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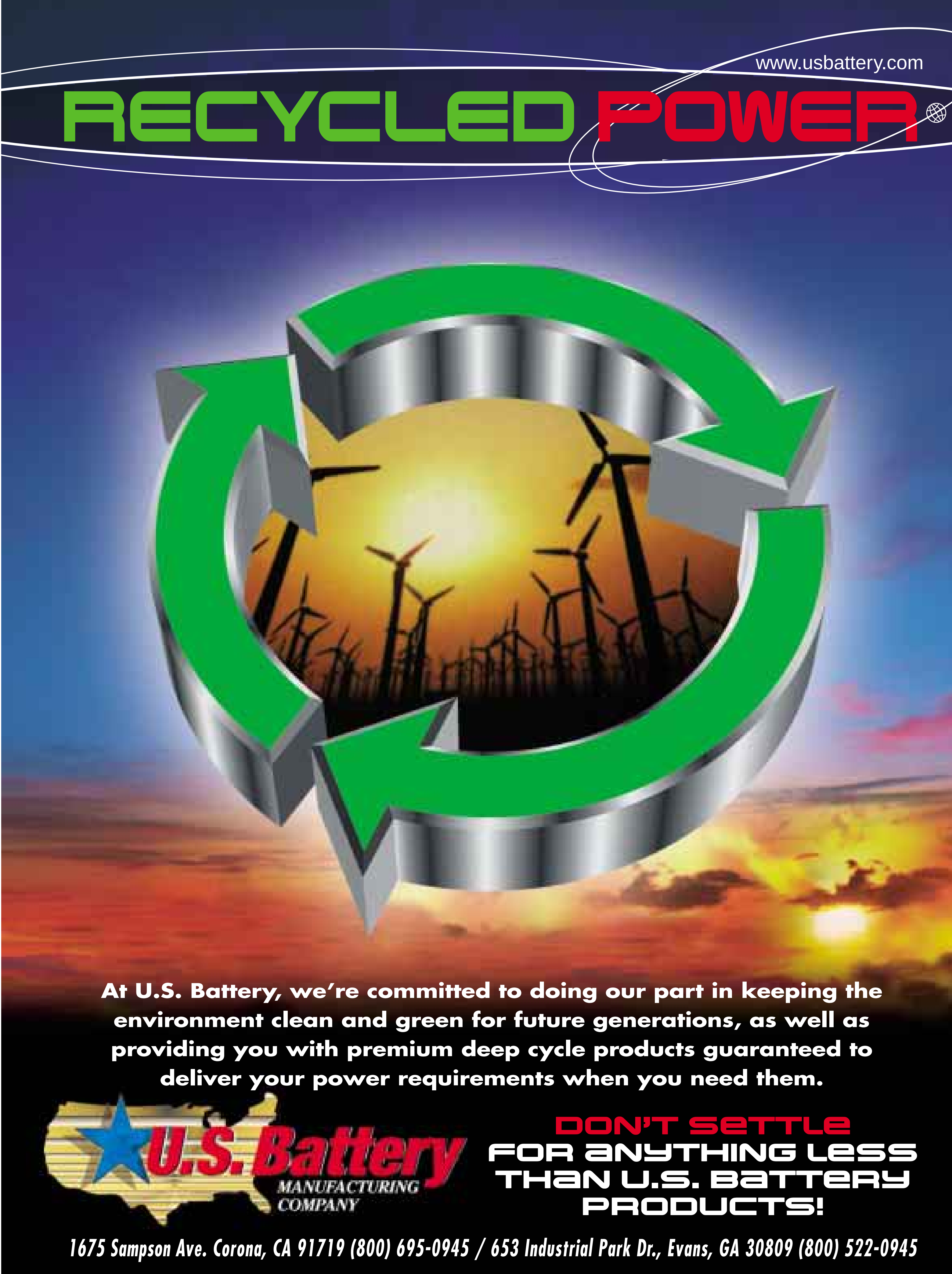
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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #87 February / March 2002

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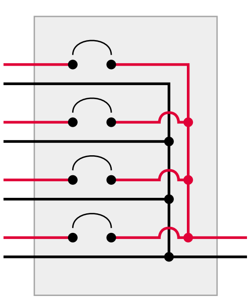
Simon Wheaton-Smith suffered a grid outage—that got him started with solar. Now, an admitted hobbyist, he loves his plug-and-play system with 2,630 watts of PV and five inverters.



