an approved connection will provide reliable and safe performance for many years.

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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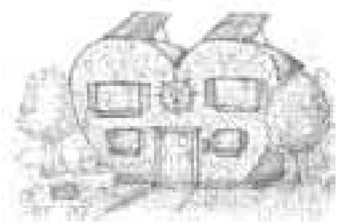

Kathleen Jarschke-Schultze

After moving to the wilds of Northernmost California, I began to view roads differently. They were not merely paved routes to get from one place to another. I came to see distinct personalties in the roads I traveled, with quirks, moods, and senses of humor that changed as quickly as the weather.

On the Salmon River in California, we lived on the river road at the 25 mile marker. This one lane, paved road followed the South Fork of the Salmon down to where it met the North Fork at (where else?) Forks of Salmon. From the 11 mile marker on the Main Fork to the 31 mile marker on the South Fork, the road was all one lane. Blind corners were *de rigueur.* Turnouts were located all along the road because many places were so narrow that two cars could not pass by each other.

Road Etiquette

They had a saying on the river, "On one side of a mountain road is a mountain." What this means is that on the other side of the road is the steep descent to the river. Sometimes in the winter, a part of the outside edge of the road would start to deteriorate. That's when some kind soul would put up a "Salmon River guard rail," which consisted of three or four cantaloupe-sized rocks, spray painted fluorescent orange and set in orderly fashion along said edge. This was your clue to hug the mountain side of the road.

Everyone had two CB radios—one in the cabin and one in the vehicle. No matter what kind of vehicle you drove, it was generically called a "rig," unless it was a four-door pickup truck. Then it was called a "crummy," and it usually was. The road channel was 18, and this was where we all kept our radios, both home and rig, tuned. When you were in your rig traveling the road, you would call the mile markers that you passed. This would alert other drivers of your position, and you would be able to pull into a turnout before meeting them head on.

A typical road conversation would go something like this:

"Mile marker eighteen coming up the South Fork."

"Mile marker twenty-three and a half coming down."

"Nineteen coming up."

"Twenty-one heading down."

"Come on by; I got a wide one."

"Be right there."

A minute or two of silence, then, "Mile marker twenty coming down the South fork."

"And one rig coming up."

Sometimes you would hear, "Mile marker twenty-four coming up; there's a rig headed down, but they got no ears." This meant it was a tourist or somebody else who didn't have a CB radio and couldn't call the markers.

Soon after moving to the river, I became aware of another point of road etiquette. I had been calling the mile markers and knew a log truck was approaching. When we were about a half mile apart, I used a turnout and told him to come on by. I was surprised when the driver flashed me a peace sign, two fingers held up in a "V." "Wow," I thought, "People here are really friendly and cool."

I started to pull out onto the road when two more log trucks passed me in quick succession. So *that* was it. It was polite and safe to indicate how many rigs were coming behind you. It would be too noisy and confusing for every rig to call its mile markers. A log truck driver once held up both hands, all fingers spread emphatically. Sure enough, ten more log trucks passed in review as I kept my place on the turnout.

Radio Etiquette

Since there were only a few phones on the river, and those were within a mile or two of Forks of Salmon, most people used their CBs for communication. Every home had a CB name, as did most of the river people. Home names included Main House, Starveout, Rainbow, Godfrey Ranch, Blue Ridge, Matthews Creek, Indian Creek, and Plummer Creek, to name a few. They were usually the name of a mining claim or a nearby geographical feature.

People's CB names usually were of their own choosing, although a few were awarded without consent but stuck anyway. I always felt that being given a CB name was a sign of affection, like a nickname. There was Donkey Puncher, Spider, Herr Rise and Shine, Bassman, Harpo, Malfunction Junction, Jawbone, Magpie, Manzanita, etc.

I never did get a CB nickname. For the duration of my life on the river, I remained Kathleen. Well, except Herr Rise and Shine did call me Starveout Sweet Potato, to which I would always answer back on the radio, "Here I yam."

Since everybody listened to channel 18, it was the contact channel, as well as the road channel. It was considered the height of rudeness to carry on a long conversation on the road channel. After all, people were calling mile markers as a real matter of safety. So, as correct river radio etiquette would have it, you would make swift contact and move off the road channel to talk. It would happen something like this:

"Godfrey Ranch, Magpie. Magpie, are you around the radio?"

"I got you, Starveout. Let's go up."

"Let's go up," meant the two of you would both turn the CB to channel 23. Since the highest channel older model CBs could go to was 23, that was the accepted place to meet. Of course, everyone who didn't need to stay on the road channel would also "go up." So, no conversation was private.

You could work out with your closest friend that by saying "let's go up," you really meant to meet on, say, channel 32. But then, when the listening public found you were not on 23, they would just scan the channels till they found your conversation in progress. In a community without phones, television, or regular radio, any entertainment is pursued.

The Bus Run
A school bus ran every weekday from Cecilville to the Forks school, where grades K through 8 were taught. Norma the bus driver made the run in all weather and all road conditions. The bus had a CB, and the mile markers were called.

Since we were halfway between Cecilville and Forks, we were often called upon to relay messages. The mountainous terrain that we lived in would not allow the radio signals to go very far. A general rule was that the higher up on a mountain you were, the farther your radio signal could be heard. In the wintertime, a relayed message from Norma to the county road crew was common. That's when either a snowplow or the "rock knocker," as it was known, would come to the rescue of the school bus.

It was in the winter, with its rain, snow, freezes, and thaws that the mountains would contribute their parts to the road. Although the rocks-in-the-road phenomenon could happen anywhere along the river road, a particularly treacherous area was known as the Samsonite Cliffs. It was named this because the rocks

Reprinted from the *Salmon River Star*, Dec. 1987.

that fell into the road resembled sets of luggage in shape and size. A common rock slide would deposit everything from a steamer trunk to a small, squarish, makeup case, all composed completely of granite.

If the slide and the rocks were small enough, Norma would stop the bus, and she and the older boys would move the rocks out of the road enough for the small bus to get by. If the slide was bigger than that, she would call for the rock knocker.

Sometimes the slide was so big that even the rock knocker couldn't clear it in time for school. Then the second small school bus, driven by Creek, would be called by radio relay to come to the downriver side of the slide. Norma and Creek would run the kids across the slide as fast as possible from one bus to the other, and their journey to school would continue.

Once, a single rock the size of a Volkswagen bus tumbled and fully blocked the Main Fork road. It had to be dynamited. Another time, Betty Ann was driving to a potluck with a plate of brownies on the seat beside her when a rock bounded off the mountainside through her window and landed in the brownies. Yet another time, some kayakers were driving along the river road when rocks started to fall on the road around them. They tried to keep driving, but the slide got worse. Their car was blocked in, so they got out and ran for their lives.

They arrived safely out of the slide area, but their station wagon, with kayaks atop, was covered by the slide, taken over the embankment, and buried in such a way that it could not be seen or found. They had a heck of a time getting the insurance company to pay their claim. The really funny part of this story is that almost ten years later, after we had moved from the river, another slide uncovered their station wagon and kayaks, rather worse for wear.

Up the Creek
We live in a different part of Siskiyou County now. We

have 1.8 miles of dirt road for a driveway. Although it has had its share of plagues, flooding, toads, and tourists, it's not that bad. Bob-O and our neighbor Stan work on it when the timing is right—when the right amount of moisture in the adobe clay makes adding rock and gravel effective.

It used to be a much worse road. In one particular place, every time I drove our pickup, no matter how slow I tried to take it, I would be bounced so hard and high that my head would hit the ceiling of the truck. That was one of the first places to be fixed.

It's still a dirt road, though. In the winter, it becomes mud and is prone to new ruts and holes. If the rain lasts for very long, the ruts get so deep that they grab my tires and roll me along their route like the rails of a roller coaster. It is not the kind of road where you would want to pick your nose or apply lipstick. But for the most part, it is a nice, calm, gentle road, and the rocks that bound into my path are no bigger than an overnight valise.

Access

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

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

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

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

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

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

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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

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Aug. 7–9, ’02; Technical Conference: Sustainable Development with Renewable Energy Resources, Northern Arizona Univ. Flagstaff, Arizona. Info: see SWREF below.

Aug. 9–11, ’02; SW RE Fair, Northern AZ Univ., Flagstaff, Arizona. In conjunction with national conference (see above). 50 vendors, workshops, keynote guest speakers, exhibits, & demonstrations. Info: GFEC, 1300 S Milton Rd., #125, Flagstaff, AZ 86001 • 800-595-7658 or 928-779-7658 Fax: 928-556-0940 • www.gfec/swref swref@gfec.org

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

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

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June 19–25, ’02; Permaculture Teacher Training Course, Bonny Doon, near Santa Cruz. Prerequisite: A Permaculture Design Course Certificate; develop teaching skills, discuss strategies & techniques. US$305. Contact: Rain, TT, 316 Main St., Santa Cruz, CA 95060 • 831-457-9469 raincascadia@yahoo.com.

Aug. 17, '02; S. CA RE Expo, Fairplex in Pomona, CA, Exhibits, demonstrations, workshops, dealers, & manufacturers. Info: Ray Boggs, Solatron Technologies, 19059 Valley Blvd., Suite 219, Bloomington CA 92316 • 888-647-6527 www.socalenergyexpo.com

August 24–25, '02; SolFest 2002, Real Goods Solar Living Center, Hopland, CA. RE, green building & sustainable lifestyles, 100+ exhibitors, 50+ workshops, tours, food, entertainment, children's ocean mural. Solar Living Institute • 707-744-2017 www.solarliving.org

Sept. 20–22, '02; CA Energy Expo 2002, San Diego Convention Center. Latest RE technologies & energy conservation strategies. Info: Richard Brown, 23672 San Vicente Rd., Ste. 363, Ramona, CA 92065 760-653-4022 • rcb@mail2usa.com www.californiaenergyexpo.com

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

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July 8–19, '02; Women's PV Design & Installation workshop; Carbondale, CO. System design, batteries, components, site analysis, & system sizing, in a supportive atmosphere. Hands-on PV system installation. Women only US$1000. Info: see SEI below.

