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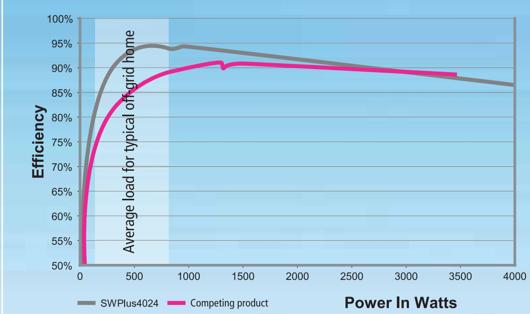

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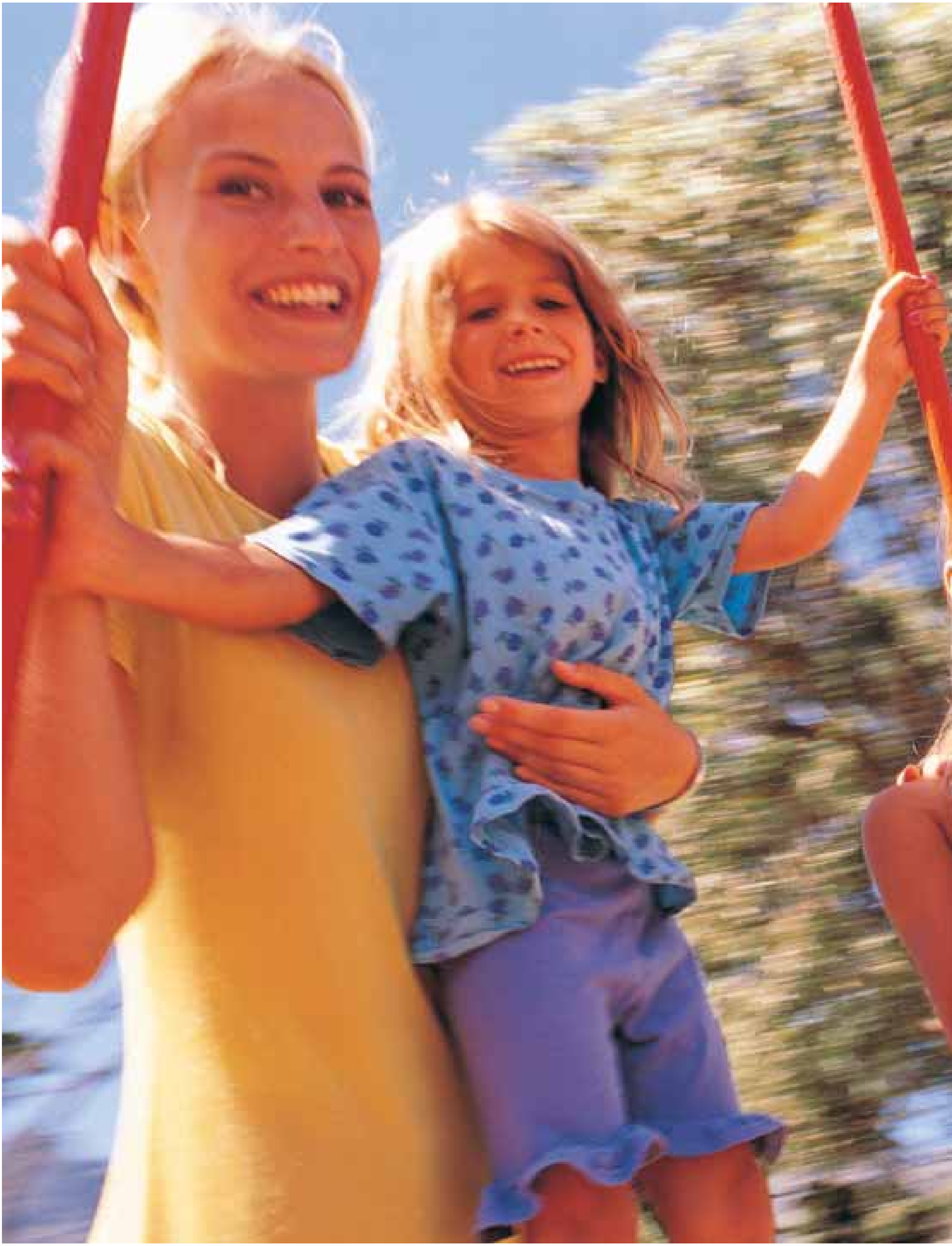
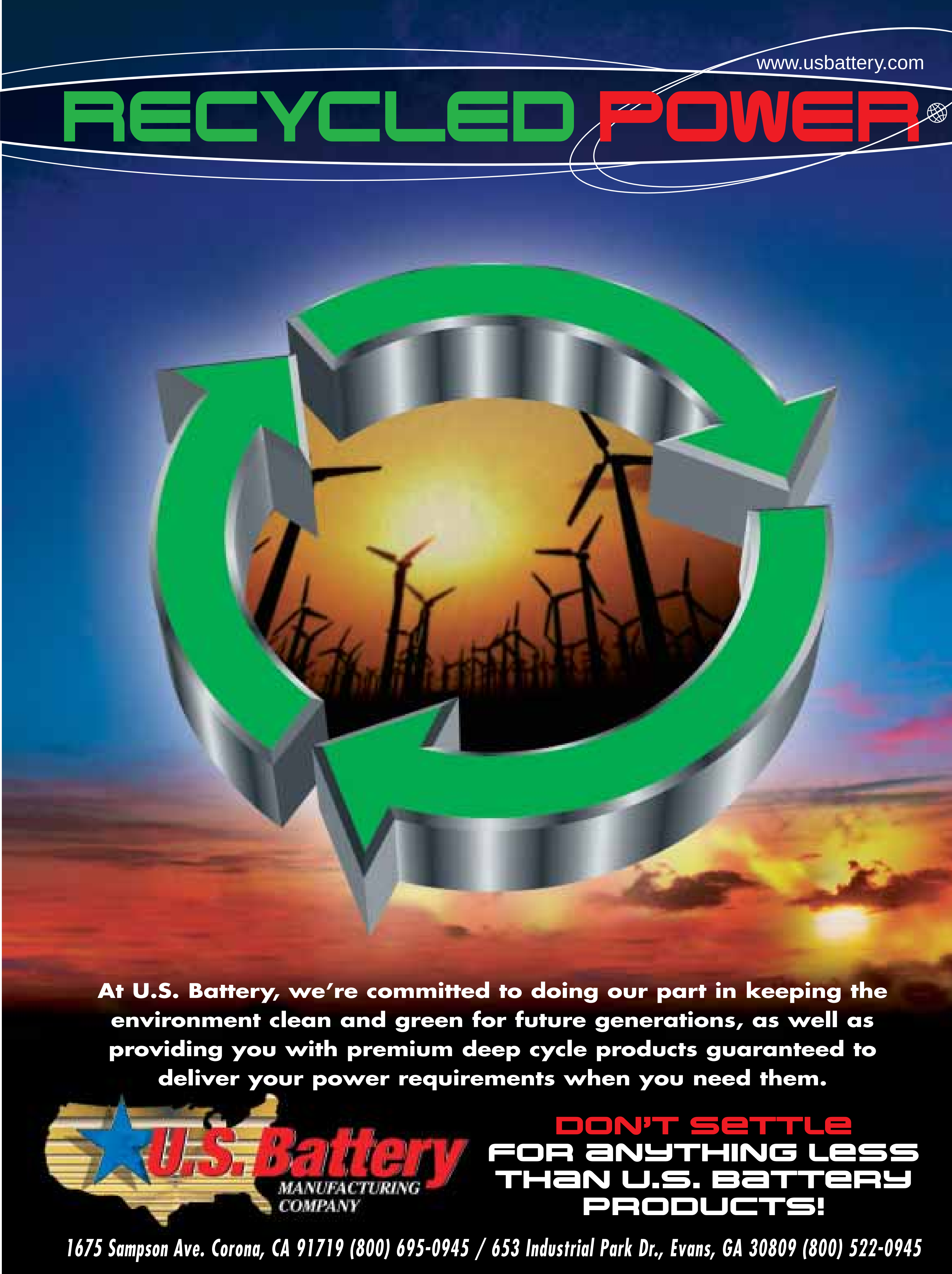
Congratulations Home Power on your 100th edition!

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HP100 contents

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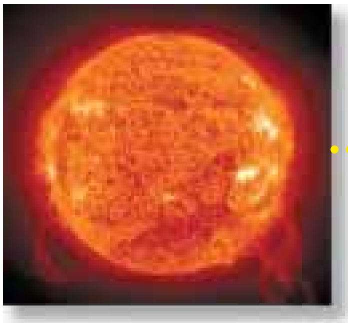

Regulars

A World of Change, One Issue at a Time

Here we are publishing the 100th issue of *Home Power.* I am continually amazed at what our readers are doing, at the shape of the RE industry, and at the brightness of the future. I had no idea that things would go and grow so quickly when we put the first issue of *Home Power* in the mails back in November of 1987.

Back when we started, a *big* PV module was 50 watts and it carried a 10 year warranty. Now, 150 watt modules are common, and most have 25 year warranties. Perhaps the brightest news is that these new modules cost roughly half as much per watt as the earlier ones. Today we are blessed with better and less expensive equipment in all the RE fields—solar, wind, and microhydro electricity, solar thermal, and alternative vehicles. The end is nowhere in sight.

Many of these advances are due to the growth of the RE industry—to the folks who actually make the hardware. The number of companies has increased radically, and we now have a wide variety of system components to choose from. The users of RE have changed over the years too. Once, small-scale RE was strictly the bailiwick of off-gridders. Now the fastest growing segment of RE users is on-grid. Once RE was strictly the domain of do-it-yourselfers—if you didn't design and install the system yourself, it didn't happen at all. Now most folks hire a dealer to design and install their system.

We began publishing *Home Power* with the intention of changing the way the world makes electricity. Since 1987, we've been supplying you with the hands-on technical information you need to make intelligent and cost-effective RE decisions, and putting you in touch with manufacturers and dealers through the advertising in our pages. We're looking forward to publishing the next 100 issues of *Home Power*, and can't wait to see what changes our collective efforts bring.

–Richard Perez for the whole *Home Power* crew

Think About It

At first people refuse to believe that a strange new thing can be done.
Then they begin to hope it can be done. Then they see it can be done.
Then it is done and all the world wonders why it was not done centuries ago.

–Frances Hodgson Burnett, Author, *The Secret Garden*

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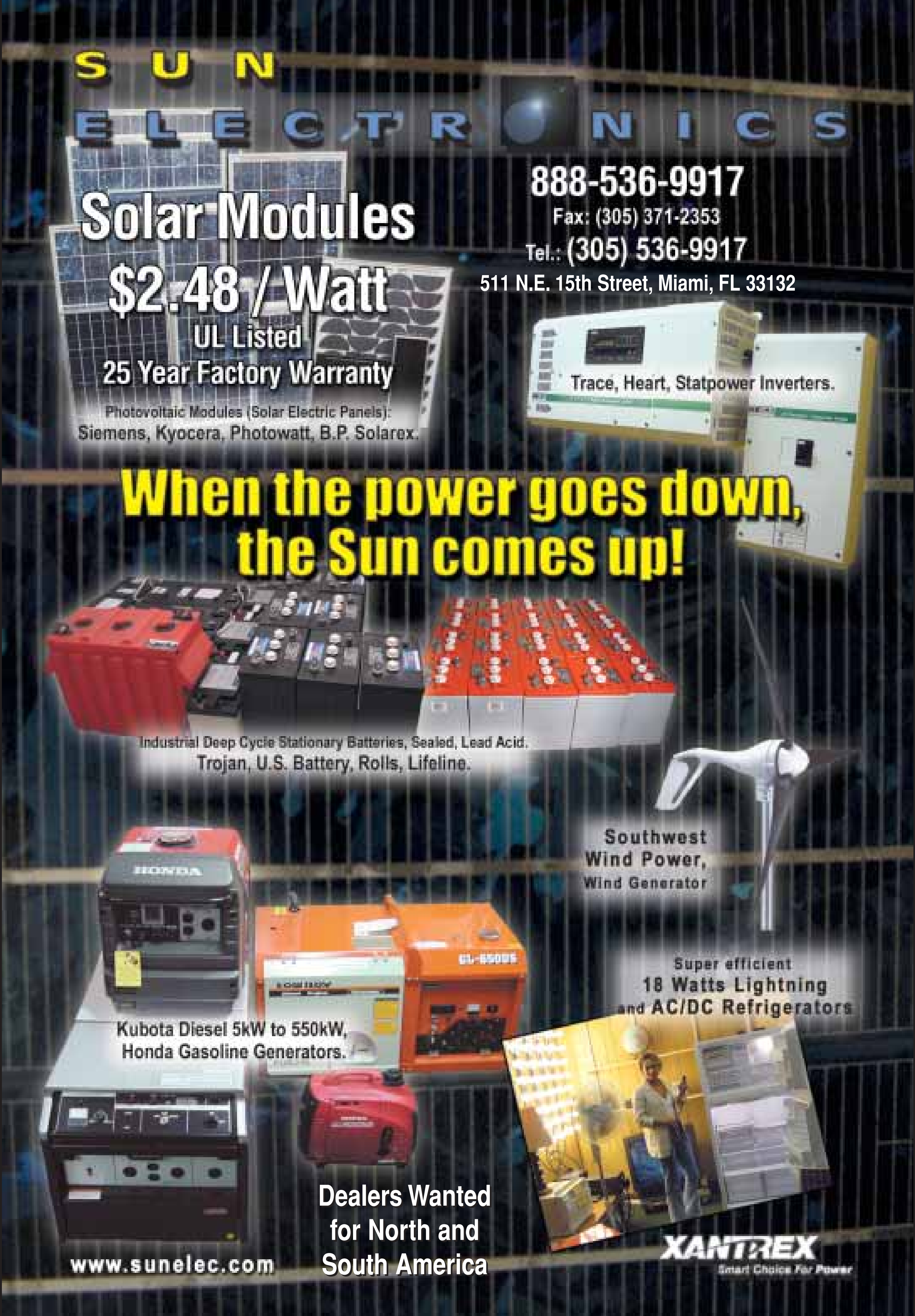
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My Solar Casita

Solar Pumping, Heating, Cooking, & More!

Samuel Gray

I stayed in a nearby inn during the early stages of building my adobe casita near Abiquiu, New Mexico. When the grid shut down for over fourteen hours during one of my visits, I learned a brutal lesson about the dangers of grid-powered electricity. What I never realized was that when the grid fails, rural water systems fail along with it. You can live a long time without electricity in New Mexico, but you can't live long without water anywhere. A fourteen-hour blackout was more than enough to convince me to go solar with my own water system.

My casita is located 1 mile (1.6 km) west of Abiquiu on a 5 acre, worn-out potato field I bought ten years ago when I lived in Virginia. I didn't know anything about photovoltaics when I bought the property, but I did know that the property was perfect for passive solar heating. The land gently slopes to the south toward the nearby Chama River and has a spectacular, unobstructed southerly view of the river valley and the mountains beyond.

Adobe Construction

After moving to New Mexico, my wife and I wanted to build a casita on the property to use as a getaway. During our research, we were impressed with adobe and its potential for an owner-built, passive solar heated building. The adobe provides thermal mass that stores heat during the day and releases it at night when it is most needed. The solar-adobe concept seemed a no-brainer for us.

Once we had committed to an adobe casita, we realized we were in over our heads. I had previously done some standard frame construction, but knew nothing about adobe. Fortunately, Northern New Mexico Community College in nearby El Rito offers courses in all phases of adobe building. I signed up for an intensive three-week course, and my wife and I were laying adobe bricks on my casita by the end of summer. The professor, Quentin Wilson, has visited my casita many times since then to offer advice and encouragement. I also learned a great deal along the way from an Internet adobe discussion group, moderated by the very same Professor Wilson.

The casita is very tiny—just one room and slightly under 120 square feet (11 m^2). It's not yet finished, but quite livable nevertheless. It has a bed, a desk and a chair, a small kitchen counter, and lots of shelves. The building is constructed with 4 by 10 by 14 inch (10 x 25 x 36 cm) adobe bricks mortared with mud from the site. I oriented the structure 12 degrees east of magnetic south and used lots of glass on the south wall to collect free solar energy during the winter. The outside walls are cement stucco over 2 inches (5 cm) of rigid insulation.

By cutting the well casing into ten foot sections and then welding them back together in place, the driller was able to complete the well working alone.

His equipment was antiquated, but it did an excellent job.

The PV panels, pump house, and frost-proof hydrant were sited well away from the well head for convenience in servicing the well.

Water System

The well was drilled in April 2003 by a local drilling contractor. It is 115 feet (35 m) deep, with a 6 inch (15 cm) steel casing perforated for water veins at 30 feet (9 m) and 90 feet (27 m). The recharge rate tested at 40 gallons (150 l) per minute, and about 85 feet (26 m) of water stands in the well.

When the well was completed, I had the drilling contractor install an underground pump house to hold the 80 gallon (300 l) pressure tank and plumbing. I also wanted to temporarily put my PV system's batteries and controls in the pump house. Later on, they'll have their own structure.

By building the pump house underground, we avoided the necessity of heating that space in the winter to prevent frozen pipes. Our contractor built the pump house out of a piece of 5 foot (1.5 m) diameter corrugated steel culvert set upright. The floor is 3 inches (7.6 cm) of pea gravel, and the roof consists of a 4 inch (10 cm) thick slab of poured concrete with a 32 inch (81 cm) access cover.

Even though the well head is above ground, the water line from the well to the pump house is buried 4 feet (1.2 m) underground to prevent the delivery pipe from freezing. A very clever

Gray System Loads

AC Loads	Qty.	Avg. Hrs. / Day	Watts	Avg. WH / Day	Max Inverter Watts
Laptop	1	4.00	40	160.00	40
Battery chargers: tools	3	3.00	15	135.00	45
Compact fluorescent lights	2	2.00	25	100.00	50
Fluorescent bug light	1	2.00	17	34.00	17
Battery chargers: cell phone, camera, PDA	3	2.00	5	30.00	15
			Total AC	459.00	167
DC Loads					
Inverter	1	24.00	5	120.00	
Shurflo submersible pump	1	1.50	72	108.00	
Pump house fluorescent light	1	0.05	1	0.05	
			Total DC	228.05	
			Grand Total	687.05	

device called a "pitless adaptor" was used to make it easy to remove the pump for maintenance and repair. The submersible pump wire travels to the pump house via a 1 inch conduit.

The pump is a 24 volt Shurflo submersible with a maximum flow rate of about 2 gallons (7.6 l) per minute. I installed it myself, working alone, by using 8 foot (2.4 m) threaded sections of 1/2 inch PVC drop pipe. The pump is designed for pumping into a storage tank or water tower rather than a pressure tank. Since my water needs are small and my pump is only 40 feet (12 m) below ground, I decided to try it with a pressure tank.

The drawdown on the 80 gallon (300 l) pressure tank is about 35 gallons (132 l), more than I anticipate needing at any given time. After the drawdown, it takes about 20 minutes for the pump to recharge the tank back to 50 psi. When I move here permanently, I will have to install a bigger pump or a storage tank with a booster pump to supply the pressure tank. For my current needs, what I have works fine.

PV System

The primary purpose of the PV system is to supply 24 volts DC to the submersible pump. Many PV systems for rural water supply are designed "PV direct"—the pump runs only when the sun shines. That is the most efficient system if you're pumping into a storage tank with an additional pressure pump or an elevated tank that relies on gravity for pressurizing. Pumping directly into a pressure tank, however, requires access to continuous electricity.

I used two Siemens SM55 PV panels, rated at 55 watts each, that I purchased on eBay. The Siemens modules have excellent tolerance for the hot temperatures in Abiquiu's summers, when water needs are the highest. The PV panels' output is regulated by a Trace C40 controller, and used to charge four, 6 volt, golf cart batteries connected in series. On the recommendation of *Home Power's* John Wiles, I grounded the system directly to the 115 foot (35 m) steel well casing. A Link 10 digital meter, power disconnects, a pump switch, and fusing complete the DC part of the installation.

DC electricity is supplied to the submersible pump via a two-conductor, #10 (5 mm^2), submersible pump cable. The pump is switched on the control panel and also through a pressure switch set to turn the pump on at 30 psi and off at 50 psi. The Shurflo draws about 1.8 amps at open flow and about 3.4 amps at 50 psi.

While my main purpose was to supply water, I also wanted a small amount of AC for the casita, located

Technical Specifications

System overview

System type: Off-grid PV

Location: Abiquiu, New Mexico

Solar resource: 6.2 average annual peak sun hours

Production: 14 AC KWH per month average

Photovoltaics

Modules: 2 Siemens SM55, 55 W STC, 12 VDC nominal

Array: 110 W STC, 24 VDC nominal

Array disconnect: Square D general duty safety switch, 30 A

Array installation: UniRac top-of-pole mount

Balance of System

Charge controller: Trace C40, PWM

Inverter: Exeltech XP 250, 12 VDC nominal input, 120 VAC nominal output

System performance metering: Link 10 digital meter

DC-to-DC converter: Solar Converters EQ 12/24-20, 95% efficiency

Pump: Shurflo 9300 submersible, 24 VDC nominal, 1.8 amps draw open flow to 3.4 amps at 50 psi, 2 gpm at open flow, about 1.5 gpm at 50 psi.

Energy Storage

Batteries: 4 Interstate, U2200 Workaholic, flooded, lead-acid, 6 VDC nominal, 220 AH at 20 hour rate

Battery pack: 24 VDC nominal, 220 AH total

Battery/inverter disconnect/overcurrent protection: DC-rated 30 amp fuse

The control panel after installation in the pump house. All switches and controls are mounted at eye level.

about 150 feet (46 m) away. I already owned a 250 watt Exeltech sine wave inverter, and decided to adapt my system to it. Since the inverter I had requires 12 volts and my battery bank is wired for 24 volts, I had to install a DC-to-DC converter to make the design work. This setup is not ideal, since the converter adds another 5 percent efficiency loss to the system. I ran the AC wires to the casita in an underground conduit. I planned this long ago, and the casita was already wired for AC and ready for an electricity source.

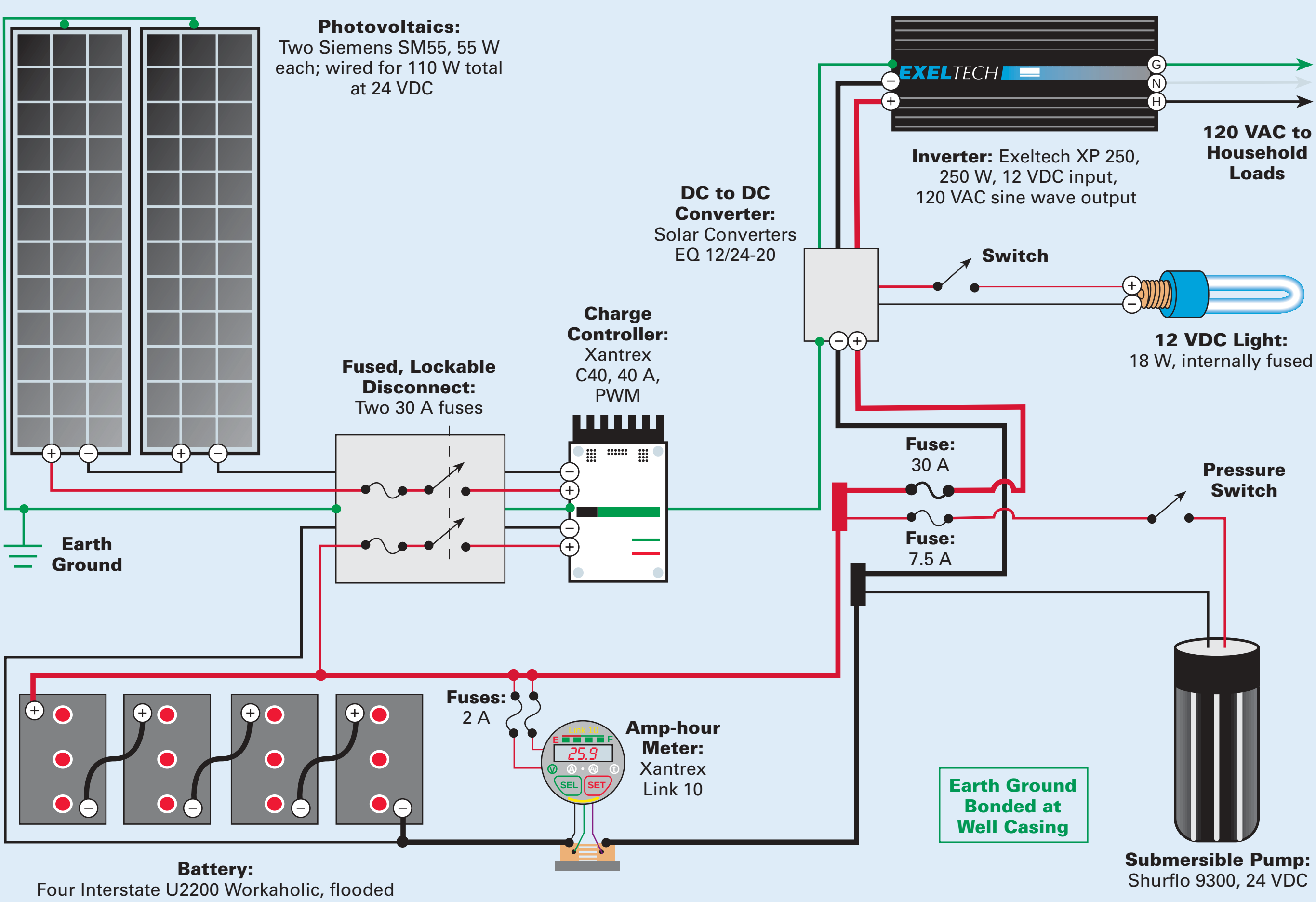
A 250 watt inverter is not much, but I don't need much. I have more than enough AC electricity to run three fluorescent lights, my laptop, a radio, and battery chargers for my cell phone, digital camera, PDA, and cordless tools. If I run all these devices at the same time, I am still well under 250 watts.

The water pump and the casita use more electricity than the two Siemens modules can produce on an average day. That's not a problem, since I only spend one week per month at the casita. When I leave at the end of the week, my batteries are drawn down perhaps as much as 50 percent. They then have three full weeks to recover before my next trip. When I build a permanent home here, however, this PV system will be dedicated to supplying electricity to the pump.

The *National Electrical Code* requires a safety placard attached to battery boxes.

More Solar Applications

I don't have, or want, access to unlimited electricity from a utility grid. My casita in Abiquiu has given me the opportunity to experiment with several solar applications other than passive heating and photovoltaics. I heat water for washing and showering in a portable 5 gallon (19 l) plastic solar water heater, available for about US$10



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

Gray System Costs

PV System	Cost (US$)
2 Siemens SM55 PV Panels	$480
Misc. wiring, conduit, battery box	325
4 Interstate U2200 batteries	270
SCI EQ 12/24-20 DC–DC converter	165
Exeltech XP 250 inverter	160
Link 10 digital meter	145
Xantrex C40 controller	128
UniRac top-of-pole PV mount	109
2 Safety disconnects with fuses	85
Pump house light, 12 V	35
Total PV	$1,902
Well	
Contractor for well & pump house	$3,770
Pressure tank, 80 gallon	530
Shurflo submersible pump	520
Misc. wiring & plumbing	290
Total Well	$5,110
Grand Total	$7,012

from various suppliers. It takes three hours of direct sunlight to produce hot water. A future project will be to add a more permanent and larger batch solar water heater that will supply pressurized hot water.

I heat water for tea and coffee in a device called a solar thermos. It consists of a black thermos bottle with parabolic reflectors on either side to concentrate sunlight on the thermos. Twelve ounces (59 ml) of cold water and thirty minutes of New Mexico sunlight yield boiling water for hot beverages or cereal.

Small rechargeable batteries such as size AA and AAA can be easily charged in inexpensive solar chargers. I have two of these chargers and use them continuously when I am at the casita. I also use a solar powered flashlight. For entertainment, I watch DVDs on my solar powered laptop or listen to a solar powered radio. For my occasional trips to the nearby store in Abiquiu, I can use my electric ZAP bicycle and charge its battery from my PV system.

My favorite solar device is my Sun Oven. I do almost all my cooking using only direct sunlight as an energy source. I have successfully cooked beans, rice, biscuits, bread, cookies, stew, and soup in the Sun Oven. Although it's difficult to prove, food seems to taste better cooked this way. The Sun Oven quickly produces temperatures of over 350°F (177°C).

Self-Sufficient Comfort

All in all, my solar-adobe casita is a self-sufficient system requiring no purchased energy. It is comfortable inside even on the coldest of winter days. The sun provides all my needs for electricity, pressurized water, cooking, space heating, water heating, entertainment, transportation, and battery charging during my visits to Abiquiu. For the seven days per month that I spend at the casita, I am quite happy just taking what the sky gives me.

Access

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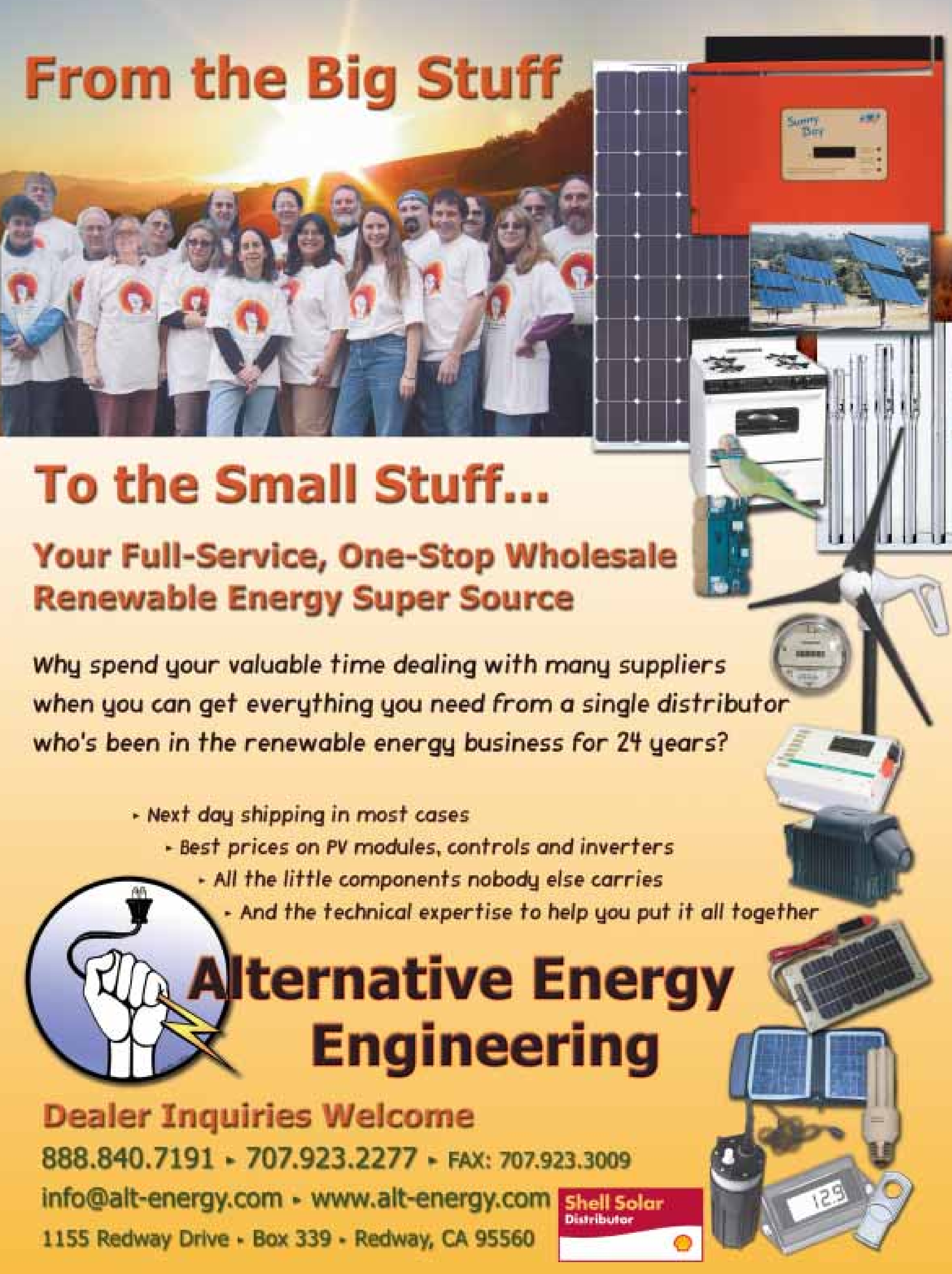
ZAP Electric Vehicles, 501 Fourth St., Santa Rosa, CA 95401 • 707-525-8658 • Fax: 707-525-8692 • zap@zapworld.com • www.zapworld.com • Electric bicycle

Northern Arizona Wind & Sun has an excellent on-line reference site for solar powered pumping applications at www.windsun.com/Water/solar_water_pumping.htm

Adobe: Build It Yourself, by Paul Graham McHenry, 1985, Paperback, 158 pages, ISBN 0-8165-0948-4 • US$24.95 from University of Arizona Press, 355 S. Euclid Ave., Suite 103, Tucson, AZ 85719 • 800-426-3797 or 520-621-1441 • Fax: 520-621-8899 • uap@uapress.arizona.edu • www.uapress.arizona.edu • Classic book on adobe construction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Bernd Geisler

Photo by Jim Waldon, Windmill Photography

We get more sunshine here in northern Texas than anyone may want. Wind often blows steadily for days and can sometimes get fierce. Wind speeds can go from 30 to 70 mph (13 to 31 m/s) within seconds. Twenty miles down the road, a truck loaded with scrapped cars was blown over and off Highway 75 last year by a severe gust!

Wind comes predominantly from the south in spring, summer, and fall, and from the north during the short winters. According to the maps, Grayson County lies within Wind Class 2 and borders on Class 3. A 10.8 mph (4.8 m/s) average wind speed makes it a decent area for a small wind generator.

So why doesn't anybody make use of wind and sun here? The answers are cheap oil, cheap electricity, ignorance, and negligence. Some efforts had been made, but none of the five small wind generators I've seen in our local area in the last few decades are still in operating condition.

Our grid-tied wind-electric system is just one part of a larger project. Our goal is to reduce and offset the energy consumption of our all-electric suburban home, so that we will generate our own electricity during nine months of the year.

We have already reduced our consumption by a quarter through more efficient appliances and inexpensive minor remodeling. We've done things like scrapping attic fans and inserting ridge vents instead, and replacing the tank water heater with an electric demand water heater. When the heat pump approaches the end of its life cycle, it will be replaced with a modern one that can heat and cool almost twice as efficiently. We also plan to add a solar water heater soon; the demand water heater will then just be used as a booster. When all these changes are made, a modest hybrid wind and solar-electric system should suffice to provide most of our electricity.

Wind Generator

Lots of valuable information about the African Windpower (AWP) 3.6 (and other small wind generators) can be found in *Home Power's* "Apples & Oranges" article by

Mick Sagrillo in *HP90.* At first I was skeptical about this machine, because according to the data, it seemed to generate little energy for its comparatively large rotor size of 3.6 meters diameter (11.8 feet). But I valued Mick's recommendation, and read about independent monitoring by Mike Klemen on the AWEA e-mail list server (see Access). This seemed to support Mick's impression that the numbers for the AWP 3.6 are realistic, maybe even a bit pessimistic, whereas some competitors use optimistic estimates.

The AWP 3.6 is available with a special, grid-tie voltage controller that shows its operation status with an LED "traffic light." The controller not only rectifies the generated wild AC into DC that the inverter can digest, but also protects the inverter by diverting surplus energy to an industrial-grade load resistor in the event of a utility outage. The Windy Boy 1800U inverter accepts a maximum input voltage of 400 VDC. When the DC input voltage reaches levels around 350 volts (yellow LED lit), a PWM circuit diverts some energy to the dump load to control voltage. A second stage, backup circuit comes into play if voltages exceed 390 volts. This "crowbar" (latching) circuit activates and connects the wind generator directly to the load resistor (red LED lit).

Although that load resistor is optional, some type of emergency load is necessary, since the generator can produce voltages high enough to damage the Windy Boy if allowed to run unloaded. Under normal operating conditions, almost all electricity is fed into the grid (green LED lit). So the load resistor has strictly a protective function—more about that later. The controller's circuit board is mounted on its own massive heat sink; the case itself is used for cooling and does not need ventilation openings. The board can be flipped over for easier wiring. Many knockouts on all four sides give flexibility when space is limited, as in my case.

The turbine's control box has two switches. The "brake" switch activates the electric brake by shorting the three alternator phases. High currents induced in the alternator will then slow down the rotor and only allow it to spin very slowly. But beware. The brake will likely not stop the rotor in high winds. It is rather intended to prevent a stopped turbine from starting up, says the manual. The wind generator is designed to protect itself in high winds through its gravity furling mechanism—just leave it alone.

Stopping the turbine seems to work better when the "crowbar" switch is on. That switch hardwires the turbine to the resistance load. It

Wind System Tech Specs

System Overview

System type: Grid-tied, batteryless wind

Location: Denison, Texas

Wind resource: 10.8 mph (4.8 m/s) annual average at 30 feet

Production: 210 AC KWH per month average (projected)

Percentage of utility electricity offset: 33 percent average (5 percent in summer, 75 percent in spring)

Wind Turbine

Turbine: African Wind Power AWP 3.6, 110 V

Rotor diameter: 3.6 m (11.8 feet)

Average rated KWH per month for battery charging turbine: 210 at 12 mph (5.4 m/s)

Peak KW output and wind speed (grid-tied): 1,580 W at 25 mph (11 m/s)

Wind turbine controller: AWP, Clamp 1

Tower: 79 foot (24 m) Rohn, guyed lattice

Balance of System

Inverter: SMA Windy Boy 1800U, maximum 400 VDC input, 120 VAC nominal output

System performance metering: AC KWH meter and integrated inverter LCD display

The Geislers' RE-powered home, AWP 3.6 wind generator, and recently added PV system.

Photo by Jim Waldon, Windmill Photography

Adding PV

A solar-electric system was started before but finished after the AWP/Windy Boy system. I ordered an SMA 700 watt batteryless inverter in March 2003, and mounted my PVs in anticipation. Working on the roof can get uncomfortably hot later in the spring. I finally received the inverter—which had been announced for June—in mid-December. This new addition to the Sunny Boy line is currently in full production and ready to ship. So the solar-electric portion of the system is complete at last and is extremely simple. The total cost of the PV system was about US$6,000.

Eight Siemens SM110 modules were wired in series using the modules' weathertight MC connectors. The DC wire run between the PVs and the inverter is 50 feet (15 m) long, and uses #10 (5 mm^2) CU wire. The resulting power losses are negligible because this is a high-voltage array. I chose the Sunny Boy 700U because it is user-configurable for three array voltage ranges or DC power inputs. One advantage of this is that it allows a given system to start small and add modules as finances allow. In my case, the Sunny Boy 700U was the best matched inverter for my array's 880 watt peak power rating under standard conditions.

Another consideration was the window in which the inverter can perform maximum power point tracking (MPPT). The SB700U tracks PV voltage from 125 volts minimum to 250 volts maximum in the configuration I chose. The inverter can accept 1,000 watts of DC input power in this configuration.

also serves as a reset if the crowbar circuit has been activated (red LED lit). An accidentally opened DC disconnect switch could let the turbine run unloaded, so instead of installing a DC disconnect switch for the inverter, I just switch "crowbar" and "brake" on. That should short the phases of the turbine and channel all electricity to the resistance load, which will normally stop it.

Inverter

SMA's Sunny Boy line of photovoltaic inverters has an excellent reputation for reliability as well as efficiency. They have won several test comparisons both in the U.S. and abroad. The Windy Boy inverter used by AWP is in fact a reprogrammed Sunny Boy 1800U. The software modification affects the maximum power point tracking (MPPT) algorithm. It causes the AC output power to be proportional to the DC input voltage. The MPPT algorithm lets the alternator work more efficiently than when charging batteries, because the load gets better adapted to the alternator's power curve. Net output increases appreciably—the AWP distributor claims a 50 percent overall gain compared to running the turbine in a battery charging system.

The physical structure of the inverter remains unaltered. With its UL 1741 listing, the inverter is regarded as precertified by our utility. It basically means that there is no special certification fee of US$200 to pay. Great! The inverter comes with an LCD display that updates vital information every five seconds, among them instantaneous power output, accumulated energy output, input voltage, and error messages. It also has three status LEDs. Documentation is extensive.

Electrical Setup

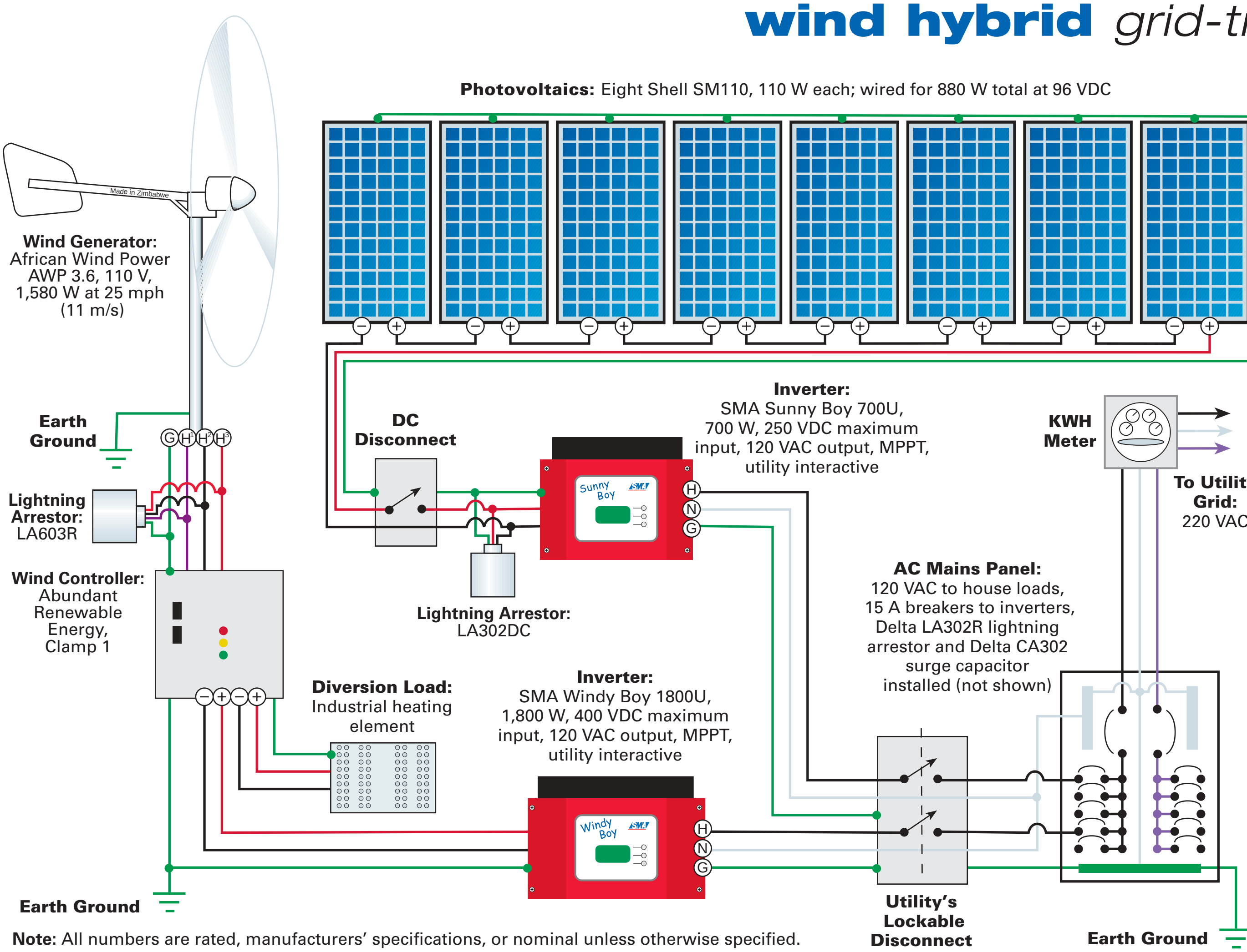
I started with the electrical installation. Besides the components mentioned above, utilities usually require a lockable disconnect switch. All generating sources must be able to be disconnected from the grid with one single switch that can be accessed outside the house and locked in the "off" position. I am not sure whether such a switch has ever been used by any lineworker.