Aug.9–11, '02; Women's Carpentry Workshop; Carbondale, CO. For women with little or no experience in construction or carpentry. Hands-on projects to familiarize participants with tool use, final project to take home.US$300. Info: see SEI below.

Sept. 8, '02; Rocky Mountain Sustainable Living Fair, Lincoln Center, Fort Collins, CO. Free, 50+ exhibitors, workshops, demos, live jazz. Info: Christa Reed, Village Earth Consortium, 970-377-1392 • Fax: 970-377-0140 • Creed9196@cs.com www.SustainableLivingFair.org

Sept. 9–13, '02; Loveland, CO. Biodiesel Fuel Workshop. Fundamentals of biodiesel, making your own fuel & processor, & convert a diesel engine. US$500. Info: see SEI below.

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

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June 25–27, '02; PV System Installation, Brookville, IN. Live & learn with PV at Camp Amakanata, Lodging, camping, & meals available. Info: see Solar On-Line in INTERNATIONAL

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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 • 563-288-2552 irenew@irenew.org • www.irenew.org

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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

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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

Intro to Solar, Wind, & Hydro. West Branch, MI vicinity. First Friday every month Basic system design & layout; on grid/off grid; AC/DC for homes or cabins. Reservations required. Contact 989-685-3527 gotter@m33access.com.

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

MONTANA

June 3–7, '02; Biodiesel Fuel Workshop. Lozeau, MT. Includes making your own fuel & processor, & how to convert a diesel engine. US$500. Info: see SEI in COLORADO listings.

July 13, '02; Sustainability Fair 2002. Rotary Park, Livingston, MT, 9 AM. Over 60 vendors with sustainable goods & services, including RE. Speakers, entertainment, model kitchen, fashion show, children's activities. Info: Corporation for the Northern Rockies • 406-222-0730 www.northrock.org • info@northrock.org

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 • 406-494-9875 cborton@sagemountain.org

NEVADA

June 15–19, '02; Solar 2002: Sunrise on the Reliable Energy Economy. Reno, NV. American Solar Energy Society conference. ASES, 2400 Central Ave. #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 • ases@ases.org www.ases.org

NEW JERSEY

June 26–29 '02; The Mid-Atlantic Sustainability Conference: Energy, Buildings, & the Bottom Line. Rutgers University, Newark, NJ. Features the Building Energy 2002 & New Jersey Sustainable Business conferences & two full days of workshops. Info: Jack Kraichnan, NESEA • 413-774-6051 • www.nesea.org jkraichnan@nesea.org

NEW YORK

July 26–28, '02; PV System Installation: On-site install, Chappaqua, NY. Learn how to put a home on-line with the sun. Info: see Solar On-Line in INTERNATIONAL

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

NORTH CAROLINA

August 23–25, '02; Southern Energy & Environment Expo, Fletcher, NC. Exhibitors, workshops, presentations, activities. RE, sustainable businesses, green economic development in the So. Mt. region. S.E.E. Expo 2002, P.O. Box 1562, Etowah, NC

28729 • 828-696-3877
nedryandoyle@earthlink.net

Sept. 9–13, '02; Celo, NC. PV & Installation Workshop. PV system design, components, site analysis, system sizing, tours, & a hands-on installation. US$550. Info: see SEI in COLORADO listings.

Appalachian State Univ. Free workshops each Tuesday night 8:20 pm during the fall semester, in the auditorium of the Kerr-Scott building, room 17. Info: Appalachian State University, Boone, NC 28608
828-264-4654 • www.asuses.org

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

OHIO

July 25–Aug. 3 '02; Permaculture design workshop, Oberlin, OH. Produce an advanced-draft permaculture design for the workshop site. Contact Eric at fstewart@oberlin.edu

OREGON

July 26–28, '02; SolWest Renewable Energy Fair, John Day, OR. Exhibitors, workshops, Electrathon racing. EORenew, PO Box 485, Canyon City, OR 97820
541-575-3633 • info@solwest.org
www.solwest.org

SolWest pre- & post-fair workshops John Day, OR. July 24–25: Solar Water Pump Installation with Windy Dankoff; July 26: Site Survey & System Planning with Larry Elliott; Sept. 21: All-day Solar Cookery Equinox Extravaganza, Seneca, OR. Info: see EORenew above.

Oct. 5, '02; Umpqua Community College's Alternative Energy Fair, Roseburg, OR. Lectures, workshops, exhibits, energy conservation, fuel cells, solar, hydro, wind, & hybrid cars. Fri. Oct. 4th: Dinner forum at Wildlife Safari on overall RE. Fri. at noon: Energy conservation talk in the UCC campus center. Thurs. the 3rd: Tour of nearby landfill energy projects. Info:
541-440-4601 • CEWork@umpqua.cc.or.us

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

RHODE ISLAND

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

TENNESSEE

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

TEXAS

Sept. 20–22, '02; 3rd Annual Texas RE Roundup, Green Living, & Sustainability Fair, Fredericksburg, TX. Info: TX Solar Energy Society & the TX Renewable Energy Industries Assoc. • 866-786-3247
Roundup@txses.org
www.RenewableEnergyRoundup.com

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

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

El Paso Solar Energy Association: meetings 1st Thur. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657
epsea@txses.org • www.epsea.org

Houston Renewable Energy Group: meets last Sun. of odd months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258 • jferrill@ev1.net
www.txses.org/hreg/

VERMONT

June 22–23, '02; Scott and Helen Nearing: The VT Experiment Symposium at Stratton Mountain, VT. Learn about the "great-grandparents" of the Back to the Land movement. Stratton Foundation. Info:
802-297-4425
www.strattonfoundation.org/nearings

Aug. 10, '02, RE for Your Home, at solar powered home in N. VT. Tour working PV system; theory, design, setup off-grid system, some wind & hydro.US$50. Reservations. Contact: Flack Family Farm, 2063 Duffy Hill Rd., Enosburg Falls, VT 05450 • sarahflackfarm@hotmail.com
www.flackfamilyfarm.com.

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

VIRGINIA

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

WASHINGTON, D.C.

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

WASHINGTON STATE

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

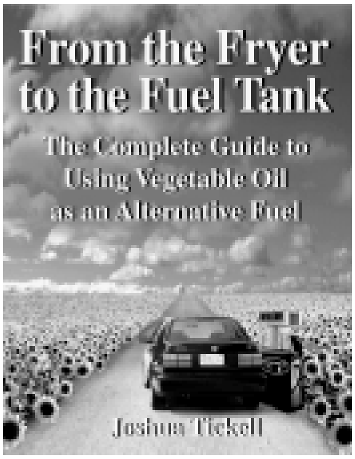
Oct. 14–19, '02; PV Design & Installation Workshop. Guemes Island, WA. System design, components, site analysis, system sizing, & a hands-on installation. US$550. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448
ian.woofenden@homepower.com

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

WISCONSIN

June 21–23, '02; RE & Sustainable Living Fair (a.k.a. MREF), ReNew the Earth Inst., Custer, WI. 120 exhibits & displays, 100+ workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids' Korral, entertainment, keynote speaker. See below for MREA access info.

MREA Workshops: Solar Space Heating; Wind System Install; PV Install; Straw Bale Construction; Rammed Tire: June 7–9, Custer; Tower PV/Wind Install: June 9–15, Belleville; Advanced PV Install: June 13–19, Amherst; Solar Hot Water: June 14–15, Custer; RE for Natives: June 24–26, Custer; Masonry Heaters; Sustainable Living; RE for the Developing World. SOs half price. MREA, 7558 Deer Rd., Custer, WI 54423
715-592-6595 • Fax: 715-592-6596
mreainfo@wi-net.com • www.the-mrea.org



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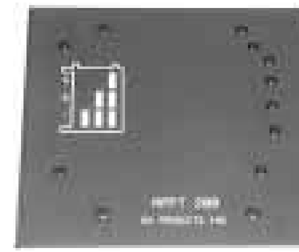

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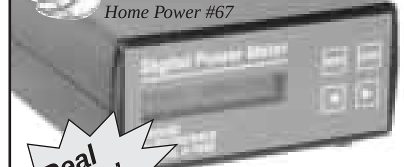

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the Wizard speaks…

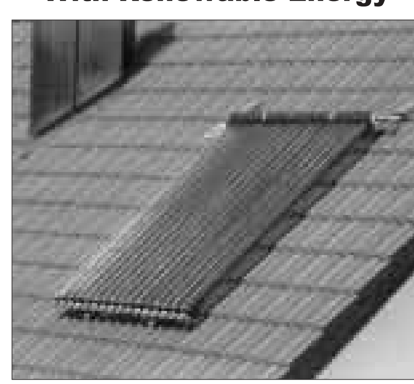
Empty Space?

Space is not really empty. Emptiness does not have properties. Space has the properties of electrical permitivity and magnetic permeability. Other characteristics inherent in the nature of space are the gravitational constant, Planck's constant, and the speed of light.

There are other, as yet unrecognized, properties of space. Two of these are an energy potential and a charge potential. Space may also have certain characteristics akin to those of a superconducting superfluid.

Possibly through the action of processes of quantum chaos, virtual particles are continually appearing and disappearing in the apparent emptiness of space. They consist of extremely short-lived clumpings of energy and charge. This creation-destruction cycle, and its interactions with normal matter, may be the reality behind many of the emerging concepts of modern physics.

Using the proper mass and field configurations, it might be possible to control the processes existing in so-called empty space. Free energy and antigravity may be only the tip of the iceberg of possibility.



Magazine Mechanics
New Paper

Karen Perez

This issue of *Home Power* magazine represents a first for us. The interior paper is 100 percent postconsumer recycled and totally chlorine free. Paper nerds may ask, "How can this be?" In most of the world, it is impossible to verify whether recycled paper is chlorine free. Germany is one of the rare exceptions.

The paper is from a German mill: Leipa, Schwedt Papier & Karton GmbH. Germany banned the use of chlorine dioxide/chlorine gas around 1996. All of Leipa's recycled material comes from Wertstoff-Verwertunep GmbH (Materials Recycling, Ltd.), a subsidiary of Leipa. The recycled paper is gathered locally in Germany, where for more than six years, it has been illegal to use chlorine in papermaking.

Leipa makes paper using a closed loop water circulation system, so none of the water is released into the environment. Leipa was awarded the 1995/1996 Environment Protection Award, given by the Confederation of German Industry for "environment-friendly technology." The mill is located on the Hohensaaten-Friedrichsthal Canal, which it uses for haulage, further reducing the manufacturing impact of this paper.

The downside is that this paper has to be shipped all the way from Germany. Eagle Paper International imports it for *Home Power.* No mills in the United States or Canada currently manufacture a 100 percent recycled, totally chlorine-free, lightweight, coated (LWC) magazine paper. We feel that the positives far outweigh the negatives. Not only is the paper very environmentally friendly, but due to the current world economy, it's very reasonably priced.

Home Power would prefer to shop locally. Spending our money closer to home would reduce the energy needed for shipping this product, and would help American workers. When an American company can offer the same high quality and environmentally conscious paper, we will be proud to again buy locally.

Access

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

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www.Leipa.de

⚠ Buyers Beware ⚠

Home Power hears about many new RE products and innovations, some claiming to solve the world's energy woes. We also hear from folks interested in investing in renewables, for their own use or as a business venture.

The renewable energy scene is not immune to the plotting of scammers out to make a quick buck by preying on your desire to do the right thing. This hurts you, and hurts the clean energy movement's reputation as well.

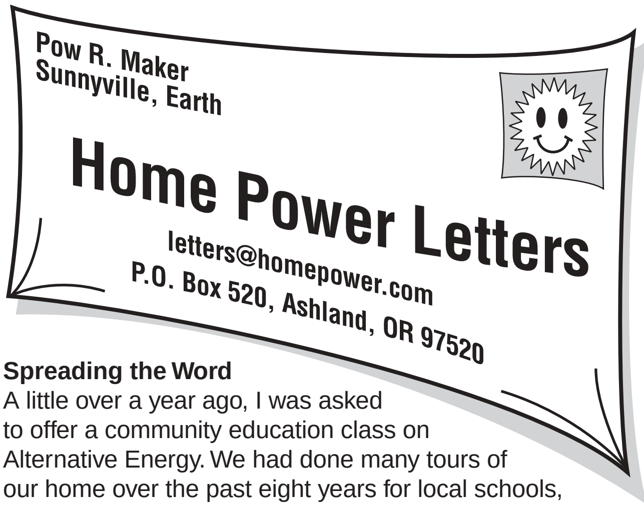
Home Power encourages forward thinking, creativity, and open-mindedness in the development of new technologies. We would never want to discourage the hope, ingenuity, and creative thinking that the renewable energy industry is based on. But we urge you to use a bit of common sense before investing your money.

Be wary of companies trying to sell you a future opportunity. Recognize that there is a difference between a product that is still in development, and a product that will never be produced and exists only as a marketing scam. You may also find vaporware from established companies whose marketing departments get too far ahead of production. But definitely, beware of phantom products that were never meant to see the light (or wind) of day.

In a young and growing industry, with new companies starting up all the time, it can be difficult to tell what's what. Demand to know the technical details of a product before buying. Even if it's not in production yet, the blueprints should be firm. Technical questions should be answerable, if not by the salesperson, by someone. Investing in a future technology should be based on more than just someone's "good idea." Get a second opinion from the professionals in the industry—they are happy to share.

Bold claims are part of our economic system. While *Home Power* would never condemn in advance, we are skeptical of things that sound too good to be true. Rather than "pie in the sky," we want "pie on the plate"—preferably with a meter attached. You should too.

Home Power can't, and shouldn't, be the police of the renewable energy industry, even though we vigorously investigate questionable products. We want to help you get good equipment at fair prices, but it is your responsibility to shop and invest with caution.



Spreading the Word
A little over a year ago, I was asked to offer a community education class on Alternative Energy. We had done many tours of our home over the past eight years for local schools, but nothing for the adults in the community. I thought this would be a good opportunity for people who had heard about our home to see it and learn about the technology. I put together a Microsoft PowerPoint presentation that was a photo tour of our home and a general presentation on alternative energy technology.

I'm not sure what my expectations were for attendance at that class, but eight very interested people came to hear about alternative energy. Since I had put the effort into the presentation, I called another community education program in the area to see if I could offer the same presentation to a different community. The reaction has been incredible. My second and third presentations were completely filled just days after the classes were offered. In fact, the interest was so strong that people who were denied registration because the class was full, came anyway.

I was somewhat shocked at the interest level, and started the class by asking why people came. The responses varied from general interest in renewable energy to contractors looking at building more efficient homes to people who had already decided to build off the grid. Lots of people are very interested in hearing from someone living off the grid. The community education classes have been a great way to spread the word! Tom Markman, Avon, Minnesota

Energy Star Problems
Dear Editors, I agree with Joe Schwartz's refrigerator suggestions in *HP88,* page 131, in response to Pete Gruendeman's letter "12, 24, or 48?" But there are a few problems with the Energy Star program that should be considered.

First, the Energy Star program excludes all manual defrost refrigerators. Only automatic defrost appliances are rated, although they generally waste more energy than the manual defrost types. Anyone looking for the most efficient refrigerator by referencing the Energy Star Web site would be left seriously uninformed.

Second, the scoring parameters and classifications used for appliances are sometimes influenced by mainstream manufacturers, to the exclusion of niche builders. Staber clothes washers come to mind. As the only top-loading horizontal axis washer, Staber doesn't neatly fit any of the industry classifications, and gets compared to what it ain't.

Third, dishwashers are tested only with a load of clean dishes. This measurement decision distorts results in favor of washers equipped with dirt sensors. These types are programmed to adjust their cycle times according to need. If you make the silly mistake of introducing dirty dishes into your washer, sensor-equipped machines will ratchet up to use as much water as dumber machines, which always run full throttle, even during "clean dish" tests. The placards for comparing energy use that you see in appliance showrooms falsely penalize some equipment based on this imaginary difference.

Fourth, I have heard numerous reports of inaccuracies in the energy consumption figures quoted on the yellow placards attached to all new appliances in showrooms. I don't know who, if anybody, audits these numbers, which probably are unsupported manufacturer's claims.

On a related topic, *Consumer Reports* magazine never seems interested in testing the super-efficient appliances available direct from niche manufacturers. They will only report on merchandise available in large retail chain stores. These mall stores will not be carrying the sort of stuff advertised in *Home Power* magazine any time soon. Kind of puts a new spin on the word "consumer," eh? Joel Chinkes

Payback on RE
Dear *Home Power,* I was disturbed after reading the article about professional wrenches and their responses to the question of system payback *(HP87,* page 44). I agree that the primary reason to purchase an RE system should be based on the environmental cost and not financial cost. However, it seems that the professionals who we rely on to give honest straightforward answers to our direct questions all appear to pride themselves on how they can turn the question of financial payback back on the customer.

Not a single representative response from this large group of professionals stated that they would answer the question about system payback, and then perhaps remind the customer of the more important reasons to use renewable energy. Shame on you all! Trying to twist the question back on the customer or attempting to shame or belittle them for asking about payback in the first place relegates you to the level of shifty, dirty-dealing, used car dealers. When I make a major purchase, I expect straight, honest answers to all my questions, not just the ones you think I will like the answers to. This is simply a matter of respect. Kurt Kiewal, College Station, Texas

Dear Kurt, The whole point of the article was to reframe the entire question of payback itself. And yes, most people are talking about monetary payback; as in "how much time has to pass before my investment in solar electricity will pay me back in avoided utility bills?"

I offer the following in the hope that you will better understand the inherent absurdity of trying to make a comparison like this. 1. The true cost of electricity is not *reflected in your bill, not by a long shot. 2. Why ask the question of payback with solar electricity, when you don't question it with anything else? In my opinion, that is what the article was most urgently trying to say. You don't ask for payback for a car or a roof, or anything else for that matter, but you ask it of an investment in renewable energy. 3. Where you interpret a "twist of the question back on the customer or attempting to shame or belittle them for asking about payback," I see a genuine attempt to give customers who would ask such a question a reasonable context to their question. In other words, the question of payback for solar electricity is culturally influenced and not necessarily based in reason, or as I mentioned above, compared equally to utility rates. I hope this helps. Colin Mitchell, for Allan Sindelar, Positive Energy • allan@positiveenergysolar.com*

Hi Kurt, I think there's definitely some validity to your point. I have also frequently been disturbed that we can't first answer the financial payback question before going on to the more important issues and clarifications. I agree 100 percent with Colin and many others that subsidized dirty energy makes the comparison wildly skewed. But we should recognize that many people asking the payback question don't know this, and are expecting a straight answer. They deserve a better explanation up front. It's too easy for people familiar with the question to skip over this essential step. The wrenches discussion we published came from a professionals' forum, where all share a grasp of the underlying issues.