Drilling holes through brick walls is no fun, so I looked for a more elegant way. Although my idea is probably not new, pulling a four-conductor cable through the conduit between the main breaker panel and the utility meter on the outside wall was a fast and clean solution. The conduit in my house could easily accept another cable besides the two hot phases and the ground. With the cable now ending in the main breaker box and the meter box, respectively, I just connected the switch with a short piece of conduit to the meter box and pulled the cable through. Since the wind generator and solar-electric array needed to be switched off simultaneously, I employed a two-pole, 30 amp disconnect switch.

Inverter Output & Input

Inside the main breaker panel, I connected the wire from the disconnect to the dedicated breaker for the Windy Boy. The wire to the disconnect was fed into the inverter as L (Line). The inverter also needed one connection to N (Neutral) and one connection to PE (Protective Earth, or ground) on the AC output side. The 15 amp circuit breaker serves as the inside AC disconnect switch for the inverter, and there is also the utility disconnect outside.

The AWP control box was easily connected between the wind generator and inverter. Eight obvious connections had to be made, three to the 3-phase alternator, two to the load resistor, two to the inverter DC input, and one to ground. I crimped and soldered all electrical connections because I think the additional time spent for good connections may protect against future trouble.



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

Lightning Protection & Wire Run

With a properly grounded and protected tower—bonded, 10 foot (3 m) ground rods at the base and guy anchors, and a lightning arrestor—the greatest danger to electronic devices comes from surges within the grid. So I connected one Delta LA603R across the three alternator phases in the control box, one Delta LA302R lightning arrestor and one Delta CA302 surge capacitor across the two grid phases in the main breaker panel, and one additional Delta LA302DC lightning arrestor for the PV panels.

For the 320 foot (98 m) wire run from the control box to the tower and up to the wind turbine, I used #6 (13 mm^2) direct burial cable with three conductors and ground. Near the junction box at the tower base and at the house entrance, the cable is run for about 12 feet (3.6 m) in 1 inch flexible conduit. A table with recommended wire sizes for different run lengths is part of the owner's manual for the AWP 3.6. House and tower ground rods are electrically connected.

No Slip Rings

The AWP 3.6 has no slip ring assembly, the component in most small wind generators that transfers the electricity from the rotating wind generator head to transmission cables going down the fixed tower. Instead, the AWP allows the transmission wires to twist up if the turbine yaws more in one direction than another. (Future versions may have slip rings, due to popular demand.)

Although this seems primitive, it may actually be a long-term reliability advantage. Several experts confirm that slip rings and brushes are a problem zone. Looking at my previous wind turbine, I realized that after 15 years of exposure to the elements, the plastic had become so brittle that the brush holders were literally crumbling apart. So I am inclined to believe that in the long run, three solid metal lugs may be a better investment than a set of cheap slip rings. Time will tell.

As the wind turbine yaws, it will twist its wires. The heavy 3/6 cable that runs up the guyed lattice tower is very stiff and cannot be twisted easily, so I used three, more flexible #8 (8 mm^2) wires that connect to the turbine through the tower top adaptor. I plan to untwist the wires when I do my twice-a-year maintenance.

Mechanical Setup

While bolting the wind generator together, I could not fail to see that its designer Hugh Piggott knew what he was doing. Although the design looks rough, almost crude at first sight, a second look reveals that it is ingeniously simple, using very few parts, which can all be produced with simple tools. I bet any person with a bit of technical talent will be able to assemble this machine without even

Balance of systems equipment—(clockwise from top right) Sunny Boy 700U inverter, Windy Boy 1800U inverter, Abundant Renewable Energy wind controller, diversion load, and AC mains panel.

looking at the manual—the parts let you know how to mount them. (Just remember that the curved sides of the blades face the tail.)

I had my 72 foot (22 m) guyed lattice tower already in place from a previous wind generator that broke down. I used the gin pole with three pulleys for pulling up the tower adaptor. My adaptor was welded at the local machine shop for US$219, with another US$102 for hot-dip galvanizing. After bolting on the tower adaptor, I set the gin pole higher and bolted it onto the adaptor with 1/2 inch (13 mm) U-bolts. That gave me the necessary height to lift the wind turbine.

I used my truck for pulling on 270 feet (82 m) of 3/16 inch (5 mm) aircraft cable. The way that I arranged the pulleys reduced the required force to half while it increased the cable travel by a factor of two. That allowed for quick and precise lifting with just three people—one in the truck, one at the tag line (rope to control swing), and one giving signals. Nobody needed to be on or even near the tower during lifting. If you try such an operation yourself, make sure you use industrial grade pulleys and cable or rope that exactly matches the roller size. My cable was too thin, jumped off the roller when the turbine reached the very top and jammed between the roller and its frame. We still got it bolted on, but had to fight much more than necessary. Hub height is at 79 feet (24 m).

Most people will use a different type of tower, anyway, so I listed costs for an 85 foot (26 m) tilt-up tower in the table. Tower kits for the AWP 3.6 are available from the American distributor, Abundant Renewable Energy, and come in heights ranging from 43 to 127 feet (13–39 m). You will need at least 5 cubic yards of concrete for the guy anchors and base.

Utility Issues

Dealing with the utilities has become easier since transmission companies were separated from the generators of electricity. In my case, the local grid is maintained by Oncor, whereas I can buy my electricity from TXU or another provider. The transmission company had no reason to put obstacles in my way because I am not going to hurt their business. They get their money either way. In fact, they employ special consultants for distributed generation who handle cases like mine. These people would lose their jobs if distributed generators did not exist. So our relationship has been quite friendly.

The interconnection process consisted of two relatively short documents—an application for distributed generation and the agreement for interconnection. The application was a two-page document and lists my address; technical information about the inverters, like voltage and current ratings, power factor, and UL file number; and a one-line diagram of the installation. The one-line diagram is a simple system schematic where all elements in the generation chain from the wind generator to the utility transformer are each symbolized and connected with a single line.

The agreement for interconnection apparently applies to all kinds of generators (one size fits all...) and therefore was more elaborate than necessary for my small turbine. I regarded the agreement as fair because the company and I both had to agree to the same terms regarding liability, indemnification, etc.

Helpful advice can be found in Paul Gipe's book, *Wind Power for Home and Business*. Do not expect any special treatment from the utility. You will either accept their terms and conditions or stay out. At least they must acknowledge your right to interconnection (PURPA). I was offered three different options: a) annual net metering with a single meter, but no payment for excess, b) payment for net production with two ratcheted meters for net production and net consumption, or c) payment for all production, metering all consumption and all production.

Since I will probably never generate more electricity than I use, I accepted the first option. This was the least bureaucratic and work intensive. I did not argue with the 800 pound gorilla that they did not have any legal right to dictate those options unilaterally. But with an annual instead of a monthly billing period, even a short-term overproduction will be fully paid for.

Operation

The AWP 3.6 operates very quietly, getting about as loud as when you hold a sea shell up to your ear. It will start up as soon as leaves in the trees are moving. Just don't expect more than a few watts output then—there is little energy in these winds. It is still pretty to watch, though. So far I have observed a maximum of 1,580 watts instantaneous output at

Geisler Wind Costs

Wind Turbine & Inverter	Cost (US$)
Windy Boy 1800U SBD inverter	$2,260.00
AWP 3.6 turbine, 110 V	2,250.00
Voltage clamp	600.00
Load resistor	240.00
Total Turbine & Inverter	$5,350.00

Tower, Hardware, & Tools	
AWP tower kit w/ pipe, 85 ft.	$3,100.00
3 Cables, #6 direct burial, 320 ft.	252.80
Concrete, 5 cubic yards	247.50
Backhoe work	150.00
Ditch Witch (rented)	125.00
Delta LA603 lightning arrestor	85.64
Delta CA302 R surge capacitor	57.43
Delta LA302 R lightning arrestor	44.95
13 Rebar, 1/2 in. x 20 ft.	38.35
Fused disconnect	34.95
Junction box	19.94
8 Wire lugs	16.80
Conduit, 1 in., 12 ft.	10.80
4 Conduit connectors, 1/2 in.	9.78
4 Cables, #8, 4 ft.	4.14
Circuit breaker, 15 A	3.56
Conduit, 1/2 in., 6 ft.	2.76
2 Conduit connectors, 1 in.	2.39
Total Other	$4,206.79
Grand Total	$9,556.79

the inverter. Considering inverter efficiency of 93 percent and 2 percent transmission losses, this indicates a peak output of more than 1,700 watts, and easily confirms the turbine manufacturer's output claims for batteryless, grid-tie systems.

The turbine generated a record output of 15 KWH during one day and night with steady high winds around 25 mph (11 m/s), which approaches the range that can be reasonably expected, according to the power curves. I have routinely observed energy outputs of 10 KWH per day in winter for five consecutive days. My AWP 3.6 keeps generating between 800 watts and 1,000 watts even while furling all the way. I like that because it would be disappointing to see it shut down exactly when the resource is best.

One time after we installed it, my turbine operated through a thunderstorm with 3/4 inch (19 mm) hailstones. Although I feared the worst, I found no damage except two tiny paint chips on the leading edges of two of the blades. Those blades are very strong for their weight. The utility grid also broke down for a few seconds, and the inverter accordingly disconnected. During that time, the DC voltage rose to 390 volts, but the energy was safely transferred to the dump load. When the grid stabilized, the system reactivated itself.

Efficient & Hypnotic

The grid-intertied AWP 3.6 does not provide emergency electricity, but generates about 50 percent more than the battery charging version, while using less space in the power room and saving battery maintenance and costs. The complete system impressed me with its sturdiness and quality, except for the paint job on the alternator. It is straightforward to install, and requires no active human intervention.

The quietly and slowly turning wind generator looks and feels more like a natural addition to our residence than like a high-tech artifact. Just watching it carries its own reward for me—it's like staring into a fire. Amazing...

Access

Dr. Bernd Geisler, 776 Lakewood Rd., Denison, TX 75020 • 903-327-4262 • texregeninfo@aol.com • www.texregen.com

Robert Preus, Abundant Renewable Energy, 22700 NE Mountain Top Rd., Newberg, OR 97132 • 503-538-8298 • Fax: 503-538-8782 • robert@abundantre.com • www.abundantre.com • U.S. distributor for AWP

"Apples & Oranges," by Mick Sagrillo in *HP90* • Excellent overview and comparison of wind generators

"Small Wind Electric Systems—A U.S. Consumer's Guide" • www.eren.doe.gov

Wind Power for Home and Business , Paul Gipe, 1993, Paperback, 432 pages, ISBN 0-930031-64-4, US$35 from Chelsea Green Publishing Company, PO Box 428, White River Junction, VT 05001 • 800-639-4099 or 802-295-6300 • Fax: 802-295-6444 • info@chelseagreen.com • www.chelseagreen.com • A truly valuable book about small wind systems

American Wind Energy Association's discussion group • http://groups.yahoo.com/group/awea-wind-home • The best resource if you have technical questions or problems

Jim Waldon, Windmill Photography, 524 Trout Ln., Denison, TX 75020 • 903-465-0317 • www.windmillphoto.com • Article photos

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Clearing the Air

Home Power Dispels the Top RE Myths

Illustrations by Harry Martin

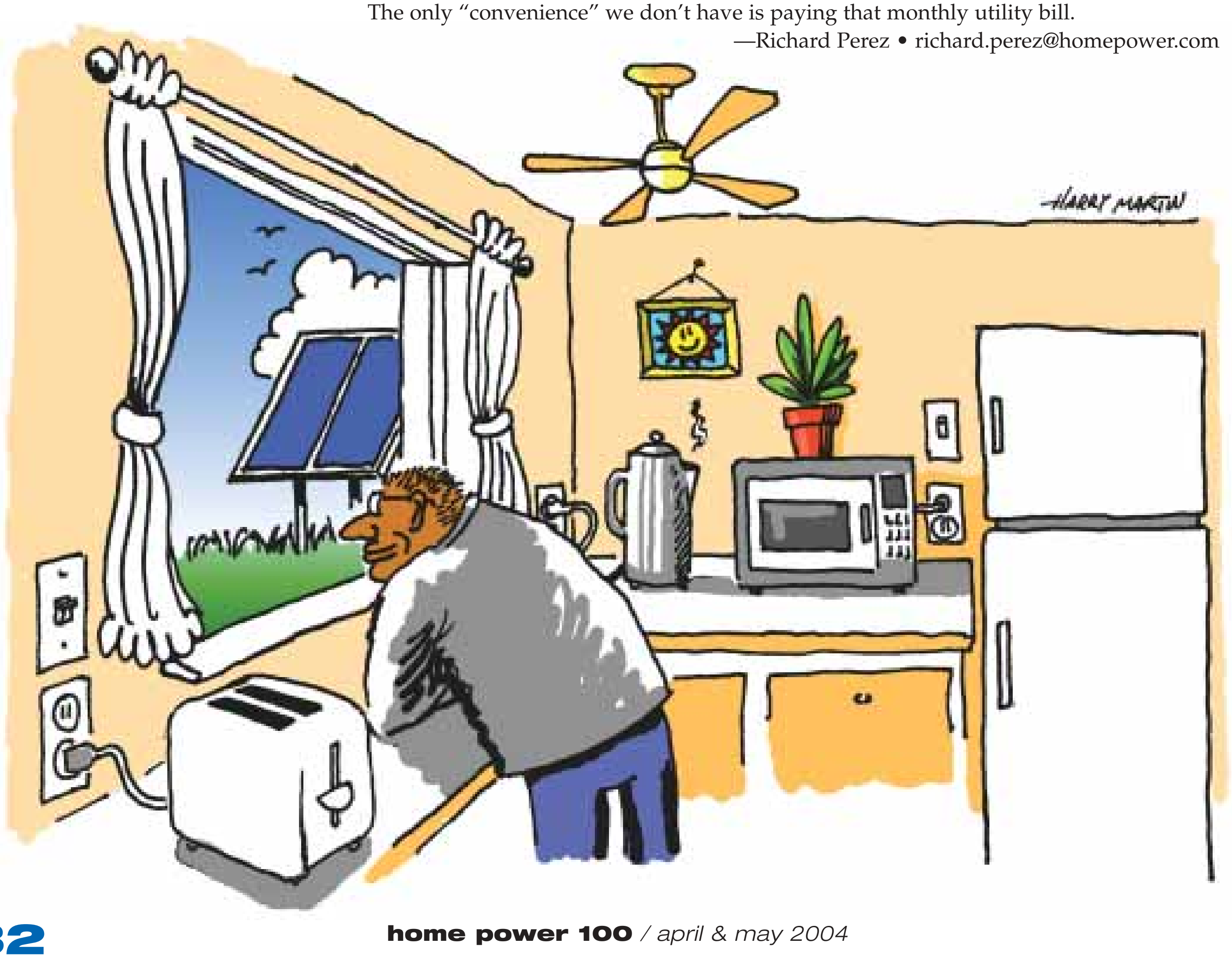
Home Power's position in the small-scale renewable energy (RE) community ensures that we hear it all, every day. Along the way, we've found that there's more than a little misinformation out there. Many RE myths are so widespread that they represent bona fide hindrances to the increasing use of these important technologies. This article is our collective debunking effort, in the interest of clearing the air.

Myth: Solar living means sacrificing conveniences.

Our solar home has all the conveniences that Karen and I want. Solar energy provides the electricity to run computers for our work; it pumps our water from the well; it entertains us with video and audio; it washes our clothes; it reheats our food and drinks in the microwave; it powers our refrigerators and freezers; it powers our ham radio, telephone, and Internet communications; it runs our power tools; and it lights up our nights. Solar heat cooks our food, heats our house, and provides hot water for washing our clothes, dishes, and bodies.

The only "convenience" we don't have is paying that monthly utility bill.

—Richard Perez • richard.perez@homepower.com



Myth: Wind turbines kill birds.

Do wind turbines kill birds? Some do. Is it significant? No. The question has been studied a great deal for utility-scale turbines. These massive turbines kill fewer than two birds per turbine per year. While no one wants to kill any birds, this number is dwarfed by the number of birds killed by habitat destruction, pollution, domestic cats, electrocution by utility lines, and collisions with windows, cars, and buildings.

For example, in the United States, agricultural pesticides are conservatively estimated to kill 67 million birds per year. Wisconsin Department of Natural Resources research suggests that rural free-ranging domestic cats in Wisconsin kill about 39 million birds each year. The windows in your house probably kill more birds in a year than the average wind turbine.

What about home-scale turbines? No studies have been done on these turbines, and researchers do not consider the issue significant enough to study. Compare a utility-scale turbine with a home-scale turbine. Even ignoring the massive towers, a typical utility-scale turbine is 50 to 200 times larger than a typical home turbine in swept area. This in itself is enough to answer any concerns about birds and a wind turbine at your home.

Birds must navigate through a wide variety of obstacles in their flying careers. Wind turbines pose no special hazards to them, and are in fact easier to notice and avoid because they move. In my twenty years of living with wind turbines, I've seen birds regularly alter their courses to avoid our turbines. Birds sometimes even perch on our turbines' stopped blades, but they leave as soon as the wind comes up and the blades start rotating.

Everything humans do has an impact on other people and on the environment. If you're looking for an energy source with *no* impact, good luck. Obviously, wind farms need to be sited intelligently, not directly in major bird migration flyways. But before we stop installing wind turbines because of a few bird kills, we should get rid of cars, buildings, utility lines, and cats…

For more information on wind turbines and birds, see www.awea.org/faq/sagrillo/swbirds.html

—Ian Woofenden • ian.woofenden@homepower.com

Myth: Solar panels make electricity from the sun's heat.

There are two major types of solar panel technologies. When it comes to how they work, they couldn't be more different from each other.

Solar hot water panels, also known as solar thermal panels or solar "collectors" capture the sun's *heat* to provide hot water for domestic use or home heating. These are large, dark, rectangular panels usually measuring around 4 by 8 feet (1.2 x 2.4 m). They look like very shallow rectangular boxes, and have been around and in use on residential rooftops for decades.

The second type of solar panel is the photovoltaic (PV) panel, also known as a solar-electric panel or module. These smaller and much lighter-weight panels use the sun's *light* to make electricity via what's known as the "photovoltaic effect." PV modules perform best in cool temperatures under bright sunlight. They come in all different sizes (including some that are cleverly disguised as roofing materials) and are turning up in a wide variety of residential, commercial, industrial, and scientific applications.

So you can get hot water from the sun's heat and electricity from the sun's light. If you've got sunshine, there's nothing keeping you from choosing both!

—Scott Russell • scott.russell@homepower.com

Myth: It takes more energy to build PVs than they can ever produce.

Some skeptics of solar energy claim that it takes more energy to make a photovoltaic module (PV) than it can ever produce in its lifetime. The truth is that PVs typically recoup their embodied energy in two to four years. According to an article published by the National Renewable Energy Laboratory (NREL), today's single and multicrystalline modules have an energy payback of about four years, and thin-film modules about two years.

Most PV modules in the field are made from hyper-pure crystalline silicon. Purifying and crystallizing the silicon consumes the most energy in making these PVs. Thin-film PVs are made from considerably less semiconductor material, and therefore have less embodied energy in them. Most of the energy consumed is in the thin-film surface. The aluminum frame on any PV accounts for about six months of its payback time.

Solar energy is an amazing technology considering that PVs go on to produce clean, pollution-free energy for at least 25 to 30 years after they have achieved payback. For more information on energy payback, see the National Renewable Energy Laboratory's Web site (www.nrel.gov) and Karl Knapp & Theresa Jester's article titled "PV Payback" in *HP80*.

—Eric Grisen • eric.grisen@homepower.com

Myth: Burning wood as fuel is bad.

Plenty of bad things can happen when burning any carbon-based material. But wood is renewable in the short term, which makes it one of the best carbon-based fuels for heating. CO_2 is a problem with burning nearly anything. In the case of wood, the same amount of carbon is released by burning as would be released by the natural decay of a fallen tree—there is no net increase in atmospheric carbon. With fossil fuels, the common alternative to wood fuel, the carbon is permanently locked up in the fuel unless burning lets it out, causing an increase in atmospheric CO_2, a proven cause of global warming.

There are negative effects of burning wood, mostly from particulates that get released. But using an EPA-certified wood heater will minimize this problem. There is always some kind of negative impact from creating heat. The goal of the considerate and responsible energy user should be to minimize these impacts, helping our world to become as sustainable as possible. The best way to heat is with the sun. But if you have to burn something, either make sure it is renewable, or that it is made with a renewable resource, and be sure it is done as efficiently as possible. See John Gulland's article on efficient and clean use of wood as a fuel in *HP99*.

—Michael Welch • michael.welch@homepower.com

Myth: Solar-electric module production is toxic to the environment.

A while back, there was a media barrage claiming that photovoltaic (PV) manufacturing was extremely hazardous to the environment. PV manufacturing does require the use of chemicals that are designated as toxic by the U.S. Environmental Protection Agency (EPA). Employee safety is paramount during the manufacturing process, and chemicals used must be disposed of in an environmentally sound manner.

The federally funded National Renewable Energy Laboratory (NREL) researched the media claims and concluded, "By using well-designed industrial processes and careful monitoring, PV manufacturers have minimized risks to where they are far less than those in most major industries. All of these risks fall well within the range already protected by OSHA and similar regulations."

A thorough analysis of the environmental impact that various energy sources have on the environment must take into account the net effect of a given source over the source's operational lifetime. When you compare the environmental impact of PV technology to traditional energy sources like coal and nuclear energy, PV comes out on top, hands down.

Nukes produce nuclear waste, and even after spending billions of taxpayer and ratepayer dollars, no acceptable disposal solution has been brought to the table. Fossil-fuel-based energy sources like coal produce air pollution over the power plant's entire operational lifetime—as long as it's running, it's polluting. Burning coal releases sulfur dioxide, which results in acid rain; nitrogen oxide, which results in smog; carbon dioxide, which results in global warming; particulates, which result in lung damage; and an array of heavy metals like arsenic, lead, and mercury, which result in birth defects and brain damage.

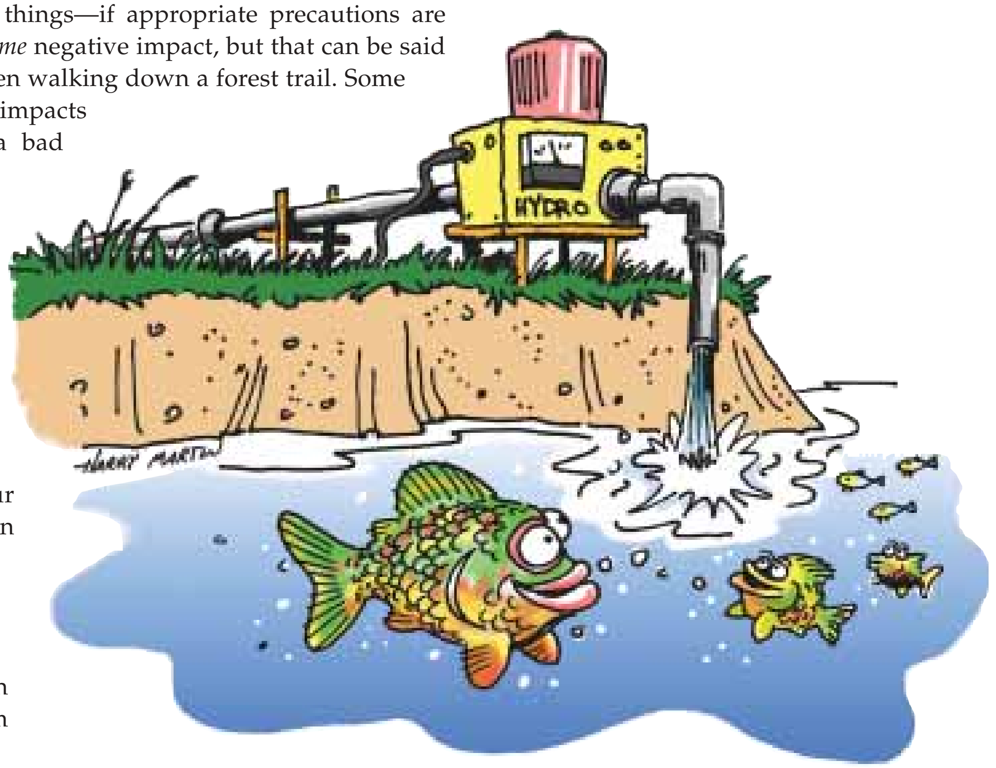
On the other end of the spectrum, PVs produce no emissions and require no use of finite fuel sources. PVs manufactured today are expected to be producing energy 50 years from now. PVs offset all the energy used to manufacture them (embodied energy) in two to four years in most locations. Fossil, nuclear, or solar—which energy source would you want in your backyard?

—Joe Schwartz • joe.schwartz@homepower.com

Myth: Microhydro is bad for river life.

The impact of microhydro on fish and other river life is tainted by association with blatantly destructive, large-scale hydro, which seriously impedes fish movement, changes stream temperatures and flow rates, slices and dices aquatic life, and even drowns entire ecosystems.

Microhydro does none of these things—if appropriate precautions are taken. There is always going to be *some* negative impact, but that can be said for nearly every human activity—even walking down a forest trail. Some misguided folks do not consider the impacts of what they do, and they give a bad reputation to those of us doing similar things in a more caring and respectful manner.



The idea is to minimize the impact of microhydro by following some simple rules.

- Always leave enough flow in the stream bed for aquatic life.
- If migratory fish use your stream, make sure that they and their fry can swim past your diversion, and cannot be drawn into the penstock intake.
- Always put the diverted water back into the same stream bed in a way that does not cause erosion.

—Michael Welch
michael.welch@homepower.com

Myth: Solar electricity is too expensive.

There is a huge public misconception that solar energy is simply too expensive to bother with. The reality is that, both on and off-grid, solar energy is cost effective in many applications.

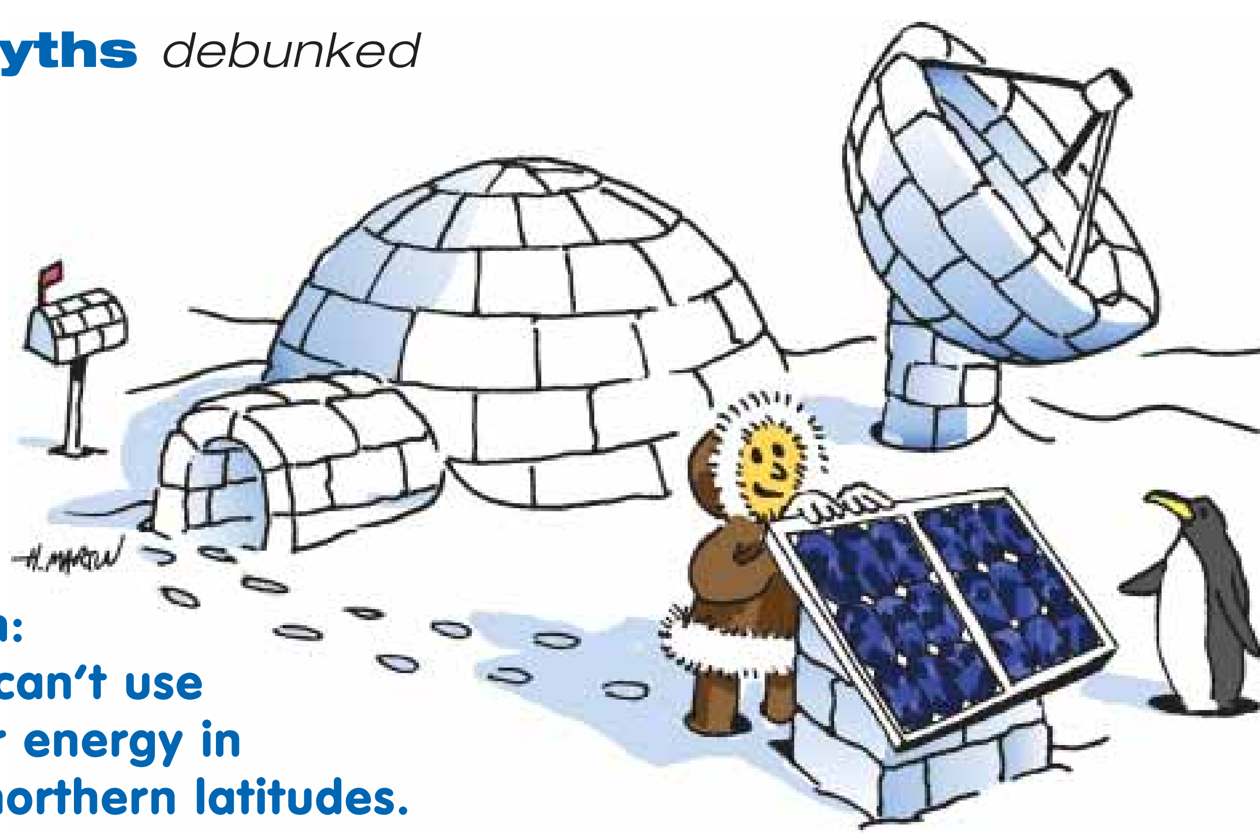
Right out of the gate, it's important to understand that on-grid, a substantial amount of "smoke and mirrors" is going on behind the scenes, making true energy cost comparisons unfair at best. The historical trend shows U.S. federal energy subsidies favoring mature energy sources like coal and nuclear over renewable sources by a factor of one hundred to one. A report based on U.S. Department of Energy (DOE) data by the Congressional Research Service (CRS) states, "Because the great bulk of incentives support mature fossil and nuclear equipment, the existing subsidy structure markedly distorts the marketplace for energy in a direction away from renewables."

The bottom line is that renewable energy *appears* to be more expensive than traditional electricity generation sources, but the reality is that you pay the difference every year come tax time. If you include the costs of increased pollution, habitat destruction, health care costs, etc., then RE looks even better. Fortunately, many individual states are doing what the feds refuse to do, and are implementing rebate programs for renewables that serve to even out the financial playing field a bit. For some great economic analyses of the cost effectiveness of grid-tied PV, see the article by Greg Bundros in *HP99* and the article by Paul Symanski in this issue.

Off-grid, people have been realizing the financial advantages of solar energy for more than a decade. Property beyond the reach of the utility grid is typically undervalued, and a great investment. We're not necessarily talking about living "out in the sticks." A good rule of thumb is that a solar-electric system costs less than a utility line extension of a quarter mile (0.4 km) or more.

I had the local utility provide me with an estimate for running a line to my off-grid home site (though I was never going to take them up on it!). They came up with a cost figure of US$32,000. I used this estimate as leverage when I purchased the property, which substantially lowered the seller's asking price. From day one, renewable energy technology saved me over US$10,000 compared to bringing the grid in. How's that for an incentive!

—Joe Schwartz • joe.schwartz@homepower.com



Myth: You can't use solar energy in far northern latitudes.

Solar energy can and does work in northern latitudes. A trip to any well-designed passive solar building can be one of the most uplifting experiences in the cold winter months because of the warm, cozy atmosphere it affords. Every square foot of south-facing insulated glass can let in the heat equivalent of about a half gallon of heating oil from the sun each heating season. Cover the glass with insulating shades or shutters at night, and the heat equivalent can increase to nearly a gallon for each square foot of window.

There are too many examples of the successful use of solar energy in northern latitudes to be included here, but hundreds of solar home owners in far northern latitudes have opened their doors in the American Solar Energy Society's National Solar Tour (www.ases.org). *Home Power* magazine has been bringing you articles about successful solar-electric systems in Canada and the northern United States for the past seventeen years. Germany, the world's second largest user of electricity generated by PV modules, is not located in the Sunbelt, but rather at 48 to 54 degrees latitude.

Obviously, the largest obstacle to using solar energy in the north is the short, cloudy days of winter. Annual net metering of PV systems has really helped overcome this obstacle for on-grid solar-electric systems by providing a year's energy "storage" (in terms of dollars and cents from a billing perspective). The long, sunny days of summer can directly compensate for the shorter days of winter in northern latitudes.

Something interesting to think about is that the peak electrical loads in many northern cities, such as my home of Burlington, Vermont, have shifted from the winter months to the summer months over the past ten years. This shows that there is ever increasing potential of solar electricity in northern latitudes to complement the passive solar and solar thermal systems that have been working for the past twenty or more years up north.

—AJ Rossman • aj@drakersolar.com

Myth: Lead-acid batteries wind up as toxic disasters in our landfills.

Hardly any other industry does a better job at recycling than the lead-acid battery industry, and this includes aluminum, glass, paper, and plastics. More than 90 percent of spent battery lead is recycled, which is two to four times higher than many other major recyclable commodities. And 60 percent of the lead used in manufacturing lead-acid batteries is derived from recycled lead. Most of the lead used in your car's battery has probably ridden around in three or four other cars before it got to yours.

Worn out lead-acid batteries are accepted for recycling by all outlets that sell these batteries—it's the law. From there the batteries are broken open, and the lead is removed and resmelted for reuse in new batteries. The only way a lead-acid battery winds up in a landfill is if a careless user dumps it there. So don't break the recycling chain—return your spent batteries to a dealer for recycling!

—Richard Perez • richard.perez@homepower.com

Myth: Grid-intertied PV is hazardous to utility lineworkers.

Although this may be one of the most pervasive myths in the electricity industry, I was unable to locate a single documented instance of injury or death to a utility worker from a grid-intertied inverter. The reasons for this are two-fold—modern inverter design and lineworker safety protocol.

Inverters are perhaps the most highly scrutinized piece of electronics used in residential applications. Their safety and proper functioning are certified by some of the same agencies that verify the safe operation of all the other appliances in your home.

Inverters for use in grid-intertied systems are required (by IEEE, the *NEC*, and UL) to disconnect from the grid for any number of conditions. These include grid outage, high or low voltage, high or low frequency, and inverter malfunction.

Inverters are required to have several redundant safety devices built into their electronics to ensure that they disconnect from the grid if anything at all is wrong. Nonetheless, utility companies and lineworkers are quite safety conscious, and leave nothing to chance.

Lineworkers are trained to always ground any potentially energized conductors when performing utility line maintenance. In addition, grid-intertied systems are routinely required to have a safety disconnect available for the lineworker's use to lock out any solar electricity generation from being backfed onto the grid.

Lineworker safety protocols make a great deal of sense. During utility outages, many people use engine generators to keep the electricity on in their homes and businesses. Most engine generators do not have the intricate electronics that inverters have to ensure lineworker safety. If they are not correctly hooked up with a transfer switch to isolate selected circuits in the home from the utility grid, the generator can backfeed electricity to the grid through the utility's transformer, which converts it to extremely high voltage.

Lineworkers have been killed by engine generators, so it's a good thing they practice safety rigorously. In fact, the problems with engine generators are the reason utilities have been so cautious about allowing any other customer-owned generating sources on their lines at all.

Since inverters have such a strong safety record, some day soon they will be a common and accepted part of many home electrical systems. They will outlast the urban myths of lineworker lore. For a more thorough discussion of utility-intertie inverters and how they work, see *HP71*, page 58.

—Linda Pinkham
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Myth: All solar heating systems need a backup fossil fuel energy source.

While it is true that most solar heating systems have a conventional backup heating system, it isn't absolutely necessary. Fossil fuel heat as a supplemental system is a cost, financing, and comfort decision. Many solar energy heating systems rely on the renewable resource of wood for any heat not supplied directly by the sun.

A combination of passive and active solar energy collection is probably the easiest and most cost effective way to avoid a conventional backup system. A super-insulated passive home design in a sun-friendly climate can provide all but a small fraction of the energy needed to heat a home. An active solar heating system typically stores heat in a large storage tank (many people use an indoor pool) for the times that the passive system is unable to collect enough energy, or a severe storm calls for more heat than normal. A PV system provides the required electricity. This type of design is not the norm by far—it's just a little too expensive up front for most people—and it might require the owners to put on a sweater indoors a few times a year.

The expense of going 100 percent solar and the possibility that the home might fall to 60°F (16°C) or so in rare circumstances are the reasons that most solar homes have a conventional backup. Another factor that looms large for many people is that mortgage bankers are very nervous about lending money on homes that fall out of the conformity they are familiar with.

—Chuck Marken • chuck@aaasolar.com

Myth: Hydrogen fuel cells are a renewable energy source.

Hydrogen fuel cells produce DC electricity from hydrogen. They do this cleanly and quietly. But where does the hydrogen come from? Though hydrogen is the most common element on earth, unlike sun, wind, and falling water, it is not freely available. It must be stripped out of hydrocarbons or split out of water. These operations take energy, and the actual energy source may not be renewable at all.

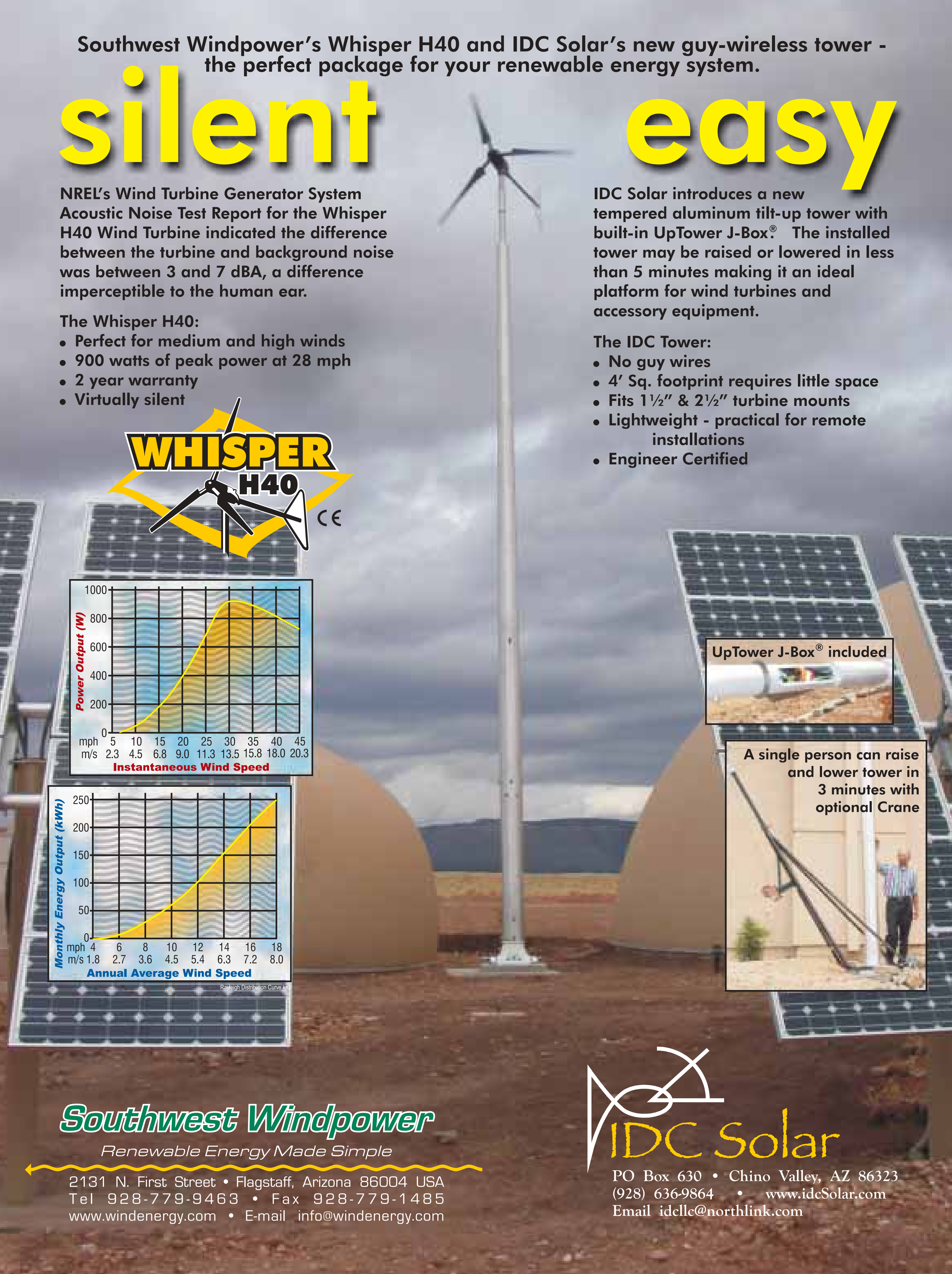
Hydrogen can be thought of as an "energy carrier." We use some energy to get it out of hydrocarbons or water, and then we get the energy back when we run the hydrogen through a fuel cell or engine. Every conversion of energy has an efficiency cost and an equipment and maintenance cost. If hydrogen fuel cells have a place in renewable energy systems, they must be a step forward in terms of cost, efficiency, and environmental friendliness. The jury is still out on this issue.

In renewable electrical systems, hydrogen fuel cells might replace two different components that we use today—generators and batteries. Many people use gasoline, diesel, or propane-fired generators as charging or backup sources in off-grid or on-grid RE systems. Fuel cells could be a quieter, cleaner answer, even if they use nonrenewable fuels.

To replace batteries in RE systems, you need two other components besides the fuel cell. First, an electrolyzer is needed to split hydrogen out of water, using your surplus renewable energy. Then you need a hydrogen storage system—not a simple proposition.

Any new technology takes time and money to develop. Hydrogen fuel cells may play a role in RE systems in the future. But the energy sources that power them should be the sun, wind, falling water, and the like. Otherwise we are just pinning our hopes on more nonrenewable energy, with a high-tech twist.

—Ian Woofenden • ian.woofenden@homepower.com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silent
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NREL's Wind Turbine Generator System Acoustic Noise Test Report for the Whisper H40 Wind Turbine indicated the difference between the turbine and background noise was between 3 and 7 dBA, a difference imperceptible to the human ear.
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Power Output (W)
1000
800
600
400
200
0
mph 5 10 15 20 25 30 35 40 45
m/s 2.3 4.5 6.8 9.0 11.3 13.5 15.8 18.0 20.3
Instantaneous Wind Speed
Monthly Energy Output (kWh)
250
200
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m/s 1.8 2.7 3.6 4.5 5.4 6.3 7.2 8.0
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From Cleopatra to Columbia

Randy Udall

It is now apparent that the space shuttle Columbia was in trouble long before it broke up over Texas last February. Within hours of the tragedy, disturbing photos taken by California astronomers were posted to the Internet. In these images, the streaking shuttle shone like a torch. Off to the side were smaller bright spots, fluttering down and away. These, NASA believes, were omens of disaster, heat shield tiles shedding from the left wing. As superheated plasma fed into the breach, it melted the wing's aluminum skeleton, dooming the reentry. When the first tiles came off, the astronauts were traveling 15,000 miles an hour. Six minutes later, and 1,500 miles to the east, their ship disintegrated over Texas.

From time to time, I lecture about energy issues, and before this accident, I had often compared our industrial civilization to a space shuttle, the world's most sophisticated flying machine. The shuttle, like the civilization, has an enormous energy appetite. During launch, each of its six fuel pumps consumes as much energy as a city of 50,000. At full thrust, its main engines could power California.

As a child of the space age, I remember watching John Glenn's first orbital mission in 1962. It was a quick trip—three laps at 17,544 miles an hour. In a few hours aloft, Glenn clocked 80,000 miles. The original astronauts were revered as a special breed. Lately, though, I've begun to wonder if all of us aren't, in some curious way, as energy-rich and speed-drunk as any NASA pilot. John Glenn and John Doe have more in common than they suspect.