I also am getting tired of hearing the couch and car analogies. People contemplating buying a couch are not looking to save money—they are looking for household comfort. People who ask the payback question are looking to save money on their energy bills—that's why they ask! It's the same as someone asking about the payback on investing in a more efficient furnace—they want to know when their savings will outweigh their investment. My normal answer to these folks is that if their only interest in RE is to save money and they are on-grid, forget it. Then I go on to talk about energy efficiency, and explain why comparing RE to subsidized dirty energy is not fair. Regards, Ian Woofenden • ian.woofenden@homepower.com

More Payback on RE

I am new to your magazine and was disturbed by the attitude of your respondents in the article "Payback on RE? How Wrenches Respond." When I engage an industry professional about any complex technical problem, I would expect them to be able to detail the cost advantages of one system over another. How the experts explain the solution, including the cost benefit, is important in determining if I want to hire them for a project as large as powering my home.

I was confounded by the response you got from Larry Elliot of kattel.org. Especially since he is apparently the director of an educational organization. If answering a legitimate question about the cost benefit of a solar energy system is pandering, I don't want anything to do with Kattel or any of its graduates. Kent Morris, Bellevue, Washington

Hello Kent, I believe you misunderstood my position on PV payback. As a new reader, I can understand why. First of all you, must understand that in pure economic terms, there really is no payback for PV. Most utility electricity is so cheap that on a cost per KWH basis, you're not going to save money.

Payback? Is that in my lifetime or my great-grandchildren's? In present or future inflated dollars? What will weather trends be in ten years? Is that before or after all oil wells run dry? Statistically, will utility outages become more or less frequent in the future and to what percent? If you can first establish a concrete set of ground rules, perhaps we could make a feeble attempt at quantifying payback. Better odds are on turning lead to gold or making water run uphill.

When I said "to hell with pandering" it was a reflection of my intense frustration with dealing with certain customer questions for close to twenty years. Two guesses as to what those questions have been. Even though PV produces electricity just like what you get from a utility, the similarity simply ends there. Thus my comment of "compared to what?" When was the last time someone calculated the payback on cruise control or leather seats? Better yet how about a hot tub or swimming pool?

My goal is to educate people about RE technologies. Most people require many hours of intense question and answer before they can become satisfied customers. I feel that if I must spend any additional time on payback issues, the person really is not a good prospect for becoming a customer. Obviously, they don't see any value beyond dollars.

If I was paid simply for my customer education time, I would now be retired and living comfortably. I have never lost a customer because I refused to pander. Hope this has cleared up a misconception. Larry Elliott larry@energyoutfitters.com

RFI Problem

Dear *Home Power,* I have noticed that since we installed our Trace DR2424 inverter, the interference on AM radio stations has been bad enough to prevent listening to them. This is not a serious problem, but it does bring up further questions. Recently our neighbor who has a similar inverter started investigating the source of these high frequency radio waves, and found that they emanated not only from the inverter, but also from all the DC wiring of the system, all the way out to his solar-electric panels. Do all inverters produce this radio interference? Since inverters are often located in the house, is there any possible health hazard to be considered? Thanks in advance for any light you can shed on this. Bob Kidwell, Michigan

Hello Bob, All inverters make some radio frequency interference (RFI), and so do most charge controllers. The RFI is actually transmitted by any wires attached to the device—the wiring acts as an antenna. While the RFI produced by inverters is intense enough to blitz AM radio reception, the signal level is far, far too weak to present any health hazard.

Your best bet for reducing the RFI in your AM radio is to locate the radio as far from the inverter as possible. Putting up a good outside AM radio antenna will also increase your received signal strength and help to override the RFI. I hope this helps. Richard Perez • richard.perez@homepower.com

Hot Water from Wind

Dear *HP,* I have a bee in my bonnet to build a domestic solar hot water system. I also want to add wind generation to the equation. A flat plate, closed loop, drainback system would be OK here in northeast Ohio, but in the winter, the "sun don't shine, but the wind sure blows." It seems that a solar storage tank with an electric heating element would round out the system—what are your thoughts?

Would the heating element actually work with infinitely variable, 240 volt "wild" AC output, say from 5 to 1,000 watts that a small wind generator might produce? Does anyone manufacture such an element? I'm an avid reader of your inspirational magazine. Keep up the good work! Steve Miller, Chardon, Ohio

Hi Steve, Using a wind generator in winter to heat hot water is a great thing to do. In fact, it is the most cost effective use of wind power, since there are no expenses for a controller, battery bank, or inverter.

I've used my grid intertied 3 KW Jacobs to heat hot water for a number of years. I used the water heater as a dump load when the grid went down. During such occurrences, with the Jake running hot and heavy, and a 50 gallon tank of cold water, the Jake could heat the water to the point that the pressure relief valve blew. In fact, this could happen four or five times a night during a good wind. Not that I'd recommend you do that!

You need to answer several questions. Do you plan to use the wind heated water only for potable domestic purposes? Or do you have plans to circulate the water for radiant heat as well? If the latter, note that most houses need extra heat when the wind is blowing the hardest in winter. This is because wind causes negative pressure in a house, increasing the infiltration rate. Again, there's a good correlation between the resource and the need for heat. If you're interested in this type of system, check out Tom Simko's system in HP36. *Tom heats his home hydronically with wood and wind.*

As far as the element that you'll need, I'd suggest using a standard 110 VAC heating element, rated at the same wattage as your wind genny. While three-phase elements are available, they are difficult to find, especially in such low wattages. To use the AC element, add a three-phase, full wave bridge rectifier to convert the three-phase wild AC wind genny electricity to DC. The heating element will do the rest, since resistive elements don't care if the energy is AC or DC. If you add a voltmeter and ammeter so you know what the wind genny is generating, you'll have all you need to heat your water. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 • Phone/Fax: 920-837-7523 • msagrillo@itol.com

Hi Steve. I'd like to add that you should try hard to not overheat your water heater. First, the pressure relief valve is designed as a backup for if a water heater temperature control fails. This wind application effectively bypasses the temperature control feature, causing reliance upon a backup as the primary and only method of preventing pressure build-up. If the valve fails to open, dangerous pressures could build up in your tank and plumbing system. Second, standard pressure relief valves are not designed for continuous duty. Once they release pressure, often they will not properly seal again, causing constant leakage. Michael Welch • michael.welch@homepower.com

Question about PVs

Hello Richard, Do solar-electric panels need a charge controller or blocking diode to keep them from causing battery drain when the sun is down? I was thinking yes; my neighbor says no—what's the truth? Thanks, Ron Hudson

Hello Ron, You are correct, PVs do need some type of device, either charge controller or diode, to prevent them from withdrawing energy from the battery overnight. The amount of energy that a PV takes from the battery at night is small and depends on the PV technology. Single crystal PVs will discharge the battery only a few milliamps, multicrystal PVs discharge in the range of tens of milliamps, while thin film PVs will discharge on the order of a hundred milliamps or more. These are small numbers, but hey, this energy is wasted, so use either a charge controller or a diode to prevent the battery from discharging into the PVs at night. Richard Perez • richard.perez@homepower.com

Solar Powered Travel Trailer

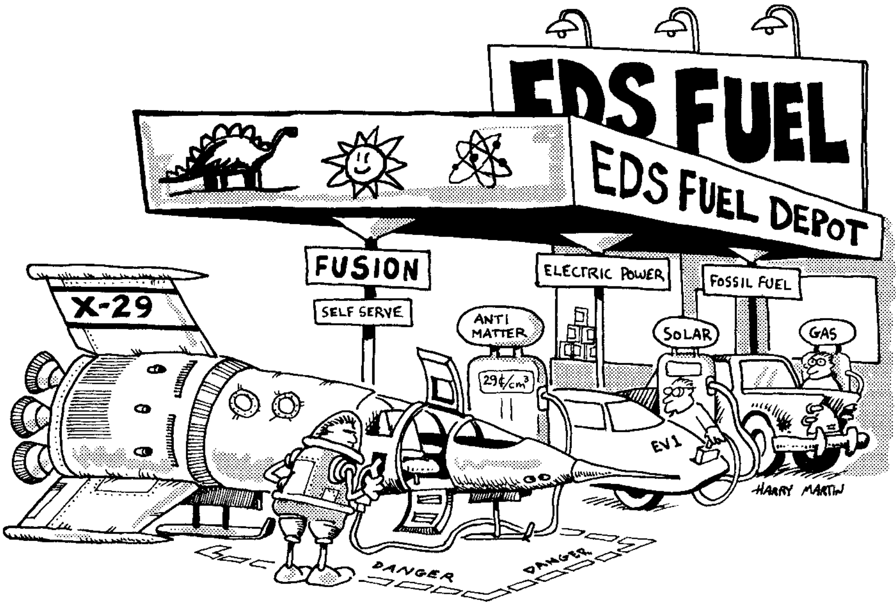
Hello! I discovered your magazine a while back. I have been inspired by it. I plan to build a solar home in about three years. Right now I want to either construct a livable building or install a travel trailer temporarily on the property. I plan to visit this shelter for about a week each quarter as I begin my experience with solar electricity, decide where I will build the house, start landscaping, and simply enjoy the property.

As I read articles in your magazine, I notice that dealing with batteries seems to be a murky, nasty issue. But I'd love to begin living with solar energy in this shelter. Tying to the grid is simple, since a utility line runs through the property. But the state is not yet a net metering state, and I have found no knowledge about net metering or renewable energy among the utility employees I've spoken with. So for now, I'd rather live off the grid.

Once I am set up with a solar powered system for this shelter, I'll be happy to spend time there. But what do I do with the batteries when it's time to leave for a few weeks? Is it possible to have an independent system I can turn off and on at will? Thanks for your great resource! Cordially, Claire Calhoun

Hey Claire, A properly designed and installed PV system requires virtually no maintenance. And PV systems are very commonly used in vacation cabins that aren't occupied full time. The PV panels charge batteries via a charge controller, which automatically regulates the batteries' state of charge *(how full they are), and keeps them from being overcharged. It's all automatic.*

Flooded lead-acid batteries require watering about four times a year. They produce hydrogen gas when charging, which needs to be vented to the outside because it's flammable. Sealed batteries do not require watering, and do not produce hydrogen gas when charging. They are maintenance free, and a great choice for a small PV system. Joe Schwartz joe.schwartz@homepower.com



36 V Forklift Batteries
Greetings *Home Power* crew, Kudos for all the good work on RE. I have been a subscriber and RE wannabe for many years. I just got some acres and buildings up on a mountain, and I'm looking forward to putting to practical use all of the good info I have archived from *HP* over the years.

I have a source for new 36 volt replacement batteries for forklifts in the US$1,800 to US$2,500 range. Could these be used in an RE system? Would they last longer than golf cart type batteries? I know they are good for a lot of deep-cycle charges and recharges. Other than the weight and difficulty moving them, I would think they would be a great way to store a lot of energy. Are there inverters that will take 36 volts? Also, can you recharge a battery bank from a DC welder? My friend has a portable unit that puts out about 36 volts. Is there a charge controller that could be adapted for this purpose? Thanks for the help, and keep up the good work. Charles Evans • cevans9@tds.net

Hello Charles, Forklift batteries are deep cycle types, and well suited for use in RE systems. They will last longer than golf cart batteries. Exeltech makes inverters that will run in the 36 volt range. You can use a DC welder to recharge batteries. B.Z. Products makes a charge controller that will handle 36 V, and charge controllers are not difficult to homebrew.

Also, if the individual battery posts are accessible, consider configuring the forklift batteries as a 24 volt system rather than a 36 volt system. This will give you access to a much wider range of RE equipment. Richard Perez richard.perez@homepower.com

Is Biodiesel Really Green?
Dear *Home Power,* After looking into electric cars and propane conversions, I read about biodiesel in *HP*. I bought *From the Fryer to the Fuel Tank* by Joshua Tickell. I am in the last stage of shopping for a diesel VW. I have a couple of questions before I take the plunge, if you could help.

1. Is biodiesel really green? 2. I intend to purchase 500 gallons, the minimum delivery from Worldenergy.net for US$1.50 a gallon. Do you know if they are a good company? Will World Energy be here next year when I need more?

3. To burn 500 gallons a year, I will either have to buy a second diesel for my wife, run biodiesel in my home furnace, or both. I have been trying to buy a Chrysler Voyager minivan with a CRD Diesel (43 mpg) in Europe. They don't sell them in the U.S., but you can read about it on the Chrysler UK Web site. Do you know of a way I can get one in the U.S.? Thank you for any info you can give. Gordon Palmer Gordair2@aol.com

Hi Gordon, 1. Biodiesel is about as green as it gets for now. Each gallon made from vegetable oil has embodied energy at least 3.1 times the energy required for production. If it is made from recycled vegetable oil, the net energy yield is much higher. Fossil fuel based components of biodiesel are limited to about 20 percent methyl alcohol, made from natural gas, plus a minimal amount of energy required for processing. Make your own at home and there isn't even energy required for distribution.

2. World Energy Corp. is the largest manufacturer of biodiesel in the U.S. They converted several factories built by Proctor & Gamble that were originally intended to make Olestra, the nonfat fat. While this is still a small industry, it is growing at more than 100 percent per year, and with new subsidies from the government, it is likely to be more available in the future.

3. The EPA doesn't make it easy to import overseas vehicles. Look at their Web site at www.epa.gov for some ideas as to the restrictions. Search for "import cars" or similar topics. Tom Leue, Homestead, Inc. Tilapia@aol.com

Taming Wild Power
Greetings Richard, In two articles in *HP86,* the term "wild" is used to describe three-phase power produced by Whisper wind generators (schematics on pages 15 and 33). What does the term "wild" mean in relationship to three-phase power? As always, thanks for your help. Regards, Stan Strickland • stanncarol@juno.com

Hello Stan, "Wild" power is AC electricity where the frequency is not constant. Normal utility electricity is 60 Hz or 50 Hz depending on where you live. The frequency of the AC power produced by most wind generators is proportional to the propeller speed. The faster the prop spins, the higher the frequency of the AC power. The fact that the AC power is "wild" is not important since it is converted to DC for use in the system. Richard Perez • richard.perez@homepower.com

Bigger Plug-N-Play Guerrilla
I really enjoy your magazine. I was very interested in your many guerrilla solar articles about people supplying electricity back to the grid. I would love to do something along the same lines. After researching your magazine and other references, it seems that most people are using OK4U inverters, and only putting a 150 watt or so panel on them. I would like some info on a system with that much simplicity but maybe a little larger—say 300 to 600 watts. The cost of the OK4U and the two smaller panels required for the 24 volt system seems cost prohibitive for such a small gain.

I understand that people want to do what they can to contribute, but if there was a simple system with a little larger gain, I think it would catch on just as much. The larger panels are cheaper and readily available. I have heard about the OK5 inverter, but nothing since last fall. A recommendation of a simple 12 or 24 volt system in the 300 to 600 watt range would be greatly appreciated. I can even be more specific for my use. I have four, 120 watt panels that I would love to hook up to a cost effective inverter with the plug and play simplicity of the OK4U. Any suggestions? Thank you, Rick • B707PHX@aol.com

Hi Rick, A good inverter choice for this size system is Advanced Energy Incorporated's GC-1000. This is a batteryless, utility-interactive inverter and is not designed to provide backup during utility outages. The GC-1000 has a 48 VDC input, so you can work in four, 12 VDC nominal panel increments. Grid synchronized AC output is 120 VAC. The inverter includes integral DC series fusing and disconnects, ground-fault protection, and an AC output breaker. And you can add another four, 120 watt PVs down the road! Take it easy, Joe Schwartz joe.schwartz@homepower.com

Efficiency Rules
Dear *Home Power,* I've been following with interest the letters you've had on the philosophy behind big RE systems. I want to address the claim by one gentleman that a big, home PV system is doing "more to help the environment than a hundred families replacing lightbulbs with compact fluorescents." Not only is the claim wrong, it betrays a misunderstanding that a lot of folks still seem to share.

If a hundred families each replace three or four of their most-used lightbulbs with CFs, the drop in their collective load is on the order of 100 KWH per day. That's a lot more than even the fanciest rich man's PV system can provide (the biggest systems profiled in your magazine run 10–40 KWH per day). Total upfront cost of all those CF bulbs is around US$2,000, or less than a tenth the cost of any sizeable PV system.

I know *Home Power* often points out that efficient appliances are a better buy than RE systems—but it takes a specific example like this to make people realize just how much better. Don't invest in RE, people—until after you have all the load-side efficiency money can buy! Regards, Geoff Pritchard, Auckland, New Zealand.

Desulfator Notes
Greetings, After the article I wrote for *HP77* describing a homebrew battery desulfator, I have been in contact with people around the world. The circuit has been a success on numerous small systems, and many kits of parts have been sent out. I have often been asked about what to do for larger systems, and now I have placed a design for a high power desulfator/maintainer on my Web site. It should answer the needs for all those wishing to reclaim monsters like submarine batteries, and to maintain large systems. Check out the latest at www.shaka.com/~kalepa/desulf.htm. Alastair Couper • kalepa@shaka.com

Wishing for Quiet Wind Genny
Hello *Home Power,* Today in Dallas, Texas, the wind is blowing a constant 30 mph. I wish I had a wind generating device on my house. I read once in your magazine that those propeller type wind generators make a lot of noise. That guy out in west Texas wrote that it sounded like a vacuum cleaner running. Can't they make a wind generator that works without so much noise? Why can't they use the design of the turbines on my roof to help keep my attic cool? Dale Crawford • dalelani@airmail.net

Hi Dale, If you want a very quiet wind generator, buy a low-speed machine, and check out any machine you are considering, since there are other factors that affect wind turbine noise. Low speed machines available today are the African Windpower machine, rebuilt Jacobs turbines, and the Proven. I don't have personal experience with the noise level of the Proven, but the other two are extremely quiet. These are all substantial and robust machines. If you buy a lightweight, high speed machine, you'll tend to get more noise and reduced longevity.

I don't advise putting any *wind turbine on your roof. Noise and vibration will resonate in the structure, and it's not the best place to capture the wind. The standard rule of thumb is to install wind turbines 30 feet higher than anything within 300 feet. Siting a turbine lower than this will decrease output dramatically, and the turbine will have to deal with lots of turbulence, which is hard on it. Regards, Ian Woofenden ian.woofenden@homepower.com*

Laptop Puzzler Comment
In *HP88, Q&A,* on pg 139, right hand column, Dan Bisbee asks about laptop charging. Some laptop chargers limit charge on the basis of time. Dan may have such a unit. His mod-square peak output voltage is lower than a sine wave inverter's, which would result in lower overall charge into the laptop battery in the allotted timeframe. This issue is avoided with a true sine waveform.

This possibility is further bolstered by Dan's mention of a five minute charge cycle on the modified square wave inverter vs. one hour on the grid. My $.02 worth. Regards from rainy Fort Worth. Dan

Laptop Power

Richard et al, I have scanned previous issues for guidance on powering my laptop directly from my home battery bank. My Tecra 8000 draws 3 amps at 15 volts coming in from the 120 volt adapter, yet my laptop battery is only 10.5 volts. I suspect there must be a stepdown voltage regulator in the laptop to give a stable 10.5 V from the 15 V supplied.