Hypermobility

A typical baby boomer, for example, will drive and fly more than a million miles during his or her lifetime, equal to forty trips around the planet. Magellan and Amelia Earhart were the famous circumnavigators of their day. But now every man is Magellan, every woman Amelia. Even if you never fly, it's still possible to log a million miles. Many commuters drive 20,000 miles per year, the distance to the Moon every twelve years. I own a rusty Volvo with 250,000 miles on it. It's been to the Moon, and is on its way back.

Our fantastic hypermobility is taken for granted. This afternoon you could drive to the nearest airport, book a flight for Paris, and fly the Atlantic just like Lindbergh did in 1927. He was greeted by thousands of awestruck Frenchmen, and like Glenn, would be a hero for life. You? You can gripe about the airline food or carp about security.

So, how did we get here—to this place where 50 mph seems slow, where jet lag is an occupational hazard, where speed rules? If as someone once wrote, "Your soul can only travel at the speed of a camel," there must be millions of plodding souls out there, searching the barren wastes, wondering where in the blazes their owners went.

Muscle Power

Our world is so dominated by machines and motors (50 in a typical home) that it's easy to forget that most of human history has been powered by muscle. In his book, *Prime Mover: The Natural History of Muscle*, Steven Vogel describes how muscle makes up 40 percent of our weight, that nature perfected muscle a billion years ago, that muscle powers ant and elephant alike, that "flies fly with it, clams clam up with it." To watch bicyclist Lance Armstrong hammer up the French Alps is to see muscle returned to its former glory.

As every backpacker quickly learns, a muscle-powered world has a different rhythm, a slower tempo. Writing about the Lewis and Clark expedition, author Stephen Ambrose explained, "In 1800, nothing moved faster than the speed of a horse. No human being, no manufactured item, no bushel of wheat, side of beef, no letter, no information, no idea, order, or instruction moved faster. Nothing ever had moved any faster and, most people thought, nothing ever would."

By canoe and horseback, it took Lewis and Clark two-and-a-half years to travel from St. Louis to the Pacific Ocean and back. Paddling downstream on the swollen Missouri, they may have broached 8 miles an hour, but that was their speed limit. To go faster than this, you need a machine of some sort. On flat ground, Armstrong can pedal his bike about 30 miles an hour, generating about one-half horsepower for short periods.

If men or women work in unison, it's possible to develop more power, and Cleopatra offers a nice example. Her idea of a good time was to have 60 slaves row her along the Nile. Tugging on the oars, with some encouragement from the lash, this crew could produce about eight or ten horsepower. Put differently, the queen of Egypt, the world's richest woman, had about 200 times less power at her disposal than a typical soccer mom in an SUV.

THE QUEEN OF EGYPT, THE WORLD'S RICHEST WOMAN, HAD ABOUT 200 TIMES LESS POWER AT HER DISPOSAL THAN A TYPICAL SOCCER MOM IN AN SUV.

Energy Rich

Unlike muscle, aka meat, the ancient edible engine, machinery is quite new. Go outside and pop the hood of your car. There in your driveway sits an engine more powerful than anything on the planet two hundred years ago. Your neighbor has one, too. From an energy perspective, both of you are astoundingly rich.

Cars have not been good for civic life, climate protection, or land use planning. But the engines manufactured by car companies each year are more powerful than all the world's electric power plants combined. American automobiles consume about four times more energy each day, in the form of gasoline and diesel, than we humans do in the form of food. They, not we, are the planet's dominant life form.

Photovoltaic panels and wind turbines and sailboats run on flows of energy. But machines must be stoked with fuels. Wood, of course, is the original. Towards the end of their empire, the Romans had built an entire fleet of ships to import wood from France and North Africa.

Whenever wood ran short, and wherever geology permitted, people burned coal. In her book *Coal: A Human History*, Barbara Freese describes how some Chinese miners used to work what they called the "big shift," living in the mine for a month at a time, digging, eating, sleeping, smoking opium, and even doing laundry underground.

Coal has long kept people warm, and still does in many places, but it took a genius to turn coal into motion and thus spark the Industrial Revolution. His name is found on every light bulb and solar panel—James Watt, the famed Scottish inventor of the steam engine. From coal came steam and iron, and the three quickly learned how to feed on each other.

The poet Emerson was among the first to grasp the implications. "Coal is a portable climate," he wrote. "Watt whispered in the ear of mankind his secret, that a half-ounce of coal will draw two tons a mile, and coal carries coal, by rail and by boat, to make Canada as warm as Calcutta, and with its comfort brings industrial power." Today, coal seems like a retro fuel, but more than half of U.S. electricity comes from burning it, and the Chinese have more coal miners than soldiers.

If coal and steam feed on each other, so too do energy and ingenuity. In 1903, the Wright Brothers, bachelor bicycle mechanics, deciphered the rules of flight and built the pieces of the world's first airplane, lashing them together with muslin cord. Wilbur Wright, in particular, was brilliant, a total genius. Their plane was powered with gasoline donated by John D. Rockefeller and a four-cylinder, 12-horsepower engine that the Wrights built above their bike shop. When Wilbur flew around the Statue of Liberty in 1905, he lashed a canoe below the wing in case of a water landing. Sixty-six years later, Americans were driving on the moon.

The essayist Loren Eiseley wrote, "Man's long adventure with knowledge has been a climb up the heat ladder… The creature that crept furred through the blue glacial nights now lives surrounded by the hiss of steam, the roar of engines, and the bubbling of vats. And he is himself a great flame, a great roaring wasteful furnace, devouring irreplaceable substances of the earth."

Oil Tribe

Those of us alive today tend to believe that we are living in a normal time, that malls and expressways are the nature of things. From an energy perspective, however, this is lunacy. In recent times, we have read about the Pashtuns, Uzbeks, and Tajiks in central Asia, strange tribes with curious customs. But contemporary Americans are arguably the world's most exotic people, members of the Oil Tribe.

Daily energy flows in the U.S. are now a million British thermal units per person. This is the energy equivalent of eight gallons of gasoline or 100 pounds of coal. One million BTUs is also roughly equivalent to how much energy it would take to ride a bike 25,000 miles. Or the amount of energy contained in a bolt of lightning. This is America—explosive, lit up, mobile, jacked to the nines.

The defining ritual of our culture is not Monday Night Football or church on Sunday; it is pulling into a gas station to fill 'er up. Per person, we Americans now consume 140 pounds of petroleum products each week—nearly our body weight every seven days. Petroleum is more addictive than cocaine, and for a culture like ours, all roads eventually lead to Baghdad, to the Persian Gulf, to five Muslim nations that own half the world's remaining oil.

We Americans are as dependent on oil as the Sioux were on bison. But whereas they celebrated the beast in dance, story, and ritual, we pull into the 7-Eleven, buy 20 gallons and whine about the cost. We ought to have a holiday dedicated to petroleum, or at least bow to Mecca when we buy it. And the fact that we don't says something troubling about us.

I'm left with two questions. If our oil-driven civilization can be compared to a space shuttle, have the first tiles already come off? How stable is our Starship Enterprise?

And it's not just the 150,000 soldiers we've sent to Iraq, and the other soldiers fighting proxy oil wars on our behalf in Colombia, Kuwait, Qatar, Kazakhstan, and Indonesia that concern me. Last summer, we also had the spectacle of Federal Reserve chairman Alan Greenspan testifying to Congress about the nation's natural gas crisis. Due to rapid depletion rates at existing wells, Greenspan noted, "More than half of the nation's current gas production must be replaced in the next three years." Two-thirds of the nation's oil has already been burned, automobile fleet mileage is at its lowest level in twenty years, the 1990s were the warmest decade in a thousand years, purchasers of Hummers qualify for a $100,000 tax deduction, and since 1990 we have added one California's-worth of people and automobiles.

Who's Driving?

And so, as we fasten our seatbelts in the event of unexpected turbulence, it behooves us to ask my second question—is anyone in the cockpit, is someone actually flying this thing, or are we on autopilot?

I've visited drilling rigs and power plant control rooms, so I know that engineers are monitoring the electricity grid, gathering the natural gas, and making sure that the Alaska oil pipeline doesn't freeze and turn into the world's largest Chapstick, in Amory Lovins' memorable phrase. But the more I read, the more convinced I am that the flight deck itself is empty. Maybe the pilot had an infarct, or maybe there never was a pilot, but U.S. energy policy is brain dead, and prospects for a soft landing don't appear good.

Join the Sun Clan

So maybe it's a good time to learn about energy, learn about home power, learn about how we might capture some of that sunlight hitting the roof, which has traveled 93 million miles in eight minutes, photons hauling ass. If we've climbed up Eiseley's heat ladder, our children and grandchildren may have to climb back down. So maybe we ought to spend less money driving to the Moon, and a bit more on compact fluorescent lights, which can reduce our greenhouse gas debts, and on photovoltaic panels, which outliving us, are a gift we can give our descendants, Godspeed on their journey.

You and I are traveling awfully fast, but no one ever said that members of the Oil Tribe couldn't join the Sun Clan, celebrate the Solstice, and rearrange our priorities. It's an unusual moment in human history. Maybe speed and power aren't everything they've been cracked up to be. If we slowed down a bit, let the engine cool, maybe our souls could finally catch up.

Access

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Other *Home Power* articles by Randy Udall:
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"When Will the Joyride End?" • *HP81*
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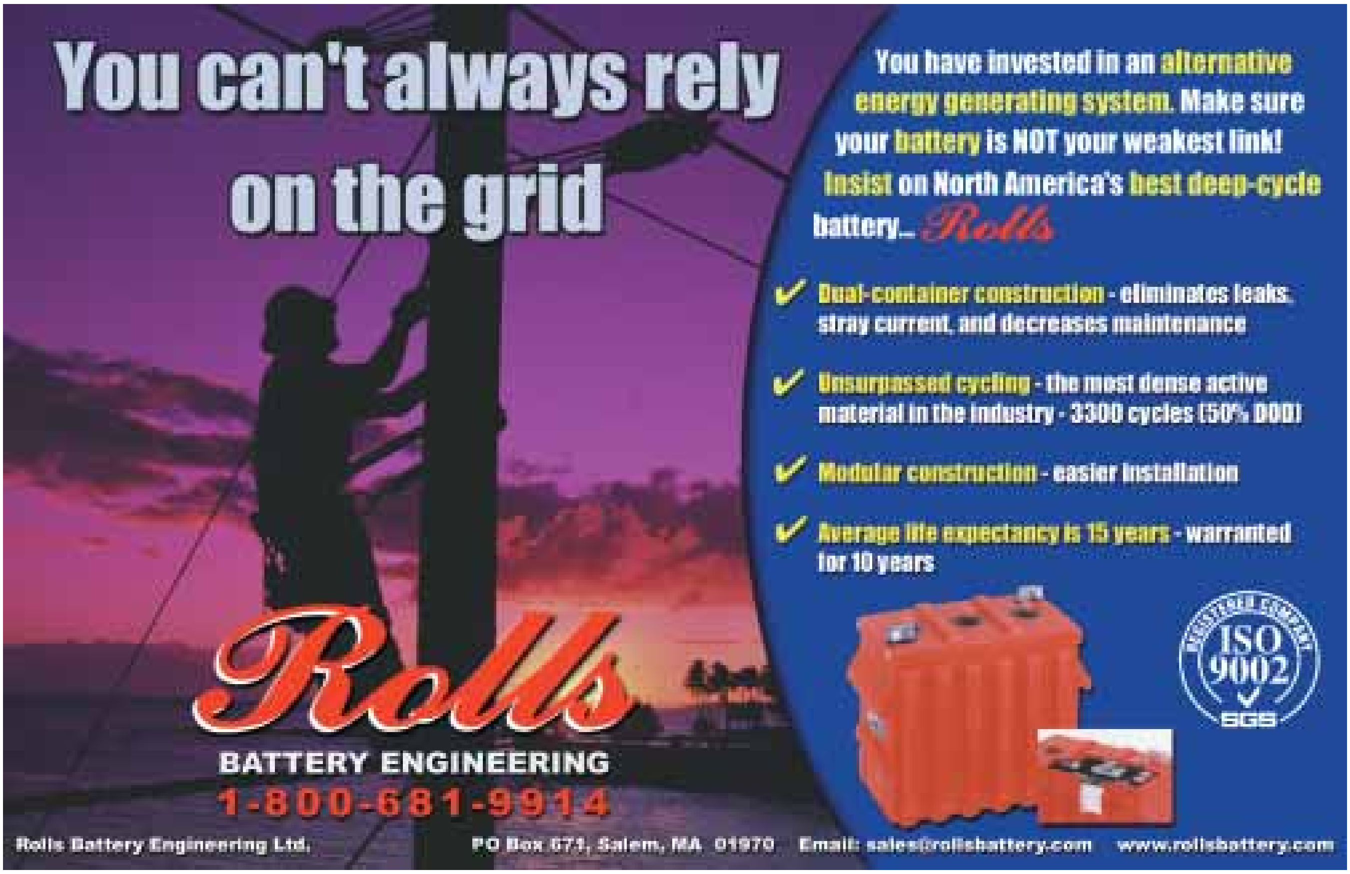
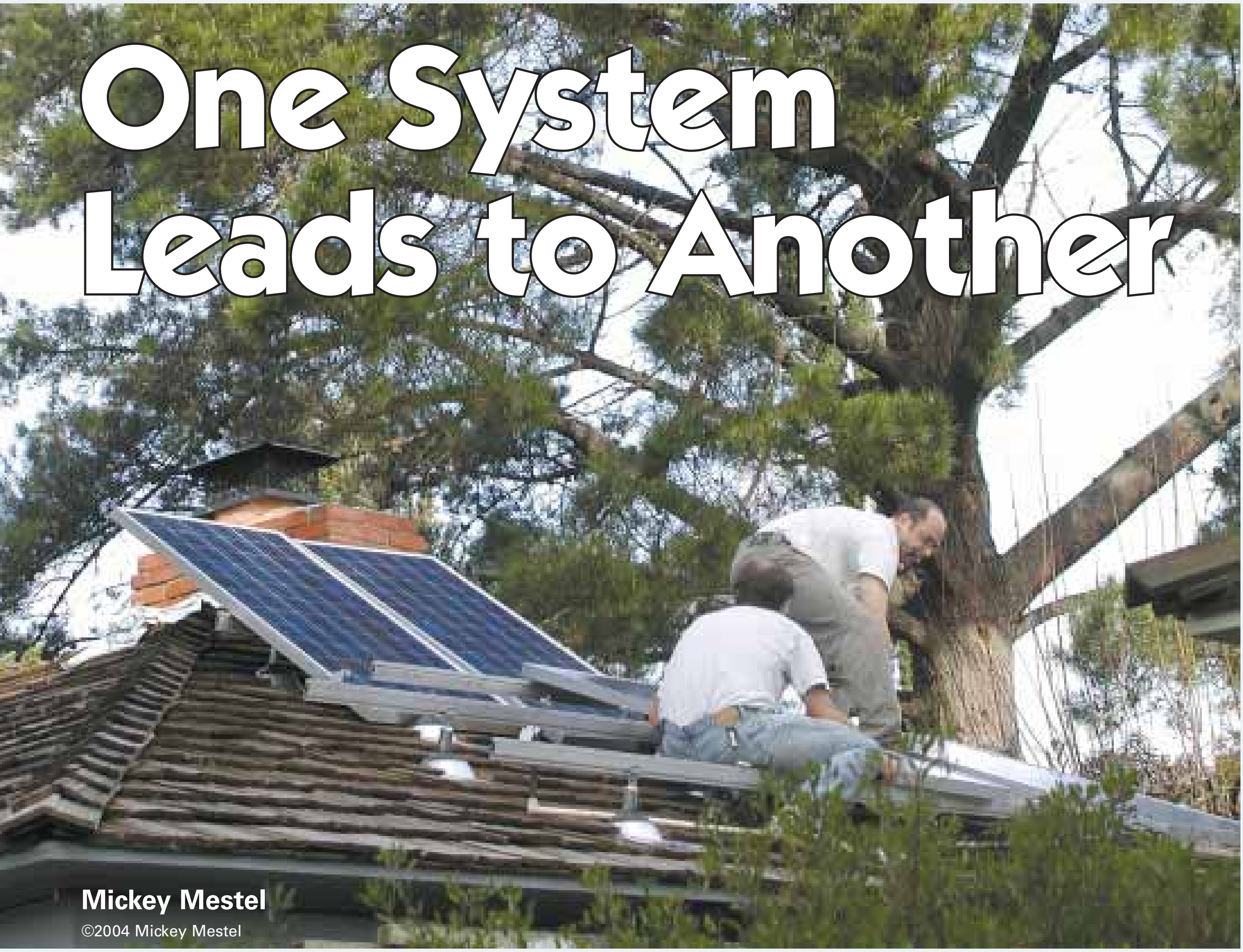


One System Leads to Another

Mickey Mestel



The author (right) and Dave Coale (left) installing the PVs.

My article in *HP93*, "Backyard Solar Made Simple," described how great it was to be able to pull some of our juice directly from the sun. At the time, I couldn't justify a grid-intertie system since we were renting the house that we lived in. Well, we still rent the same house, but circumstances called for us to do it anyway. Once it became clear to me that we were going to war in Iraq, and in my opinion the motive was little else besides oil, I decided that I had to do something more.

We already owned a Toyota Prius as our main vehicle, used an on-demand water heater in the house, and used an average of only 6 KWH of electricity per day. Still, the small, stand-alone system we had previously installed wasn't enough, and I wanted more.

I went to my landlord and told her what I wanted to do. She is a wonderful woman who lives right in front of us, and was actually more concerned for us than for herself in this matter! This house will go to her nieces and nephews as their inheritance, and she wanted to make sure that if we are still here when this happens, we will be able to prove that the system is ours and not the estate's. Everyone should be blessed with a landlord like this.

We drew up a document saying that the system belongs to us, and when we leave, we can either take it with us or the estate has the option to buy it. That gives us a great deal of flexibility, and we know that if we sell it, we are leaving a smaller environmental footprint behind us.

Tech Specs

System Overview

System type: Batteryless grid-intertied PV
Location: Palo Alto, California
Solar resource: 5.4 average daily peak sun hours
Production: 98 AC KWH per month average
Percentage offset by PV system: 54 percent

Photovoltaics

PV: 6 Sharp NE-Q5E2U, 165 W STC, 24 VDC
Array: 990 W STC, 144 VDC nominal
Array disconnect: Siemens heavy duty safety switch, 30 A, 600 VAC, 600 VDC
Array installation: Roof-mounted UniRac SolarMount, oriented true south; 20 degree tilt angle

Balance of System

Inverter: SMA Sunny Boy SB1800U, up to 400 VDC input, 120 VAC output, 139–400 VDC MPPT voltage window
System performance metering: Schlumberger Centron KWH meter

DC disconnect (left) and Sunny Boy inverter (right).

(Down) Sizing the System

So, off I went! Sizing the system was relatively easy for two reasons. The first is that our utility bills give the usage for each month for the past year. This eliminates the need to make up a whole system load chart. We could determine the size of the array we needed simply from these utility bill numbers. The annual total showed that we are using an average of 5.87 KWH per day, which I rounded up to 6 KWH per day.

Our small, stand-alone PV and battery system does reduce our utility bill, but not much. We still run the juicer, blender, vacuum cleaner, and cell phone chargers off the small system, but this probably saves us no more than about 250 WH per day. The biggest draw on this system is the vacuum cleaner, which I run about once a week. The juicer and blender only run an average of once a day for 2 to 5 minutes, so they are not much of a load.

The number of kilowatt-hours we use continues to amaze me, even though I've known it for a while now. The average American home uses about 20 KWH per day. We live in a 1,200 square foot (110 m^2) house, and have most of the modern appliances, except for a microwave and a dishwasher. We do all the things most households do, except that the television is only on for an average of 1 hour a day or less. With a 1-year-old, we do three to four loads of laundry a week. And our refrigerator isn't even Energy Star compliant! We needed a small unit due to lack of space in the kitchen, and it is harder to find smaller units that are efficient. Our range/oven and space heating are both gas.

We have done a number of simple things that have enabled us to use as little energy as we do. We have almost all compact fluorescent (CF) bulbs. We have eliminated all phantom loads, (TV, VCR, DVD player, computer, DSL modem, printer, and speakers). We switched from a desktop to a laptop for our main computer system. We installed an in-line manual switch for the electric water heater that serves only the washing machine. And maybe most important, we are very conscientious about turning off lights when not in the room.

Being conscientious was the hardest part of all, and it is still an unlearning process from many years of growing up and abusing energy. After two or three years at it, I still find myself walking out of a room and leaving the lights on once in a while, but will almost always notice that the lights are on and no one is in the room shortly afterwards.

Since both of us tend to use the computer a lot, it is common for the computer system to be on for eight or more hours a day. With the old desktop system, it would draw anywhere from 100 to 120 watts continuously. Averaged over the course of a day, this would use more energy than our refrigerator! With the laptop, this is down to about 40 watts continuously, a huge savings. The laptop is also configured to go into sleep mode if not in use for more that 5 minutes, another huge savings when we aren't using it.

It is said that for every $1 of efficiency measures, you save $3 to $5 in RE generation costs. This also means major savings if you are using grid electricity. It is difficult for me sometimes when I see how easy and cheap it is to save large amounts of energy, and yet most people simply aren't aware of their energy use.

Array Sizing

The second reason that sizing was easy for us was roof space. I have only a small area of available south-facing roof. It is triangular, with a 25 foot (7.6 m) base and 12.5 foot (3.8 m) height, totaling 156 square feet (14.5 m^2). Obviously, only a portion of that is usable, the portion that can fit a number of rectangular panels without going over the edges. (Some major PV manufacturers are now making triangular modules to fit into those rooflines.) I drew up a small diagram, and played with various sizes of rectangles, based on the sizes of the panels listed in the specs by the various manufacturers.

In the end, I decided on a little less wattage to be able to go with fewer large panels instead of more small panels. I liked the idea of fewer connections and fewer panels to install, fewer holes in the roof, and a quicker installation. I opted for six Sharp 165 panels, since the size and output was right. I could easily fit the six panels on the roof, and they added up nicely to 990 W and 144 V nominal when connected in series, enough for one string on a high voltage Sunny Boy 1800 watt inverter.

Putting It All Together

I ended up with a very straightforward system design—about 1 KW of panels and a Sunny Boy inverter. The Sunny Boy was a given. It has the best reputation in the industry right now. It's a high voltage inverter, which makes for much simpler wiring, and the price is right.

The meter spinning backwards—selling to the grid!

I found what I needed at Northern Arizona Wind and Sun. They had great prices both on the panels and the inverter, as well as an AC disconnect and the UniRac SolarMounts. The only other major thing I needed was the DC disconnect and all the wiring and conduit, which I got from the guys at Palo Alto Hardware's solar division. (This is an Ace hardware store that has a very successful solar

The completed system, with the small 64 W system in the background (see *HP93*.)

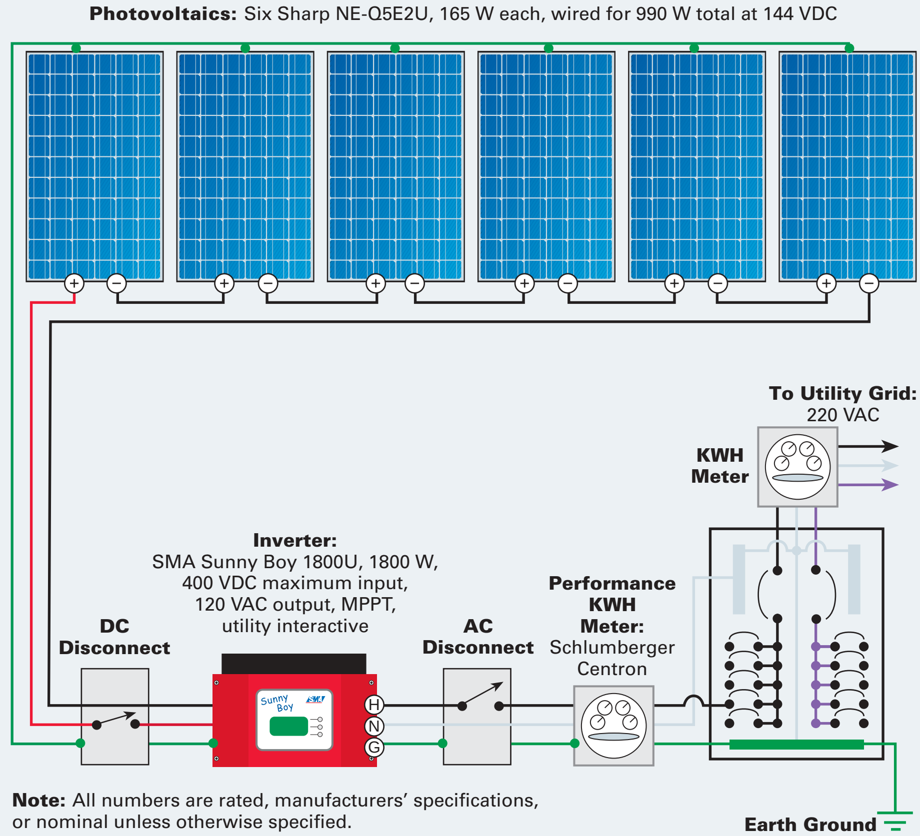
division, and 30 KW of PVs on their own roof. I guess there's more to the name "Silicon Valley" than meets the eye…)

The toughest part of the installation was working on the roof. It took almost a whole day to cut the cedar shakes away down to the slats so we could bolt the PV mount standoffs to the rafters, and then get the roof jacks over the standoffs and under the remaining shingles to make a watertight seal. Not a job I look forward to doing again—I would probably hire this out next time.

Once that was done, it was all very easy. I am lucky to have a friend, David Coale, an electric vehicle whiz, who is expanding into photovoltaics, around to give me a hand. Early on a northern California January day, we got started.

The six panels went up quickly, with the positive, negative, and equipment ground from the series string going into a weatherproof junction box, and then into 1/2 inch EMT. The EMT goes over the roofline and gutter, under the soffit, and around to the DC disconnect, which is on the back side of the house. I wanted the inverter and disconnect on the back side of the house out of view, and in a place where I would have easy access to it, right out the back door.

We used #10 (5 mm^2) THHN wire for the 25 foot (7.6 m) run from the panels to the inverter, which gave us less than 2 percent wire loss for 25 feet (7.6 m) at about 5 A. From the inverter, the AC also ran via #10 for the 70 foot (21 m) run to the AC disconnect. This was more than adequate for this distance, but again ensured minimal line loss.



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

Mestel System Grid Usage

The service panel for this house is on the detached garage about 25 feet (7.6 m) from the house, so we ran the wires in 1/2 inch EMT under the house, and made use of the underground 1 inch EMT that exists to bring the utility feed from the service panel into the house. This is where a good wiring fish tape was invaluable!

From there, it was a (relatively) simple hook-up from the AC disconnect to the service panel. This older panel uses stab-lock circuit breakers, and there wasn't an available slot. So I had to buy not only a single-pole, 20 A breaker for the PV to connect up, but also a dual-pole, 20 A, 220 V breaker to replace a 20 A, 220 V, four-pole breaker to free up a slot. That cost me US$97 for used circuit breakers! If it was my own house, there's no question that I would have just upgraded the whole panel.

Painful Process & Just Rewards

And that was it. On a warm, sunny Sunday in late January 2003, we threw the switch and watched the Sunny Boy go through its initial checks. After 5 minutes, we saw it start producing. We had a small party with champagne for all as we celebrated our (almost) energy independence.

The most difficult part of the whole installation was dealing with the California Energy Commission (CEC) for the rebate. California was giving a rebate of US$4.50 per watt on systems at that time, (it is now US$4, or US$3 on self-installed systems), and it was hell dealing with them. I heard later that they were hiring student interns to answer

Mestel System Costs

Item	Cost (US$)	% of Total
6 Sharp 165 W modules	$3,570.00	50%
Sunny Boy 1800 inverter	1,968.00	27%
Uni-Rac PV mounts	486.40	7%
Shipping	343.00	5%
Schlumberger Centron KWH meter	250.00	3%
Wire, roof jacks, EMT, hardware	137.87	2%
DC disconnect	105.30	1%
Stab-lock breakers	103.95	1%
Building permit	100.00	1%
AC disconnect, 60 A	95.00	1%
Cables	14.00	0%
Fuses, 60 A	13.00	0%
Total	$7,186.52	100%
CEC rebate	-$3,593.31	-50%
15% Tax credit	-538.00	-7%
Net Cost	$3,055.21	43%

the phones, and most of them couldn't care less about what they were doing, or if they could help you or not. In my case, it was "or not."

I lost about five weeks on the installation time waiting for them to approve my application, which they lost, couldn't figure out, couldn't properly tell me what I was missing, and just basically abused. It was a trying experience, but in the end I got my rebate, and all was well.

A lesson learned: triple-checking that you have everything in order can save weeks of time when people who don't care to help are involved. And finding someone who had done the process before would have helped tremendously. I hope that others I can inform will benefit from this. And certainly this doesn't apply to just the CEC rebate program, but any time you are dealing with government, especially if it concerns getting money back from them!

And now for the rewards! The house here isn't an ideal place for a PV system, since I estimate that we are getting about 30 percent shading. The Solar Pathfinder showed that we would see almost complete shading for the winter months of November through February, with the hours of available sunlight per day creeping up until finally at the end of April, we would get a full day of sunlight on the panels.

This proved to be the case, since we were getting less than 1 KWH per day when we put the system in, and about 5.2 KWH per day in late April and early May. Unfortunately, without the shading, this system would probably cover about $^{7}/_{8}$ of our energy usage. With the shading, it covers a little over half.

Still, to me it is worth it. We are drawing significantly less off the grid, and either we will leave this system behind so someone new can see the benefits of RE, or we will take it with us when we move, which will almost assuredly be to a place where we can get full sunlight on the panels, and truly make as much use of them as possible. Overall, it has been an incredibly rewarding experience.

And Yet Again...

So just as I ended up adding a second 32 W UniSolar panel to my small battery-based system, I'm going to add 1 more Sharp 165 W panel to this system. Even though I knew that my output would be low because of the shading, it was still disappointing to see it put out only 2 or 3 KWH per day, even though we were having full days of sun.

Once I looked at the roofline in relation to where the panels sit, I realized that I could slip one more panel in there, and still not overhang the roofline on either side. When I put the system together, I was thinking in terms of twos, since that is how the panels are shipped. With four panels on the bottom row, and two on the top, that was an easy three crates of two panels each.

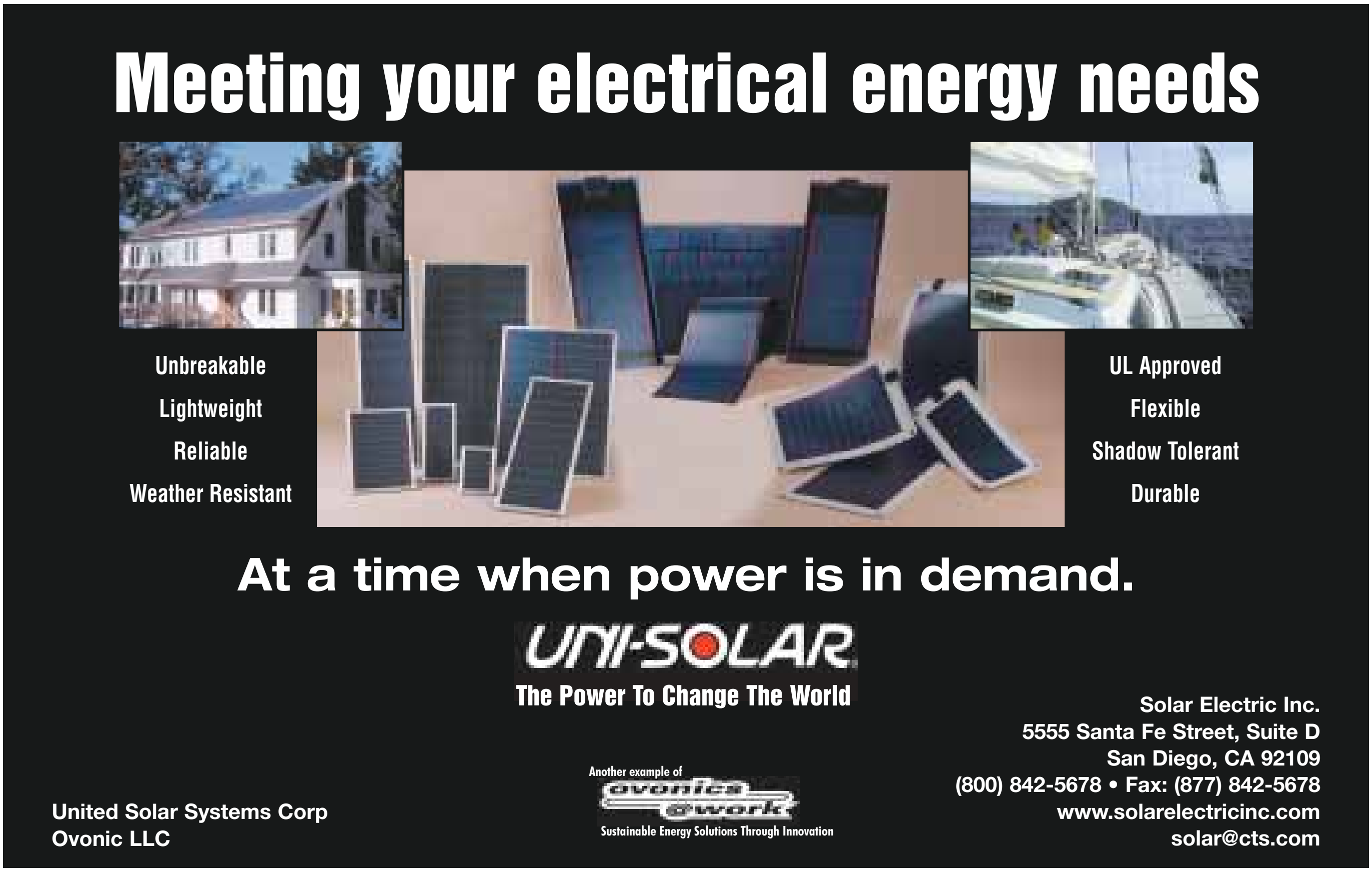
But I've found a single panel for sale, and I hope that within a month or so it will be up and running, boosting my output by another 16.6 percent. Will my quest for more renewable energy ever end?

Access

Mickey Mestel, 936 Boyce Ave., Palo Alto, CA 94301 • mickm@carmick.com

Northern Arizona Wind & Sun, 2725 E Lakin Dr., Flagstaff, AZ 86004 • 800-383-0195 or 928-526-8017 • Fax: 928-527-0729 • windsun@wind-sun.com • www.wind-sun.com • PVs & rack, inverter, AC disconnect

Palo Alto Hardware, Solar Division, 875 Alma St., Palo Alto, CA 94301 • 650-327-7220 • solar@paloaltohardware.com • www.paloaltohardware.com • DC disconnect, wiring, conduit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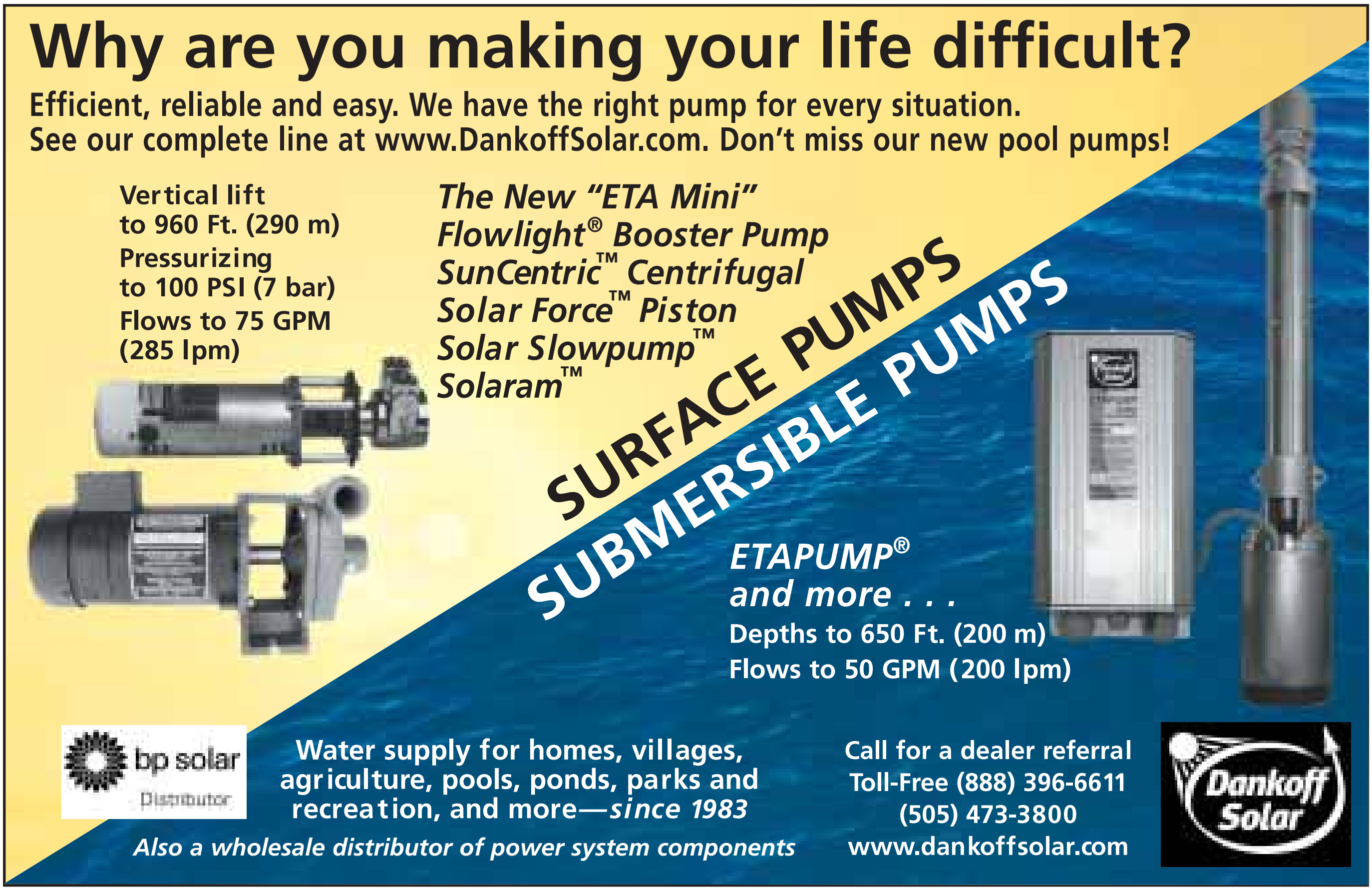
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Meeting Design Goals

Photo by Dale Abrams

The Aspen Center for Environmental Studies straw bale house strives for a Victorian look to fit with other buildings on the site.

with Straw Bales

Laura Struempler

Energy efficiency and resource efficiency are often targeted as goals when planning a new home. Low embodied energy of the building materials is another important objective. Building with straw bales can help you to achieve these and many other design goals—from energy efficiency to indoor air quality to aesthetic style and more.

Straw bale construction, the use of stacked bales of straw as an insulative wall material and as a structural component, has become a wide and much traveled path in the natural building movement. Homes, schools, retail establishments, bed and breakfasts, and even a winery and a blacksmith shop have been built using straw bale construction. It has spread to at least nineteen countries on six continents and is supported by code and testing programs in several countries. Much has been published on the how-tos and the beauty of straw bale construction.

Baled Gold

The unique properties of straw bales allow them to fulfill many needs. Straw is a superb choice for creating a wall with excellent thermal performance. Bale walls offer an R-value of 2.4 per inch, or up to R-50 total. They are covered with plaster, which adds substantial mass to the super-insulated wall assembly. This allows energy and cost savings over the life of the home, as well as high comfort for the inhabitants.

Straw is a waste product after grain is threshed, so it can help to replace other higher embodied energy materials, such as lumber and fiberglass insulation. You can decrease the embodied energy further by finding a source for your straw (and all your building materials) as close to home as possible.

Your site and region may dictate fire resistance as an essential design goal. Straw bale construction has proven through testing and example to be a first-rate material for fire-resistance. Seismic durability is also a good quality of a plastered straw bale wall. Other goals that are met easily with straw bales are nontoxic construction, construction cost reduction, good acoustic insulation, curved or round walls, and beautiful, sensuous spaces, among others.

Super insulation was a top design goal at the Struemplers' high altitude site.

Gold Examples in the Field

You don't have to look far to find straw bales successfully meeting design goals set by the owner-builder or architect. The following four buildings, which I worked on in capacities from owner-builder to straw boss to project manager, all demonstrate project intentions being met with straw bales. They also offer examples of a variety of design options, styles, and details.

My own home is an example of straw bales meeting demanding thermal performance goals. At 8,250 feet (2,515 m) in elevation on a windy but south-facing site in Colorado, my family and I set out to create a home with very high thermal performance, high comfort, and low energy use. Using basic passive solar design principles, R-45 straw bale walls, and R-50 cellulose attic insulation, the home performs beyond expectations.

The lower level is partially earth-bermed, so we chose a foam form foundation wall that is R-26. The floor joists are hung 6 inches (15 cm) below the top of the wall so that the straw on the upper level is raised above the floor level. This was done to prevent the bottom of the bales from getting wet if there is ever a plumbing break and flood at floor height.

The bales sit on the sealed foundation wall and a plywood box, which creates a base wide enough for the three-string bales. The walls on this level are post and beam, using dimensional lumber infilled with bales. The walls are covered with cement stucco on the outside and gypsum plaster on the interior, which provides substantial thermal mass. As a testament to the mass, before the bales were plastered, the daily temperature swings were approximately 20°F (11°C). Once plastered, the mass brought that down to about a 5°F (3°C) swing from day to night.

Beyond the passive solar heating, we supplement with radiant floor heating fueled by propane. This gave us mass in the main floor, since the radiant tubing is laid in sand between 2 by 2s nailed every 1 foot (31 cm) onto the plywood subfloor. The finished floor is tongue and groove pine nailed perpendicular to the 2 by 2s.

We stubbed copper pipe into the attic for solar hot water panels, but our propane use has been so minimal that we haven't felt compelled to make the installation a priority over all the other things we are still doing. The first few years after construction, the propane truck driver was totally confounded by how rarely he needed to refill our 500 gallon (1,900 l) tank. He'd knock on our door when he was up to fill our neighbors' tanks and leave shaking his head.

All of the propane use, which includes heating, domestic hot water, and cooking requirements for our 2,324 square foot (216 m^2; interior measurements) home has averaged 42 gallons (160 l) or US$42 per month. The straw bale walls also make a beautiful, quiet sanctuary inside, even when there's a storm howling outside.

Photo by Wendy MacPhail

The organic walls in the Aspen School District's environmental education classroom.

No Highway Noise in the Classroom

Jeff Dickinson, the architect of the Waldorf School on the Roaring Fork, in Carbondale, Colorado, had many goals as he set out to design an entire campus, with more than 20,000 square feet (1,860 m^2) of straw bale buildings. Among these goals was isolating the campus from the roar of the highway.

Luckily for solar design, the campus sits to the south of the highway, so that the more open and highly glazed south sides of the buildings face away from the busy road. However, choosing a wall material such as straw bales was still essential to creating a barrier to the highway noise. The straw bales with just a few small windows in the north wall allow students to meander the beautifully painted north hallway, unaware of the roar of truck traffic on the busy highway just in front of the school.

The straw bales also helped to meet such design goals as the use of nontoxic, natural materials, super insulation, heavy use of volunteer labor, and construction cost reduction. The construction of the first wing came in at an astounding US$63 per square foot compared to conventional local school construction costs, which run about US$150 per square foot. This was largely due to the amount of volunteer effort incorporated, as well as donations and discounts on materials.