I have seen two *HP* articles on buck converters, one that is just the LM and a few resistors running at 52 kHz (considered an inefficient voltage waster), and another that uses an inductor and runs near 220 kHz. (I also read the great article on your travel pack for the Mac, Richard.) What are the constraints on using one of these linear converters for running a PC laptop directly through the laptop battery connection and skipping the 15 volt feed in from the 120 VAC converter? I suspect the frequency the buck converter runs at would have some effect on the laptop processor innards. Can I do this? Will I fry the innards? Thanks for your computing thoughts. Jim Marquardt, St. Paul, MN marqu009@tc.umn.edu

Hello Jim. Most laptop manufacturers offer a 12 VDC car cord for their computers. These power supplies are the way to go if you have 12 VDC nominal available. Since they are designed specifically for that particular computer, there is no problem with noise or voltage parameters.

In terms of aftermarket car cords, I can highly recommend those made by Lind Electronics at www.lindelectronics.com. These are high efficiency switching power supplies that accept very high voltages (over 24 VDC) on their input. This allows the laptop to be operated and recharged from a full-sized PV module if you are in the field. Richard Perez richard.perez@homepower.com

EVA Disease

I have some old Arco Tri-lams (I believe that's what they were called) with three rows of twelve, square cells per panel. Carrizo Solar Corp. is printed on the back of them. I heard that they were used/salvaged and pulled from some utility test project. I understand that they had a Fresnel lens focused on each cell. They are badly solarized and have a brown color except for a very thin margin around each cell that is still blue. The open circuit voltage on these panels is 6.7 volts, which I think is normal. But the short circuit current is only 666 mA. As I recall, when they were sold to me, they were supposed to only have lost 10 percent of their capacity due to the baking that they had received.

I am wondering if anyone knows about these panels. Since they all have this same failure mode, I am wondering what the problem is. Is it the cells themselves or the glass or plastic covering them, or is it the interconnects that connect them together? If it's the cells themselves, what happened to them? And finally, are the entire panels, or at least some of the cells within them, salvageable for small projects? Thanks, Clyde Feral • wobblie@skyhighway.com

Hello Clyde, Your Tri-lams have what is know as EVA (Ethyl Vinyl Acetate) Disease. The EVA is used as a backing pottant to the cells. Over time, it out-gases acetic acid and corrodes the metalization on the cells' surfaces (both metal electrical traces and the metallic anti-reflective coating). Alas, EVA Disease is fatal, as you have discovered. The metallic traces lose electrical connection with the cells' substrates. These modules should put out more than 4 amperes at short circuit. With only 666 mA output for your cells, they are effectively dead.

These modules were originally made by Arco Solar, and used in PG&E's Carrizo Plains generating plant. The facility did not use Fresnel lens concentrators, but did use reflectors on each side of the modules to increase the light on the modules. Upon this plant's closing, these modules were bought secondhand by Carrizo Solar. Richard Perez richard.perez@homepower.com

Alternator Question

I have just set up a Trace SW4024 using six Group 27 Costco batteries. It works great, and the batteries are being charged from a 120 volt AC hydro generator. When water is scarce this summer, I hope to convert the source power to a Chrysler type, 12 volt alternator, driven by a 5 inch diameter cast iron Pelton wheel. I have been testing it with an electric motor, and can get 30 amps at 30 volts through a portion of dryer heating coil with no apparent alternator overheating. However, to get this 900 watts, I am using 4.3 amps through the field winding at almost full 12 volts from a battery. I have found no information on the characteristics of alternator field coils. Will the alternator field be able to handle this current on a continuous basis? Do you know of any sources of alternator information? Thanks, Jim Peterson

Hello Jim, Automotive alternators are incredibly rugged. They are designed to work under the hood of a car during the summer with a hot engine. You can run up to about 5 amps through the field without damaging the alternator. The worst thing that will happen is short brush life. The Internet is full of alternator info, but unfortunately, nothing applies to your unique operation situation. Richard Perez richard.perez@homepower.com

Amps & Watts per Hour

Hi Ian, I just received my *HP88,* and was glad to see an explanation for the correct use of amp-hours and watt-hours. As you would expect, however, someone has to find a "flaw." This time it's me! It's nothing serious, but it does provide a certain amount of entertainment when watching folks do the mental gymnastics.

Amps per hour and watts per hour do exist. I admit, however, that I've never had the opportunity to work with them. They are simply the electrical analogy of acceleration. As an example, watts per hour is a description of the rate of change of power. If power at time 0 is 1 watt and at time 0 + 1 hour it's 2 watts, the average rate of change of power was 1 watt per hour. I wonder if there's any techno-discipline that actually uses these units! Regards, Alain Chuzel, SunCat Solar • ahmchuzel@aol.com

Hi Alain, Thanks for your message. This text was cut from the first draft of my column: "(OK, you nitpickers, there is one instance I can think of where "watts per hour" and "amps per hour" could be used. If we were talking about the rate of increase of the output of a PV array as the sun came up and grew in intensity, we could conceivably (it's a stretch) say that the output increased by X watts per hour or X amps per hour.)"

So I agree with you, but I decided this was so unreal that it isn't real. I have never heard these terms used in this (correct) way. Every time I've heard or read these terms, the speakers have either meant amps or watts, or amp-hours or watt-hours. I just did a "Google" search on the net, and found hundreds of hits for these terms. So far, I've only found one that seems to be referencing acceleration. The rest are misuses (mostly), and folks trying to correct the misusage. A surprising number of the misuses are perpetrated by RE companies, which is frustrating. Thanks for your help and encouragement. The point of all this is to help people understand electricity better, and these misused terms make it harder. Regards, Ian Woofenden ian.woofenden@homepower.com

Speedometer; Odometer

Ian, Thanks for your column on "Watts Per Hour" in the April/May *Home Power.* I've spotted "hour" confusion in such varied magazines as *Scientific American, E* magazine, and *Dr. Dobb's Journal.* Perhaps *HP* could run a "watt-spotting" contest. Points could be awarded based on circulation—an error in the *New York Times* would bring more points than one in *Podunk Times*.

When I show people the meter on my PV system, I sometimes skip the units and say "This is like the speedometer and this is like the odometer." This seems to help, though I'm not sure how to carry the concept into general usage.

Maybe a new name would help—if we anagrammed "watt-hr" to "thwart," then a watt is a "thwart per hour" or tph. Electric bills would then be measures in "kilothwarts", or "kt" for short. Cheers, Mike Morton • mike@mikemorton.com

Hi Mike, Thanks for your comments. The names are certainly not intuitive, and I don't know what the answer is, beyond continued education. I especially like your speedometer/odometer (watt-meter/watt-hour-meter) comparison. This is a very helpful image, and I plan to use it regularly. Thanks, Ian Woofenden ian.woofenden@homepower.com

Ozonal Notes

Want a Career in Renewable Energy?

Richard Perez

Hardly a day goes by when I don't receive an inquiry from someone who wants to work in the small-scale RE industry. This country is awash with folks who have been laid off by high tech businesses downsizing during the recent economic slump. Many RE users are so energized by their systems that they want to go into RE as a business. Everyone is looking for a secure job that's good for themselves and good for the planet.

A Very Short History of RE

The small-scale RE industry, as we know it, was born in the early 1980s. The "back to the land" movement of the 1970s resulted in many homesteads that were, and still are, beyond the utility grids. Real estate prices really were the impetus for this fledgling industry. If you wanted a good deal on country property, it came without utility connections. This is still true today.

Early homesteaders rapidly grew tired of the expense and hassle of running an engine generator every day. They were looking for something better, and the PV industry was glad to oblige. Before 1980, only NASA and suchlike could afford PVs. By the mid-1980s, the price of PVs had fallen to the point where they were affordable to common folks. Homesteaders quickly realized that solar electricity was cheaper and less hassle than running a generator.

The early off-grid systems were far less sophisticated than those we have today. Most were DC-only systems, and those who were running inverters were operating modified square wave models. It wasn't until the mid-1990s that sine wave inverters became commonly available. Starting in the 1980s, individual states began passing net metering laws. This fostered a steady increase in PV and wind systems operating on the grid.

I estimate that there are now more than 180,000 off-grid RE systems in the United States, and that number is growing by about 30 percent each year. While on-grid RE systems number far fewer at about 9,000 (not including guerrillas), this is growing very rapidly—the rate of growth over the last year has been more than 140 percent. With annual sales exceeding US$200 million, the small-scale RE industry has definitely arrived.

Skills & Experience

If you are considering a career in this industry, you need to examine your skills and experience. Are you familiar with RE systems and with the various technologies that they employ? It's quite possible that you're not, since the industry is still very new. You need to realistically evaluate your abilities, and seek the training and experience to bolster them.

Your very first step, regardless of the position you see yourself holding in this industry, should be hands-on experience with RE. The first system you survey, design, and install should be your own. Doing your own system will give you firsthand experience in load analysis, site survey, system design, installation, and maintenance.

It is only by actually living on RE that you can gain the knowledge and experience of what it can and can't do. Without exception, every employer in this industry highly rates the direct experience of actually living on RE as a job qualification. Even if you are starting your own business, you need the experience of living on RE to effectively serve your customers—you must walk the talk.

If your background is nontechnical, consider seeking training in RE technologies, either on-line or in person. I can highly recommend these sources: SoL Energy (SoL) and Solar Energy International (SEI) both offer on-line courses on the Internet and hands-on training featuring actual installation of RE systems. Murdoch University in Australia offers both in-person and on-line courses, along with a variety of RE college degree options. San Juan College in New Mexico also offers in-person RE education, leading to a college degree. The Midwestern Renewable Energy Association (MREA) offers a variety of weekend and week-long workshops.

See Access at the end of this article for contact information. Check *Home Power's* Happenings section regularly for local workshops and other RE education opportunities. Other avenues for breaking into the field include interning or apprenticing with a professional, or taking classes in household electrical wiring at a community college.

Even if your background is technical, you will probably need to come up to speed on the specifics of RE technology. I am reminded of the EE graduate from Cornell University I met who, while very bright and committed to RE, had never designed or built an electronic circuit, or even touched a soldering iron....

Where Do You Fit In?
The small-scale RE industry is just like any industry—many types of jobs need to be done. Consider what you want to do as a career. Do you like working in the field with people? Do you want to run your own business, or be involved with a larger company? Do you primarily prefer intellectual work to hands-on work? Can you, or do you, want to run a screwdriver as your primary tool? Evaluate your career desires—this industry probably has a position for you. Here are just a few of the major jobs that need to be done.

Installing Dealer
The installing dealer is on the front lines of the RE industry. These folks offer their customers A-to-Z service—they do site surveys, load analysis, system design, and system installation, in addition to selling the equipment. Most installing dealers own and operate their own businesses. Many installing dealers are state-certified electricians, electrical contractors, plumbers, or solar thermal contractors.

Being an installing dealer is difficult, but very rewarding. There is no thrill like electrifying a homestead for a family. Installing dealers must know RE inside and out and have good tool skills. They also must know small business management and marketing. Since the installing dealer can order hardware as it is needed, the amount of startup capital required is small. Folks with a service orientation seem to do best, since customer relations are paramount for the installing dealer.

Home Power's InBiz database shows 463 installing dealers operating inside the United States. This is a miniscule number in comparison with the population and land area of the U.S. This industry could easily absorb thousands of installing dealers before the market becomes saturated—opportunities abound.

Retailer
Most retailers sell the RE hardware necessary to install a system, as well as ancillary gear, such as efficient appliances. Some offer design assistance, fewer still offer *NEC* compliant installation, and almost none offer load analysis and site survey. While all installing dealers are retailers, not all retailers are installing dealers. Most retailers market via catalog sales or Internet Web sites, while a few operate retail storefronts.

The qualifications for being an RE retailer are a knowledge of RE systems and hardware, small businesses management and marketing, and a modest amount of startup capital. *Home Power's* InBiz database lists 761 retailers. This number is growing rapidly as RE spreads on-grid.

Wholesaler
The wholesaler acts as an intermediate distribution step between the manufacturers and the dealers. The distributor needs to know which RE hardware works and how, and must maintain a large supply of that hardware to immediately fill orders from RE dealers. Extensive business skills and a warehouse with good access to all types of shipping services are required. Since the wholesaler must stock a big inventory, a large amount of startup capital is needed.

In the early days of RE, a wholesale distributorship could be had pretty much for the asking. Those days are gone—this industry has already matured to the point where distributorships are difficult to obtain. The InBiz database shows 42 distributors inside the U.S., and this number is increasing slowly.

OEM
Original equipment manufacturers (OEMs) are the folks who make the RE hardware we all use. This field is populated by many different types of products—PVs, solar thermal collectors, wind generators, inverters, controls, batteries, instrumentation, and efficient appliances, just to name a few.

Employment opportunities are present with existing OEMs. Most of these OEMs are larger companies and have many types of jobs other than just manufacturing—management, marketing, R&D, technical writing, and customer service. But doing the OEM job doesn't necessarily mean joining an existing company. The field of small-scale RE is very fertile for entrepreneurs and inventors.

Many of today's most successful OEMs started out manufacturing in their garages—Trace Engineering is a good example of this. This field is still wide open to those with better products and new ideas. Many OEMs are small businesses, particularly when it comes to manufacturers of wind generators, microhydro turbines, controls, and instrumentation.

Our InBiz database shows 270 manufacturers of RE products. This number is growing about 12 percent annually as new firms and products enter the field.

Ancillary Jobs
The RE industry holds many jobs not directly related to RE hardware sales and manufacture. This industry employs and needs marketing people, technical writers, designers, energy analysts, financial analysts, and educators. *Home Power* itself is a good example of an ancillary RE business—our product is information. SoL, SEI, and MREA are good examples of small organizations whose business is RE education.

Successful Solar Businesses
Home Power is dedicated to helping the small-scale RE industry grow and prosper. It's good for the earth, it's good for the folks who live on the earth, and it provides jobs with a future, where you can be proud of your work. There is no downside.

One of the ways we foster the growth of this industry is by teaching a seminar called Successful Solar Businesses. This three-day seminar is oriented towards helping folks become installing dealers, retailers, distributors, and OEMs. This seminar concentrates not on RE technology, but on the business of RE.

We are planning the next Successful Solar Businesses seminar in Ashland, Oregon, taught by Bob-O Schultze of Electron Connection, Bob Maynard of Energy Outfitters, and me from *Home Power.* The dates are February 21–23, 2003. Cost is US$350 for the three-day seminar. This includes three lunches and a Saturday night banquet. Lodging will be available at discounted rates for seminar participants. Seminar size is limited, so please contact me if you are interested.

The reason Karen and I started this magazine in 1987 was to change the way that we make our energy. We wish you Godspeed with your renewable energy endeavors, and stand ready to aid you in any way we can.

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Get Organized

Richard Perez

Utah just became the 35th state to pass a net metering law. Is our struggle to bring homemade renewable energy on-grid just about done? No such luck. As with many legal issues, the devil is in the details....

At a recent solar business seminar held by Energy Outfitters, more than 35 RE dealers heard presentations by industry representatives, including three grid-intertie inverter manufacturers. One of the major grid-intertie problems discussed was the Institute of Electrical and Electronics Engineers (IEEE) 519 and 929 standards. These standards set power quality and anti-islanding requirements for grid-intertie inverters, and are included in most state net metering laws.

Many dealers and manufacturers are finding that grid-intertie inverters jump off-grid, or even refuse to connect to the grid at all. When utility grids are undervoltage, overvoltage, or have too much distortion, inverters programmed to IEEE standards will not connect.

This isn't a safety issue. Safety is taken care of by other grid-intertie inverter standards (UL 1741). This is an issue of the grid's power quality. What we are discovering is that in many areas, the grid is far too funky to allow inverter intertie. The utilities are holding our RE inverters to standards that they cannot maintain themselves!

I view these IEEE standards as just another in a long series of roadblocks that utilities have put in the way of grid-intertied, RE. Having a state net metering law is irrelevant if the inverter is held to standards that will not allow it to connect to the grid. The further irony is that our grid-connected RE could help the utilities clean up their grid power quality problems!

It's time to get organized again. The only way to effectively change this situation is for us, state by state, to question the IEEE standards. We need to go to our state PUCs and governments, and lobby for change. I'm sorry that our work didn't end with passing net metering laws. Now we have to go for the devil in the details.

If you want to help, e-mail me. I'll act as an information clearinghouse until individual state groups get organized. We've got some work to do.

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Q&A

Send your questions to letters@homepower.com

How Do LEDs Work?
Could you please tell me what makes an LED (light emitting diode) work? Thanks, PT Gavin

Hello PT Gavin, LEDs are semiconductor junctions. They are designed to lose energy in the form of photons in the visible light range. When electricity is passed through an LED junction, the materials in the junction (mostly gallium arsenide) have their outer valence electrons stimulated to change energy bands. When these electrons change energy bands, they lose a small amount of energy in the form of photons (visible light).

LED junctions inherently produce a single frequency of light (monochromatic light). This is why LEDs come in very specific colors. The new white LEDs have a high frequency blue junction that is surrounded by phosphors. These phosphors absorb the hard blue light, and emit light of various colors, thus giving the illusion of white light. I hope this helps. Richard Perez • richard.perez@homepower.com

PV-Wind without Batteries?
Do you have any information on using a combination of wind and solar electricity to feed the grid without battery backup? All of the grid-tie inverters are designed around PVs, and have no inputs for wind generators. In my situation, I don't need battery backup, but would like to use a small wind generator to help supply the grid.

I don't want to invest US$3,000 for a SW4024 plus a large bank of batteries that has the sell feature but also many features I will never use just to feed the grid. Why couldn't I connect a device such as a regulator that would limit the current and or voltage to what the ST1000 would see when it is connected to the PV array (48 V approximately 6 amps)? I don't think the ST1000 would know whether the input was from PV or wind as long as there was a way to regulate it. Any suggestions would be much appreciated. I have a fair amount of wind and not a lot of money. Gary McBurney gdmcburney@switch.com

Hello Gary, This is a real problem. During an MREA wind installation workshop, we installed a 3.6 KW Jake with a Trace SW5548, and a 48 volt bank of L-16s. The problem is that the Trace SW with batteries is not a good grid-interactive inverter. To paraphrase Steve Bell of SunWize, the Trace SW inverters are essentially grid-interactive battery chargers.

Unfortunately, he's correct. The SW wants to keep the batteries in top shape, no matter what. With a wind genny connected to the grid, I don't care about the batteries. I want to offset the KWH consumed from the utility, and store my excess on the grid for later retrieval. The SW does this, but only after babysitting and pampering the batteries.