Straw for Staff Housing

When the Aspen Center for Environmental Studies (ACES), a nonprofit educational center, began the design process for a building to house their staff, they wanted to create a demonstration of highly energy efficient, low embodied energy, compact housing. To meet their goals, I helped them by searching diligently to find as local a source as possible for good bales, which involved talking with many ranchers and crawling on a lot of straw stacks looking for dry, tight, weed-free bales.

ACES also chose to source nearly all their lumber from a hotel that was being demolished right in town. The crew pulled nails and recut boards to create both structural members and finish material for the new structure. The duplex staff housing also uses a straw bale wall to acoustically isolate the two, 500 square foot (46 m^2), one-bedroom units.

The straw bale house at ACES also shows how you can meet aesthetic design needs with straw bales. The site already included a historic Victorian home, and the new structure was to blend with that aesthetic. Accordingly, the building uses sharp corners, flat walls, and corresponding wood trim details. See the intro photo.

Straw & Tire Environmental Classroom

ACES partners with the Aspen School District to provide weekly environmental education classes to all the local students in grades K-4. They were sorely in need of a permanent home for the program. With the vision and tenacity of environmental education and art teacher Wendy MacPhail, a classroom building was created with an enormous community effort, which in its form and technology teaches many of the lessons of the program it houses. The inside is even filled with Plexiglas "truth windows" to show students the construction methods and technologies at work.

Design Rule of Thumb

One of the most common mistakes we witness around straw bale construction has nothing to do with the bales. Many inexperienced people interested in building with bales do a tremendous amount of research, but only on straw bale construction. Most of them do not know why windows are detailed the way they are in frame construction, thereby missing the point of hundreds of years of experience by others. A rule of thumb: if it works, don't change it! Do your homework from all points of view. —Jeff Ruppert, P. E. and owner of Odisea LLC

Wendy was clear with architect Jeff Dickinson that she wanted an organic form for the building. Straw bales bend and easily create a beautifully curved south wall. Since the north wall was below grade, rammed earth tires complete the back wall and successfully mimic both the bales' ability to bend and their thick wall construction. The classroom building is an example of straw bales meeting the goals of organic form, involvement of all ages, use of natural and recycled materials, energy efficiency, and renewable energy. The building is also equipped with a grid-tied PV system installed by Solar Energy International, and a solar hot water system heating the radiant floors, installed by Aspen Solar.

A wall at the Waldorf school. Note the short wall below the bales, and the post set to the inside of the straw.

Check Out Your Options

Just as straw bale construction offers many opportunities to meet design goals, it also offers many design options. Some of the most fundamental structural choices you will make when planning a straw bale building are which type of foundation to use and how to hold up the roof. Obviously, there are many, many more options you will weigh through the planning process.

As you can see in the following discussion, each choice and how well it is detailed can have ramifications through to the last stage of construction. Knowing and understanding your options and the effects of these options should dictate your design choices while you're still at the drawing board. As Catherine Wanek, author of *The New Straw Bale Home* cautions, "To live up to its promise, straw bale building systems must be understood and optimized."

High & Dry

Foundations in our cold climate in Colorado serve several purposes. Among these, they:

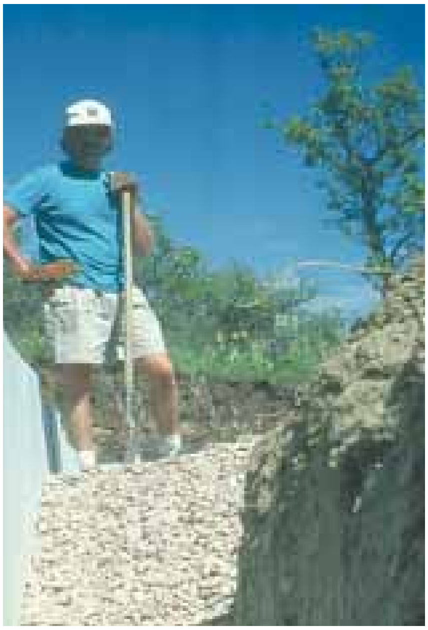
- Carry the load of the building down to stable, frost-free soil
- Isolate the rest of the building materials from rising soil moisture with a capillary break
- Protect the bottom of the bale wall from rain splash or snow
- Provide a platform wide enough for bales without excessive use of concrete

Preparation for this shallow, frost-protected foundation at the Waldorf School allows for a thicker perimeter.

One good choice for a foundation is the shallow, frost-protected footing as used in most of the Waldorf School buildings. Because rigid foam insulation is laid down and out from the perimeter of the building to keep the frost from reaching the thickened edge slab, the need for excavating to the frost line (which in our area is 4 feet; 1.2 m) and pouring concrete in that huge trench is eliminated. Bales with this system are typically raised, or "toed up," by setting them on two treated 2 by 4s with insulation in between.

At the Waldorf School, an innovative approach was used to raise the bales even higher and to provide a space where the electricians could run most of the wiring. The bales were set on a short wall made of one course of foam form blocks with a framed wall set inside, and topped with plywood.

Another useful approach, which we used on our workshop building, is the rubble trench foundation popularized by Frank Lloyd Wright (see the natural building intro article in *HP99*). This also saves a lot of



Gravel fills the rubble trench before concrete is poured for the footer at the Struemplers' workshop.

Dealing with Moisture

Water is the main enemy of straw. Straw that gets wet and stays wet will surely decompose; kept dry, it seems to last forever. –Paul Lacinski and Michel Bergeron, authors of *Serious Straw Bale*

1. Buy dry bales and keep them dry during storage and construction.
2. Design an adequate foundation and roof (boots and hat), and provide excellent detailing at openings and transitions. This approach helps to minimize wetting from the main external water sources—rain, snow, and soil moisture.
3. Seal the bale walls well with a natural plaster. This tackles both exterior liquid moisture and moisture from the interior through air leakage and vapor diffusion.
4. Think clearly about and plan well for indoor moisture issues. Straw bale structures typically create a very tight house, unlike the drafty houses of our ancestors. This condition means that we must pay more attention to indoor air quality and indoor moisture.

concrete while still providing a high and dry platform for the bale wall. Since the floor is not poured at the same time, it allows you to choose something other than a concrete slab floor, such as a poured adobe floor.

The top of the foundation details are important for planning ahead to the plastering stage. In almost all cases, the exterior stucco should end at least 6 to 8 inches (15–20 cm) above your final grade to prevent moisture damage. A "stucco stop" (often a preformed metal edge) is important to cleanly stop the plaster above grade and provide a capillary break from soil moisture. Because a stucco stop is often attached to the foundation, deciding what form of stucco stop you plan to use and how and where you will securely attach it should be decided before you begin building.

Nicely detailed stucco stop at the ACES straw bale house.

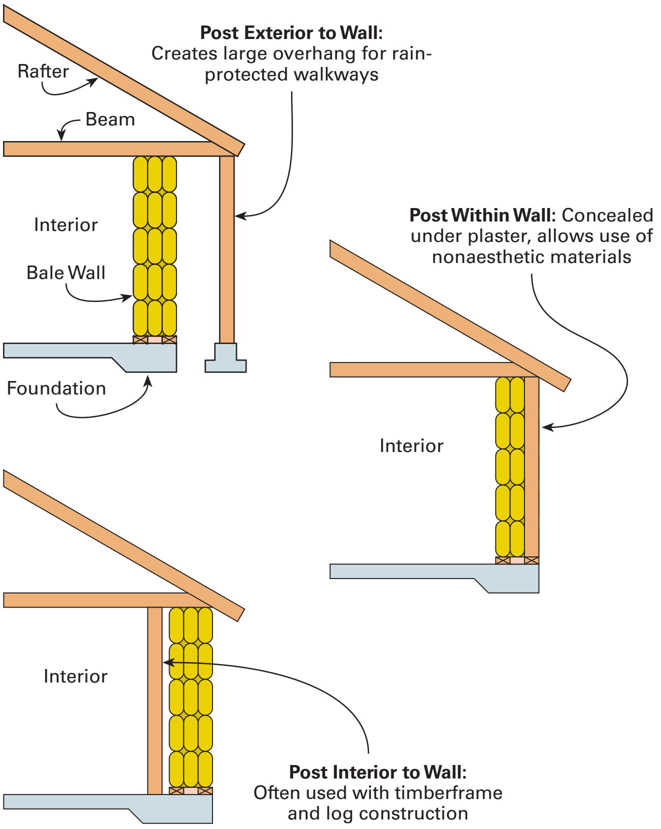
Also, if you have to apply rigid insulation to the exterior of your foundation, make sure that it will not stick out past your plaster and create a place for moisture to sit or be trapped. Any moisture barrier used at the foundation level should be applied in overlapping shingle fashion to prevent moisture intrusion.

Holding Up the Roof

Structurally, straw bale buildings can be load bearing, which means that the bale walls support the roof, as in the historic straw bale homes of Nebraska. Alternatively, they can be post and beam structures with the straw bales as infill. Because the codes in our area do not yet allow load bearing straw walls, all of the structures presented here are post and beam.

Post and beam structures are unique to straw bale walls as opposed to other natural building systems, such as adobe, rammed earth, or cob walls. This element alone offers several options to be considered when designing. Posts set to the outside can allow porches or storage areas. Posts within the straw walls give the opportunity to use nonaesthetic dimensional or composite lumber, preferably recycled, for your structural members. Posts set inside the wall can allow the beauty of logs or timbers inside the living space.

Options for Post Position



Planning & Preparing for the Approval Process

When approaching the permitting process for an alternative building, start early. The first rule is to recognize that getting approval is a process. Identify as many of the nonstandard aspects of the project as early as possible, giving yourself and the building department a long lead time to address these.

Gather information about the jurisdiction and applicable codes. Learn what you can about the jurisdiction in which the project is located. Familiarize yourself with local permit process requirements, and the current codes and standards that will apply to your project, including the sections related to the alternative approaches that will be included in the project.

Gather information about the specific alternatives. Identify potential areas of concern for each alternative proposed. Then research and collect relevant information. Try to obtain the best reference materials—technical reports, test results, books, authoritative publications, videos, and documentation of the successful use (and approval) of the alternative in other places. Supporting material should be as regionally, climatically, seismically, or generally similar to the local circumstances as possible.

Find and enlist the help of allies and sources of expertise. Seek out and, when necessary, engage knowledgeable experts and resource people, including sympathetic code officials, to support your position. Use networking to find others who have previously gone through an approval process for the alternatives you are proposing. Involving people with the right expertise or prior experience in addressing anticipated problem areas can help you develop the rationale for what you are proposing, often shortening the approval process.

–David Eisenberg, Development Center for Appropriate Technology.

Paul Struempler reminds us why we build with straw—for future generations.

Choosing the post and beam option and materials for your situation will have impacts on the foundation, roof structure, straw installation, and plaster detailing. For example, in my own home, I used dimensional lumber that assembled quickly for the posts that would be hidden in the wall. We did have to notch the bales to fit around the posts using an electric chainsaw, but when it came to plastering, we had a smooth unbroken surface to work with, and did not have to worry about shrink cracks where the plaster met a protruding post.

At the Waldorf School, the north side of the east wing was built with Parallam posts (a composite wood product) supported by post pads and concrete pillars all set to the outside of the straw wall. This created a useful north porch off the parking area, and an external hallway for the older classes. The straw wall went up easily with no notching, and the small north windows are set in "rough bucks" directly in the straw wall. The straw on that side is very well protected from exterior moisture both at the top and bottom of the wall.

The straw bale house at ACES placed posts within the straw walls to hide the reused lumber, which had unattractive brown paint and nail holes. Because of the need to approximate the Victorian style of a nearby structure, the house does have a lot of corners, which necessitated many extra posts, more notching, and more preparation to stucco the posts. This speaks to the ideal of simplifying the design of your building so that you don't create the trickle down effect of excess materials and labor from one design decision.

Logs were used to support the south straw wall at the environmental education classroom, and they alternate between being buried in straw and being exposed between the windows. This has presented some moisture detailing challenges along the sill as the logs and stucco have shrunk. When details like this are thought through ahead of time, it can help to prevent substantial problems with your building.

Straw Built to Last

All homes or structures are a combination of many design goals. Straw bales are an excellent choice to bring you to success with many of your goals. As you move through the design process of your straw bale project, remember to know and understand your design choices, prethink your details, study the books, volunteer on jobs, and get as much help and advice as you need.

From identifying your design goals to working through the details of connections, interfaces of different materials, attachments, custom details, embellishments, to plaster details and moisture details, take time with the process. Any good material becomes an even better choice for the environment if put into a well planned building that is built to last many generations.

Access

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The New Straw Bale Home, Catherine Wanek, 2003, hardcover, 188 pages, ISBN 1-58685-203-5 • US$39.95 from Gibbs Smith, Publisher, PO Box 667, Layton, UT, 84041 • 800-748-5439 or 801-544-9800 • Fax: 800-213-3023 or 801-546-8853 • alison@gibbs-smith.com • www.gibbs-smith.com

Serious Straw Bale, Paul Lacinski and Michel Bergeron, 2000, paperback, 371 pages, ISBN 1-890132-64-0 • US$30 from Chelsea Green Publishing, PO Box 428, White River Junction, VT 05001 • 800-639-4099 or 802-295-6300 • Fax: 802-295-6444 • info@chelseagreen.com • www.chelseagreen.com

"From the Ground Up: A Primer for Natural House Building," Rachel Ware and Laurie Stone, *HP99*, page 62.

Solar Hot Water History

Nothing New under the Sun

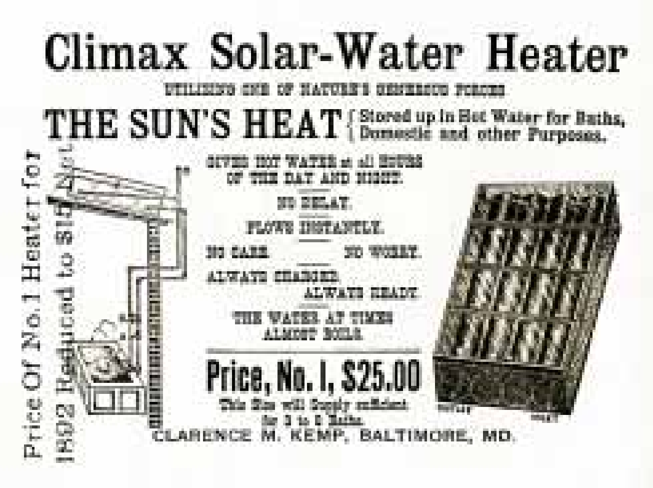
John Perlin

A Pomona Valley, California, house with a Day and Night solar water heater near the turn of the *last* century.

It may surprise you that the first commercial solar water heater went on the market in 1891. Clarence Kemp invented and sold it through his Baltimore appliance factory outlet.

Kemp had seen earlier solar water heaters put together by farmers—metal water tanks painted black and placed directly in the sun out in the fields during the summer. By late afternoon, when farm work had everyone's skin full of grit, grime, and sweat, and their bodies exhausted, farmhands opened up the spigot on the tank, and filled buckets with water hot enough to soothe their aching muscles and refresh their overheated bodies.

The problem with these simple solar heaters, Kemp observed, was not whether they could produce hot water, but when and for how long. Even on clear, hot days, it usually took from morning to early afternoon for the water to get hot. And as soon as the sun set, the tanks rapidly lost heat because they were uninsulated and unprotected from the cool night air.



Advertisement for the first commercial solar water heater—the Climax—invented in 1891.

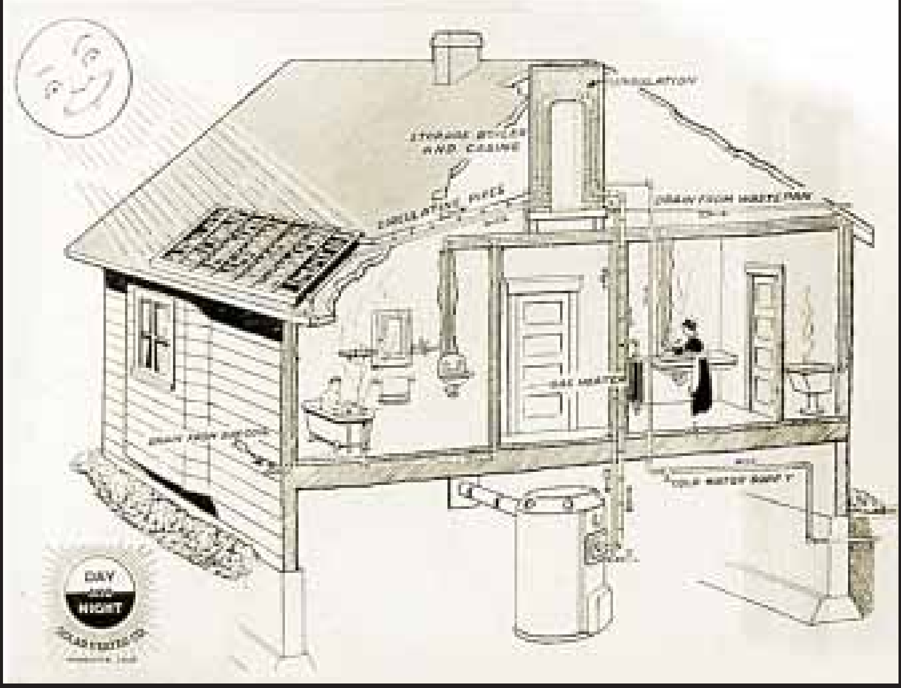
Kemp had also read in popular journals how the American astrophysicist Samuel Pierpoint Langley had taken an insulated, glass-covered box and exposed it to the sun on the snow-covered slopes of Mount Whitney. Though outside temperatures had dropped below freezing, the inside of the box heated up above the boiling point of water. Kemp realized that if he placed several tanks painted black inside a glass-covered box, he would have a superior method of heating water with the sun. In 1891, he won a patent for the new heater, and called it the Climax, the world's first commercial solar water heater.

He advertised his heater as "the acme of simplicity" compared with conventional water heaters. Just turn on the faucet and "instantly out comes the hot water," the sales literature boasted. Thanks to the Climax, according to company brochures, housewives no longer had to fire up the stove in summer, and wealthy gentlemen, who had to stay behind to work while their families and servants left sultry Baltimore to summer in more pleasant climes, could return home at night and instantly draw hot water with no fuss or bother.

Sales of the Climax really took off in California. By 1897, one-third of households in Pasadena relied on the Climax for heating water. More than 1,600 were sold in southern California by 1900. Economics was the prime lure of the Climax. For an investment of $25, the owner saved about $9 a year on coal. As one journalist pointed out, exorbitant fuel prices forced Californians "to take the asset of sunshine into full partnership. In this section of the country where soft coal sells for $13 a ton (and the huge peaches bring only $2 a ton), a builder cannot afford to waste his sun-rays. California is in particular need of its solar heaters."

Clarence M. Kemp of Baltimore, Maryland—the father of solar water heating and inventor of the Climax solar collector.

Cutaway drawing from a company brochure of a typical southern California home with a Day and Night Solar Heater installation. The system was also connected to the house gas heater to warm the water after several days without sun.



Daily Gifts

Others, though, saw a more important reason for going solar. Charles Pope, writing in 1903, urged consumers to "consider that wood and oil and coal and gas are steadily consumed by use. Not only will the coming generations be less comfortably supplied—a thing most of us care very little about—but the drain today may produce distress in our own homes and lay an embargo on our own business tomorrow. Contrast this with the freedom of the people who receive daily gifts of fuel from the Creator, taking all they wish, all they can use, freely."

Between 1898 and 1909, more than a dozen inventors filed patents for new solar water heaters, but everyone merely refined the Climax design. In 1909, William J. Bailey saw the shortcomings of the glass-covered tank solar water heaters—collecting and

William J. Bailey, founder of the Day and Night Solar Heater Company.

storing solar heated water in the same unit allowed the water to cool down after dark or when the weather got bad.

Bailey revolutionized the solar water heater industry by separating the solar collector from the storage unit. He attached narrow water pipes to a black metal plate and put them into a shallow, glass-covered, insulated box. Then he connected the collector to an elevated, autonomous, insulated storage unit. As the sun heated the water, it became lighter than the colder water below, naturally rising into the storage tank. His solar water heater worked better than Kemp's because the sun heated a smaller volume of water at a time, and the heated water immediately went to a storage tank protected from the elements.

Bailey called his company the Day and Night Solar Heater Company, because unlike the Climax, it supplied solar heated water during the day *and* at night. The added benefits of the Day and Night soon put those manufacturing the Climax out of business. By the end of World War I, more than 4,000 households in southern California heated their water with Day and Night solar water heaters.

Cheap Gas & Electricity

The discovery of cheap local supplies of natural gas concurrent with the development of the thermostatically controlled gas water heater in the early 1920s killed the solar water heater industry in southern California. The solar water heater business then migrated to southern Florida, where a booming housing market and high energy costs created much demand for Bailey's invention. By 1941, more than half the households in Miami heated their water with the sun. But war came, the government froze the use of copper, and the solar water heater industry came to an abrupt halt.

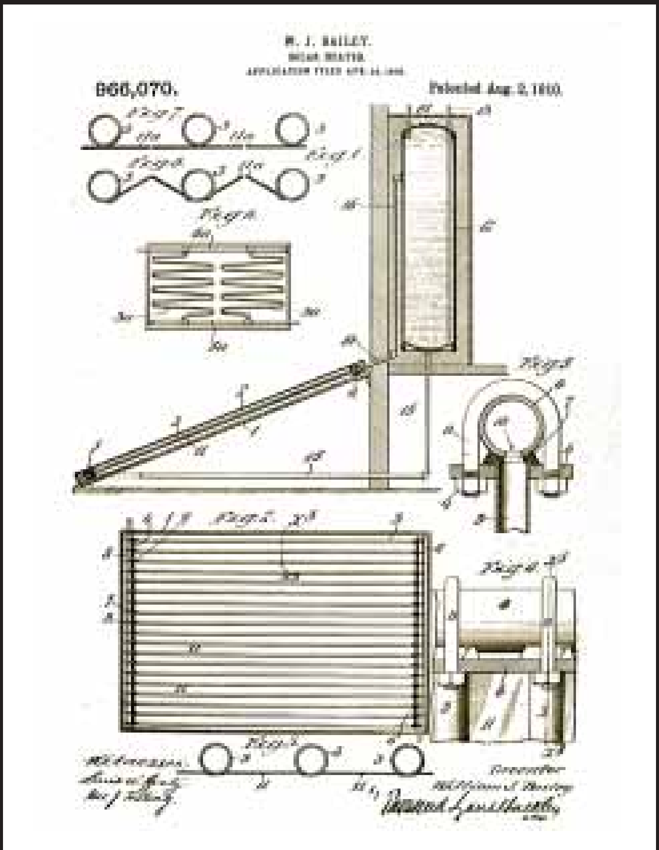
Solar water heating took off again after the war, but cheap electric rates, combined with aggressive sales of electric water heaters by the utilities, stymied new growth. The once thriving Floridian solar water heater industry was reduced to a small service business by 1955.

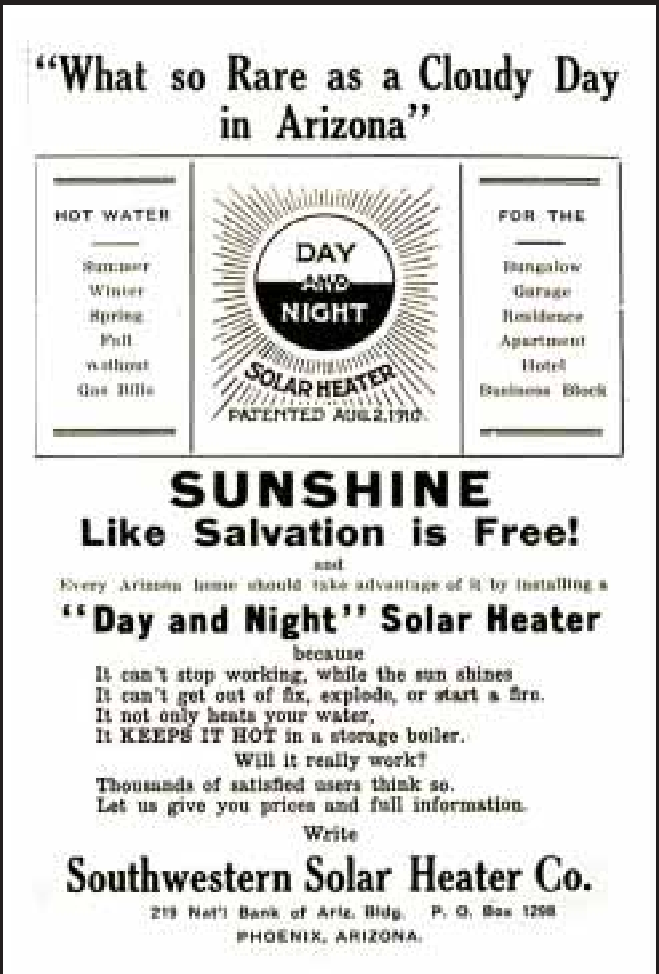
The two oil embargoes of the 1970s encouraged new interest in solar water heating. Subsequent sharp drops in fossil fuel prices, combined with the end of tax credits for purchasing solar water heaters, once again put a damper on the American solar water heater industry.

Ahead of Us

Other parts of the world have enthusiastically embraced Bailey's invention. Millions of Japanese have purchased solar water heaters. More than ninety percent of Israelis heat

Bailey's patent for the first solar water heater to separate heating from storage. Filed in 1909, it closely resembles most solar water heaters used today.





Day and Night branches out from southern California to Arizona as this 1914 advertisement documents.

their water with the sun. In Europe, so many people use solar water heaters like the Day and Night design that they save the equivalent of the energy produced by five large nuclear power plants. Most never imagined that the technology they use dates back so far and comes from California!

Access

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This article is adapted from *A Golden Thread: 2500 Years of Solar Architecture and Technology*, by John Perlin and Ken Butti, Van Nostrand Reinhold Company, 1980. Out of print, but check used book stores.

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The Sun

(Almost) Everything You Always Wanted to Know but Were Afraid to Ask

Bob Yoesle

I first became interested in astronomy when, as a small boy of six or seven, I looked through my godfather's telescope at the first quarter Moon's surface. The mountains and craters stood out in unbelievably stark relief, and I was hooked!

With my first telescope, I viewed the Sun and its spots as they grew and evolved on a daily basis. Each day, I would draw a picture of the Sun and track the spots as they rotated across the Sun's surface, just as Galileo did almost 400 years earlier.

Throughout the years and successively larger and larger telescopes, I have stayed with observing the nearest star for its ever-changing details. (It may also have something to do with the fact that as I get older, it's harder to stay up all night!) The incredible detail that can be seen on the Sun is unique. With no other star can we actually observe surface details such as sunspots, flares, and prominences, which at times can change on a minute-by-minute basis.

Prominences dance off of the Sun's surface. Prominences are huge clouds of relatively cool, dense plasma suspended in the Sun's hot, thin corona.

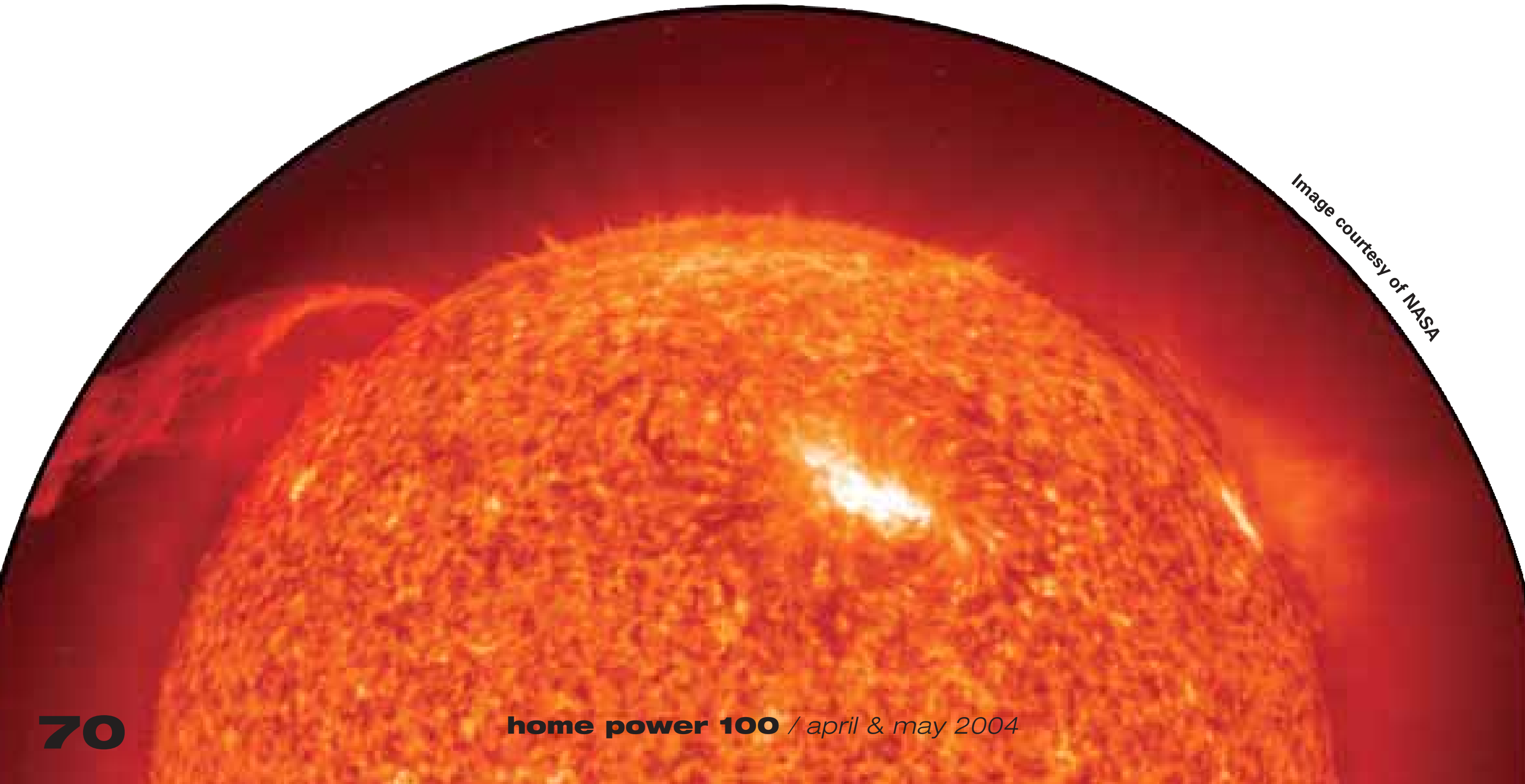
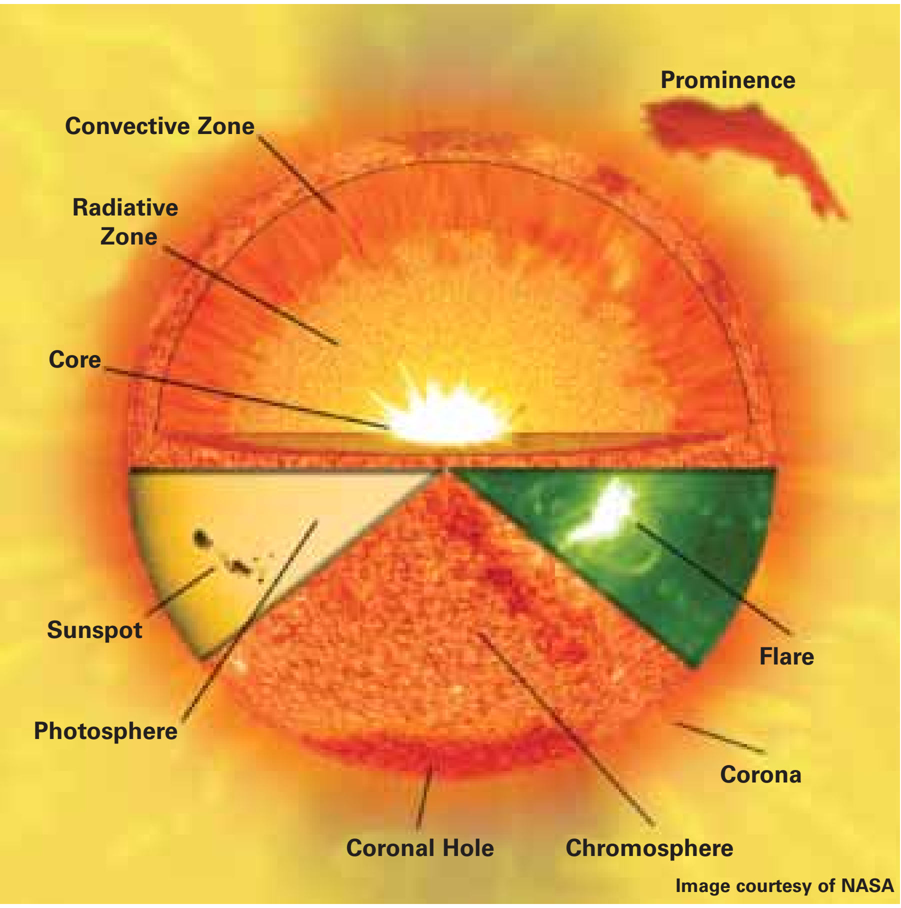


Image courtesy of NASA

I share my enthusiasm for astronomy and the Sun at gatherings of amateur astronomers—"star parties" held in the Northwest—and more recently at renewable energy fairs, where I use sunlight to power the tracking motors of my solar telescopes to view the Sun.

Most people at renewable energy fairs are blown away by the ability to view the Sun safely, and the ability to see sunspots and prominences. I hope they leave with a little of the same awe and wonder I have at the incredible power of the Sun from experiencing it firsthand through the telescopes.



A topical and cutaway diagram of the Sun.

Fire of Life

The Earth orbits the Sun at just the right distance to power the cycle of life, allowing it to thrive. It is neither too close nor too far, too cold or too hot; this balance permits liquid water to exist and, therefore millions of species of plants and animals to flourish. The Sun warms the oceans and air, lifting water into the sky and causing the winds that push the clouds over the continents, where the water falls as rain and snow, which then flows through streams, lakes, and rivers back into the seas.

The Sun directly and indirectly provides most of the energy used by people today. Fossil fuels—buried plants that long ago perished after using sunlight to make sugars now provide much of the energy (often wasted) that drives our society. Newer and more efficient technologies, however, with far less damaging environmental effects, are allowing us to use sunlight and wind directly to generate electricity. Ancient civilizations recognized the importance of the Sun in their religions, and even today we relate good health to a suntan (false) and a "sunny" disposition (true).

Solar Vital Statistics in Perspective

The Sun is an average star, except for the fact that it is very close, about 92.8 million miles (150 million km) away from Earth. The next closest star, Alpha Centauri, is 25 trillion miles (40 trillion km) away. If you could drive to the Sun at 65 mph (105 kph), it would take a mere 163 years. Driving to Alpha Centauri would take longer—50 million years.

The Sun's diameter is 865,000 miles (1.39 million km), 109 times the Earth's. Over a million Earths could fit inside the Sun. The size-distance relationship between the Earth and Sun can be visualized as a model where the Sun is a 2 foot (0.6 m) diameter beach ball, and the Earth is a small pea 215 feet (65.5 m) away. On this scale, Alpha Centauri would lie more than 10,000 miles (16,100 km) away.

The Sun's mass is 200,000,000,000,000,000,000,000,000 tons, or about 329,000 times the Earth's. The Sun accounts for 99 percent of the mass of the entire solar system, and is composed of 92.1 percent hydrogen, 7.8 percent helium, and 0.1 percent of most remaining elements. The Sun's total energy output, or luminosity, is 3.9×10^{23} kilowatts. The Sun radiates 13 million times the annual energy consumption of the United States every second. In one thousandth of a second, the Sun radiates enough energy to supply the entire world's current energy needs for 5,000 years. One square inch (6.5 cm^2) of the Sun's surface is as bright as a 90,000 watt incandescent light bulb (or a 22,500 watt compact fluorescent).

The Sun is one of the more than 200 billion stars in the Milky Way Galaxy, one of a hundred billion galaxies in the visible universe. The Sun orbits the center of the galaxy, 27,000 light-years away, once every 230 million years, at a speed of 670,000 mph (1.08 million kph).

Photosphere

The visible surface of the Sun is called the photosphere. It is composed of a thin gas, less than 0.01 percent of the density of the Earth's atmosphere at sea level. It has a temperature of about 6,000°C (11,000°F). Light from the photosphere is generated by the energy released when the thermonuclear conversion of hydrogen into helium takes place deep in the Sun's core.

The core has a density 45 times that of steel and a pressure of 3.3 billion tons per square inch. Yet it remains gaseous because the temperature is 15.5 million degrees Celsius. This tremendous temperature and pressure results in the fusion of hydrogen into helium, which as a byproduct converts about 4.5 million tons of matter per second into energy in the form of gamma radiation.

Over the next 170,000 years, this radiation undergoes untold billions of collisions in the radiative zone, where it loses energy. This energy helps heat gases in the next level, known as the convective zone, and eventually leaves the Sun as x-rays, ultraviolet, visible, and infrared light, and even radio waves. This light then takes just 8 minutes to traverse the 93 million miles (150 million km) to the Earth.

The major features visible on the photosphere are sunspots, regions where powerful magnetic fields erupt

Viewing the Sun

Warning: It is extremely important that you never look directly at the Sun without proper filtration, especially with any type of optical instrument. Instantaneous and permanent eye damage can occur. My telescopes are equipped with specialized filters to enable safe observation of the Sun.

Unlike faint stars, nebulas, and galaxies, which require larger telescopes to be seen in better detail, the Sun is so close, big, and bright that almost any telescope, binocular, or spotting scope can be used to view its surface and sunspots, provided it is properly filtered to reduce the tremendous brightness prior to sunlight entering the 'scope.

Some cheap department store telescopes come with an inexpensive dark-glass filter used by welders. It sits near the eyepiece end of the telescope—after sunlight has entered and is concentrated to a focused beam. These should never be used. They can crack from the intense heat (mine did!), and permanent blindness will result if you happen to be looking through the telescope at the time. If you have one of these filters, throw it away and get a filter for the entry end of the telescope.

White Light Filters

Most full-spectrum or "white light" solar filters consist of a piece of polished glass or thin plastic film coated with layers of vacuum-deposited metals such as steel, chromium, or aluminum, mounted on a cover that fits over the end of the telescope tube.

These filters reflect 99.99 percent of the Sun's light and heat away before it even enters the telescope, and allow unlimited safe viewing of the Sun's surface detail. These can usually be purchased from amateur astronomy equipment dealers for about US$50 to $200, depending on the size of the telescope being used.

My favorite white light solar filter is made by the Baader Planetarium in Germany. It is a thin-film type of filter, is very reasonably priced, and can be purchased in small sheets for you do-it-yourselfers, or ready to go in an aluminum cell that fits over the end of your telescope's tube. It is available from Kendrick Astro Instruments in Canada and AstroPhysics, Inc. in the United States. It is very important to make sure that whatever filter you use is securely fastened to the telescope, so that a sudden gust of wind or curious hands cannot remove the filter while the Sun is being observed!

Hydrogen Alpha Light Filters

To view the Sun's chromosphere in "hydrogen-alpha light" requires a much more sophisticated filter that removes every color (wavelength) of light from the solar spectrum except an ultra-thin slice of ruby-red colored light where hydrogen gas glows at 20,000°C (36,000°F).

These "narrow band interference filters" consist of precisely spaced and extremely flat layers of special glass coated with exotic materials. The manufacture of these filters is more of an art than a science. So they are very expensive, starting at about US$500 for an entry level hydrogen alpha (HA) filter to more than US$6,000 for a top-of-the line model. These filters are usually made in small batches, and can take up to several months to obtain after an order has been placed.

HA filters are available from the Coronado Instrument Group and the DayStar Filter Corporation. I have used HA filters from both companies, and both work very well. The Coronado filters are a bit easier to configure for a particular telescope, with the tradeoff that they are more expensive than the DayStars. The DayStars also require a US$300 to $400 refurbishment every five to ten years of use, so in the end, the long-term costs of the two filters are about the same. My current favorite is the Coronado Solar Max 90, which offers incredible views of solar prominences and flares and details of the chromosphere. It is ideal for telescopes of 4 inches or larger in aperture.

through the Sun's surface. The Sun's magnetic field originates in the convective zone (lying just below the photosphere) where hot ionized (electrically charged) gas or plasma rises and falls, creating electrical currents and accompanying magnetic fields. Being gaseous, the Sun rotates once in 25 days at the equator, but takes more than 35 days at the poles. This differential rotation twists and stretches the Sun's internal magnetic fields, until they eventually break the surface.

Sunspots appear dark only because these intense magnetic fields inhibit the transfer of energy from below and the sides, and consequently they are about 4,000°C (7,000°F), which is 2,000°C cooler than the photosphere. The number of sunspots visible varies over an 11-year sunspot cycle, during which time the Sun's overall magnetic field reverses from one hemisphere to the other.

Sunspots can vary in size from several hundred miles to many times larger than the Earth, and generally can be found in sunspot groups up to hundreds of thousands of miles long. These groups usually have two main regions of opposite magnetic polarity, with most of the spots within the group demonstrating similar magnetic characteristics.

Most individual sunspots survive for just a few days, while the larger groups may last for several weeks to a few months. Sunspots generally consist of a dark central portion known as the umbra, and a lighter surrounding portion known as the penumbra.

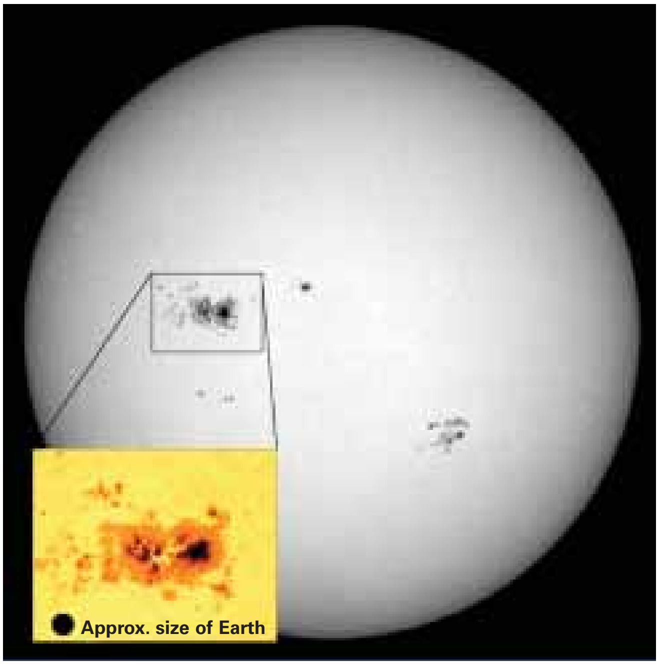


Image courtesy of NASA

Sunspots, seen as darker spots on the Sun's surface, are cooler regions of plasma.

Bob Yoesle shows a renewable energy fair-goer how to safely view the Sun through his Celestron C102, PV powered telescope with special filters.

Under ideal atmospheric conditions, you may also be able to see granulation, a very fine graininess of the entire photosphere. Granulation defines convection cells, regions where hot gas rises from the solar interior, cools, and then falls back to the interior. Each granule on the surface of the Sun is about the size of Texas.

You may also be able to see faculae, blotched and irregular regions of brightness that are usually more easily viewed when contrasted against the decreased brightness of the solar limb, or edge. Faculae are the brightened sides of convection cells heated by the energy of locally intense magnetic fields, and are usually associated with solar active regions and sunspots.

Chromosphere

Lying next to the photosphere and rising about 1,300 miles (2,100 km) above is the chromosphere. Under high magnification and excellent atmospheric conditions, 6,200 mile (10,000km) long jet-like spears of gas known as spicules give the chromosphere the appearance of a "burning prairie." The chromosphere is even less dense than the photosphere, with a temperature of 20,000°C (36,000°F).