You might ask, "Why have batteries?" After all, you don't need them with a PV-only setup. That's right, but the difference between PVs and wind is the voltages that can be reached. An unloaded 12 PV panel may hit 15, 16, or even 17 volts. An unloaded 12 volt wind genny will hit 90+ volts. It's the nature of any rotating electrical generating equipment. That is why the batteries are required. The SW can't deal with those high voltages. Nor can the SW clamp the wind genny voltage down enough to keep it from getting away. In discussions early on with Trace about this, their only solution was to use a battery bank to do the clamping. That's where we still are.

Not that it's an impossible problem to solve. I have a 3 KW Jake grid-tied to a 22-year-old Gemini synchronous inverter, happily backfeeding the grid with my excess electrons without a battery bank. And there were several other grid-tied inverters that did the same. Unfortunately, none of them are commercially available any more.

But remember, while the SW can go grid interactive, that's not what it was primarily designed for. So we're stuck with the batteries, and an inverter that does a lousy job of grid tying. Several manufacturers are working on batteryless grid tied inverters for wind applications, but don't hold your breath.

Sorry. If I knew a better solution, I'd offer it. At the MREA's wind installation, I am going to try a 100 amp-hour battery and get rid of the L-16s in an attempt to improve the SW grid performance. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 • Phone/Fax: 920-837-7523 • msagrillo@itol.com

Solar Submersible Pumps
Is there a back issue that you can cite that has an article on solar submersible pumps and how to hook up the linear current booster? If one exists, can I obtain a copy? I am a new subscriber to the magazine. Thanks for your consideration. John Morony

Hello John, Many new solar pump products have been introduced in just the last few months. I would not rely on old information to answer your question. There are two types of solar submersible pump motors to be considered. The low-power, lower-priced diaphragm pumps use a traditional brush-type DC motor. Each manufacturer supplies its own controller that has the linear current booster (LCB) function within it. This helps the pump to start and not stall out when the available solar power is weak. You may be able to substitute a generic LCB made by another manufacturer if you have reason to do so. The LCB has input for the PV array, output for the pump, and connections for a remote float switch to stop the pump when your tank is full.

The second family of solar pumps is the more powerful ones that use a brushless motor system. These require specific controllers that are always supplied as a part of the system. The LCB function is built into the controller, so there is no need to supply it yourself. A brushless motor has no normally wearing parts and no potential for water leakage into the motor, so it's a much more reliable and durable system. Windy Dankoff, Dankoff Solar Products, Inc.

Flat vs. Serpentine SDHW Collectors
I read the solar thermal article in *HP85,* and I want to know if a flat plate collector is more efficient than a serpentine collector. I am in the process of building one, and I would prefer a serpentine collector because I will not have as many

connections to solder. Will the water flow evenly in all tubes in a flat plate collector? I will be using a pump to circulate the water. I am installing these collectors inside two, 4 by 8 foot windows in my upstairs, so I will not have freezing problems. Thank you, Dale Spann

Dale, Flat plate collectors may have any of several flow patterns—parallel tube, serpentine, or trickle down types whereby the water flows between two metal sheets. The most common is the parallel tube with headers. This is the type that is available from manufacturers. Although the serpentine is easy to homebrew from soft copper, it has a less efficient flow pattern because it causes the collector to run hotter. I know this sounds counterintuitive because hot water is what we are looking for. But the hotter a collector operates, the greater its heat loss to ambient surroundings and the lower its efficiency. The bottom line is that at the end of the day, the parallel flow pattern will have produced more hot water.

The flow is even in a parallel tube pattern if you take care to have supply and return connections at diagonally opposite corners of the collector. No matter how you follow the path through the collector, the length and resistance of each path is the same, therefore flow is even.

Far more important than flow pattern is the efficiency of the flat plate and its connection to the tubes. You should strive for a highly conductive, continuous bond between tubes and flat plate; the closer the spacing the better. Ken Olson Sol@Solenergy.org

Drainback Solar Heating

Hello, I have an involved question about building a drainback solar water heating system. I heat all my DHW in winter with a thermosiphon system run off my wood/propane cookstove. The hot water is stored upstairs in a nonrunning 80 gallon electric water heater tank. Since we use the cookstove daily, we have all the DHW we need for our three-person household, plus space heat. We also have a wood heating stove in the livingroom that shares space heating chores. In summer we run an ancient 1980s vintage Saunier Duval tankless propane water heater and the propane side of our cookstove for cooking for DHW.

For the last three years, we have been installing an in-floor hydronic heating system to ultimately replace the wood burner in the livingroom. This is a DIY setup, hence the long-term installation. I am now ready to take the plunge and install some sort of hybrid space/DHW system with solar and wood heated water being used as the primary space heating/DHW sources. A propane tankless water heater will be an optional, backup component. I really would like to avoid using a fossil fueled heater if possible. I would even oversize my solar hot water system if necessary. I am open to any workable system.

My house is a relatively snug scribe-cut log home of about 1,500 square feet. I realize that this is a complicated question, but I have not come across any info concerning the use of solar hot water space and DHW heating in conjunction with a wood heated hot water system. The complexity comes in as the cookstove not only heats the water but also heats the air directly. Any feedback on this idea would be appreciated. Thanks for the finest alternative energy rag on the planet. Andrew Leven • fruitcakes@mail.tds.net

Andrew, here are a few initial thoughts. As far as the solar hot water system is concerned, you would be building a standard drainback system, just a bit larger than the standard DHW system. To do any good operationally and economically, you would need to place a large storage/drainback tank, say 400 gallons, somewhere in the building. You would also need a high head pump and a differential control to operate it. Simple so far.

A similar concept would work with the wood cookstove. In this case you would use a circulating pump and a differential controller. The way you have the stove hooked up now, the fire is pumping the water via convection. If the stove gets rearranged to heat the big tank, there is a potential problem. If a fire is burning, and for some reason there is a no flow condition due to a utility outage or a pump or controller failure, the water in the cookstove will quickly flash to steam. I can't predict what problems this may cause, but I don't think it would be a good thing.

With the information you have provided, I think you have two options on the path you have started down. 1. Leave the stove hooked up the way it is now, and have the solar hot water system operate on its own. 2. Connect the stove to the large solar storage tank, and immerse a coil of soft copper in the storage tank as a heat exchanger that would be plumbed to your existing 80 gallon water tank. This loop would be pumped or perhaps thermosiphoned. Good luck, Smitty, AAA Solar Supply • smitty@aaasolar.com

Writing for *Home Power* Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small-scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your renewable energy (RE) experiences printed in *Home Power.*

Informational Content
Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough that our readers can actually use the information. Name names, and give us actual numbers, product names, and sources.

If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article.

Article Style & Length
Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible.

We prefer simple declarative sentences that are short (fewer than twenty words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power.* After you've studied a few, you will get a feeling for our style.

We edit all articles for accuracy, length, content, organization, and basic English. You can help by keeping your sentences short, simple, and to the point. Our editing crew will make your text shine.

Photographs
We can work from good photographic prints, slides, or negatives. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs, since the ink can transfer to the front of the next photo. Please provide a comprehensive caption and photo credit for each photo. Include some vertical format photos—you might even find your system on *HP's* cover. People are nice in photos; a fuse box is only so interesting, even to solar nerds.

Digital photos should be at least 280 pixels per inch (ppi) at the final printed size. This means that a column width photo should be 1,000 pixels wide or more. A full page width photo should be at least 2,300 pixels wide. Basically, set your digital camera at its highest resolution, and crop thoughtfully. We prefer Photoshop files, but we can handle the following formats in descending order of preference—EPS, TIFF, and JPEG.

Art, Schematics, & Tables
System articles must contain a schematic drawing showing all wiring. Our art department can make gorgeous diagrams, charts, and schematics from your rough sketches. If you want to submit a computer file of a schematic or other line art, please call or e-mail us first.

For system articles, we require a load table listing all loads, with wattage and run time. We also require an itemized cost table listing each system component and its cost. We prefer to have the tables come to us in Excel format. But we can use them from any word processor or spreadsheet format if they are saved as "text only," with tabs as the delimiter between data.

Computer Talk
We can take text from most word processors. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use the "Save As Text" option in your word processor.

If you want to send files larger than 5 MB (such as digital photos), use removable media and snail mail it to us. We can read ZIP disks (either Mac or IBM) and CD-ROMs. You can also FTP your large files to us at ftp.homepower.com, to the "incoming" folder. Please let ben.root@homepower.com know after you have sent us files via FTP.

Putting It All Together
We get many more articles submitted than we can print. The most useful, specific, organized, and complete get published first. Here are the basic components of a great *Home Power* article:

- Clearly written, well organized, and complete text, with a strong introductory paragraph, subheads for each major section, and a strong closing paragraph.
- Photos (plenty) with comprehensive captions.
- Cost table.
- Load table.
- Other tables, charts, and diagrams as appropriate.
- System schematic.
- Complete access information for author, installers, consultants, suppliers, and manufacturers.

Have any questions? Give us a call Monday through Friday from 9 to 5 Pacific and ask. Or send e-mail. This saves everyone's time. We hope to see your RE project in *Home Power* soon!

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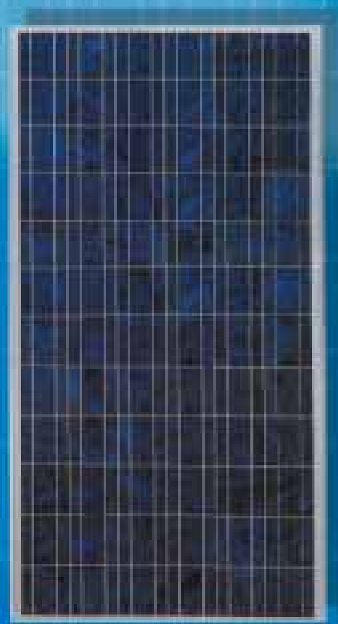

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(continued on reverse)

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