Often rising out of the chromosphere are luminous fountains of hydrogen gas known as prominences—some of the most beautiful and impressive sights to be seen in the heavens. Prominences are closely associated with solar active regions and their magnetic fields. Because of the interplay of these forces, they may assume many shapes—arches, columns, loops, "trees," and "hedges," in many sizes.

Prominences can surge spaceward at speeds up to one million mph (1.6 million kph), and then stream downward towards the Sun's surface. Or they can remain almost motionless in the Sun's atmosphere (the corona) like luminous clouds for a few hours or as long as six to eight months (a quiescent prominence). Prominences are fainter than the chromosphere itself, and when silhouetted against it, they appear as shadowy ribbons known as filaments.

Also directly linked to solar active regions are flares. Flares are usually smaller than prominences, but are tremendously more energetically explosive eruptions of plasma and subatomic particles and radiation, releasing as much energy as several billion H-bombs. They are caused by interacting and collapsing magnetic fields, and appear as rapidly brightening jets or irregular patches around solar active regions—sometimes resembling lightning—and can last from a few minutes to several hours, and travel at speeds up to 2.5 million mph (4.0 million kph).

Following a strong solar flare, the Earth may also be exposed to a greatly intensified solar wind two or three days later, and this can result in displays of auroras (northern or southern lights). The largest solar flares can produce radio and electricity disruptions, and the radiation released could prove fatal to any astronauts outside of the Earth's protective magnetic field.

Corona

Beyond the chromosphere lies the Sun's atmosphere, the corona, usually visible only during a total solar eclipse. This extremely tenuous gas is heated to more than 1 million degrees Celsius by intense radiation constrained in the magnetic fields emanating from the solar active regions.

Lower density regions of the corona, the coronal holes, are where most of the solar wind (mostly protons and electrons) originates. It is constrained to flow outward by the Sun's magnetic field at about 470 miles (760 km) per second. Because the Sun's magnetic field rotates with the Sun itself, the solar wind flows outward in a spiral pattern, much like the pattern of water drops from a rotating sprinkler.

Past & Future

The first stars were born from pure hydrogen and helium created when the universe burst forth from the "Big Bang" 14 billion years ago. Heavier elements were produced in their cores, as well as when massive stars exploded in super novas.

The Sun is a second or third generation star born from a rotating interstellar cloud of gas and dust that collapsed about 5 billion years ago out of the remains of these previous stars, and the hydrogen and helium of the big bang. The planets—including Earth—are the leftover debris from these ancient events—we are all "children of the stars."

The Sun has existed in its present state for about the last 4.5 billion years, and has converted about 37 percent of its available hydrogen into helium. However, as the Sun continues to fuse hydrogen into helium, its core will shrink and become hotter. At the same time, the Sun's surface will become brighter, and over the next 500 million years, this will have catastrophic effects on the Earth's climate and atmosphere. Within 3 billion years, the oceans will boil away and Earth will become completely uninhabitable.

In another 7 billion years most of the hydrogen in the core will be depleted, and the Sun will begin to fuse helium into heavier elements. The increased temperature of the core will cause the outer layers of the Sun to expand to 170 times its present size, beyond the orbit of Mercury and Venus, vaporizing both planets. The Earth's atmosphere will be completely stripped away and its surface will melt. The Sun will then be in its red-giant phase and 2,300 times its current brightness, which will substantially warm the frozen outer planets of the solar system—temporarily.

Telescope Specs

White light telescope: Celestron C102, 4 inch f-10 refractor

White light solar filter: Baader Solar Filter

This 4 inch refractor telescope is equipped with a full-aperture, "white light," metal-on-Mylar filter. It provides a view of the Sun in all visible colors of light, although greatly reduced in brightness. Features that can be seen in white light are sunspots, faculae, and solar granulation.

Hydrogen alpha telescope: Celestron C102, 4 inch, f-10 refractor or Astrophysics 130 EDT, 5 inch, f-8 refractor

Hydrogen alpha solar filter: Coronado Solar Max 90-BF30

This 4 inch refractor telescope is equipped with a sophisticated "hydrogen alpha" or "HA" narrow-band interference filter. It provides a view of the Sun in essentially one wavelength (color) of light, the glowing deep-red light of very hot hydrogen gas. Features that can be seen in "HA" light are flares, prominences, and filaments.

Fusion Power Is Here Today

The telescope mounting's electric drive system (which tracks the Sun by compensating for the Earth's rotation), is powered by a 12 volt battery that is recharged by a photovoltaic (PV) module. This panel uses the energy of sunlight (photons) to displace electrons in an array of specially treated silicon wafers, which produces an electric current that charges the battery.

Telescope mount and accessories: Losmandy G-11

Battery: Kendrick PowerPack 12 V, 33 AH sealed battery

Charge controller: Specialty Concepts ASC 12

PV panel: BP 250F 2F, 50 W

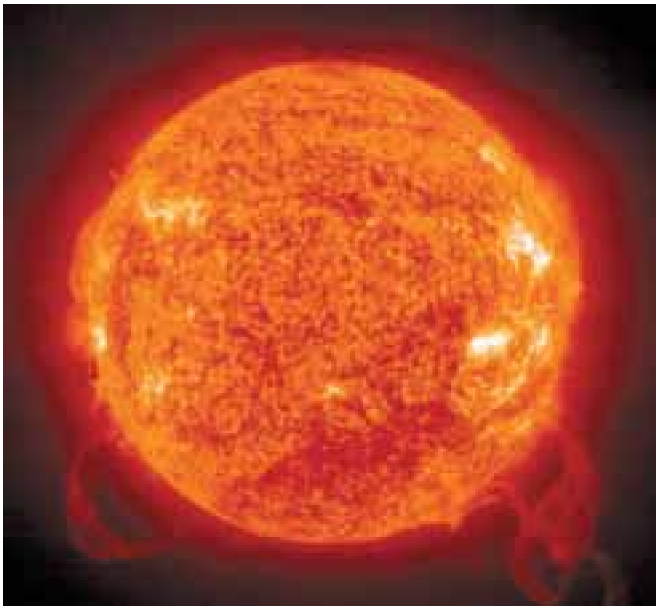


Image courtesy of NASA

This picture taken on April 18, 2003, from the SOHO satellite, shows prominences, flares, and magnetic loops.

The red-giant phase will last for only a few million years, and once the Sun has fused lighter elements into carbon and oxygen, its energy will be depleted and gravity will slowly begin the Sun's final collapse. The Sun will have expelled great shells of matter, while the remaining core—about one-half the Sun's current mass—will finally contract to about the size of the Earth and become a white-dwarf star of extraordinary density, where a mere teaspoon of its degenerate matter will weigh more than 5 tons.

Over untold eons, the Sun will slowly radiate the last of its heat into space, becoming a cold dead cinder of extremely dense crystallized carbon and other elements. The Sun's outer remains—an expanding cloud of gas and dust—eventually will be incorporated into another interstellar cloud, someday perhaps to be reborn as another star, and conceivably another generation of planets. These planets too may give rise to life, possibly even living beings who may wonder about the nature of their sun, the stars, and the astonishingly infinite universe beyond.

Access

Bob Yoesle, PO Box 170, Bickleton, WA 99322 • 509-896-2624 • ryoesle@bentonrea.com

Celestron, 2835 Columbia St., Torrance, CA 90503 • 310-328-9560 • Fax: 310-212-5835 • mtraxler@celestron.com • www.celestron.com • Telescopes and accessories

Losmandy-Hollywood General Machining, 1033 Sycamore Ave., Los Angeles, CA 90038 • 323-462-2855 • Fax: 323-462-2682 • scott@losmandy.com • www.losmandy.com • Telescope mount: G-11 German equatorial

Coronado Solar Filters, 1674 South Research Loop Suite 436, Tucson, AZ 85710 • 866-786-9282 or 520-740-1561 • Fax: 520-624-5083 • info@coronadofilters.com • www.coronadofilters.com • Hydrogen alpha filter: Solar Max 90, CEMAX eyepieces

Astro-Physics Telescopes, 11250 Forrest Hills Rd., Rockford, IL 61115 • 815-282-1513 • Fax: 815-282-9847 • info@astro-physics.com • www.astro-physics.com • Telescope optics: AP 130 EDT 5 inch refractor • White light filter: Baader AstroSolar Material

BP Solar, 989 Corporate Blvd. Linthicum, MD 21090 • 888-274-7652 or 410-981-0240 • Fax: 410-981-0278 • custhelp@bpsolar.com • www.bpsolar.com • BP 250F 2F 50 watt PV panel

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www.spaceweather.com • Science news and information about the sun-earth environment. Great Web site updated daily and full of information about current and past solar activity, eclipses, meteor showers, and auroras, with links to many other informative Web sites.

Nearest Star: The Surprising Science of Our Sun, Leon Golub & Jay M. Pasachoff, 2001, Paperback, 286 pages, ISBN 0-674-01006-X, US$16.95 from Harvard University Press, 79 Garden St., Cambridge, MA 02138 • 800-405-1619 or 401-531-2800 • Fax: 800-406-9145 or 401-531-2801 • Contact_HUP@harvard.edu • www.hup.harvard.edu • Introduction aimed at the general reader

The Cambridge Encyclopedia of the Sun, Kenneth R. Lang, 2001, Hardcover, 268 pages, ISBN 0521780934 • US$50 from Cambridge University Press, 40 West 20th St., New York, NY 10011 • 212-924-3900 • Fax: 212-691-3239 • information@cup.org • www.cambridge.org • Reference aimed at the general reader

The Sun: An Introduction, Michael Stix, 2002, Hardcover, 506 pages, ISBN 3-540-42886-0, US$89.95 from Springer-Verlag New York, Inc., 175 Fifth Ave., New York, NY 10010 •

800-SPRINGER or 212-460-1500 • Fax: 212-473-6272 • service@springer-ny.com • www.springer-ny.com • Advanced reference aimed at college physics students

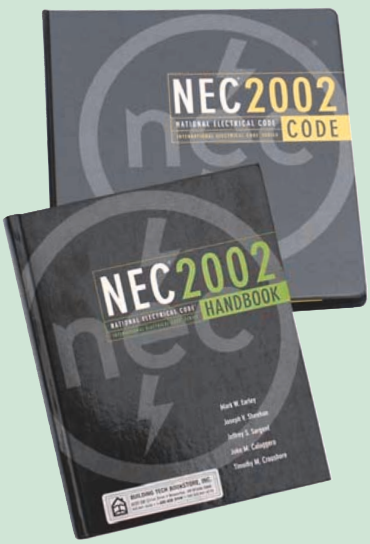
Observing the Sun, Peter O. Taylor, 1992, Hardcover, 173 pages, ISBN 0521401100, US$40 from Cambridge University Press (see above) • Beginning to intermediate amateur observer

Solar Observing Techniques, Chris Kitchin, 2002, Paperback, 218 pages, ISBN 1-85233-035-X, US$44.95 from Springer-Verlag, (see above) • Beginning to intermediate amateur observer

Solar Astronomy Handbook, Beck, Hilbrecht, Reinsch, Volker, 1995, Hardcover, 546 pages, ISBN 0-943396-47-6, US$29.95 from Volker, Willmann-Bell, PO Box 35025, Richmond, VA 23235 • 804-320-7016 • Fax: 804-272-5920 • www.willbell.com • Intermediate to advanced amateur observer

What the Heck? 13

Code Book



Used In: Building and construction trades throughout the United States

AKA: Code, the code

What It Is: A written set of standards that gives the minimum requirements for all types of building construction projects, usually in the areas of health and safety, as opposed to operation and efficiency

What It Ain't: Used in conjunction with a Captain Marvel decoder ring

Code books are published to standardize the quality of work done by building tradespeople and the equipment and material they install. Over forty states and every metro area in the United States have adopted one or more of the major codes. This is what gives the code books their clout. Many states and municipalities, in addition to adopting the national codes, have published their own local codes. Codes are primarily concerned with standards for the work performed by tradespeople (carpenters, electricians, plumbers, solar installers, etc.)

The major codes and their spheres of influence are:

- The *NEC—National Electrical Code*—Electrical wiring, safety devices, and equipment
- The *UPC—Uniform Plumbing Code*—Supply, waste, and vent piping in buildings and building sewers
- The *UMC—Uniform Mechanical Code*—Heating, ventilation, air conditioning, and refrigeration equipment
- The *UBC—Uniform Building Code*—The code for general contractors covers structural requirements and general building standards
- The *USEC—Uniform Solar Energy Code*—This code applies only to solar thermal equipment. Photovoltaic work is incorporated in Article 690 of the *NEC*

For the most part, code books are tough to read and have so many gray areas that they spawn other sources of info to help interpret the dull reading. For example, regular *Code Corner* columns in *Home Power* help to make sense out of the *NEC.*

–Chuck Marken • chuck@aaasolar.com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Battery Filling Systems of the Americas

Single-Point Watering System

Ian Woofenden

Application: Two Solar Energy International (SEI) workshops installed these battery watering systems on installation projects in our area in the past two years, and recently my family installed one on our home's battery bank.

System: The first SEI workshop system uses eight Interstate L-16 batteries. The second SEI workshop system uses four Deka industrial batteries. The watering systems for these banks use pump sprayers to hold and pressurize the distilled water. My home system uses eight Dyno L-16 batteries, and a 5 gallon jug for a gravity-feed reservoir.

Close-up of a BFS cap and float, with the lid lifted. On the left is the hydrometer access hole, and on the right is the level indicaor.

If you have flooded (not sealed) batteries, battery maintenance is critical to the success of your renewable energy (RE) system. (Sealed batteries do not need watering, but they are more expensive and typically don't last as long.) Most people say that the weakest part of RE systems is the batteries, but clearly the weakest part is the owners. I'm a case in point. In a classic case of the cobbler's children not having shoes, I do not check on my battery water frequently enough. It's really not that terrible of a chore, but for some reason I tend to put it off.

My view is that anything you can do to make battery maintenance easier and to *get it done* is worth the price. Build your battery box so that the battery tops are at a comfortable height—then you won't have to break your back to get at them. Make sure you have full standing room in front of your batteries. Build a sloping lid on your battery box so you can't pile stuff on top of it. And add a single-point watering system to your battery bank.

Until recently, these systems have mostly been used in large, industrial battery banks. But small home system owners are getting wise to what the big system owners have known for years—single-point watering systems make battery watering a snap.

In the old days (pre-watering system), I had to get a flashlight, funnel, and a jug of water. I had to remove each cap, check the level with the flashlight, pour some water in through the funnel, and check again. I had to do this for all 24 cells in my bank, and after I finished, electrolyte levels still varied. Occasionally I overflowed a cell, which is not a good idea. The whole process took perhaps 20 to 30 minutes, plus the time to get set up and cleaned up.

With a one-point watering system, I can water a bank of eight L-16s in less than a minute. Need I say more?

Installation & Operation

The watering systems we've used were imported from Germany by Battery Filling Systems of the Americas (BFS), and purchased from All Battery Systems in Everett, Washington, our local Interstate Battery distributor. Vern and Tom Allen of All Battery have been very helpful with SEI workshops for a number of years, speaking to our groups, supplying batteries and equipment, and answering our many questions. The watering systems they supply come with all the components except the pressure tank or reservoir.

The first step in the installation process is to remove the old battery caps and replace them with the BFS caps. Small pieces of clear tubing are then installed, running from cap to cap. The system comes with collars that clamp the tubing to the cap fittings, and a tool to help you push the collars in place. Smaller battery banks can be plumbed in one series run. We chose to split our battery bank into two parallel tubing runs to speed filling.

A flow meter shows you that water is flowing in the system, and a quick-release setup allows you to disconnect the system from the water source when it's not in use. We added a valve to our system, for convenience.

One-point watering system on a string of industrial batteries.

Kevin Green waters the battery bank in his SEI-installed system quickly, accurately, and conveniently.

The two SEI systems use portable garden sprayers for a distilled water reservoir and for pressurizing. To use the system, you pump the sprayer up to pressure, and water flows into the cells. For our battery bank, we opted for a gravity-fed system. When it's time to water, I lift our 5 gallon (19 l) reservoir up onto a shelf just above the battery bank and leave it for an hour or so.

It probably wouldn't be a problem to leave it up there all the time, but I'm not set up with a winterized space for the reservoir yet. The distributor does not recommend leaving the system under significant pressure, so we either release the pressure from the pump sprayers when we're done watering, or disconnect the quick release.

Smart Cap

The battery cap used in the BFS system has multiple functions. A plastic float rides down in the battery and is pushed up by the electrolyte. When the level is correct (you need to buy the right floats for your battery and electrolyte level), the float turns off a valve in the cap, preventing water from flowing into that cell. The cap allows water to flow on to cells farther along in the string.

Built into the cap is a white indicator button that rises up with the float, so you can see at a glance whether a cell is full

Features

High Points:

- Easy, quick battery watering
- No removal of caps for equalization
- Exact level fill; no over and underfilling
- No contamination of cells

Low Point:

- Cost

List Price: US$15.95 per cell for complete system

Warranty: 2 years

or not. A flip top exposes a hydrometer access hole, so you can still check specific gravity, and without removing the caps! The cap is quite sophisticated, with hydrogen and water flows separated, so no hydrogen gas can get into the tubing system, and a special chamber helps remove water from escaping gases, reducing the watering interval.

Problems? We have not had any so far. Of course, anything can fail. But the worst-case scenarios with this system look better than with the previous (human) system. The only potential problems I can see are if the valves stick, and the manufacturer has done a great deal of engineering to avoid this. The corrosive gases are isolated from the water channel, and I'm told that sticking valves are not a problem. I've checked the water level on the systems we've installed and all are just right. Replacing a bad cap would be a simple operation if it was ever necessary.

At about US$16 per cell, the system is not cheap up front, but I think it's a better buy than hydrogen recombining caps. BFS caps can be left in place for the life of the battery bank, and the system can easily be removed and reinstalled when you replace your battery bank. No removal for equalization or watering is ever necessary.

To me, this system looks like all benefit and no drawback. No more overfilling or underfilling; no more contamination; less procrastination. Battery watering is a quick, simple, and exact operation. Even a battery cobbler like me can handle a solution like this!

The author's watering system uses gravity feed.

Access

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Master Distributor for Renewable Energy Industry: All Battery Sales & Service, 727 134th St. SW, Everett, WA 98204 • 800-562-3212 or 425-743-7677 • Fax: 425-742-1739 • vern@allbatterysalesandservice.com

Money from the Sun

An Investor's Guide to Solar-Electric Profits

Paul Symanski

It happened quietly. On an ordinary day, a few years after the end of the last century, solar-electric energy became cheaper than fossil fuel energy. There were no great celebrations, no dancing in the streets, no discussion or mention in the news. The fossil fuel age has begun its decline, and the too-long-delayed renewable energy age is ready to supplant it.

Of course, photovoltaic (PV) energy has been economical for many years and in many situations—in remote areas where fossil fuels are not readily available, where the fossil energy utility grid does not reach, or in nations that do not control adequate supplies of fossil fuels. What happened recently is different, and has much more far-reaching consequences. It is becoming less expensive for us in the Sunbelt of the southwestern United States to power our homes and businesses with energy that is generated on-site by a solar-electric system than it is to purchase fossil fuel energy from the utility.

This is not to say that everyone can generate all of their electricity and do it economically. But, if your system is sized and sited properly, you are working within a comprehensive energy management plan, and if a number of other factors converge, then a small investment in supplemental solar-electric energy generation for your home or enterprise can exceed the average, long-term real return of the stock market.

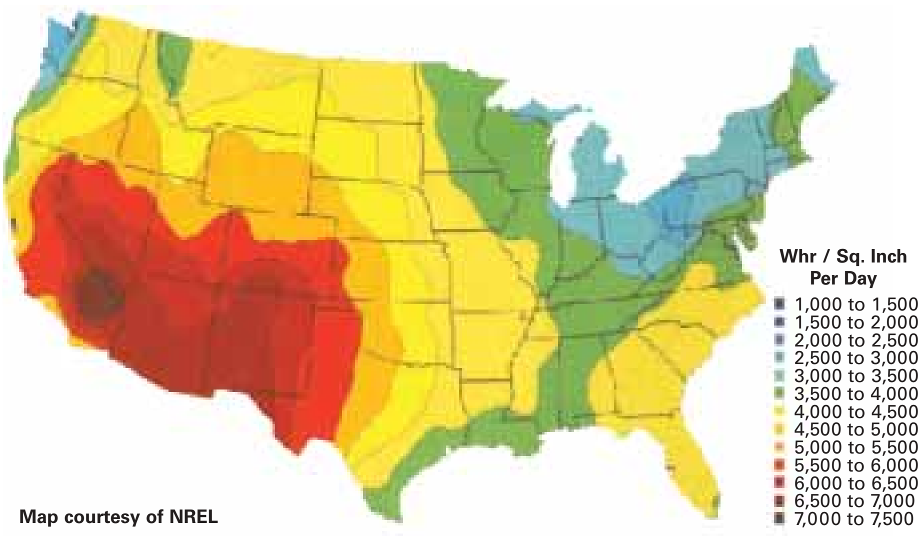
In more than fifteen years as a software engineer, I performed a multitude of roles, including designer, developer, system and information architect, systems analyst, network engineer, project and program manager, human factors specialist, author, and publisher. Several years ago, becoming disillusioned with the extravagances of the software industry, I returned to my roots as an electrical engineer and began to explore the fascinating world of renewable energy and sustainable living. To convince myself that pursuing a career in renewable energy would not just benefit society but would also support my family, I began to examine the economics of solar energy. I had to prove to myself that renewable energy would pay.

Fundamentals

To understand how to profit from solar-electric energy generation, you can perform a competitive investment analysis (CIA) between traditional investments, say, in the stock market or in treasury bills, and an investment in a solar-electric system. The fundamental question of this analysis is, "If I have a sum of money to invest today, can I expect a higher return with traditional investments or with an investment in a supplemental solar-electric energy system?"

The analysis shows that generating your own solar-electric energy is often the better investment. The factors

Solar insolation map of the continental United States.



Map courtesy of NREL

of this analysis come from five areas—natural resource assessment, technology, energy consumption, economics, and policy.

Natural Resource Assessment

The first factor to consider is the energy that the sun provides us. The insolation map shows the amount of solar radiation that is received throughout the United States.

Obviously, the Southwest has a great natural resource in the sun. To perform an accurate analysis, we need solar radiation data for each month throughout the year. The National Solar Radiation Database (NSRDB) can be found at the Renewable Resource Data Center (RReDC). For this analysis, the data is found in *The Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors.* (See Access.)

From this data, we can determine how much energy an unshaded array of solar-electric modules will receive in a specific location. We can then calculate how much energy the array will produce throughout the year. For example, see the table on page 89. It shows the average daily equivalent peak sun hours and production for an array of modules in Phoenix, Arizona.

Technology

Solar-electric energy systems consist of two basic types—those connected to the utility and those that operate independently of the utility. These are referred to as "grid-tied" (or "utility-tied") and "off-grid" systems, respectively. Some grid-tied systems include energy storage for when the utility is down. Others operate only when the utility is operating.

For my analysis, I focused on systems that are connected to the grid and have no storage component. If you are fortunate to be in a region where true net metering (i.e. your electric meter spins in both directions) is provided, you already have the perfect storage if backup is not needed. An investment in a solar-electric energy system of any size can then earn a maximum return, up to the amount of energy that is consumed.

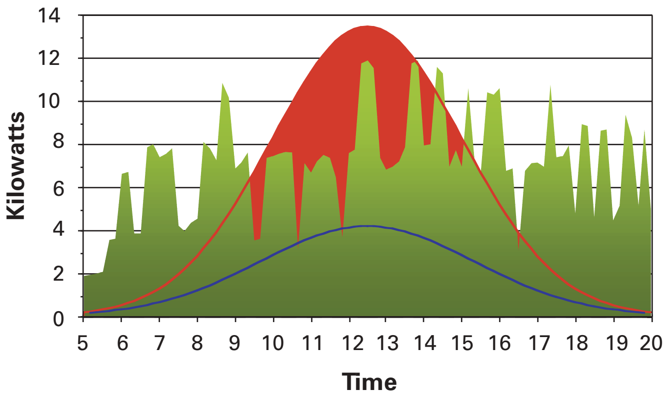
Today, most solar-electric modules are warranted for 25 years. Many first generation modules are still generating significant output after 35 years. For this analysis, a 20-year period is considered. In a batteryless grid-tied system, the one component that is subject to failure is the inverter. Repair costs for inverters are incorporated into the analysis, as are additional insurance costs for the entire system. The good news is that inverters of the latest generation may be far more durable and reliable than those of the previous generation.

The final element of solar technology to consider is module degradation. This competitive investment analysis uses an annual degradation rate of 0.7 percent based on an NREL white paper. (See Access.)

Energy Consumption

The first aspect to consider when specifying a solar-electric energy solution is the energy consumption. An electric load analysis must be performed, and energy consumption patterns must be considered.

Energy Production & Consumption for Phoenix



This analysis contains one critical assumption. Either you have true net metering that is zeroed annually, or in the absence of this optimal energy storage, all the energy produced by the PV system is consumed. In other words, unless you can sell the solar energy you generate at the same price that you pay for utility energy, don't make it!

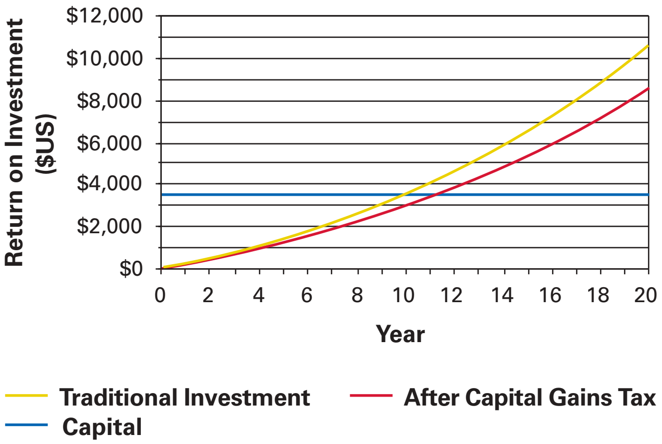
Without net metering, to maximize your profit while also maximizing your energy generation, you must implement energy management techniques. It is not only how much energy you use, but how and when you use it. A solar-electric system generates energy throughout a consistently sunny day in a smooth fashion. The red and blue lines in the Energy Production & Consumption for Phoenix graph (above) are clear-day energy production profiles of two different sized solar-electric systems.

The irregular, green area shows the daily consumption profile for a typical, 3,000 square foot (280 m^2) home in Phoenix, Arizona. The red area under the taller production profile represents the excess energy that will be returned to the public energy grid.

Without true net metering, to accomplish the largest annual return with the smallest possible system, the production and consumption curves must match for every day of the year. The energy consumption curve must be made smoother. In Arizona, cooling typically demands the greatest energy, just as it does during the longer summer days in more northern latitudes. The availability of solar energy matches this demand. With very little adjustment to lifestyle, an energy consumer can take a few simple measures to control how energy is used.

The degree to which the energy generation curve matches the consumption curve is called a load-matching factor. A factor of 1.0 indicates that solar-electric generation meets all energy demand and no energy is returned to the grid. In lieu of implementing energy management techniques, the PV system can be sized to fit the daily energy consumption profile. This smaller system generates the shorter energy production profile in the graph.

Traditional Investment Growth at 7.15%



Economics

The time value of money is critical to our analysis. Whether my utility bill is paid monthly or annually is just as important as how often my interest is compounded. All the rates in the analysis are effective rates adjusted for relevant periods and based on nominal annual percentage rates.

Traditional Investments

Since 1926, the average, long-term annual rate of return on large company stocks has been 10.2 percent. However, over this same period, the rate of inflation has been 3.05 percent. Therefore, the real rate of return on large company stocks has been 7.15 percent. The Traditional Investment Growth graph shows the growth of an investment at 7.15 percent over twenty years with interest payments being reinvested. An initial capital investment of US$3,250 earns US$10,500 in accumulated interest in twenty years. Not bad! Unfortunately, something is missing.

Taxes

Savings on utility bills are like post-tax income. This is a critical point for this analysis: you pay taxes on interest income; you don't pay taxes on money you save.

Currently, the capital gains tax rate stands at 15 percent, lowered from its previous rate of 20 percent on May 28, 2003. I used the current rate in my analysis. I ignored eligibility, brackets, effective dates, sunset provisions, and other capital gains tax complexities. The long-term annual return on large company stocks thus becomes 5.65 percent. The lower curve in Traditional Investment Growth represents the return on investment after capital gains taxes are subtracted.

An important aspect of the analysis is the point at which interest earnings match the original investment. This is when your earnings have doubled. For capital expenditures, this is known as "simple payback." Before taxes, at 7.15 percent, this occurs at month 110 (9 years, 2 months). After taxes, this occurs at month 130 (10 years, 10 months)!

Solar Investment

Question: If you were to take the savings realized from the lower energy bills resulting from the on-site generation of solar-electric energy, invest those savings at the same rate as the traditional investment, and reinvest any interest earned just as we do for traditional investments, how would the two alternative investments compare?

In this analysis, the interest earnings on the reinvested savings realized from on-site solar-electric generation are taxed at the capital gains rate, just as are the earnings on the traditional investment. The practical issues of brokerage fees are not considered as part of this analysis.

Before the returns can be compared, another key factor must be understood—utility rate schedules. By understanding rate schedules, you can calculate your avoided costs. The utility energy that you avoid consuming by replacing it with solar-electric energy is typically the most expensive energy that you purchase from the utility. The Monthly Production and Consumption table is an example of monthly consumption for a residence in Phoenix, Arizona.

The savings realized from on-site solar-electric generation can be calculated with knowledge of the monthly energy consumption, the avoided costs (including sales taxes, regulatory fees, etc.), and the amount of energy provided by the PV system. For example, the system illustrated in the table offsets 22.5 percent of the peak usage during the month of May. Since peak usage is charged at a higher rate than off peak, the savings are significant.

Efficiencies

For a 1 kilowatt array, you might expect that if 4.4 sun hours per day were available in January, you would achieve 4.4 kilowatt-hours per day from the system. However, no solar-electric system is 100 percent efficient. For example, high module temperatures will diminish an array's performance. Also, modules do not usually produce the output that the manufacturers imply by their ratings.

Other factors contribute to the total AC output of the inverter being lower than the total solar-electric array output rating. For the calculations in the Monthly Production and Consumption table, we use monthly overall efficiencies that give an annual average efficiency of 71 percent. In January (with a monthly efficiency of 75 percent) the actual daily kilowatt-hours available from the solar energy system will be 3.3 KWH per m^2 rather than the ideal 4.4 KWH per m^2.

Without true net metering, if you want to maximize the return on your investment, you must size the system to minimize the amount of excess energy produced. The calculations for our sample home with a solar-electric system size of 1,000 watts show that we are generating on average about 20 percent of the monthly on-peak energy needs. Is it reasonable to assume that this home will consume all the solar-electric energy it is generating? No, not necessarily.

This Phoenix, Arizona, home has two independent, split HVAC systems with heat pumps. If these two systems operate concurrently, the energy demand during that period will be higher than can be met by the PV system. Conversely, if neither is running after they have together

Monthly Production & Consumption for Phoenix, Arizona Residence

	Billing Period (Data in KWH unless Otherwise Noted)												
Consumption	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Annual**
Total used	2,923	2,528	1,731	1,618	1,908	2,604	2,434	2,556	2,312	1,396	1,797	3,116	26,923
On-peak	781	600	470	474	793	963	984	1,116	973	473	587	932	9,146
Off-peak	2,142	1,929	1,261	1,144	1,116	1,641	1,450	1,441	1,339	923	1,210	2,184	17,780
Days in billing period	29	34	28	29	32	30	29	31	28	31	33	32	366
Average daily	100.8	74.4	61.8	55.8	59.6	86.8	83.9	82.5	82.6	45.0	54.5	97.4	73.6
Average daily on-peak	26.9	17.6	16.8	16.3	24.8	32.1	33.9	36.0	34.8	15.3	17.8	29.1	25.0
Average daily off-peak	73.9	56.7	45.0	39.4	34.9	54.7	50.0	46.5	47.8	29.8	36.7	68.3	48.6
% On-peak	26.7%	23.7%	27.2%	29.3%	41.6%	37.0%	40.4%	43.7%	42.1%	33.9%	32.7%	29.9%	34.0%
Production*													
Average daily sun hours	4.4	5.4	6.4	7.5	8.0	8.1	7.5	7.3	6.8	6.0	4.9	4.2	6.4
% Seasonal system efficiency	75.2%	74.3%	73.3%	71.6%	69.6%	67.5%	66.3%	66.8%	68.1%	70.6%	73.4%	75.1%	71.0%
Adjusted sun hours available	3.3	4.0	4.7	5.4	5.6	5.5	5.0	4.9	4.6	4.2	3.6	3.2	4.5
Avg. daily on-peak use	26.9	17.6	16.8	16.3	24.8	32.1	33.9	36.0	34.8	15.3	17.8	29.1	25.0
Remainder on-peak use	23.6	13.6	12.1	11.0	19.2	26.6	29.0	31.1	30.1	11.0	14.2	26.0	20.5
% Solar on-peak	12.3%	22.7%	27.9%	32.8%	22.5%	17.0%	14.7%	13.5%	13.3%	27.7%	20.2%	10.8%	18.1%

*1 KW PV system in Phoenix, AZ with a fixed mount facing south at a 20 degree tilt.

sufficiently chilled the house, the energy from the PV system may be wasted (returned to the grid for less than its full value), if true net metering is not in force. The technique of load balancing multiple air conditioning systems is perhaps the best example of the importance of effective energy management for maximizing the return on an investment in solar-electric energy generation. Of course, there are many other energy management techniques, and the effectiveness of any technique depends on the region and other interdependent factors.

Policy

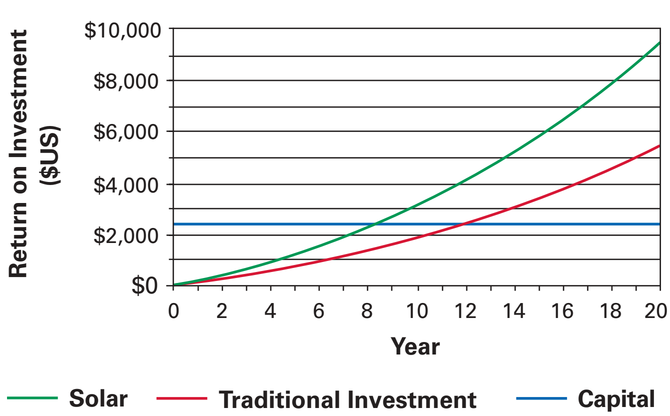
Policy dramatically affects the return on investment in solar-electric energy. Existing policies provide some important incentives for solar-electric and other forms of renewable energy. An excellent resource that lists renewable energy incentives is the Database of State Incentives for Renewable Energy (DSIRE).

The state of Arizona provides several incentives to homeowners for solar-electric systems. There is a one-time tax credit for 25 percent of the cost of a qualifying system up to a maximum of US$1,000. In addition, PV systems are exempt from sales taxes in Arizona. Arizona has also implemented an environmental portfolio standard (EPS), which includes Arizona Public Service (APS) providing a rebate of US$4 per DC watt, up to 50 percent of the installed cost of the system, for small (less than 5 KW), grid-tied, solar-electric energy systems.

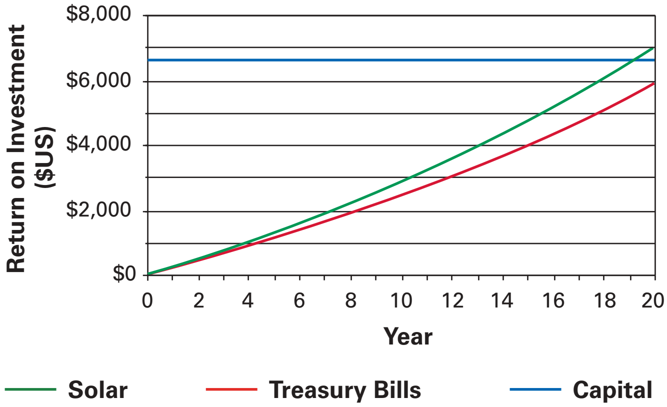
Results

The PV vs. Traditional Investments graph (below) shows the results of the comparative analysis of on-site solar-electric generation versus a traditional investment with a 7.15 percent annual return. The installed cost of this system

PV vs. Traditional Investment at 7.15%



PV, No Incentives vs. Treasury Bills



is US$6,500 (1,000 watts at US$6.50 per watt). After incentives, the effective cost is US$2,250.

Utility rates are rising. The Arizona Corporation Commission (ACC) recently approved a request by APS to increase rates by 9.8 percent. The price of natural gas, the fossil fuel that powers the newest generating plants, is increasing. The ACC also recently approved a so-called "power supply adjuster" that allows APS to pass on to consumers the cost of electricity purchased on the open market. My analysis includes the 9.8 percent rate increase and a conservative 2 percent increase in each following year.

More complex factors can be introduced into the analysis, such as the value of the equipment over time, or a comparison that includes the value of the original capital. Inflation has a near equivalent effect on both sides of the comparison, so it does not need to be considered in calculations for projected earnings.

Another question often raised regarding on-site solar-electric energy generation comes from the fact that we live in a mobile society. What happens to my investment when I move to a new home in five or ten years? As on-site solar-electric generation becomes more prevalent, the value of these systems is becoming better understood and accorded value just as is a pool, a kitchen upgrade, or other home improvement. According to the National Association of the Remodeling Industry and Wells Fargo Bank, "The [increase in home] appreciation ranges from 20 times your expected annual savings to the full cost of the solar system."

Risks

The return on your investment in home solar-electric energy generation compares favorably with the average, long-term return on stock market investments. But what are the comparative risks? Solar electricity can be considered a low-risk investment because its return is relatively predictable.

The PV, No Incentives vs. Treasury Bills graph (above) shows the results of the comparative analysis of on-site solar-electric generation *without* incentives versus treasury bills as a low-risk investment. The average, long-term return (before inflation) of treasury bills is 3.79 percent. Remember, inflation was 3.05 percent over the same period, so the real rate of return on treasury bills was actually 0.74 percent! Even without incentives, on-site solar-electric generation is an extraordinary investment today. Consider your portfolio diversification strategy—what better low-risk investment than solar energy?

Many Happy Returns

We have shown that in Arizona and with incentives, the return on investment in home solar-electric generation is comparable to the average, long-term return on investment in the stock market. However, the return for PV generation is predictable. Therefore, an investment in PV generation may be considered a low-risk investment. Even when incentives are excluded, an investment in home solar-electric generation is comparable to a traditional low-risk investment.

The same analysis can be performed for systems on commercial or industrial buildings. Even though different incentives apply, the results are as good or better than for residential systems, especially when utility energy rates rise. Rates for commercial and industrial utility customers are usually higher than for residential customers.

In regions outside the Sunbelt, incentives can result in comparable returns. An excellent example is New Jersey where, despite a relatively low natural resource, the combination of high energy costs and extraordinary incentives combine to deliver a high return on investment in on-site solar-electric energy generation. Finally, when benefits, such as improving the environment, natural resource conservation, and job creation, are considered as part of the investment analysis, the return for an investment in solar-electric generation is immeasurably better!

As exciting as the return on investment for on-site PV generation is, the returns for energy management measures such as efficient lighting, solar domestic hot water, solar pool heating, etc., can be even greater. When implemented as a complement to PV generation, these measures increase the amount of energy that can be profitably generated, thereby maximizing the initial capital investment and subsequent returns.

Consequences

The immediate personal reward is that there is money to be made with on-site solar-electric generation. The scale of the investment correlates with your energy needs and is a relatively small investment of capital whether you are a homeowner, a business owner, or a large institution. Because of its low-risk nature, on-site solar-electric energy generation makes an excellent addition to your portfolio and complements an investment diversification strategy.

With today's low financing rates, now is a good time to fund capital projects. You can finance a system at a portion of the expected rate of return for a relatively short initial period before realizing the full return during the remaining decades of the system's life.

On-site solar-electric energy generation can also be an effective risk management tool, since our aging, fragile, vulnerable electricity grid is susceptible to disruptions. A solar-electric energy system can be designed to meet your energy surety needs. Risk prevention may balance the greater costs of such a system. In any event, investing today in a small, supplemental solar-electric system can provide valuable experience with on-site energy generation and prepare you for the future.

Finally, within the warranty period of the system, you will have accumulated as much or more savings with a solar-electric energy system than you would have with a traditional investment. It will be enough savings to expand or upgrade your existing system, or to purchase an entirely new, next-generation system. To wait is to waste.

Access

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The Database of State Incentives for Renewable Energy (DSIRE), NC Solar Center, NC State University, Campus Box 7902, Raleigh, NC 27695 • susan_gouchoe@ncsu.edu • www.dsireusa.org

Arizona Public Service, PO Box 53999, Phoenix, AZ 85072 • 602-250-1000 • www.aps.com

National Association of the Remodeling Industry (formerly The National Remodelers' Association), 780 Lee St. Suite 200, Des Plaines, IL 60016 • 800-611-6274 or 847-298-9200 • Fax: 877-685-NARI • info@nari.org • www.nari.org

"Photovoltaic Module and Array Performance Characterization Methods for All System Operating Conditions" • www.sandia.gov/pv/docs/PDF/KINGREL.PDF

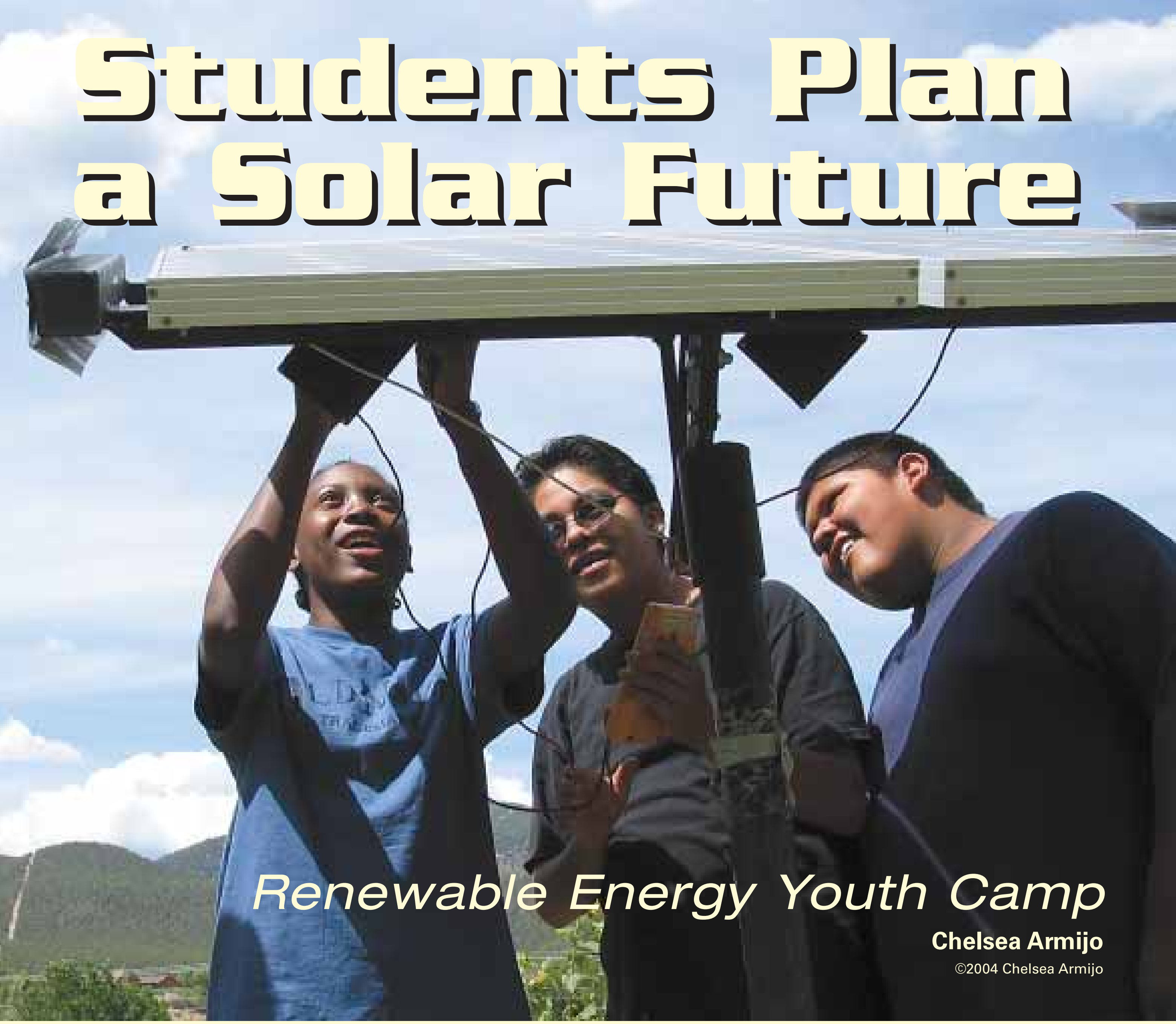
"Commonly Observed Degradation in Field-Aged Photovoltaic Modules," by M. Quintana, D. King, T. McMahon & C. Osterwald, 2002, 0-7803-7471-1/02 IEEE

"PV Orientation," by Zeke Yewdall, *HP93*

Students Plan a Solar Future

Renewable Energy Youth Camp

Chelsea Armijo



Dashauna Briscoe, Charles Wadsworth, and Samuel Masayumptewa wire a photovoltaic array at the 2003 Renewable Energy Youth Camp in Paonia, Colorado.

Paonia, Colorado, is a small town of about 1,500 people located on the western slope of Colorado. It is supported mostly by agriculture and coal mining. Folks have either lived here their whole lives, sometimes on the same ranch their great-granddaddy owned, or have moved here to live a simpler life. Paonia is my home, and it was the site of this year's Renewable Energy Youth Camp.

The camp is in its fourth year of empowering and educating youth to live more sustainably. Solar Energy International (SEI) brings together students from all over the world to address the serious issue of how we use energy today. I had the awesome opportunity to participate in this year's youth camp. I am a homeschooler, or I should say "unschooler," and I feel that educating youth about renewable energy is one of the smartest things our society can do.

How can we live our lives without consuming more than this planet can support? We need to look at the amount of resources our lifestyles demand and start realistically identifying our true needs. This is what we should be teaching youth. It's something families should be discussing with their children around the dinner table. We need to start becoming aware of our impact and its cost.

During our week at the camp, we studied renewable and finite resources, the science of electricity, natural building, and practical ways to cut back our energy consumption right away. We did hands-on projects, installing photovoltaic systems and cooking with solar ovens. We also toured sustainable and off-grid homes, as well as a local coal mine.

We cannot change the actions of yesterday, but we can learn from them, and every day make the changes we wish to see in our future. During the camp, director Ed Eaton asked the attendees to write about their experiences, and the importance of this type of camp.

SEI staff member Jeff Tobe shows campers how to evaluate solar exposure with a Solar Pathfinder.

Sky Scholfield
Age 14, Redding, California

I am from the Wintu Tribe. My sister and I participated in this summer's solar/renewable resource camp. On the second day, I learned that solar cooking has all the advantages you could wish for. First, solar cooking takes no energy to power it, but on a hot day it will cook in the same time as a regular oven, up to a temperature of 300°F.

The greatest part of using a solar oven during the summer is that you do not heat up your house when it is already hot from summer heat. If you haven't seen or learned about solar ovens, they are the best thing you can do to conserve energy. As a Wintu, I believe that we should use the resources that are already available to us.

Sky Scholfield provides the pedal power while camp assistant director Melanie Thibodeaux explains energy efficiency.

Charles Wadsworth
Age 16, Hopi Reservation, Arizona

I am from the Hopi Reservation in Arizona. I had a great opportunity to come to the Renewable Energy Youth Camp. We have done many great things in this camp. The one thing that really interested me was the straw bale homes. This to me was a very good thing to hear. We saw how people could build a nice cool home from natural materials, such as horse bedding (straw), clay, or recycled wood. The homeowners don't have many bills to pay because they use natural lighting and house coating. This is a great way to live.

Skylar Upshaw
Age 17, Boulder, Colorado

I participated in this year's Renewable Energy Youth Camp. This is what I want to say about it. Unplug your TV. Okay. Now open your eyes. Every electronic device with a remote (TV, radio, computer monitor, etc.) and with memory (channels, time, etc.) in your house uses energy when you assume it is off. They call this a phantom load. Though it is not costly to one family, when you add up all the users, it is wasteful and endangers the environment. Renewable energy is the way to go, but definitely costly. If it is not affordable or accessible for you, you should definitely lighten your load. Plug all your phantom loads into a power strip. Turn them all off to lighten your load and the impact on our world.

Ian Burritt
Age 15, Hotchkiss, Colorado

Participating in the Renewable Energy Youth Camp was one of the most interesting and informational things I have

Camp director Ed Eaton and camp facilitator Richard Garcia show Sky Scholfield and Skylar Upshaw how to use a digital multimeter.

ever done. Since I am good at many technical things, the section of camp that excited me most was our class on electricity and basic PV principles. Although I do not have a grasp on the technology used to produce electricity from the sun, the fact that solar panels are only 15 percent efficient gave me a good idea of what to work for. I would like to develop solar panels that have efficiencies of 70 percent and up. In the future, I hope that other people and I can create a new level of clean electricity, and encourage its use.

Samuel Masayumptewa
Age 16, Hopi Reservation, Arizona

During our camp, we went to a coal mine where I learned lots of things. I learned that you can use coal for electricity and many other things. On the Hopi Reservation, we use coal to heat our homes. Another thing I learned was that coal is not a very healthy material. The coal dust can eventually kill you, and contains lead, arsenic, and uranium. Coal miners have to breathe this stuff, so the mine has a black lung disease fund to help miners when they get sick. When we rode on the coal mine's bus, the black coal dust was all over, and we got dirty just walking and sitting on the bus. I don't think that any more coal mines should be made. I don't want any more holes in the earth.

Dashauna Briscoe,
Age 14, Jamaica, West Indies

This summer I made an excellent choice by coming to the Renewable Energy Youth Camp. The information and hands-on exposure I received excited me so much that I want to try to teach what I learned to people who want to learn about this.

The most interesting part of this experience for me was the hands-on part. I learned how to use a meter and how important it is when installing a photovoltaic system. I also learned that a PV system is more energy efficient. It uses the main source of energy, the sun, and converts it into electricity, instead of using coal! It's very simple to install if you know your math. This camp has changed and will continue to change my life.

Sloan Oeinck
Age 11, Paonia, Colorado

I participated in the Renewable Energy Youth Camp. After touring a coal mine and two solar homes, I began to realize that we have to give back to the earth before it dies. We can't keep on draining nature's supplies without consequences. We must learn how to nourish the earth back to a living state. I know that at the rate we are going, the earth will turn into a big dirt clod that will slowly chisel off into space. Then we will fly to another planet, use up all its resources, and eventually kill it too. If we use renewable energy, the human species will last longer or forever.

Ian Burritt and Chelsea Armijo install components inside a battery box.

Vanessa Scholfield and Richard Garcia do the prepping for a solar cooked feast.

Vanessa Scholfield
Age 16, Redding, California

Spending a week in Paonia at the Renewable Energy Youth Camp and gathering knowledge about renewable energy has empowered me to teach others back home what I have learned. Renewable energy education opened my eyes to a whole new lifestyle. This community uses renewable energy, shares a common interest in health, concern for the environment, and a sense of well-being of mind, body, heart, and spirit as a whole.

What I want to do is carry this atmosphere back to California where people aren't as aware of these things. I believe that sharing the perspective of building our homes and communities' energy needs around renewable energy like photovoltaics or hydropower will create the same contagious community feeling that I have experienced here in Paonia. This is one of the greatest things anyone could be a part of. Much like the renewable resources that we will be using, the feeling of community will be unlimited.

Hillary Briscoe
Dashauna's mom, Jamaica, West Indies

About two years ago, my family and I were moved to make changes in the supplier of our electricity. The electric

Visions for the Future!

Ed Eaton, director of the Renewable Energy Youth Camp, envisions an expanded camp and apprenticeship program in the future. The purpose of the new youth camp is "to educate young people worldwide on the merits of renewable energy and sustainable living."

Ed has been leading workshops on solar energy and its practical uses for more than twenty years. Over these years, he has worked in the solar energy industry as an educator, system designer, installer, consultant, and camp director. His passion as an instructor is to inform young minds about renewable technology and the energy choices that they can make.

For the past four years, Ed and his staff, Melanie Thibodeaux, Richard Garcia, and others, have directed the Renewable Energy Youth Camp. At this year's camp, he shared with us his dream of expanding the camp. His vision is to invest in a piece of land where young people can come for two or three weeks or do summer-long internships. Youth from all over the world would come to "learn what the effect of their choice is." Their education would be directed toward renewable energy, organic farming, and sustainable living, with the opportunity to enroll in the Renewable Industry Apprenticeship Program.

Ed also talks about the importance of discussing social issues and our shared concerns of what is going on in the world. I asked him why or how some of these topics tied into renewable energy. "Energy is at the heart of every ecosystem. Everything is interconnected, and to separate them is a limiting perspective," he says. "When you are dealing with these issues all alone, you feel helpless, but to come together as a group, you start to feel empowered."

Ed had been trying to come up with a name for his new camp, and it became apparent during a brainstorming session at this year's SEI Youth Camp—"Camp-Us." "Complete with a youth advisory board, the sun shall shine on us all," Ed says.

What would the world look like if you had the opportunity to recreate the way you lived? This was the first question that popped into my head when Ed shared his visions of a future camp. I thought of an inspired group of people from all around the world living simply, growing all their own food, building with natural and local material, and using renewable energy for everything. I thought of a learning atmosphere where students have the hands-on experience of being completely self-sustained. I imagined the reward of not only working for change in the world, but living it every day.

Campers and staff of the 2003 Renewable Energy Youth Camp with a solar powered light they installed at the local food co-op.

company in Jamaica disconnected our electric line, stating that the meter reading was not reflecting what they thought we were using. Based on the size of our home, they said that the bill should be more. So I started looking into alternative sources of energy.

We have a home on the east coast of the U.S., and not too many companies are involved in renewable sources of energy there. I got on the Internet and found SEI. Then my husband and I took a class in solar energy. We were able to purchase and install, with assistance, our own system. While taking the class, I learned about the Renewable Energy Youth Camp. I was very excited and spoke with my 14-year-old daughter, who decided to attend. We applied, were accepted, and she attended. I came along to drop my daughter off and was allowed to stay for two days at camp. I was encouraged to stay longer, but had other plans.

The camp was exciting; the material covered was presented well. I believe that this camp is a very important part of educating our youth about the environment and renewable resources. I hope we will all get actively involved in helping this program to expand.

Chelsea Armijo
Age 18, Paonia, Colorado

I speak to everyone but, specifically to youth when I say this, because as Ed says, "We are the consumers of tomorrow." I say we are also the warriors of today. Our actions are the future, and now we start. We have the power to decide what we will and will not be a part of. Take that power. Create. Be an independent thinker. Educate yourself on where your resources come from. Know what you buy. As Ed said to me, "We cannot change the system if we do not change our demand for finite resources." Educate yourself on what you are supporting. As Gandhi said, "You must be the change you wish to see in the world."

Access

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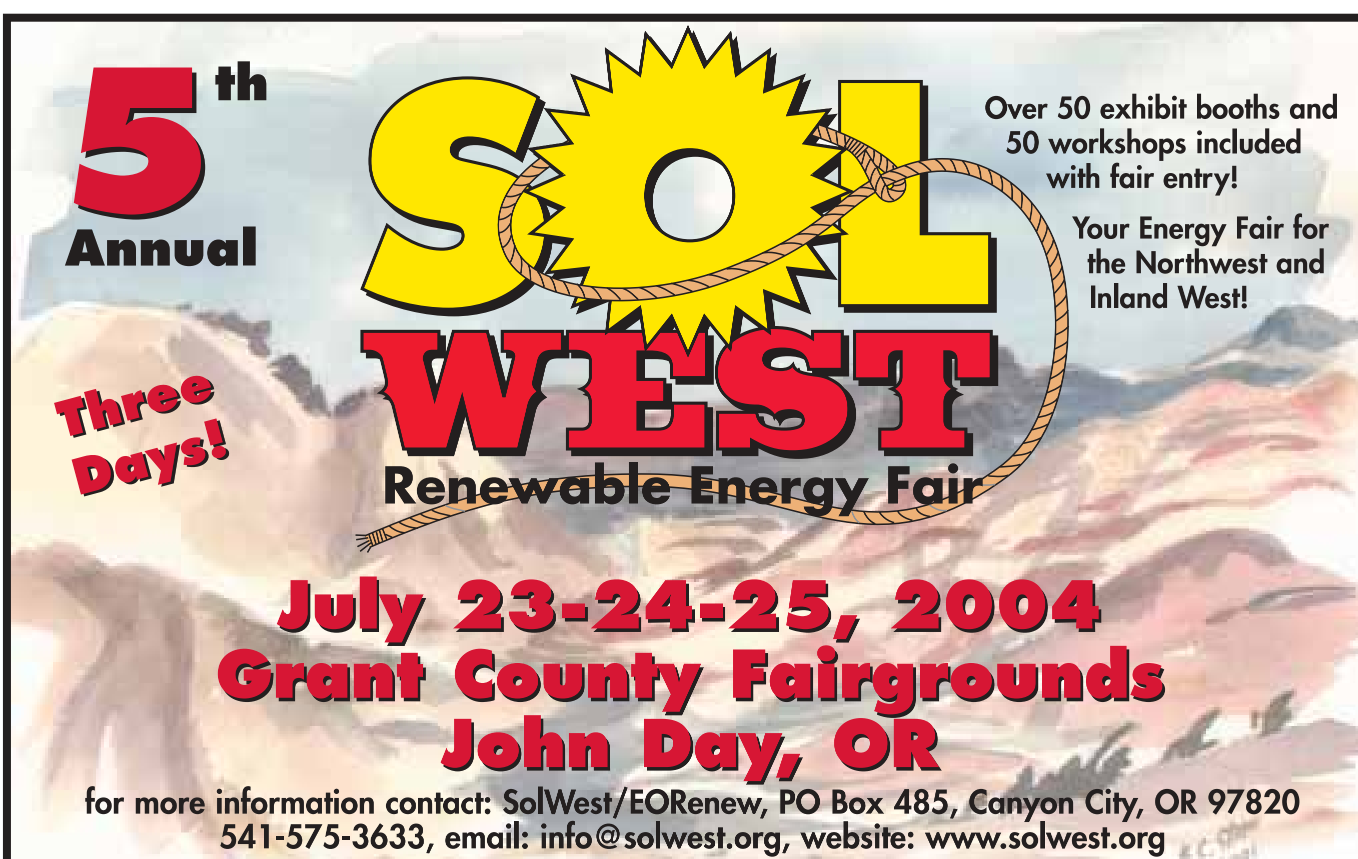

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The Nuts & Bolts of Fasteners —Part 2

Mike Brown

Bolts alone can't do the job without nuts and washers.

Last issue, I talked about the importance of using the right hardware for the job in your electric vehicle conversion. We looked at bolts and machines screws—sizes, head styles, grades, and finishes. But bolts aren't much good by themselves. Let's look at the rest of the hardware.

Nuts—The Second Part of the Team

Unless it is being threaded into a tapped hole, a bolt cannot do its job without a nut. The first and most obvious requirement for the correct nut is that the thread has the same diameter and thread form as the bolt. In U.S. hardware, correct means coarse threaded nuts with coarse bolts and fine nuts with fine bolts.

With metric fasteners, this is a little more difficult, particularly if you are trying to replace lost or broken nuts or bolts. There are two conflicting thread types. In European vehicles, and some U.S. cars and trucks built since 1975, the ISO (formerly the Deutsche Industry Normal or DIN) metric thread system is used. This system falls between the USS (coarse) and SAE (fine) pitches (the distances between the thread peaks).

Fasteners in Japanese vehicles conform to the Japanese Industry Standard. The JIS system has two pitches: one between the ISO and SAE pitches, and a second pitch that is finer than SAE. This means that not all 10 mm bolts will fit all 10 mm nuts. This is why you should save all the fasteners you take off the vehicle you are converting.

Since the hex nut is the type most commonly used in the automotive world, it is the type we will be referring to in this article. Square nuts are available, but they are generally used on farm implements and decorative ironwork.

Although nearly all automotive nuts are made of the same low carbon steel, they are hardened to Grade 5 or Grade 8. As for finishes, nuts are offered either plain or zinc plated to match the grade color code. Stainless steel nuts should only be used with stainless steel bolts. As we discussed last time, due to the expense and brittle nature of stainless steel, it should only be used where needed to avoid corrosion.

Wrench size is determined by the width of the nut, measured across the top, from the center of one flat side to the opposite flat side. To make things easy, there is a

Left to right: nut, jam nut, heavy nut, heavy jam nut. All of these nuts fit the same size bolt.

Left to right: slotted thread locknut, deformed thread locknut (also called a "stover"), and nylon insert locknut.

standard that dictates the nut width and height for common bolt sizes. For example, the nut for a 1/4 inch bolt is 7/16 inch wide and 7/32 inch high.

The dimensions described above are for a standard 1/4 inch hex nut. There is also the jam, or half-height, nut. This nut has the same width as the standard hex nut, but is a little more than half as high. The jam nut is used where clearance between moving parts is an issue. Since the strength of a nut is determined by its thickness (the thicker the nut, the more threads gripping the bolt), jam nuts should only be used when absolutely necessary. A jam nut can also be used to lock another nut in place, which is probably where its name came from.

The only other size variation involves "heavy" nuts. These are wider than the standard nuts, for a bigger contact area, and thicker for greater strength. The heavy jam nut has the same width as the heavy nut and is a little more than one-half the heavy nut's height.

Nuts Come in Different Flavors

So far, we have identified nuts by their material, hardness, thread diameter, thread pitch, width, and height. Nuts are also identified as plain or self-locking. A plain nut is the type we have been discussing up to now. It threads on the bolt and turns easily until it contacts one of the parts that it and the bolt are holding together. Then the head of the bolt is held with a wrench and the nut is turned with another wrench until your elbow or a torque wrench tells you it is tight enough (more on "tight enough" later). Once tightened, the plain nut is held in place by the friction between the threads of the nut and bolt. If the assembled parts are subjected to vibration, it is only a matter of time before the nut loosens and the assembly fails.

Since the effects of a fastener failing on an automobile can range from inconvenient to deadly, keeping the fasteners tight is desirable. This leads us to the second type of nut—the locknut. We will look at the two most common versions of locknut—the nylon-lined or Nylock nut and the all-metal, self-locking nut.

The Nylock nut is a plain nut with a nylon ring built into its top. When the Nylock nut is threaded onto a bolt, the nylon ring deforms to match the threads of the bolt. This produces an interference fit between the bolt and the nylon insert, which locks the nut in place.

This does not harm the threads on the bolt, which allows easy assembly and disassembly. However, the Nylock nut should be discarded after six applications. Its features make the Nylock nut the most widely used type of locknut. A word of caution: Nylock nuts should not be used where they are subjected to more than 250°F (121°C), which will melt the nylon.

There are two types of all-metal, self-locking nuts. The first type has the top half of the nut slotted multiple times around the diameter of the threaded hole. The threads in the slotted part of the nut have a slightly smaller inside diameter than the standard threads in the bottom half of the nut. When the bolt hits the slotted portion of the nut, it forces the metal parts of the nut to spread between the slots. This creates an interference fit, which locks the nut in place. This locknut does not distort the threads of the bolt and is reusable.

The second type of all-metal locknut is the deformed thread locknut. These nuts have part of their threads deformed, which forces the bolt to act like a thread-cutting tap to reform the threads of the nut. This causes a very heavy interference fit and can damage the bolt. These nuts should be used where the assembly is considered to be permanent. If disassembly becomes necessary, both the nuts and bolts should be discarded.

Washers—The Third Part of the Team

There are many different kinds of washers. We are going to discuss two types—lock washers and flat washers.

Lock washers—springs and teeth. A lock washer is installed on a bolt between the nut and the part. Its purpose is to keep the nut from vibrating loose. A pure spring lock washer, like the slightly dished Belleville washer, works by increasing the friction between the threads of the nut and bolt. It does not damage the nut or the part, but costs five times as much as the common split spring washer.

The split spring lock washer is what most people think of as a lock washer. It has a split across it, and one edge of the split bends up while the other edge bends down. It is widely used, does its job pretty well, and best of all, it's cheap. Its main disadvantage is that it gets part of its locking ability from the ends of the spring digging into the nut and into the part, which permanently damages both of them.

You can put a flat washer between the lock washer and the part to protect it, but then all you accomplish is locking

Lock washers, left to right: Belleville concave spring, split spring, internal toothed, and external toothed.

These are all 1/2 inch flat washers. The lower right one is SAE standard. The other three are from different batches of USS standard. Note the wide disparity among the USS washers.

the nut to the flat washer, leaving only the spring force to prevent loosening. A plain nut and a split spring lock washer should not be considered the equivalent of a Nylock nut.

Toothed lock washers are steel stampings that can have either internal or external teeth. They do their job by digging their teeth into the nut and into the part. Since they are low strength, their use is usually limited to machine screws under 1/4 inch in diameter.

Flat washers—no nut and bolt should go without. The basic flat washer has two jobs to do. The first is to spread the clamping force of the nut and bolt over a larger area. The second is to prevent damage to the parts during tightening.

Like everything else in this article, flat washers come in many different types. We are going to look at the difference between two types—USS and SAE. Both are identified by the size of bolt they fit, but that and being round is all they have in common.

The USS washer is kind of a free spirit. The inside and outside diameters and thickness vary among manufacturers, and among countries of origin. This lack of consistency makes the USS flat washer useable for distribution of force and part protection only.

The SAE flat washer, however, is a precision part. Its inside and outside diameters as well as thickness (all of which are smaller than the USS washer) meet an established standard. Knowing these dimensions is important when you are designing parts for your conversion. If a part has a limited amount of space between the bolt hole and the edge, it is nice to know that the washer you are planning to use will fit.

The SAE washer's uniformity has many technical advantages, such as the ability to use it as a precision spacer. It also gives the finished product a more professional appearance. Use SAE washers. You may pay a few pennies more, but you will be going first class.

No Loose Nuts

Determining how much force to use with nuts and bolts can be tricky. If a plain nut is not tightened sufficiently, there won't be enough friction between the threads to hold it in place. Vibration will work on the loose nut until it falls off, usually at the worst possible time.

Although a Nylock nut is not affected by vibration, if it is not tightened enough, the parts being held together will move against each other. This movement can result in bolt hole distortion as well as damage to the mating surfaces. Either of these conditions, left uncorrected, can result in a big oops.

A little too tight. The obvious solution is to get the longest wrench you have that will fit the nut, apply some real muscle to it, and get that nut tight. The problem with this technique becomes apparent when the bolt snaps and comes off in your hand. This usually occurs with small bolts (1/4 to 5/16 inch diameter), when the force exceeds the tensile strength of the bolt.

With larger bolts (3/8 inch and up), what usually happens is, just as you're really pulling on the wrench, suddenly the nut starts to turn easily but it isn't getting any tighter. When you try to back the nut off the bolt, it spins but doesn't move in that direction either. What we have here is a case of stripped threads. This happens when the force being applied to an already tight nut and bolt exceeds the tensile strength of the threads of the nut or bolt or both.

Just tight enough. The way to avoid the two failures above is to know exactly how much force (called "torque") to apply. There are two ways to determine the tightening torque for the fasteners used in your conversion. If the parts being assembled were originally part of the vehicle, your factory service manual will have torque tables. These are usually at the end of each section relating to a specific group of components such as brakes or steering.

If the fasteners are for parts being added as part of the conversion, you must refer to a torque chart (see the table). The torque chart tells the torque limit for a bolt of a specific size and grade. As you choose fasteners and look up their torque ratings, note these in your project notebook. After the conversion is done, use those notes to create a torque table for the conversion parts of your EV.

Use the right tool. To determine how much torque you are applying, use a torque wrench. The simplest form of this tool has a drive for a socket wrench on one end of a long arm with a handle on the other end. It has a pointer attached to the socket drive end that runs along the arm until it ends at a calibrated scale just below the handle.

Torque Chart (Foot-Pounds)

Type	Bolt Size (In.) 1/4	5/16	3/8	7/16	1/2	9/16	5/8
Grade 5	10	19	33	54	78	114	154
Grade 8	14	29	47	78	119	169	230

When force is applied to the fastener, the arm bends. The pointer does not bend, and its free end points to a graduation on the calibrated scale that shows how many foot-pounds of torque are being applied. While this tool sounds primitive, it is quite accurate. I rebuilt an awful lot of VW Bug engines using this kind of torque wrench.

With the more modern torque wrenches, the desired number of foot-pounds of torque is preset against a calibrated spring. When that amount of torque is reached, the handle gives a bit and a loud click is heard. This type is easier to use because you don't have to watch the pointer. An experienced mechanic will develop a calibrated elbow over the years, and only use the torque wrench when a more precise amount of torque is required.

If you don't have much mechanical experience, it might be best if you tighten all the fasteners until they are snug, and then go over them again with a torque wrench. After using this procedure enough times, you may develop a calibrated elbow of your own.

Another good habit involves tightening a number of fasteners that are in a pattern around the edge of an assembly. Instead of tightening one nut and bolt and then moving to the next set in line, use the criss-cross method. Start with one fastener and tighten it a few turns. Then move to another one across the assembly and give it a few turns. Keep moving this way from fastener to fastener until they are all tight.

This method pulls the two parts of the assembly together evenly and avoids distortion. Examples of places to use this technique are fastening the battery rack to the vehicle's frame or body, and bolting the flywheel to the adaptor hub.

Two versions of the torque wrench for precision tightening, the older style on top and the newer style on bottom.

You might not feel like putting a torque wrench on every fastener you put on your conversion. Few people do. However, as a minimum, you must torque any fastener that is helping to support a lot of weight or is part of a rotating mechanism. These are the areas where failure is likely and will cause the most damage.

Attention to Detail Counts

Fasteners are such small things, so people rarely give them much thought. But as you can see from what we've discussed in this article and the previous one, there are a lot of differences among them. These little differences can make a big difference in the success of your electric vehicle conversion project, or any other project.

Access

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Carroll Smith's Nuts, Bolts, Fasteners, and Plumbing Handbook, by Carroll Smith, 1990, ISBN: 0879384069, 224 pages, US$21.95 from Motorbooks International, 380 Jackson St. Suite 200, St. Paul, MN 55101 • 800-826-6600 or 715-294-3345 • Fax: 715-294-4448 • trade@motorbooks.com • www.motorbooks.com

The National Electrical Code—

Past, Present, & Future

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center
Sandia National Laboratories

The *National Electrical Code (NEC)*, updated and published every three years by the National Fire Protection Association (NFPA), is the most current and comprehensive electrical safety installation requirements document in the world. The 2002 *NEC* is the current edition, and work is nearly complete on the 2005 edition.

Hundreds of volunteers work on a three-year cycle to review and update the *NEC* to accommodate the latest technology and methods of wiring electrical systems. Representatives from the photovoltaic (PV) industry, academic institutions, the inspector community, testing laboratories, and the electric utility industry meet regularly to modify and update Article 690 of the *NEC*, which deals with PV systems. Although Article 690 covers only eleven pages in the *NEC*, most of the remaining 711 pages of the code also deal with wiring practices and requirements that affect PV installations.

The *NEC* has been legislated into law by nearly all states and by most major cities in the United States. It has been published for more than 100 years and represents the best ideas that have evolved in more than a century of electrical power systems theory, design, and installation practice. There is always room for improvement, and the document continues to evolve. Paperback copies of the *NEC* are available for less than US$50 at most electrical equipment distributors. The *NEC* and the hardbound *NEC Handbook* are also available directly from NFPA (see Access). The *NEC Handbook* provides additional explanatory detail and numerous pictures and diagrams.

A Safety Code

The *NEC* began as a fire safety code, but now includes personnel safety. It requires that all equipment be examined for safety. While the local electrical inspector or authority having jurisdiction (AHJ) will inspect the field-installed wiring, the AHJ relies on the listing or labeling mark of an acceptable nationally recognized testing laboratory like UL, ETL, or CSA to provide an indication that all equipment, conductors, and devices have been examined for safety. The listing mark ensures that the equipment has been tested to meet a number of appropriate safety standards relating to electrical shock and fire hazards. Many inspectors will only inspect or approve systems that have been assembled with listed components. Insurance and mortgage companies may require electrical inspections, particularly on new construction or on additions to existing structures.

The inspector will be looking for the good workmanship required by the *NEC.* PV installations that resemble other electrical installations will be more readily accepted than those installations using equipment or unconventional installation practices that do not resemble normal electrical supply equipment.

All listed equipment comes with labels or instructions that define the requirements (developed in conjunction with the requirements of the *NEC*) for installation and use of that equipment. Violations of these instructions or requirements may result in unsafe systems and equipment damage. The inspector, in many cases, will verify that these instructions have been followed. Almost all of the material that is printed on labels attached to electrical equipment has been placed there to meet a safety requirement—either established by the *NEC* or by a listing laboratory. Much of the material found in equipment instruction and installation pamphlets and manuals is also mandated by safety requirements.

Code Arrangement

The first four chapters of the *NEC* are general in nature and apply to nearly all electrical systems. Here are the chapter titles and some of the contents:

- Chapter 1. General: Includes definitions and general requirements for electrical installations.
- Chapter 2. Wiring and Protection: Includes the calculations of loads and circuit sizes, overcurrent protection, and grounding.
- Chapter 3. Wiring Methods and Materials: Includes all of the fixed (nonmoving) wiring methods, and ampacity tables showing the current-carrying ability for conductors.
- Chapter 4. Equipment for General Use: Includes numerous types of electrical equipment and portable cords and how they are to be connected and used.

The later chapters of the code cover all of the different types of electrical installations:

- Chapter 5. Special Occupancies: Includes hazardous locations, healthcare facilities, recreational vehicles, mobile homes, motion picture theaters, and numerous other commercial buildings.
- Chapter 6. Special Equipment: Includes items like electric vehicle chargers, audio systems, fuel cells, swimming pools, X-ray equipment, electric welders, and of course, PV systems.
- Chapter 7. Special Conditions: Includes emergency systems, standby systems, utility-interactive systems, fiber optic systems, and power-limited systems.
- Chapter 8. Communications Systems: Includes radio and TV transmitting and receiving systems, CATV systems, and broadband communications systems.
- Chapter 9. Useful tables on conductor properties and sizing, and using raceways and conduit.

Requirements of the NEC *Are Complex*

Article 690 in Chapter 6 covers PV installations, but relies on the material in the first four chapters and much other information throughout the code for the basic electrical system requirements. Because many aspects of PV systems are sufficiently different from other electrical systems, Article 690 was developed in 1984 to cover them. Where the requirements of Article 690 differ from other requirements in the *NEC*, Article 690 takes precedence. However, the local electrical inspector has the final say.

The installation of PV systems is at least as complex as the installation of residential electrical systems, and in some cases more complex. To illustrate the complexity—one of the numerous training guides that covers the installation of residential electrical systems is 647 pages long! It takes the apprentice electrician nearly four years of study and practice to reach the journeyman level.

Safety vs. Performance

NEC requirements for PV installations and the requirements found on labels and in instructions for listed equipment, when followed, will generally result in a safe installation. While using equipment listed to UL standards and installing that equipment to *NEC* requirements does not guarantee high levels of performance, higher performance and reliability frequently are achieved.

The code-required manner of sizing components, covered in past (and future) *Code Corner* columns, and the higher quality of listed equipment will generally result in PV systems that have higher levels of performance and reliability than systems that do not meet *NEC* requirements and are not listed. Of course, it is possible to install a code-compliant system using listed equipment in a poorly designed system or with misadjusted equipment, and performance and reliability may suffer.

Please remember that the *NEC* is not a design document, and to quote a senior code-making official: "The *NEC* will not contain anything that will keep stupid people from making stupid mistakes." On the other hand, the *NEC* does contain substantial amounts of guidance on how to make your PV system safer and perform better.

The 2005 Code Cycle

Ward Bower at Sandia National Laboratories and a team of people from the PV industry met several times throughout 2002 and 2003 to write, substantiate, and coordinate proposals and comments for the 2005 *NEC*. Proposals and comments from the *NEC's* PV industry forum were balanced and contrasted with proposals submitted by organizations like the International Brotherhood of Electrical Workers (IBEW) and others.

The initial proposals for the 2005 *NEC* were submitted on November 1, 2002, just eleven months after the 2002 *NEC* went into effect. The code-making panels met several times during 2002 and 2003. The report on these original proposals was published in July 2003. Comments on the original proposals were submitted at the end of October 2003, and the code-making panels met in late 2003 and early 2004 to formulate the final language. By the time this article is printed, the 2005 *NEC* will be finalized except for minor editorial changes. It will be published in late 2004, and will become effective in most locations on January 1, 2005. In the next *Code Corner*, I will present some of the code changes that have been approved for PV systems in 2005, and start covering some of the code basics.

Access

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The 2002 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org

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A Winning Solar Policy

Don Loweburg

During the last several years, *IPP* has chronicled the evolution of a winning solar strategy in California. A broad coalition of solar activists working within the industry, in the public sector, and in the legislature has crafted legislation and programs making California the nation's leader in solar electricity. California could be an example for other states and countries, and energy activists worldwide can learn from our successes and failures.

Key elements in the California strategy are: net metering, customer rebate programs for both large commercial and residential utility customers to encourage on-site PV, a renewable portfolio standard that requires utilities to include a minimum percentage of renewable energy, and a community choice law that allows communities to purchase renewable energy from independent energy providers. San Francisco and San Diego are among several cities pursuing this option in California.

Two actions last December at the California Public Utilities Commission (CPUC), if not successfully challenged, will slow California's successful solar program. They could deal a serious blow to California's solar rebate program, which promotes customer ownership of solar-electric generation, and to community choice laws, which allow local communities to aggregate electricity purchases and choose renewable energy and efficiency.

A Big Surprise

The first action was the CPUC approval for a 5 megawatt solar-electric plant to be financed using rebate funding. Southern California Edison (SCE) received that approval on December 4, 2003. This project may short circuit the state's successful customer-oriented solar program by allocating a large block of the funding to a single project. Four major problems make this project unacceptable.

The first is secrecy. The solar industry first heard about the CPUC vote on this project one day before the vote. It was quickly determined that the original filing for the project was done in secret more than a year ago. Because the filing was done in secret, the solar industry and the public could not make comments or protest in an organized way.

Perhaps related to the secrecy are some questionable connections between the president of the CPUC, SCE, and the company slated to build the solar plant. Mr. Michael Peevey, current president of the CPUC, was an SCE executive before quitting to lead an unregulated energy company. The company that is designated to build Edison's solar plant is TrueSolar, a subsidiary of Mr. Peevey's employer prior to his moving to the CPUC. Mr. Peevey was appointed president of the CPUC last year. The secret filing for the proposed SCE solar plant was initiated about a year ago.

A second criticism of the Edison plant is based on technical issues. Central station PV may not be the most efficient way to use photovoltaics. Last isue, I mentioned that up to 20 percent of centrally generated electricity is lost during its transmission and distribution. Furthermore, utility central station PV has a very poor track record in California.

For example, in 1985, Arco Solar built a 6.5 megawatt central station PV plant in the Carrizo Plains near San Luis Obispo, California for Pacific Gas and Electric (PG&E). It was the largest PV installation in the world. The plant received a 40 percent subsidy from the federal government, but closed in 1990. The PV modules were salvaged and resold on the consumer market. Though heat damaged and with low output, the modules were aggressively marketed. The resulting flood of cheap modules on the market hurt the sale of new modules.

Bill Yerkes, founder of Arco Solar, commented on this failed project in the January–February 2004 issue of *Solar Today*, "Later, many utility companies learned that distributed, grid connected PV applied directly at the load (on the roof of a building) was much more effective than traditional central power plants with long transmission lines." Evidently Edison has failed to learn this lesson.

Another example of poor track record for large utility projects: In 1993, PG&E built a 500 KW PV plant near Kerman, California. It was conceived as a utility-scale distributed generation project. In operation for only five years, this project was shut down in 1998 after repeated breakdowns. It sits idle now, purportedly for sale. Do these failed projects prove that utility-scale PV is a bad idea, or are they isolated examples of poor design or management?

A third problem with Edison's plan is that it is not consistent with the purposes of the proposed funding source. In the secret filing, Edison stated an intention to access funding from the Emerging Renewables program account. This proposal violates two provisions of the Emerging Renewables rebate. First, CEC staff has stipulated that a majority of the funding should go to systems 30 KW or less in size. With an output rating of 5 megawatts, Edison's plant does not qualify. Second, funding is for systems located at the customer's site that offset customer load. Edison's project complies with neither requirement.

A fourth problem with the Edison project is that it violates state law. Public utilities law 2775.5 section (b) states, "The commission shall deny the authorization sought if it finds that the proposed program will restrict competition or restrict growth in the solar energy industry or unfairly employ in a manner which would restrict competition in the market for solar energy systems any financial, marketing, distributing, or generating advantage which the corporation may exercise as a result of its authority to operate as a public utility." Put simply, a utility cannot use its monopoly position to the disadvantage of competitive businesses.

Subtle Sabotage

Is the Edison PV project a Trojan horse? While appearing to advance solar energy, is it actually designed to sabotage California's customer-targeted solar program by depleting its funding? Consider Edison's comments quoted from the December 5 issue of the *Los Angeles Times* lauding the project as "part of our longstanding commitment to renewable-energy resources that offer California important environmental and economic benefits." These are the guys that brought us exit fees (aka departing load charges)—charges levied on electricity customers when they choose to generate some of their own electricity.

From an economic point of view, Edison's central station PV project looks like an artful scam. The funding for this project is collected from utility customers via a "public goods" surcharge on their electricity bill. When Edison taps this funding, they are essentially using customer dollars. Edison then resells the customer-subsidized electricity back to the customer at the full rate, or even at a premium as "green power."

The Second Punch

A second threat to solar electricity was delivered on December 18, 2003, when the CPUC approved a preliminary resolution of PG&E's bankruptcy. The primary focus of the resolution was financing PG&E's debt and setting electricity rates. However, two provisions that would damage PV's future in California were included in that resolution.

The solar unfriendly provisions are a five-year hold on the implementation of California's "green power" renewable portfolio standard (RPS) law (SB1078) and the community choice law (AB117). SB1078 requires a minimum renewable content in utility supplied electricity, while AB117 allows cities and communities to procure nonutility electricity. Numerous communities, including San Francisco and San Diego, are planning locally funded renewable energy projects.

A backdrop to this resolution is what I have referred to in past *IPP* articles as an "unsavory" relationship between the state of California and the regulated utilities. The fact is, to keep the lights on two years ago, the state purchased large future contracts for electricity at above-market prices. Behind the scenes, we have the state owning high priced electricity and being pressured to support utility recovery as a means to maintain state solvency. On the hook are the ratepayers, forced to eat dirty electricity while being held captive for five additional years, unless the commission's decision is rectified.

It is unclear how these two issues will be resolved. In spite of opposition from the widest possible spectrum of stakeholders, Edison's secret PV plant was approved by the CPUC with a tie-breaking vote cast in its favor by CPUC president Peevey. However, it is not a done deal yet, since the project must be approved by the California Energy Commission (CEC). A hearing on the proposal is scheduled for early 2004.

Green Choice Is Threatened

The status of community choice and the RPS is also unclear. The CPUC decision to put these legislated programs on a five-year hold challenges the intent of the legislature. The CPUC is casting itself in the role of deciding, on its own, what state laws it will comply with. This behavior on the part of the CPUC may be perceived as a slap in the face by those legislators who forwarded these two bills. It may take legislative and legal action to override the CPUC, and I suspect that those legislators who promoted and voted for both laws are somewhat hot about the CPUC's disregard for their legislation.

Putting community choice and the renewable portfolio standard on hold for five years as a way to bail out both the state and utilities is very shortsighted from the point of view of the renewable energy community. However, if we adopt the apparent view of central station generators and their state sponsors, this move looks like a winning strategy. It stifles competition from renewable providers and guarantees sufficient revenue flow to finance additional central station natural gas generation in California.

Taking RE Mainstream

Renewable energy is moving from the realm of "alternative" to mainstream. In this process, the energy establishment is challenged, and we are currently witnessing their reaction. Because California is at the forefront of this transformation, the reactionary impact appears here first. Lessons learned by the renewable community in this struggle will certainly be applicable elsewhere in the country. Struggle can be taken as a measure of success as the transformation to renewable energy occurs.

Access

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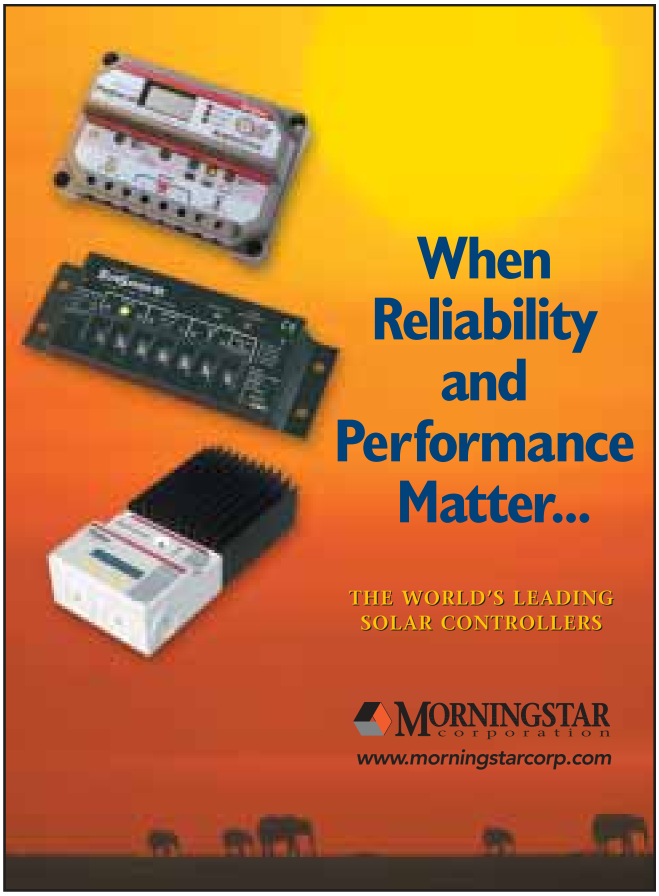
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100 Issues of RE Solutions

To Old, Familiar Problems

Michael Welch

As *Home Power* celebrates its 100th issue, the crew has been reflecting on where we've been, while keeping our eyes on the prize and where we want to go. This magazine has always been about empowering folks to become users of renewable energy. Keeping you informed about what is going on with the politics of energy is an important part of that.

I first got turned on to *Home Power* with issue #11 when a friend handed me the newsprint issue with a weird asymmetric design on the cover. Once I opened it up, I realized that the magazine was exactly what I was looking for. (And now I know that the weird design was a close-up photo of a multi-crystalline solar-electric cell.)

I felt compelled to make a pilgrimage to *Home Power* Central, and soon became friends with *HP* publishers Richard and Karen Perez. They appreciated and were supportive of the work I was doing with Redwood Alliance, and soon we were collaborating on several projects, most notably the Home Power BBS, our early online effort. My first article in *HP* was not about the politics of energy, but rather a review of the High Lifter water-powered pump (see *HP23*). Karen and Richard soon asked me to write about energy politics, and my first column appeared in *HP30* in August 1992.

Still Mad

That very first *Power Politics* column began, "I am mad as hell, and you should be too!" Nothing much has changed on that front—I am still quite POed, though I have mellowed a bit since then. There is a bit of irony in that the subject of my first column was the first Bush administration's energy policy, and I am just as upset with the present Bush administration's energy policy. While vast, fantastic changes have been made in the fields of both home and utility-scale RE over the last twelve years, not much has changed in the energy politics scene, which is the defining need for this column. As reported in *HP30*, special interests continually find ways to influence our government.

One thing that has changed since 1992 is the brazen openness of politicians to special interests, and the citizenry's ignoring of it. The recent war in Iraq has resulted in the transfer of control of resources (fossil fuels) from an independent nation to U.S.-based corporations. Was that an inadvertent byproduct or the goal of the war? In *HP92*, I suggested a similar motivation for the war in Afghanistan. Time will tell whether my theories prove true.

In that first column, I said that the way out is through voter revolution. I called for making our desires into reality by making our voices heard as political constituents. This means not only calling and writing your political representatives, but also exercising your vote at election time. Maybe there are other kinds of revolution that could work, but frankly, I do not see enough heart for it among U.S. citizens. The bad news is that this lack of heart has become a too common behavior of the voting public, with fewer and fewer folks taking part in the process all the time. The influence of moneyed special interests has increased proportionately to the public's lack of participation.

The good news is that with less and less of the general public taking part in our political process, the door is opening up for folks who are aware of the need for change and are willing to work and vote for it. We can't any longer afford to let elections be close. We all must take the time to vote for change. The last presidential election was so close that we ended up having the final decision made by the Supreme Court in favor of the candidate who actually received fewer popular votes. If more people had voted in that election, things could have turned out differently.

H_2 from Nukes

An example of corporate control over government is shown by current energy policy, which includes the building of a hydrogen economy. For years, environmentalists and renewable energy activists have been looking forward to a day when we burn renewably produced hydrogen instead of fossil fuels. But now that the needed technologies are getting closer to that possibility, current energy policy calls for using them on behalf of the nuclear and fossil fuel industries.

This misguided effort looks like they are doing something new and "green" for our energy future. But instead of using renewable energy to liberate hydrogen from water, the push is for building new nuclear power plants to do the job. Other hydrogen would come from reforming fossil fuels, rather than from renewable energy. Fortunately, a new effort to head that off is being formed, called the Green Hydrogen Coalition. (See Access.)

Candidate Survey

To move towards a sustainable energy policy, I and many others believe that we need a new president. Some pretty good candidates are out there, and they are paying attention to energy policy. The Sustainable Energy Coalition commissioned a survey to explore major-party candidate opinions and stances on various energy issues.

The survey is quite comprehensive, and can be downloaded from the Promised Files section of the *Home Power* Web site. The executive summary states, "The survey questioned the candidates regarding their position on federal tax and budget support for renewable energy, energy efficiency, fossil fuels, and nuclear power. It also asked for their views on such policy issues as a federal renewable energy portfolio standard, a federal renewable fuels standard, a federal wires charge to support energy efficiency investments, fuel efficiency standards for automobiles, opening the Arctic National Wildlife Refuge to oil and gas development, and opening the federal high-level nuclear waste storage facility at Yucca Mountain, Nevada. Finally, the survey posed a number of questions regarding climate change, the Kyoto Protocol, oil imports, and rising natural gas prices."

It is difficult to condense the survey results to fit into this column, but all eight respondents favored increased funding levels for RE and energy efficiency programs. They agreed that human activity is causing global warming and that immediate precautionary action is warranted, and are against drilling in the Arctic National Wildlife Refuge. All had something to say about ending the funding of nuclear power to various degrees.

As I waded through the details about the candidates, both subtle and not-so-subtle differences began to emerge, and one candidate stood out for me. While we all must make up our own minds based on a lot of different factors, I know who I would be proud to have as the next President of the United States.

Turn It Around

As we deal with similar problems to those that existed in the early days of *Home Power*, we need to do all we can to make sure I don't have to write about the same, tired energy policy again in some future anniversary issue. Please vote in the upcoming primaries and the November election. It is the best way to give the RE world a chance.

Access

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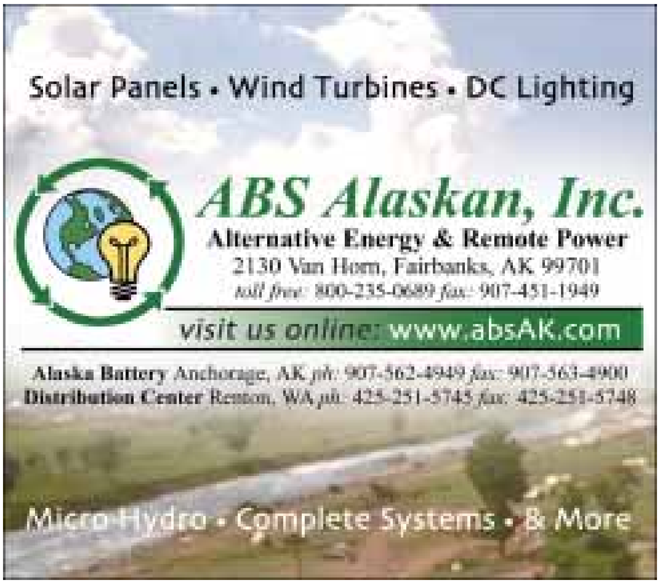

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Basic Electrical Terminology Summary

Ian Woofenden

I started writing *Word Power* columns when I joined the *HP* crew in 1998, beginning with a piece on "Volt" in *HP68*. Thirty-two columns later, I haven't run out of terms to write about. I've covered all the basic electrical terms, and some not so basic ones too. I look forward to delving into more of the same, and also covering some terminology from specific renewable energy technologies. If you have ideas for future columns, please drop me an e-mail message.

For this, our 100th issue, I'm going to recap and summarize some of the basic electrical terms, with a special emphasis on terms that are frequently misunderstood or confused.

Voltage (V or E) can be thought of as electrical "pressure." It's the push that moves electrons, and hence energy, through wires. Voltage is not an indication of energy capacity. You can have the same voltage in a tiny blood vessel and a huge viaduct, which have very different capacities. Voltage is also known as electromotive force, electrical potential, and electrical potential difference.

Amperage (A or I) is the rate of charge flow. Charges (electrons, in wires) move around or back and forth in a circuit at a certain rate, and the amp is the unit measurement. It's also known as amperes, amps, intensity, electrical current, and coulombs per second. "Current" is not "stuff" that flows through wires, but the *rate* of charge flow. Saying "current flow" is redundant (it's like saying "charge flow flow")—current is the flow rate. **1 amp = 1 coulomb per second = 6.28 billion billion electrons per second**

Amp-hours (AH or Ah) are the units of accumulated or cycled charge. It's the same type of measurement as coulombs. This is a quantity of "stuff," but it's not "used up," it just moves around in a circuit. We also talk about battery capacity in terms of amp-hours (though using watt-hours would make life easier). There is no such thing as "amps per hour" in normal electrical life—don't say it!

Wattage (W or P) is the rate of energy flow. Two things move in electrical circuits—charges and energy. Charges move slowly around or back and forth in a circuit, never leaving. Energy moves almost instantaneously from generating source to load, changing form. Wattage is the rate of energy movement. Other related terms are watts, power, and joules per second. It's a rate, not a quantity of "stuff."

There is a clear, technical difference between "power" (watts) and "energy," (watt-hours). We would be less confused about them if we would observe this difference when we speak and write. In common speech, "power" is very often used to mean "energy," so it's no surprise that many people don't understand the difference. **1 watt = 1 joule per second**

Watt-hours (WH or Wh; KWH or kWh) describes accumulated energy. If a turbine generates at the rate of 100 watts for one hour, it will have generated 100 watt-hours. This is the same sort of measure as joules. Energy, which is measured in watt-hours, is a quantity of "stuff," and is in a sense "used up," but really just changes form, such as from fuel energy to heat, or from wind energy to electricity to light.

Watt-hours are like miles traveled, while watts are like miles per hour. Or to say the same thing another way, "energy" is like distance traveled while "power" is like speed. There is no such thing as watts per hour in normal electrical life—banish this one from your vocabulary too, along with amps per hour. **1 kilowatt-hour = 1,000 watt-hours**

Ohm (R or o or Ω) is the unit of electrical resistance. It is resistance to the flow of charges in a circuit, like friction that slows down a motor belt.

DC stands for "direct current" the one-way movement of charges in a circuit, around and around. There is a distinct positive and negative in DC circuits.

AC stands for "alternating current," the oscillating movement of charges, back and forth in a circuit. Energy is still transferred by these oscillating charges. The polarity (positive and negative) in AC circuits changes many times per second.

Ohm's Law states the relationship between volts, amps, and ohms. It can be presented in three ways:

Amps = Volts ÷ Ohms
Ohms = Volts ÷ Amps
Volts = Amps x Ohms

Example: If a generating source has a voltage of 100 volts and the circuit's resistance is 30 ohms, the amperage will be 3.3 amps.

The **Power Equation** states the relationship between volts, amps, and watts. It can be presented in three ways:
Volts x Amps = Watts
Watts ÷ Amps = Volts
Watts ÷ Volts = Amps
Example: A lightbulb running at 120 volts and drawing 1 amp is using energy at the rate of 120 watts.

You may think that I'm an electrical terminology genius. In fact, I'm a fairly ordinary word nerd and RE maniac who is interested in renewable energy terms. I think it's important to use terminology carefully, and I sympathize with people who are new to these terms, since they can be very confusing.

Each column I write is a learning experience for me. I rely heavily on a string of people who are smarter than I am when I research and write my columns. I would like to thank *all* of my reviewers for their help over the years, and especially Bill Beaty, Hugh Piggott, Clay Eals, Mac McIlvaine, Johann Beda, Allison Bailes, Windy Dankoff, and my dad. I couldn't do this without them.

After quite a few months of work (some) and procrastination (more), and help from a variety of sources and reviewers, *HP* is putting a glossary of renewable energy terms on our Web site. It is available for free download or perusal. This document is a work in progress, and I welcome your suggestions for improvement. You can see it at: www.homepower.com/glossary

Access

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ian.woofenden@homepower.com

The Lowdown on Pasteup

Stories from HP's *Early Days*

Kathleen Jarschke-Schultze

As *Home Power* hits its 100th issue, I've been thinking about the early days of the magazine. It was between *HP16* and *HP17* that Bob-O and I moved to the creek, our present home near Hornbrook, California. Since we had the biggest house of everyone involved with the magazine, pasteup was held in our front room every two months. It was always a whole day's worth of work, and afterwards, dinner and relaxation.

In the Beginning

In the beginning, *Home Power* magazine was printed on a local web press, the kind that prints newspapers. Every part of every page of the magazine was physically assembled onto pasteup "boards" that the printer photographed with a copy camera to make film negatives. The printer then used the film to "burn" the image onto aluminum lithography plates, which were used for the actual printing.

Articles were typeset on computers (really early Macs). Pages were then printed out on a special paper used for pasteup. Advertisements were either constructed on the computers or they came in by mail, and they were also prepared for pasteup. Text and art for both articles and ads were separate items that did not meet until they were pasted up.

Pasteup

Pasteup was a ritual. The day would start early with every flat surface in the room being cleared and scrubbed. We had two long tables, like the kind used at church socials. We placed these strategically, one in the middle of the room, the other behind the couch that defined the living room area. We had a desk with a portable, slanted desktop placed on top. Richard brought his own folding, slant-top desk. These were positioned by windows for the best light, and had their own lamps to boot—compact fluorescents, of course.

At first, Richard was the only one to actually paste up the pages. But with *HP19*, the first color cover issue, Richard began training Bob-O for page pasting as well.

Before touching anything, everyone, especially Richard and Bob-O, washed their hands with Dawn dishwashing liquid. Several times. No surgeon would have been more thorough. The large artist portfolio that contained the printed pages, photos, and ad materials was placed on one of the large tables for Karen to organize and prep.

First came the mixing of the thinner and rubber cement adhesive used on the pages. It had to be just the right consistency. Karen was in charge of that. She set up the other long table for painting the adhesive onto the pages and materials. Next, all the tools of pasteup were brought to the ready. They were carefully cleaned and placed by their respective desk stations. Large gummy erasers, T squares, lamps, glasses, markers, X-acto knives, and transparent rulers were all put in their places.

When pasteup actually began, it was a steady rhythm of movement. First the back of each printed page was completely painted with adhesive and given to Richard or Bob-O at their stations. These pages were placed on the base sheet, which held four individual pages. These had to be in a specific (non-numeric) order and position so that when our printer, Valley Web, printed the pages, they would be in the correct order.

For each page, the back of the appropriate ads, graphics, and photos were also painted with rubber cement and brought to Richard and Bob-O. These needed to be carefully attached, nice and straight, to the pages. As they worked on that sheet, the next sheet would be gummed and that page's material set out to be ready.

When they finished a four-page sheet, Karen whisked it (very carefully) into a fresh cardboard portfolio. As the number of pages in each issue grew, friends and neighbors, and at times even I, assisted in the process.

My Kitchen

My place was in the kitchen. I supplied finger foods to keep everyone's strength up. It was great for me. I love planning meals and treats. I would always provide some known crew favorites, and I would try some new hors d'oeuvres each time. Not being a perfectionist, pasteup was best left out of my hands.

I kept a smaller folding table constantly supplied with food and drinks. When there was a slight break in the action, any of the crew could readily find refreshment.

Meanwhile in the kitchen, I was cooking the main meal of the day—the dinner where we all sat down together

Bob-O laboring over a four-page pasteup sheet of *Home Power*, circa 1991–1992.

when the work was done. Admittedly that was the best part of the day for me. We could all relax and talk. It was just a big family meal around one of the long tables.

Sometimes the Wizard or our neighbor Stan would show up. It was a time to socialize, to gather. When I think of those days of the small *Home Power* crew and the times we spent together, I miss it.

Mail Stop

When the issue was due to be delivered from the printer, we got together again. In preparation for that rendezvous, Richard spent literally days printing out mailing labels on a dot matrix printer. We would all meet down at the Hornbrook post office at midmorning. Soon the truck from Valley Web Printers would show up, and the work began.

The magazines were unloaded from the printer's truck into our pickup trucks. Backing up to the back porch of the post office, we used the tailgates of our pickups as tables. One group put all the first class subscriptions into manila envelopes. These already had their labels attached. They were sealed and stacked and put on a postal cart for Elden, our postmaster, to process. The other group put labels on all the third class subs. These were then stacked and bagged by zip code—not each and every zip code, but a range of codes for a geographical area. These too went onto carts for Elden to process. This took several hours.

All the leftover issues were left in their boxes. The boxes were marked with their issue number on all sides with a black marker. Earlier issues didn't have boxes; they were bundled and tied with white cotton string. They did not need marking. All the leftovers were now considered back issues. They were loaded into the pickups and brought back to be stored in our basement.

Betty's Kitchen

After we finished mailing, we walked across the parking lot over a small walkway and into Betty's Country Kitchen. Betty's husband Bob was the "waitress." It was an ongoing joke with him. It was a tiny little place. Along one wall was a free library. Bring a book or take a book. No one kept track.

We would all order the same thing—Betty's cheeseburger and fries. Real cheeseburgers, with fresh sliced onions and tomatoes. Real fries, made right then, with the skins still on. Lunch could easily take an hour-and-a-half. Not because the food was slow in coming—it wasn't. It was because we lingered and talked. Not just among ourselves, but with Betty and Bob and any locals who happened to be there. Gustatory memories can be very strong. I can almost taste that food now.

I know it seems like we spent a lot of time eating. But that is what we did when we got together. We would work hard and then eat together. The basic and ancient ritual of friends is breaking bread together.

Now the magazine goes to the publisher on disk, and the digital files are transferred "direct-to-plate" without cameras or film. The subscriptions are mailed from the printer in Wisconsin, where they have their own postmaster and postal station on premises. I send my column in by e-mail. It is now rarer that we can all get together anymore. That time and closeness has passed, as all things do. *Home Power* magazine is bigger than we ever dreamed. I can say I was there in the early days.

Access

Kathleen Jarschke-Schultze is busy in her organic garden and orchard 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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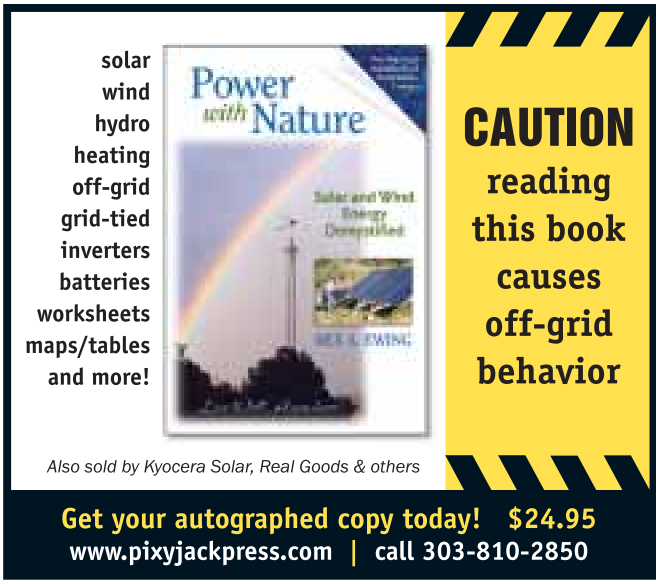

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Solar Energy International online courses: PV Design, & Solar Home Design. Info: see SEI in Colorado listings.

CANADA

Alberta Sustainable Home/Office, Calgary. Open last Sat. every month 1–4 PM, private tours available. Cold-climate, conservation, RE, efficiency, etc. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 • 403-239-1882 • jdo@ecobuildings.net • www.ecobuildings.net

CHINA

Apr. 7–9, '04; REAsia 2004, Beijing. Marketing RE in Asia. Info: Vivian Li, Grace Fair Intl. Ltd. Room 1311 Tower A, Zhongyun Bldg., Wangjing New Industrial Zone, Chaoyang Dist., Beijing 100102, China • ++86-10-64390338 • Fax: ++86-10-64390339 • vivian@gracefair.com • www.gracefair.com

CUBA

Apr. 10–18, '04; Cubasolar RE Conference, Guantanamo, Cuba. RE, energy education, rural electrification, efficiency, eco-tourism, & more. Info: Rachel Bruhnke, 800-497-1994 ext. 354 • Rachel@globalexchange.org • www.globalexchange.org

FRANCE

May 20–23, '04; Rallye Phebus 2004, Southern France Solar Vehicle Rally; Puigcerda, Spain to Toulouse, France. Info: Rallye PHEBUS 2004, Le Ploumail, 09600 DUN, France • 05 61 68 62 17 • laurent.koechlin@obs-mip.fr • www.phebus-ariege.org

GERMANY

May 11–14, '04; Wind Energy Intl. Trade Fair; Hamburg Fair Site. Info: Hamburg Messe und Congress GmbH, PO Box 30 24 80, 20308 Hamburg, Germany • +49 40 3569 2123 • info@windenergy-hamburg.de • www.windenergy-hamburg.de

Jun. 24–26, '04; INTERSOL 2004; Freiburg, Germany. Solar energy industry exposition & conference. Info: Solar Promotion GmbH, PO Box 100 170, D-75101 Pforzheim • ++49 (0) 7231 / 35 13 80 • dufner@intersolar.de • www.intersolar.de

Oct. 21–24, '04; RENEXPO 2004; Augsburg. Hydro power, decentralization, biofuels, solar, biogas, energy-efficient construction. Info: Erneuerbare Energien Kommunikations und Information Service GmbH, Unter den Linden 15 • 72762 Reutlingen, Germany • +49 (0)71 21-30 16-0 • Fax: +49 (0)71 21 - 30 16 -100 • redaktion@energie-server.de • www.energy-server.com

ITALY

May 20–22, '04; Solar Expo; Verona. Exhibits & speakers on biofuels, biogas, solar thermal, PV, hydro, wind, geothermal, alternative vehicles & fuels, & hydrogen. Info: ExpoEnergie, Piazzetta Trento e Trieste 10/b, 32032 Feltre Bl., Verona, Italy • 0439 84 76 52 • info@solarexpo.com • www.solarexpo.com

Sep. 30–Oct. 2, '04; Eolica Expo Mediterranean; Rome. Expo & conference on utility-scale wind power. Info: Solar Energy Group, Via Antonio Gramsci 63, 20032 Cormano (MI), Italy • +39 0266301754 • info@eolicaexpo.com • www.eolicaexpo.com

KENYA

Jun. 19, '04 in Kisumu; Sep. 18, '04 in Mombasa; & Dec. 18, '04, place TBA. Regional energy fairs. Info: Solarnet, PO Box 76406-00508, Nairobi, Kenya • 254-20-572656, 565027 • david@solarnet-ea.org • www.solarnet-ea.org

NICARAGUA

Jul. 19–30, '04 (again Jan. 3–14, '05); Solar/Cultural Course. Managua. Lectures, field experience, & eco-tourism. Info: Richard Komp • 207-497-2204 • sunwatt@juno.com • www.grupofenix.org

SPAIN

May 16–19, '04; SCELL-2004: Badajoz, Spain. Intl. Conf. on science of solar. Info: Formatex Research Center • Fax: +34/924/258-615 • scell-2004@formatex.org • www.formatex.org/scell2004/scell2004.htm

U.S.A.

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

Info on state & federal incentives for RE. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 • www.dsireusa.org

Ask an Energy Expert: online or phone questions to specialists. Energy Efficiency & RE Network (EREN) • 800-363-3732 • www.eere.energy.gov

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

ARIZONA

Apr. 3, '04; Solar Potluck & Exhibition; Catalina State Park, Tucson. Bring solar ovens &/or a dish to share. Music, solar-cooked samples, camping. Info: Bill Cunningham • 520-885-7925 • cuningham@dakotacom.net

Apr. 17-18, '04; SolFest Southwest; Scottsdale. Exhibits, keynotes, entertainment, kids' activities, displays, & demos. Info: 928-649-8180 • belle@solfestsouthwest.org

Scottsdale, AZ. Living with the Sun; free energy lectures, 3rd Thurs. each month, 7 PM, City of Scottsdale Urban Design Studio. Dan Aiello • 602-952-8192; or AZ Solar Center • www.azsolarcenter.org

CALIFORNIA

Apr. 8–10, '04; Understanding Grid-Connected Solar Electric Systems. Humboldt State Univ., Arcata, CA. For homes or businesses. Info: HSU Office of Extended Education • 707-826-3731

Apr. 16–17, '04; Utility Interactive PV workshop San Diego. System design, components, site analysis, & system sizing. Info: see SEI in Colorado listings.

Apr. 27–30, '04; Hydrogen: A Clean Energy Choice; Los Angeles. National Hydrogen Assoc. conference & expo. Info: NHA,1800 M St. NW #300, Washington, DC 20036 • 202-223-5547 • Fax: 202-223-5537 • HydrogenConference@ttcorp.com • www.hydrogenconference.org

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

COLORADO

May 14–15, '04; Solar Home Design for Net-Zero Energy. PV, solar thermal, passive solar. Info: see SóL Energy in International listings.

May 21–22, '04; PV Systems Design & the NEC. Learn to design code-compliant PV systems. Info: see SóL Energy in International listings.

Sep. 27–Oct. 5, '04; Sustainable Resources 2004: Solutions to World Poverty; Boulder. Grassroots conf. on sustainable development, technology, & use of resources. Info: Sustainable Resources Conference, 717 Poplar Ave., Boulder, CO 80304 • 303-998-1323 or 888-317-1600 • info@sustainableresources.org • www.sustainableresources.org

YouthCamp-Us; RE camp for teens. Jul. & Aug. sessions. Lectures, labs, hiking, & more. Apprenticeships available, campers & volunteers wanted. Info: Ed Eaton, Our Sun Solar, PO Box 1876, Paonia, CO 81428 • 970-948-5304 • hareef99@yahoo.com • www.youthcamp-us.org

Carbondale, CO. SEI hands-on workshops & online distance courses on PV, solar pumping, wind power, micro-hydro, solar H_2O, alternative fuels, green building, women's courses, & online distance courses. Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

IOWA

Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. Call for changes. IRENEW, PO Box 3405, Iowa City, IA 52244 • 563-432-6551 • irenew@irenew.org • www.irenew.org

KENTUCKY

Mt. Vernon, KY. Appalachia: Science in the Public Interest. Projects & demos in solar electricity, solar hot water, gardening, sustainable forestry, more. ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • solar@a-spi.org • www.a-spi.org

MICHIGAN

Urban Enviro Discussion, Ferndale, MI. 2nd Wed. each month, 7 PM. Sustainability, energy efficiency & conservation, RE, & green building. Potluck. The GreenHouse, 22757 Woodward #210, Ferndale, MI 48220 • 313-218-1628 • www.hometown.aol.com/ecadvocate

Intro to Solar, Wind, & Hydro. West Branch, MI. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com

MINNESOTA

May 1–2, '04; Living Green Expo, St. Paul. Workshops & vendors on RE, conservation, transportation, building, etc. Info: 612-331-1099 • www.livinggreenexpo.org

Jul. 23–25, '04 (again Jul. 30–Aug. 1); Straw Bale Construction wkshp; St. Cloud. Info: see MREA in Wisconsin listings.

MISSOURI

Apr. 22, '04; Earth Day Clean Energy Show; New Bloomfield, MO. RE off-grid, wind, microhydro, PV, biodiesel, solar H_2O, & more. Info: Missouri RE Center, 800-228-5284 • www.moreenergy.org

NEW JERSEY

Apr. 17–18, '04: Grid-Connected Solar Electric systems workshop for home or small business. Brookdale College, Lincroft, NJ. Info: see SEI in Colorado listings. Local coordinators: Gaurav Naik • guarav@geogenix.com • Brian Kelly • brian@seabrightsolar.com.

NEW MEXICO

May 3–7 '04; Natural House Building, Kingston, NM. Building with straw bale, adobe, pressed block, cob, & natural plasters. Info: see SEI in Colorado listings.

NEW YORK

Apr. 12–17, '04; PV Design & Installation, Woodstock, NY. System design, components, site analysis, system sizing, & a hands-on installation. Info: see SEI in Colorado listings.

May 7, '04; Long Island Solar Energy Conf.; Long Island, NY. PV booths, energy efficiency, NABCEP certification info, green pricing, PV design & architectural issues, & more. Info: Solar Energy Center, Farmingdale State Univ., 2350 Broadhollow Rd., Farmingdale, NY 11735 • 631-420-2450 • http://info.lu.farmingdale.edu/depts/met/solar/solarLI2004.html

Jun. 26–Jul. 3, '04; Natural Building Colloquium; East Bath, NY. Exhibition, workshops, presentations, & lectures on natural building & sustainable technologies incl. RE. Info: Gaiatecture Design, 585-624-2540 • gaiatecture@hotmail.com • www.gaiatecture.com

NORTH CAROLINA

Apr. 23–24, '04; Electricity from the Wind wkshp; Raleigh. Classroom, hands-on, & a wind turbine raising. Info: NC Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-513-7644 • tim_dunn@ncsu.edu • www.ncsc.ncsu.edu

Saxapahaw, NC. How to Get Your Solar-Powered Home. Call for dates. Solar Village Institute • PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OREGON

Apr. 24, '04; Family Earth Day Event & Energy Fair, Douglas County Fairgrounds, OR. Speakers & booths on sustainable energy, & family events. Info: Al Walker, Energy Independence Co. • 541-496-3987 • alwalker@mcsi.net

Jul. 10–14, '04; SOLAR 2004; Portland. American Solar Energy Society national conference. Info: ASES • 303-443-3130 ext.103 • www.ases.org • bchowe@ases.org

Jul. 25–27, '04; SolWest RE Fair, John Day, OR. Exhibitors, workshops, Electrathon racing, music, & more. Info: EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • info@solwest.org • www.solwest.org

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10 weeks, 14 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 • 541-942-0302 • apro@efn.org • www.efn.org/~apro

PENNSYLVANIA

Penn. Solar Energy Assoc. meeting info: PO Box 42400, Philadelphia, PA 19101 • 610-667-0412 • rose-bryant@erols.com

RHODE ISLAND

Jun. 5, '04; RI Sustainable Living Festival & RE Expo; Coventry, RI. Exhibits, vendors, artists, kids' stuff. Info: Apeiron Inst., 451 Hammet Rd., Coventry, RI 02816 • 401-397-3430 • info@apeiron.org • www.apeiron.org

TENNESSEE

Apr. 21–24, '04; Solar Electric Design; Summertown, TN (The Farm). Basic PV, hardware, system design, installation, & troubleshooting. Info: Ed Eaton, Our Sun Solar, PO Box 1876, Paonia, CO 81428 • 970-948-5304 • hareef99@yahoo.com • www.youthcamp-us.org

TEXAS

El Paso Solar Energy Assoc. meets 1st Thurs. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group: e-mail for meeting times: HREG • hreg@txses.org • www.txses.org/hreg

UTAH

Apr. 12–17, '04; PV Design & Installation, Salt Lake City, UT. System design, components, site analysis, system sizing, & hands-on installation. Info: see SEI in Colorado listings.

WASHINGTON STATE

Apr. 8–10, '04; Grid-Tied PV Design & Installation workshop, Guemes Island, WA. System design, components, site analysis, system sizing, & hands-on installation. Info: see SEI in Colorado listings. Local info: (see below).

Apr. 12–17, '04; Home Built Wind Generators workshop with Hugh Piggott, Guemes Island, WA. Building wind generators from scratch; blade carving, winding alternators, assembly, & testing. Info: see SEI in Colorado listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Apr. 18, '04; Intro to RE workshop, Guemes Island, WA. Solar, wind, & microhydro for homeowners. Lectures & tours. Info: see SEI in Colorado listings. Local info: (see above).

WISCONSIN

June 18–20, '04; RE & Sustainable Living Fair (aka MREF); Custer, WI. Exhibits, workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids' Korral, entertainment, keynote speaker. See below for MREA access.

MREA workshops. Apr. 3–4, Custer: Int. PV; Jun. 5–6, Ashland, WI: Basic PV; Jun. 12–13, Ashland, WI Int. PV; Jun. 12–17, Custer: Women's PV. Also, Alternative Construction, Intermediate PV, Solar Domestic Hot Water, & Solar Space Heating. Info: MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • mreainfo@wi-net.com • www.the-mrea.org

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

Buying Utility Wind Energy

Hi, I just read my first issue, *HP98* , cover to cover, including all of the ads. I realized after reading it, that I never want to touch a battery, try to figure out how to read electrical plans, or go to the trouble to move where I would be allowed to erect a 75 foot tower. What looked easy to me was to install one of the air ducts I saw advertised to circulate heat from the attic into the house. What I am very excited about is that my electric company here in New Mexico just offered me the option of getting 90 percent of my electricity from wind! My normal bill is about US$20 a month, and it will go up to US$23—only US$3 extra a month to get wind electricity! This seems awesome to me. Am I naive to think that this is awesome?

I called the utility and asked where the electricity comes from. They use electricity from 136 wind generators on towers that are 21 stories tall. They sell extra energy to other states and companies when it is not being used here. They are 1.5 megawatt GE wind turbines, and it is the third largest wind generating facility in the country. Right now 85 percent of the wind energy is being sold to other states because not many people in New Mexico have heard that they can sign up for it. You can check it out on their Web site (www.pnm.com) and look under Sky Blue.

I realize that this may not be perfect, but hey, if today I can choose electricity from wind instead of a nonrenewable resource, I think it's so awesome. And I am glad not to have to build anything to do it. Let me know if I am missing something here. Suzanne Hruschka • suzhru@netzero.com

Hi Suzanne, No, you are not missing anything. The New Mexico wind program is awesome, and folks should buy into it to encourage more of the same. I have seen the systems that circulate attic heat into the house. The problem with them is that the attic is usually hot at times when household heating is not needed. A better project is to use solar hot air collectors, instead of attic heat. See HP98 *for an intro article on it, and* HP99 *for a second part on that subject, with more do-it-yourself information.*

The idea of installing your own solar or wind-electric system can be quite daunting. That is why we recommend that most folks use a reputable installer. Please don't yet dismiss the idea of making your own electricity. It is a fun and important way to make a difference. Keep reading Home Power*, and pretty soon you may get hooked. Michael Welch • michael.welch@homepower.com*

Seeking RE Folk in Indiana

Dear *Home Power*, I live in central Indiana and am very interested in solar energy. I just moved to a home on 2 acres in the middle of a cornfield. I have two, 85 watt BP-585 panels, a C40 charge controller, and an Exeltech 1100 inverter. I plan to replace my four T-105 batteries with L-16s soon. The problem is that Indiana is like nonexistent for people who have the slightest idea of what solar energy is. The government is about as bad. I have already been called nuts for spending all that money when electricity is already hooked to the house and so cheap.

What I would like to know is, are there going to be any energy fairs or workshops in the central Indiana area in the near future? I love your magazine and look forward to every issue. You have opened my eyes to a lot of fascinating things. Keep up the good work. I would like to talk to more people in Indiana who like solar energy as much as I do. Thanks, Mike Lynas, Elwood, Indiana • lampsandbarns@yahoo.com

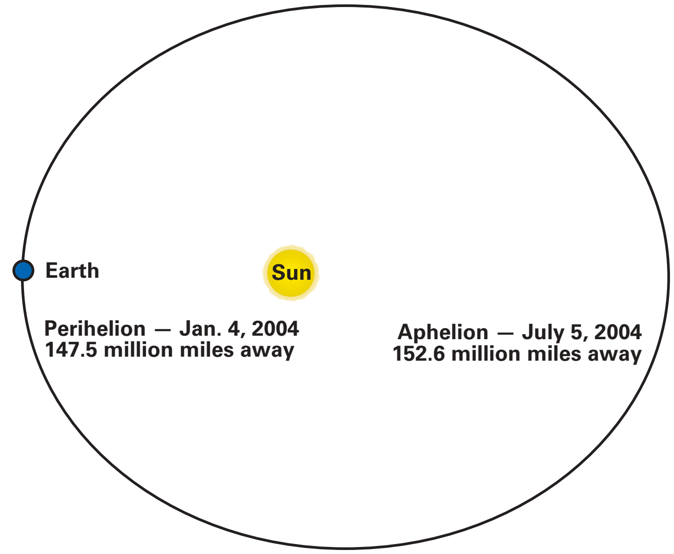
Hi Mike, I am not aware of any fairs and workshops that have happened in Indiana in recent years. But definitely check out the Midwest Renewable Energy Association in Wisconsin. Their energy fair every summer solstice is worth the trip! They have great workshops as well. Wouldn't it be great if some Indiana folks could hook up and start an RE advocacy organization in your state? Michael Welch • michael.welch@homepower.com

Pump Soft Start

I read Kirk Wishowski's question about running an AC well pump off-grid in *HP98's Q&A* column. There is a simple solution to this problem. I have used it for both well pumps and air conditioners: Use the Baldor S23CA soft start. See www.baldor.com. This device limits the current and works well with the Xantrex SW-series inverters. Bill Kaszeta, Photovoltaic Resources, Tempe, Arizona • bill@kaszeta.org

Consider Perihelion

Despite our attention to science and the earth's temperature, few are aware that the sun is 7 percent stronger in January than July. Perihelion, on January 4, 2004, is when the elliptical orbit of earth brings us 3$^1/_2$ percent closer to the sun than in July.



Our calendar balances on the solstices, but perihelion is not connected to the solstices. Perihelion slowly moves to later dates; on average, 25 minutes later each year, one day later in 57 years, a complete cycle in 21,000 years. The movement is jerky—some years moving forward a day or two, some back—but the progress is very predictable over many years. The solstices, equinoxes, and eclipses are easy to see. Perihelion can be identified only with exact instruments. Though the climate we live in is a consequence of perihelion, we have only known about it since Johannes Kepler discovered the earth's elliptical orbit in the seventeenth century AD.

Perihelion moves through our calendar like a giant century hand. It moves fast enough; one day in a lifetime for us to recognize its movements, yet so slowly it makes us giddy to consider the vast momentum of its drowsy progress. In "perihelion time," the atom bomb was invented a day ago, the steam engine a week ago, and fire a year or two ago. We might remember that perihelion coinciding with winter in the Northern Hemisphere is a big favor we enjoy that will pass. Steve Baer, Zomeworks Corporation

Solar Powered Atomic Waste Dump?

Dear *Home Power*, I read with much interest Michael Welch's report this summer from his tour of Yucca Mountain, Nevada, the federal government's proposed burial site for U.S. high-level radioactive waste from nuclear power reactors and the nuclear weapons complex.

I'd love to share a story that Judy Treichel of the grassroots Nevada Nuclear Waste Task Force in Las Vegas tells as she travels the country opposing the dump. She explains that the radioactive waste would be so thermally hot that it would likely damage the burial containers as well as the surrounding rock, thus accelerating the already inevitable release of radioactivity into the drinking water supply below.

The U.S. Department of Energy has proposed a system of industrial-sized ventilation fans to exchange the air within the tunnels, thereby cooling the waste. But the ventilation system would have to work for several centuries, until the heat dissipates. Thus they need a long-lasting and reliable source of electricity.

What, you might ask, has DOE proposed as the electricity source? You guessed it, a wind farm and a mountainside of solar-electric panels! As Judy says, it'd be the world's first solar-powered atomic waste dump. Why weren't solar and wind energy used instead of nuclear energy to generate the electricity in the first place, thus avoiding the generation of the radioactive waste?

As Michael Keegan of the Coalition for a Nuclear-Free Great Lakes in Michigan says, "Electricity is but the fleeting byproduct of nuclear reactors. The actual product is forever deadly radioactive waste." And of course, if billions more dollars of taxpayer money are sunk into the nuclear energy industry's "renaissance" (better described as a relapse), those are energy research and development dollars that much more worthy wind, solar, and other renewable, conservation, and efficiency industries will never see. Kevin Kamps, Nuclear Waste Specialist, Nuclear Information and Resource Service (NIRS), 1424 16th St. NW Suite 404, Washington, DC 20036 • 202-328-0002 ext. 14 • kevin@nirs.org • www.nirs.org

Grid as Generator

We've been avid readers and fans since *HP1*. Kudos to all of you for such a wonderful magazine. We've lived off-grid for more than two decades, now. We used a Honda generator to supplement our (at first) meager PV system. As we added to the system (and to our lights, appliances, etc.), we found that we used the generator more and more in the winter to supplement the PVs. During the summer, we used the generator to irrigate a forest garden. Our field garden is irrigated by a PV/battery system and a Dankoff pump, but is too far from the other forest site to be of help.

Well, in early September we had grid electricity run in from the electric co-op. We use it as we would our backup generator. It cost us US$90 for connection fees to the co-op and another US$300 or so for the necessary meter and circuit box, circuits, conduit, and wiring. We now pay a fee of US$14 each month to belong to the co-op and to be able to purchase electricity from them at 6.5 cents per KWH. We used 170 KWH up to the winter solstice.

Sometimes I feel like I've sold out. But then again, I wasn't comfortable hauling gasoline and listening to the brute of a generator insistently whining when we needed backup. What do you think? We just installed a Prosine 2.5 sine wave inverter to replace our old Heart Interface Freedom 2000. This unit doesn't hum like the other and has cleaner output. I need something else to run the meter backwards in summer, yes? We have energy to spill off quite often from April through October or so.

Thanks again to all of you. We met Richard and Karen Perez many years ago at the first Midwest Renewable Energy Fair, and hope to see some of you there again this summer if we can break away at that time. Peace on all of your houses, and on Earth. Bruce Brummitt & Cheryl Valois, Smoky Hills State Forest, Northern Minnesota

Hello Bruce and Cheryl, It's great to hear from you again! Your experiences exactly parallel ours. I see nothing wrong with using utility electricity instead of a generator—it's cheaper, cleaner, and more convenient. If I could plug into a utility here at a reasonable price, I would do so. I would also maintain my batteries so I had electricity during utility outages. And, like you, I'd go shopping for a utility intertie inverter so I could put my summer surplus on grid for others to use. Life with RE is like life in general—constant change. Either roll with it, or it rolls over you. Richard Perez • richard.perez@homepower.com

Battery Concerns

I am considering powering my house with solar energy, since I am a nature lover and really do not enjoy harming the environment. When I was doing my research, I realized that every Web site was promoting solar panels for the health of the earth, but what every site failed to mention was—what do we do with all the batteries when they are no longer useable? I also noticed that a battery's lifespan is only three to five years. If everyone was disposing of batteries that frequently, the earth would be doomed! I'm wondering if there is a way to safely recycle or dispose of the batteries. And is there a battery that is pollution free? Thanks for your time. Eric Biehn • ericjamesbiehn@hotmail.com

Hi Eric. Thanks for doing the right thing by our environment. Not all solar-electric systems need batteries, but more on that in a moment. Of all the industries in the U.S., none does a better job at recycling their old and worn out products than the lead-acid battery industry. Nearly every battery dealer in the U.S. takes back their customers' old batteries. When you buy a new battery, you pay a core charge that covers the cost of recycling. This has been very effective, and results in most batteries using lead that has seen life in several other batteries previously. The only reason there is a problem is because some folks are not holding up their end of the deal, and are throwing batteries away. Folks like you would never do such a thing.

Only an abused or overused battery will die in three to five years. My battery bank was secondhand when I got it, and has worked for me for more than ten years. If you are already on the utility grid, consider doing a batteryless, grid-intertie solar-electric system. The way this works is that you still rely on the grid for energy when the sun is not shining. When the sun is shining, you turn your electric meter backwards. This is called "net metering," and it allows you to save up your KWH production credit for when the sun does not shine. Most states have net metering laws.

Batteryless net metering systems provide the most efficient use of the solar-electric panels, since they are putting out their max all the time. With an off-grid battery system, as the batteries get full, the output of the panels is wasted. The drawback to a batteryless system is that you will not have electricity when there is a utility outage.

If you are off-grid, or want to completely disconnect from the utility, you will need batteries as part of your system so that you can have electricity when the sun is not shining. Or you can be on-grid with an intertie system with a battery backup. This works well if your region suffers from frequent or lengthy utility outages.

There is no such thing as a "pollutant-free" anything. Batteries are no exception. Nickel-iron batteries do not have toxic metals in them, and are less harmful to the environment as a result. But they are quite expensive if you can find them at all, and they do not store energy nearly as efficiently as lead-acid batteries. Let me know if you have any other questions. Michael Welch • michael.welch@homepower.com

Understanding Thermal Mass

In *HP99*, pg 65, I see an often-cited benefit of high thermal-mass building materials: "Adobe bricks absorb the sun's heat during the sunny winter days. When the temperature drops at night, the bricks radiate their heat into the home. Likewise, thermal mass keeps homes cool in the summer, acting as a heat sink."

Logically, this seems to be a case of stating only the good. Doesn't thermal mass act as a heat sink during the winter too? And doesn't it release heat at night during the summer? Thermal mass would also seem to provide thermal inertia, making your winter mornings colder as the mass slowly heats up.

I think I know the answer to my own questions. The time-lag that thermal mass provides is a lot like the I-V lag a capacitor causes. So with high thermal mass, your house won't get as cold as the outside, and won't get as warm either. This might be bad, depending on your climate. Greg Bell • gregbell@znet.com

"Is the mass half full or half empty?"

–Chuck Marken, *HP* solar thermal editor.

Hi Greg, I like the analogy of a battery for thermal mass—a thermal battery. People seem to grasp the concept more quickly with something familiar. The thermal mass is determined by the weight of the battery and its capacity to hold or carry heat, known as specific heat. All substances are different. Water has a specific heat of 1, concrete and brick are about 0.2. It takes about five times the weight in concrete to equal the same weight in water as far as the thermal battery capacity is concerned. Thermal mass is also sometimes expressed as heat capacity in BTUs per cubic foot per °F, which also factors in the density. Water with a specific heat of 1 and density of 62.5 pounds per cubic foot is said to have a capacity of 62.5 BTUs per cubic foot per °F. Brick has a heat capacity of 0.2 x 120 (lbs./cu.ft) or 24. This makes for an easy comparison of the different mass amounts.

You're right Greg, thermal mass can be disadvantageous in some cases, and this is where good passive design is important. Shading (charge regulating) the mass with overhangs or trees in the summer will solve most of the problems with any tendency to overheat. The heating season charge and discharge times of the thermal mass is about the same, although this can be complex and vary depending on many things, including direct gain or indirect gain, the time of year, the amount of mass (thickness in many cases), and the heat transfer properties of the mass. If it takes a full day of winter sun to charge the mass, and it takes about the same to discharge it, you're right again, the mass will be relatively cooler in the morning, ready to take another charge cycle. This brings up another question though—is the mass half full or half empty? Cheers, Chuck Marken • chuck@aaasolar.com

Tilting Large Arrays

I saw the letter in a recent *HP* about tilting large arrays, and thought I'd add my 2 cents. I haven't tried this, but the problem seems similar to that of raising a wood-framed wall in new construction, and a couple of tools (besides strong backs) are used there. Both are referred to as "wall jacks." One uses a mechanical jack (around US$100) that mounts on a 2 by 4 (Qual-Craft is one manufacturer). The other uses a come-along mounted on a metal pole (see www.lynnladder.com/lynlad/lynlad037.htm for an example). The "come-along on a pole" model seems like it could be home-built. Depending on the weight of your arrays, two jacks could add a measure of safety. The advantage of both of these options is that they break down into loads that can be carried and placed by one person. Warning: Brace the bases securely! I've seen them kick out, with spectacular results. Take care, Tim Maxwell • tmacswell@earthlink.net

Responsible Wood Heating

Dear *Home Power*, Thank you for your informative article "Responsible Wood Heating" by John Gulland. I have been burning wood in my Jotul airtight stove since 1978. Dead wood on my two acres has been the major source of wood to heat our home on weekends and evenings in the cold weather. But since I have retired, I can now "keep the home fires burning" more consistently, and save fossil fuel to the furnace.

Thank you for the encouragement! I would like to add though, that I can also cook anything from eggs to spaghetti on the stove and never use gas or electricity. And to top it off, the teakettle is always hot. Staying warm, Liz Murphy, Stepney, Connecticut • Lizasmurphy@aol.com

Net Metering in British Columbia

Hi Guys, Just thought you'd like to know that BC Hydro has applied for net metering from the utilities commission. See www.bchydro.com/info/epi/epi6814.html. If this happens, we'll be able to bank our production with a KWH credit each month if we make more than we use, and be paid for surplus KWH annually at Cdn$0.054 per KWH. Keep up the great work with your magazine! When net metering comes into effect, I'll be adding some solar-electric panels and a grid intertie inverter. Peter Ferlow • pferlow@shaw.ca

Hello Peter, We have had quite a few inquiries from Canadian readers lately who want to see more Canuck homes featured in our magazine. So, once you get going on your grid-tied system, be sure to take lots of photos, and write this up for us. For more info, see "Writing for Home Power*" on our Web site. Michael Welch • michael.welch@homepower.com*

Other Satellite Internet Options

Richard, I was interested to read of your upgrade to the new Ethernet version of your StarBand service. The energy savings of the Ethernet modems as well as the compatibility with other operating systems than Windows is a huge plus. I was surprised, however, at the cost of your system. I have been operating on a USB-based dual modem system from Direcway (through Earthlink, initially), and the cost of purchasing and installing the modems was in line with your original system. However, Direcway has just come out with their own two-way, Ethernet-based modem system, which offers a very slick and easy upgrade path from the existing modems.

I switched our account from Earthlink to Direcway to take advantage of their better upgrade path and price, and paid an additional US$324 for the new modem (after a refund for returning the USB modems). I could have saved an additional US$100 had I chosen to sign up for 15 months of service. The monthly cost with Direcway using their Ethernet modem is actually less than the Earthlink system (due to not having a dialup account as backup—we never needed it). The cost is US$59 per month now instead of the US$69 per month we were paying.

Like your system, our modem draws just 28 watts, and in tandem with a Linksys wireless router, draws only 35 watts and gives us a wireless network in the home for use with our two laptops and my wife's flat panel iMac (also an energy sipper).

As I write this note, I'm sitting in the bedroom using the laptop and running on the laptop's battery, which really makes me feel miserly on energy. With dual batteries in my Dell laptop, I can run six hours before needing to connect to AC for a recharge, and that's using the wireless network card. It makes for great low-power nighttime Internet surfing.

You also mention that you are paying a premium for higher bandwidth, but I've found that with the satellite system I'm using, I can get as high as 1.7 megabit/sec download speeds, with rarely less than 500 kilobit speed, and 100 kilobit upload speeds. Much of the speed difference you see in switching to the Ethernet modems is in the Ethernet connection and its superiority over USB, along with dumping the PC based proxy software. Our speed increased noticeably, especially for Maggie with her iMac across the wireless network. Plus the self-contained Ethernet modem is simply much more efficient than the external modems with the PC based proxy used with the USB systems. Of course, there is always the lag time from latency, the time it takes for the signal to be sent to the satellite, down to the Direcway earth station and through their servers. The round trip adds a couple of seconds to the response time (I call it the "foreign correspondent effect").

Any Ethernet based modem will support Macs. That is one of the reasons for my switch to the new Direcway modem. It works seamlessly with Maggie's iMac. So to say that StarBand is the only one to support Macs is not accurate.

Our system costs just a bit more than cable or DSL, but is really our only broadband alternative this far up in the mountains. I was frankly surprised to see that you pay that much for satellite service. Direcway also has no limit on the number of computers that can be networked to the system. Our local elementary school has networked their whole computer system (about 20 computers) through their Direcway Ethernet modem.

Our energy system is doing quite nicely now, ten years into its life. I pine for an OutBack inverter, but our SW4024 is still plugging along, though with some noise on the line. I upgraded our battery bank recently to 24 brand new Interstate-labeled Dynasty AGM batteries—12 volt, 100 amp-hour units wired for 24 volts (through our buss bar, check it out at www.wagonmaker.com). They are working fine, and cost less than Concordes too. Everything else is still ticking along. The SolarBoost 50 works great, and on these cold winter days, our 10-year-old, 1,200 watt array kicks out more than 1,200 watts, a nice side effect of extreme cold, clear skies, and snow reflection, in addition to the benefit of being at 9,000 feet. Tom Elliot • telliot@wagonmaker.com

Simple Instructions Wanted

Home Power should publish instructions for making simple, inexpensive solar cookers, water heaters, and other energy efficient devices. These devices should be made of discarded products such as cans, (beer, pop), milk jugs, old newspapers, etc. The magazine ought to be an inspirational guide showing how to recycle junk into valuable solar conversion products. Anybody can buy a finished product; few know how to make them. Show them how! Now! Bozidar Kornic, Shelbyville, Michigan

Hi Bozidar, You are correct—folks should be recycling any materials they can into usable objects. I am a firm believer in the axiom "reduce, reuse, recycle." However, you should know that we can only publish what we get, assuming it works and it's valuable to our readers. If you or anyone else would like to submit articles in this subject area, or any other subject relevant to home-scale RE, please let us know. Michael Welch • michael.welch@homepower.com

Induction vs. Synchronous

I have been bothered a bit by what appears to be confusion about the technical description of "induction generator" versus "synchronous generator." Case in point: the *HP96* article on the Crown Hill Farm hydro setup. An induction generator is the electrical analog of the common induction motor that is used in all power ranges from sub-fractional to mega-horsepower. It has a solid armature (squirrel cage) that is an electrical short circuit, and delivers electricity by slipping rpms against grid output (that is, 1,720 rpm vs. 1,800).

An induction generator would be the same device, except driven above the synchronous speed to, say, 1,850 rpm. It will not function except when connected directly to solid grid output. A synchronous generator on the other hand, has rotating poles, either DC excited or PM, and stands on its own at synchronous speed (1,800 rpm, say). It can be locked to the grid or other generators, but does not depend on them for excitation. It can be made to work from watts to gigawatts. I think the difference is worth noting; in the article in question, it is not clear which type is being employed. Sincerely, W. Van Aller, PE and K3CZ • wvanaller@hotmail.com

Hello W., Your point is entirely correct, and there is an error in the sidebar on page 19 of HP96. *It should have said "Induction or Synchronous?" not "Induction or Asynchronous?" Induction generators* are *asynchronous generators because, as you pointed out, they operate slightly above synchronous speed. For grid interconnection, induction generation is a lot easier because you don't need a synchronizing device that ensures that frequency and phase are matched with the grid before bridging the two. An induction generator inherently has a lot of "slop" because the field current is magnetically induced in the rotor. In a synchronous generator, the field current is hard wired. Connect a synchronous generator to the grid out of phase (even if the frequency is right), and the generator will lose a fight with the grid. But an induction generator doesn't care. Chris Greacen • cgreacen@socrates.berkeley.edu*

Hello W., The Crown Hill Farms turbines drive an induction generator. Canyon uses induction generators on smaller systems designed for connection to the grid. Interface is easy. In fact, if you want to waste the energy, you can first switch on an induction generator (motor), have it come up to speed, and then begin pushing it with the turbine. The water power pushes the induction motor to design speed, at which time it may begin its function as a generator.

We use synchronous generators for all our stand-alone projects. But there has been quite a bit of work using induction generators as stand-alone generators. They are made to work that way, but there are a few problems, mostly in voltage regulation. Regards, Dan New, Canyon Industries • CITurbine@aol.com

8 Volt Batteries?

I noticed the photo of the battery bank on page 76 in *HP98* shows the batteries to have four cells. Are these 8 volt batteries? Are they hooked in series to give 24 volts? Is this a better way to go for a 24 volt system? Richard F. Curtin • curtin@inreach.com

Hello Richard, Yes, these are 8 volt batteries (four cells in a case). The batteries are wired three in series to give 24 VDC. It's better for 24 VDC systems than 6 volt batteries since there is less interconnect wiring and fewer connections. Richard Perez • richard.perez@homepower.com

Solar Success in Canada

We have been reading your magazine since issue *HP11* , and for eight years we have been doing off-grid installations. We finally landed a job in downtown Toronto and received some publicity in the local newspaper. Mr. Richard Perez and crew have been a real inspiration to our company staff and me. We also had the pleasure of meeting Bob-O at a convention in Las Vegas in December 2003.

It is amazing how far the solar independent energy business has come in the last ten years. What's really amazing is where it is going to go—even in Canada, the land of long dark winters and no subsidies. Vern Sherwood • vernsherwood@rogers.com • www.excessenergy.net

Using Surplus PV Heat

Dear *Home Power*, Here's some food for thought about the article titled "Solar Hot Air Design" in *HP98.* PVs absorb and radiate heat as a byproduct of electricity generation—why not try to make use of it? I keep hearing about solar-electric panels being derated because of higher operating temperatures. Why not put that hot air to good use and cool the panels down at the same time? Replace the hot air collectors with solar-electric panels, using insulated ducting behind the panels to contain the heated air, and duct it into your home either through the wall or through the ceiling and roof. Move the air with a solar powered fan—a side benefit is that you only use electricity for the fan when you need it. I would imagine there would be a gain in the energy generated from the panels because they are kept at a cooler operating temperature. With proper ducting, dampers, and bypasses, the air could be exhausted either into your home, or if your home is comfortable enough, to the outside, enabling the panels to operate at a lower than normal temperature.

For that matter, how much energy would you lose if you sandwiched the panel between glass on the front and insulated ducting on the back, removing heat from both sides of the panel. Anyone for an add-on industry? Rack manufacturers could make the ductwork as part of the rack, and PV manufacturers could sell it as standard equipment, part of the PV. How about using a heat pump to cool those panels down? Everything done in the RE industry involves trade-offs. The big question is, do we get a net overall gain in the energy used within our homes? Will the losses associated with putting another glass panel in front of a PV more than offset the heat recovered from the same panel? Maybe the panel manufacturers will have to add another specification indicating the heat generated from each panel based on the other stated specifications as part of their rating process. I realize that there may be something I am missing in doing it this way, but I can't seem to find it.

I thoroughly enjoy reading *Home Power*, and especially like reading the tales about Kathleen Jarschke-Schultze and Bob-O. Keep up the good work and best wishes for the New Year. Donald McMow • drmcmow@telus.net

Hello Donald, There was an attempted commercialization of this idea in the 1980s. A government contractor (BDM Corporation) had the same idea. They built a prototype and installed it on their headquarters in Albuquerque, New Mexico, in about 1983. It did not generate enough extra electricity and heat to pay for the costs associated with the extra production and installation costs. Would it pay today? It's doubtful. The price of PV modules has been reduced quite a bit in the last twenty years. If the idea of circulating environmental air to heat a home wasn't a good value when modules were selling for US$10 per watt, the idea would seem to be less attractive at US$5 per watt. The lower cost would leave less margin for the increased efficiency to pay off, unless the alterations were less expensive today. I don't think that would be the case. Perhaps the cost to value may be there some day if some new innovation in module manufacturing is found.

What you might be missing here are the real costs associated with the manufacture and installation of the modifications. These costs are probably underestimated more than 95 per cent of the time in alterations like this. New professional contractors typically lose money on many of their first jobs because they underestimate the cost of the material and or labor—it's just part of the learning curve, but it happens all the time. I hope that answers your question. Chuck Marken • chuck@aaasolar.com

Send your letters and photos to *Home Power* magazine at letters@homepower.com or PO Box 520, Ashland, OR 97520

What a Long Strange Trip It's Been....

Richard Perez

Since this is *Home Power's* 100th issue, I thought that you might enjoy a short history of the solar energy systems at our remote home and home office.

Back to the Land

In 1970, Karen and I left the city of San Francisco and headed for our new homestead in the Siskiyou Mountains of southwestern Oregon. To say we were greenhorns would be an understatement—we knew virtually nothing about country living. There are many mistakes that first-timers make when homesteading, and we made most of them. At least we made one decision right—buying property far from civilization. Our homestead is 6 miles (10 km) from both utility electricity and telephone service, and 7 miles (11 km) from the nearest paved road. We were content to do without, and for many years, doing without is exactly what we did.

For the first seven years, we lived life much as it was lived a century ago. We hauled our water from a spring 1,500 feet (460 m) from our cabin. We burned kerosene for light. A woodstove cooked our food and kept us warm. We worked odd jobs for neighboring ranches, and did what we had to for survival.

By 1977, the novelty of country living had worn off and we were ready for some modern conveniences. In retrospect, I think that hauling water was the straw that broke the camel's back. I figure that during that seven-year period, I hauled more than 100 tons of water. We also did without an automobile for five years. This meant that all our supplies were backpacked or horse packed into our homestead. This got old after a while....

The original Plywood Palace, circa 1982—416 square feet and no insulation.

Power to the Homestead!

With a background in physics and electronics, I figured that I could at least bring some electricity to our homestead. Our initial system was modeled after a truck's electrical system. A neighbor gave me a 3 hp gas engine and I belted it up to a junkyard truck alternator. A car battery provided energy storage. The lightbulbs, sockets, switches, and wire were scavenged from a local automotive junkyard. After a few weeks of work, we had rudimentary 12 volt electricity—enough to run lights at night and power some radios. This early system consumed about two quarts of gasoline a week, and ushered our homestead into the 20th century.

I read about and drooled over PV modules, but at that time, we couldn't afford even one module. After saving for more than two years, we bought our first PV module in 1981. What a revolution! Electricity from sunlight! We were hooked. During the next few years, many more modules followed. Not only did these modules provide us with simple and clean electricity, but they also started putting beans on the table. Our neighbors noticed what we were doing, and before I knew it, we were in the business of providing solar-electric systems for others.

Before the big remodel—the Plywood Palace with battery room addition (1992) on the left, *Home Power* office addition (1992) on the right, and pantry addition (1997) in back.

PV mosaic—*Home Power's* PV history started with just one 59 watt panel (still working!)—and has grown with our needs to over 4 kilowatts.

We also continued to add electrical creature comforts—a well pump powered by solar electricity, kitchen appliances, radiotelephones, bi-directional satellite Internet, and other communications gear, a home entertainment system, and power tools. These days, folks who come to visit our homestead don't know that it's off-grid unless we tell them. Our system now has 4.1 KW of PV installed, and cycles about 15 KWH of renewable energy per day. Using renewable energy is a lot like eating peanuts—once you get started, it's hard to stop.

The evolution of our solar-electric system paralleled the development of the entire industry. As modules became less expensive, we bought more of them. When sine wave inverters became available, we deep-sixed all our old modified square wave models. We bought into the emerging new electronics technologies, such as amp-hour instrumentation and MPPT PV controls, and generally kept our system on the cutting edge. Things got better, more reliable, and even less expensive.

Our system, like just about every early system, continued to grow. We bought our first inverter in 1984. Though it was a modified square wave model, it gave us limited access to standard 120 VAC appliances, such as our first Macintosh computer. And with this computer came the desktop publishing technology that, coupled with my experiences of installing PV systems for others, eventually gave birth to *Home Power* magazine.

Over the years, our system grew as we needed more and more electricity. At one time, all the computer work that went into *Home Power* was done at our homestead. We had as many as eight computers—with peripherals, such as scanners, printers, etc.—working at once. This consumed many kilowatt-hours per day, and we expanded our system to meet the demand.

Solar Thermal Systems

Since I have limited plumbing experience, establishing the solar thermal systems here was much more difficult than doing the solar electrics. My background was in electronics, so using solar electricity seemed simple. The scene was far more difficult with solar thermal systems. In the case of solar hot water, first you have to have running water, a luxury that took us two decades to establish here. Then you

Four, 4 by 8 foot flat plate solar collectors contribute to the direct gain of the thermal mass floor. In the background, a flat plate collector and a 20 tube, evacuated-tube collector make hot water on the roof of the bathhouse/greenhouse.

have to keep the water systems from freezing, and it gets cold here in the winter. In the case of solar space heating, a tight building envelope, hi-tech windows, and good insulation are prerequisites. Our original building was anything but tight and well insulated.

Properly sized overhangs allow only wintertime sunlight to warm the 6 inch thick slab floor—cats love the natural radiant warmth.

Solar Hot Water

Hot running water here is a recent advancement. It wasn't until Joe Schwartz and Ben Root built the solar bathhouse/greenhouse that we had a space large enough to house this gear without it freezing up in the winter. See *HP63* and *HP64* for a thorough report on this straw bale, solar building.

Once we had a home for the solar hot water gear, we lost little time installing a shower, a bathtub, and a washing machine. We installed two solar hot water systems—one employs a 4 by 10 foot (1.2 x 3 m) flat plate collector, and the other has twenty evacuated heat-pipe tubes. These collectors are mounted on the roof of the straw bale bathhouse/greenhouse. Each closed loop system uses a 50 gallon (190 l) tank for hot water storage.

A propane-fired 30 gallon (115 l) water heater provides backup for sunless winter months (usually only November and part of December). Almost all of the time, we have all the solar hot water we need for the four permanent residents, and even for the times when we have up to eight visitors. And during the summer months, we have a glut of solar hot water—more than enough for everyone to shower twice a day if they wish.

Solar Space Heating

Heating our home with the sun was tougher to get operational than heating our domestic water. Our original 416 square foot (70 m^2) cabin was aptly named the "Plywood Palace"—all that separated us from the outside world was a half-inch of plywood. Trying to do solar space heating with no insulation, a very leaky building envelope, and funky, recycled, single-pane windows is a joke.

Over the years, this cabin underwent the typical farmhouse metamorphosis—rooms grew on all sides. About four years ago, the *Home Power* crew took pity on us and rebuilt the cabin to its present size of 2,300 square feet (215 m^2). But this expansion was far more than just more cubic feet under a roof. This time we took the trouble and spent the money to upgrade the building's thermal envelope.

The new building is well insulated, with R-30 in the walls and R-60 in the ceilings. In addition to putting R-21 fiberglass insulation between the wall studs, we also added a layer of 1 inch (2.5 cm), double foil backed, foam insulation on the outside of the building before adding the exterior siding. And this really paid off far more than adding up the

The open floorplan allows natural daylight to illuminate the kitchen, previously a dark corner, on the north side of the house.

Richard and Joe (*HP* publisher and CEO) recline in the cozy warmth of the solar-heated movie watching zone.

insulation R-values would indicate, since the rigid insulation eliminated any thermal coupling between the inside and outside via the wall's framing studs. All the windows were double pane and located to catch the maximum amount of winter sun. All of this combined to make the building a very efficient passive solar home. But we weren't done yet....

We decided to add active solar space heating to the building. Four solar hot water collectors, each 4 by 8 feet (1.2 x 2.4 m), were mounted on the building's south facing, 45 degree roof. This is a drainback system—the panels contain no water at night or when the sun isn't shining. This system heats a 32 ton concrete thermal slab on the building's ground floor, using PEX tubing embedded in the 6 inch (15 cm) thick slab. This slab is insulated from the earth by 4 inches (10 cm) of rigid, high density insulation. We finished the slab's surface with beautiful red Spanish tiles, which add even more thermal mass to the slab.

Once the slab gets warm, we can go for four sunless days before the house cools down. As long as the sun shines (and it does most winter days here) the house is cozy warm regardless of outside temperature. A thermostat rides herd on the system and prevents overheating in the fall and spring months. Backup heat is provided by an efficient wood heater that uses a secondary catalytic combustion chamber to extract all the heat from the wood burned, and reduces air pollution at the same time.

The proof of the pudding is in the performance. It gets cold where we live, with nighttime temperatures falling well below freezing most every winter night. In the original, uninsulated cabin, we would burn about five cords of firewood during a winter. The new 2,300 square foot (215 m^2) building has used less than a half cord of firewood per winter for the last three winters running. This is roughly a fifty-fold performance increase—the building is five times larger and consumes one-tenth the firewood.

When it comes to performance, the numbers mean less than the comfort of the creatures. In the old building, it was difficult to stoke the woodstove, since all the cats and dogs were welded to it, soaking up the heat. In the new building, the cats and dogs snooze happily on the warm solar slab. The wonder of solar heat never gets old. Karen and I wander around barefoot on the solar slab at night. It's warm to the touch even though there may be feet of snow piled up outside.

An unexpected boon of this solar building is its summertime performance. The south-facing windows are shaded from the summer sun by overhangs, and ship very little heat into the building. The tight building envelope and high degree of insulation make the building impervious to the summer's heat. The outside temperature often gets into the high 90s here on summer days. The inside of the house rarely gets above 75°F (24°C). We just open all the many operable windows at night, and allow the cool mountain breezes to chill down the building's interior and the thermal slab. First thing in the morning, we close all the windows and trap the cool inside the building. During summer days, we can keep the building about 23°F (-5°C) cooler inside than outside.

Lessons Learned

During the decades it took us to effectively use solar energy in our home, we learned several lessons that apply to anyone wanting to live with solar energy. Solar energy systems do not have to be bought and installed all at once. They can grow over a period of years as you can afford them. Using solar energy is like buying a home instead of renting it. With renting, the payments never end, but when you buy, you eventually own it. It's the same with energy. You can pay the monthly bill, or you can own the generating equipment yourself. Solar energy provides freedom—freedom to live where you want, even if it's off-grid, freedom from monthly utility bills, and freedom from blackouts.

While it's been a long strange trip, we wouldn't have had it any other way.

Access

Richard Perez, *Home Power*, PO Box 520, Ashland, OR 97520 • 541-941-9716 • richard.perez@homepower.com • www.homepower.com

Can I Go Off-Grid?

I've been thinking a lot about being off the grid, or maybe less dependant on the grid. How do I know if my site can use solar, wind, or hydropower? I live in Ohio and we rarely see the sun. And the wind doesn't blow 24/7, at least not enough to generate much. David Ruck • N8YMZ@cboss.com

Hi David, Thanks for writing. The only way to find out if you have a good renewable energy site is to do a survey. See the interview with Chris LaForge in HP82 *for lots of information on surveying for RE. If you are unfamiliar with RE, often it is best if a reputable pro does the survey. That way you can be positive about the findings. And at that point, you have somebody that can help you to the next steps—designing, purchasing, and installing the RE system.*

I live in an area that is considered rain forest, and is foggy and rains quite a bit. Yet I live off-grid with solar electricity, and rarely find myself using my backup generator. So things might be better than you think in Ohio.

Common thinking these days is to stay on-grid if you can net meter a system, because a utility-intertie system is the most efficient use of solar-electric panels. And you really do not need battery backup unless utility outages are frequent or lengthy in your area. For on-gridders, the decision to go off-grid is mostly a political one based on their feelings about their utility or being self-sufficient. Michael Welch • michael.welch@homepower.com

Fuse Sizing & Placement

I have some background in residential (110/220 VAC) electrical systems, but am new to the DC world. I am in the process of setting up a simple portable DC electrical system (a deep cycle battery on a hand truck), and have two questions regarding proper overcurrent protection. The system will initially be charged by a regulated battery charger, but will soon incorporate a PV panel.

Much of the material I have read in back issues of *HP* indicates sizing the safety protection (typically a fuse) for short circuit amperage, often in the multi-thousand amp range. What concerns me is that it seems that lower ampacity components (such as the wiring) could heat up (with undesirable side effects) before the high ampacity fuse would blow. Shouldn't the fuse be the current limiting device, and therefore have an amp rating equivalent to that of the wiring (for example, a 50 A fuse for short runs of #6 wiring)? For device protection, there will be lower amperage fuses on each of the circuits this power supply will feed.

Second, since current from the battery is from negative to positive, it seems that I would want the safety fuse to be as close as possible to the negative battery terminal; however, most diagrams I have seen (and the manufacturer of the battery charger I have) show all fusing in the positive leg of the systems. Does it matter which leg is fused? Thanks in advance for any specific assistance you can offer, and for the wealth of information in your magazine. Tim Maxwell • tmacswell@earthlink.net

Hello Tim, You're right on target here. The fuse/breaker in a given circuit is based on the gauge of the wire it's protecting—15 A for #14, 20 A for #12, 30 A for #10, etc. These amperage ratings are the same for AC or DC, but keep in mind that DC is typically running at a lower voltage, so the current is higher.

The reason the positive lead is typically fused relates to grounding. According to the National Electrical Code (NEC), *all DC systems operating above 50 VDC must have the DC negative bonded to the system's equipment ground. Keep in mind that 24 VDC nominal systems will theoretically operate at more than 50 VDC (open circuit voltage of modules plus derating factors), so only 12 VDC nominal systems can technically be ungrounded.*

The reason the fuse is placed in the positive leg is to keep the negative-to-ground path intact if the fuse or breaker opens the circuit due to overcurrent. If the fuse was in the negative leg, this negative-to-ground path would be an open circuit, and the grounding of the system would be defeated. Let me know if you have any additional questions and thanks for reading the mag! Joe Schwartz • joe.schwartz@homepower.com

Selective Surface Recipe

Hello *Home Power*, Keep up the good work—your magazine has some incredible articles. I am working on a solar hot water collector for our home in southern Alberta, and was wondering if *HP* has ever come across a "recipe" to make and apply a "selective surface." I realize that a selective coating is not a necessity for the DIYer's flat plate collector, but I would sure like to try. Thank you. Sincerely, Sam Lougheed • ssl@myexcel.ca

Hi Sam, The only product I've ever heard of or that we have ever used is Solkote. This is a semi-selective paint—0.28 to 0.49 emissivity when applied correctly. To apply it correctly, you should follow the manufacturer's directions to the letter. Contact Solec, 129 Walters Ave., Ewing, NJ 08638 • 609-883-7700 • Fax: 609-497-0182 • solec@attglobal.net • www.solec.org. Trying to make a black chrome selective surface in a home workshop or garage is pretty much out of the question. Good luck, Chuck Marken • chuck@aaasolar.com

Energy Math

I have a small RE system running at 12 volts. The battery capacity is 460 amp-hours. I figure I have about 230 AH available if I don't want to drain the batteries more than half way. Question: Is it correct to multiply these 230 amp-hours by 12 volts and figure on 2,760 available watt-hours? Thanks for your help. Wylie • watchman@tds.net

Yes, Wylie, that's correct. Volts x Amps = Watts. Volts x Amp-Hours = Watt-Hours. Make sure you've figured the amp-hour capacity of your battery bank correctly. Amp-hours are not additive when you wire batteries in series. For instance, two, 6 volt, 230 AH batteries in a 12 V system is 230 AH at 12 V.

Also, make sure you derate for system inefficiency. Batteries are generally thought to be about 80 percent efficient, and overall system efficiency is in the 65 to 75 percent range. It's better to *estimate low and be pleasantly surprised than to run short on energy or damage your batteries by overdischarging them. Ian Woofenden • ian.woofenden@homepower.com*

MPPT Basics

I am a little confused about maximum power point tracking (MPPT) controllers. Do these controllers work better with panels like the Shell SQ 160-PC that have a higher peak power voltage or the Kyocera KC158G that have a higher maximum power current? Fred Bennett, C&C Services • cncservices@kingmanaz.net

Hello Fred, MPPT trackers work best on modules (or arrays) with a higher voltage at the maximum power point. It's a voltage thing—the MPPT converts that extra voltage into more current. Richard Perez • richard.perez@homepower.com

Wooden Wind Turbine Blades

Hello, I am in search of information on refinishing wooden wind turbine blades. Would you have any suggestions on where to find the information needed to do an effective job? Thank you for your time. Alexandra Papasavas • alex_papasavas@hotmail.com

As former owner of Lake Michigan Wind & Sun for seventeen years, I carved many a wood blade for a variety of wind turbines that are or were on the market. In fact, we were the largest supplier of wood replacement blades in the country during that time. Wood blades work well, provided they are protected from the elements. That means protecting against erosion of the coating, as well as UV from sunlight and penetration by water. Any of these will quickly deteriorate wood blades.

The best way that we developed to finish wood blades was to use very high quality automotive paint. Wind generator blades live in similar environments to cars—high winds, erosion due to a variety of substances flying thru the air, intense sunlight, freezing cold temps, rain, snow, sleet, hail—you get the idea.

We primed the wood with DuPont Imron with a paintbrush. Imron is a really nasty polyurethane paint that does an excellent job as a primer. It's typically used to paint semi-trucks and industrial machinery. This coat raises the grain, but after you sand the primed coat down, you end up with a really hard and tough base for the top coats. Imron costs about US$20 or so a quart, plus the activator. It will take at least a half quart to do three, 7 foot blades. It takes about two weeks for this coat to "dry" or set up. After the primer set up, we balanced the blades.

The top coats we used were DuPont Centari, a high quality automotive finish. This is really a system of coatings, all of which are spray painted. The Centari system (that is, all of the various paints, hardeners, and other agents) will set you back at least US$80 for a set of three 7 foot blades.

The first two coats are a "fill and sand" primer, followed by a sealer. The top coat is an acrylic enamel finish, with an activator added to allow the paint to set up. Added to this coat are a hardener and a flexing agent, which allows the paint to flex with the blades without popping off. (Wind turbine blades flex just like plastic automobile parts do.) While all four of these coats are applied in one day, it takes about a week for the top coat to set up. After this top coat is set up, the leading edge tape is applied. This tape is an adhesive aliphatic resin material that is UV stabilized and very resistant to erosion. Its purpose is to protect the paint on the leading edges of the blades.

While this method is expensive, I have had blades in the field for ten years before they have needed repainting. You can probably get by with some cheaper paints, but you'll be back on the tower making repairs to the paint surface much more frequently. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Rd., Forestville, WI 54213 • Phone/Fax: 920-837-7523 • msagrillo@itol.com

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SWWP H80 48V or alter. Never used $1650. 2 GSE used hot air collectors. As is. Can e-mail photos. $800 includes crating. 64' tower for Bergey XL.1. Gin pole used 3 times. $900. Visa MC. 734-913-9944 www.sur.biz • HP10033

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2 TRACE SW5548 INVERTERS on Trace panel with C40 Charge Contr. &DC Disc. $4000; 2 Onan 16kw propane gensets < 6 hrs. $2500 each. Contact Chris 719-330-7715 ckp500@yahoo.com • HP10035

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SOLARFRIDGE SFRF-19 High-Eff. refrigerator. 16 cu. ft., 120V. Brand new (store price $2,790). Power use: 0.71 KWH. $2,000 OBO. Email: texashillcountryman@yahoo.com • HP10037

REBUILT JACOBS 140v, Wincharger parts, Hatz diesel 24v generator $350. 406 547-2266 • HP10038

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LAND FOR SALE- Belize, Central America—Community for sml farmers—maryjanewalport@msn.com • HP10041

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FOR SALE-40 SECLUDED ACRES, no restrictions,3BR 2B 16X12 shop, property taxes are $90/yr,solar tracker poles etc remain on property,$100,000 many pictures & info at www.empyrean-eye.com • HP10045

WINCHARGER-SW Windpower. AirX Marine 12V 400W. New, in box $400 (1/2 price). 360-268-5158 • HP10047

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installers *directory*

Do you want a renewable energy system, but don't want to install it yourself? You deserve a system that meets your expectations and budget! A renewable energy professional will design and install a safe, code-compliant system, and offer you service and support after the sale. Check out the state-by-state installer listings below.

Home Power **does not guarantee the quality provided by the businesses listed below—please shop carefully, request references and certifications, and compare.**

New Hampshire

Sunweaver Incorporating innovative technologies for power, water and heat. Encouraging knowledge and direction towards resource responsible solar living. Installing in New England and the Carribean since 1985. www.sunweaver.org. mailto: info@sunweaver.org 603-942-5863 Showroom hours: Monday-Saturday 11am-6pm

New Jersey

Akeena Solar is the nation's largest residential solar electric installer with two NABCEP-Certified PV Installers on staff. Our design/build services coupled with our complete financial analyses, based on actual site conditions, support our growing list of satisfied customers in making the switch to clean reliable energy. Serving CA, NJ, MA, RI, CT, & NY. Visit www.akeena.net or call 888-akeena-8

New Mexico

Positive Energy Inc. High quality renewable power systems. Licensed, bonded, and insured specialty electrical contractor serving Santa Fe & northern NM. Owner Allan Sindelar is a NABCEP Cert. Solar PV Installer, Xantrex Trace Cert. Dealer, Outback Cert. Field Service Tech., Sunnyboy Cert. Installer, and HP author. 505-424-1112, 505-424-1113 fax. www.positiveenergysolar.com allan@positiveenergysolar.com.

New York

Daystar Energy Systems We're making it easy to choose renewable energy. Unparalleled pricing guarantee, exceptional installation service, and backed up with a comprehensive warranty. Not your average installer, ask about our Sweat Equity and Referral Incentive Programs. Putting customers first in NY and NJ. Call Desi 585-224-9105 www.daystarenergysystems.com

Oregon

Electron Connection Licensed in CA and Oregon. NABCEP Certified installer. Serving northernmost California and southern Oregon. PV, wind, microhydro installs. (800) 945-7587 email: bob-o@electronconnection.com, www.electronconnection.com

South Carolina

SC Solar designs/installs PV systems—residential, US military, solar lighting, water pumping, traffic management power systems. Solar thermal & micro hydro. Custom UPS systems for off grid. Installation area: NC, SC, VA, GA, TN, & Mexico. For more info & credentials: 803-802-5522 www.scsolar.com CCR# & Cage Code #1SLJ5.

Texas

Meridian Energy Systems specializes in the design and installation of high quality solar and wind energy systems throughout the State of Texas...and beyond. Factory trained technicians and NABCEP Inaugural Certificant on staff. Visit our website www.meridiansolar.com or call toll-free: 888-477-3050

Texas, cont.

North Texas Renewable Energy Inc. North Texas' premier solar and small wind energy service. Complete system design and installation. Available service contract Independence–Reliability–Conservation. Jim Duncan answers@NTREI.com 817.917.0527

Vermont

Vermont Solar Engineering has provided the finest in renewable energy throughout New York and New England, since 1991. We design, install, and support solar electric, wind electric, and solar hot water systems. K. Herander, NAPCEP certified installer. Xantrex Certified Dealer. NYSERDA eligible installer. Vermont Solar and Wind Partner. www.vermontsolar.com 1-800-286-1252

Washington

SolarWind Energy Systems, LLC P.O. Box 1234, Okanogan, WA 98840 (509) 422-5309 www.solar-wind.us WA Cont. # SOLARES983RQ. Serving Eastern WA & Northern ID grid-tied & off-grid RE systems. Solar PV, wind, solar hot water, remote stock watering. Design, installation, service, maint. Solar Energy International (SEI) trained. Lic. & bonded. bclark@solar-wind.us or jmartin@solar-wind.us

Sound Power Contractor Reg. # SOUNDPI983NW www.soundpower.us 425-844-8748 phone 425-844-8928 fax Licensed, bonded, insured electrical contractor. Renewable energy specialist. We will travel anywhere in Washington to install PV, wind, and microhydro systems.

Wisconsin

Great Northern Solar. In business since 1988. "Waking the Northland to renewable energy & sustainable living!" We install PV, wind and microhydro systems. Large focus on education—workshops on residential and commercial installations available. Instructor at MREA. Contact Chris LaForge at 715 774-3374, email: gosolar@cheqnet.net 77480 Evergreen Rd Ste #1 Port Wing, 54865

Wyoming

Creative Energies Wyoming's premiere full-service RE company. Solar & wind power for remote cabins, homes & ranches, utility grid-tied solar & wind power, solar hot water & heating, solar water pumping & passive solar home design. We custom design a system that fits your needs & budget. Trace certified dealer. Phone/fax: 307-332-3410 toll free 866-332-3410 info@creativeenergies.biz www.creativeenergies.biz

RE Installer? Get Listed.

Our readers continue to look to *Home Power* for referrals to RE installation professionals in their area.

For more information or to get your business listed in *HP*'s installers directory, e-mail advertising@homepower.com or call 541.512.0201.

adopt a library!

When Karen and I were living with kerosene lamps, we went to our local public library looking for a better way to light up our nights. We found nothing about small-scale renewable energy. As a result, one of the first things we did when we started publishing *Home Power* sixteen years ago was to give a subscription to our local public library.

If you'd like to do the same for your public library, we'll split the cost of the subscription with you. Inside the U.S., you pay $11.25 and we'll pay the rest. Outside the U.S., the same offer stands, so call us for rates.

— Richard Perez, Publisher

Check with your local library before signing them up. Eligible libraries must be open to the general public.
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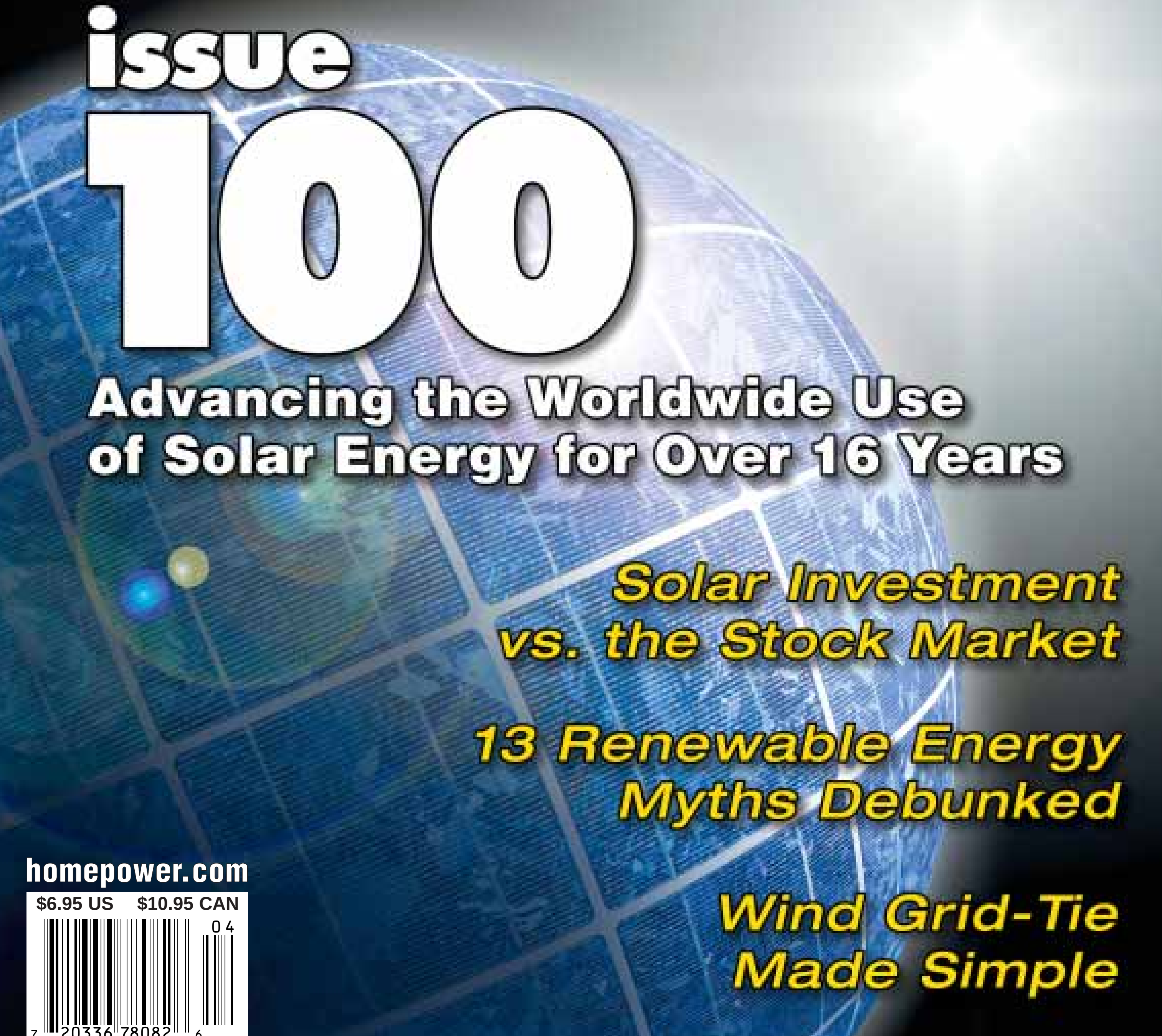
April – May 2004

issue 100

Advancing the Worldwide Use of Solar Energy for Over 16 Years



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Now you can reduce your electric bills without sacrificing your home's elegance.

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Energy Survey

The following optional questions about your renewable energy use help us tailor the magazine to meet your needs. All information is kept confidential. We appreciate your input.

I use, or plan to use, renewable energy for:

Now	Future	
☐	☐	All electricity
☐	☐	Most electricity
☐	☐	Some electricity
☐	☐	Backup electricity
☐	☐	Recreational electricity (RVs, boats, camping)
☐	☐	Vacation or second home electricity
☐	☐	Business electricity
☐	☐	Transportation
☐	☐	Water heating
☐	☐	Space heating

My site(s) have the following renewable energy resources:

- ☐ Solar power
- ☐ Wind power
- ☐ Hydro power
- ☐ Biomass
- ☐ Geothermal power
- ☐ Tidal power
- ☐ Other (explain)

Electric utility grid use:

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

______% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me ______¢ for electricity (cents per kilowatt-hour).

I use, or plan to use, the following renewable energy products (check all that apply):

Now	Future	
☐	☐	Photovoltaic modules
☐	☐	Wind generator
☐	☐	Hydroelectric generator
☐	☐	Battery charger
☐	☐	Instrumentation
☐	☐	Batteries
☐	☐	Inverter
☐	☐	Controls
☐	☐	PV tracker
☐	☐	Engine/generator
☐	☐	Methane digester
☐	☐	Thermoelectric generator
☐	☐	Solar oven or cooker
☐	☐	Solar water heater
☐	☐	Wood-fired water heater
☐	☐	Solar space heating system
☐	☐	Hydrogen cells (electrolyzers)
☐	☐	Fuel cells
☐	☐	RE-powered water pump
☐	☐	Electric vehicle

Feedback

Please write to us here. Tell us what you like and don't like about *Home Power*. What would you like to read about in future issues? Thanks for your attention and support.

☐ It's okay to print my comments as a letter to *Home Power.*

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