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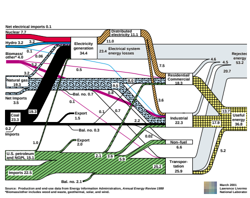

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Finding and Buying Your Place in the Country *hasn't landed Eric property yet, but he'll know it when he sees it.*

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Solar City

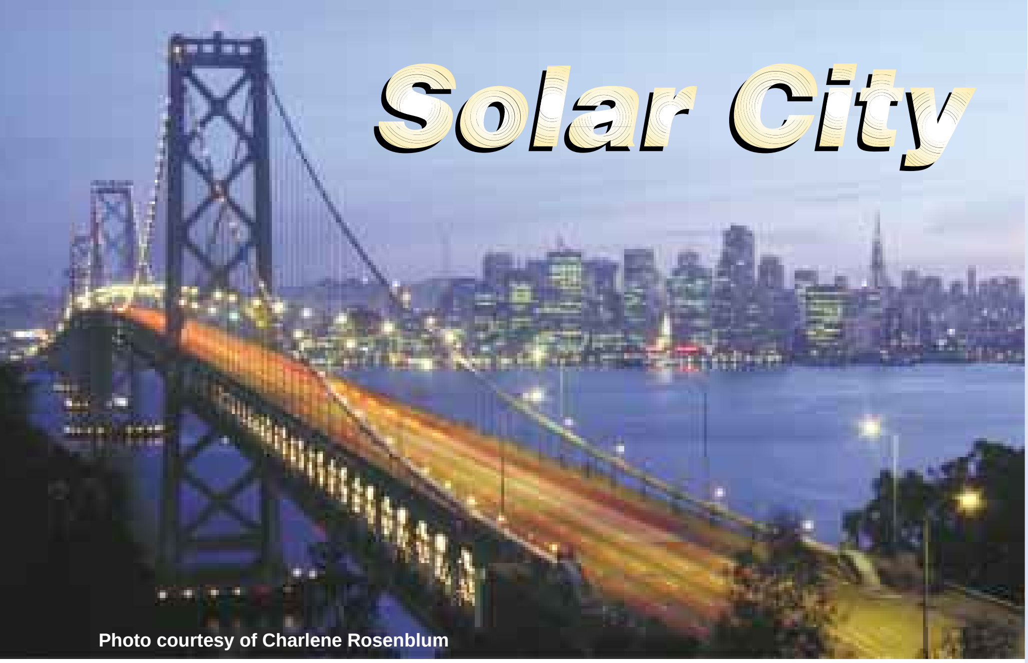

Photo courtesy of Charlene Rosenblum

The Northern Californian poet Gary Snyder once wrote, "Revolution begins in the country." For the last two decades, the solar revolution has been quietly taking place in tens of thousands of off-grid homes in the U.S. Well, the solar revolution just moved to the big city.

On November 6, 2001, San Francisco residents voted for solar and wind energy, and they did it in a big way. Seventy-three percent of those voting just said "yes" to the Solar Revenue Bond, better known as Proposition B. The vote gave the green light to a US$100 million dollar investment in city-owned solar and wind generation facilities and energy efficiency programs.

Proposition B took a creative economic approach. The Solar Revenue Bond will be repaid exclusively by the city's future savings in expenditures on electricity. Unlike general obligation bonds typically used to fund libraries or parks, revenue bonds are not funded by an increase in property or other state taxes. For the financial details on the Solar Revenue Bond, check out: www.votesolar.org/the_proposal/budget_analysis.htm.

The bond will fund an estimated 10 to 12 *megawatts* (MW) of photovoltaic generation. The PVs will be installed over the next two to four years on city-owned buildings in sunnier areas of this city known for its foggy weather.

San Francisco's decision to go solar is likely to have a strong impact on the U.S. photovoltaic industry. In the year 2000, U.S. manufacturers produced 75 MW of photovoltaics. Over 50 MW of these PVs were exported, primarily to Germany and Japan. The PVs required to implement Proposition B equal close to 50 percent of the PV capacity installed in the U.S. in 2000.

In addition, Proposition B will also fund the development of 30 MW of city-owned wind turbines scheduled to be installed in Alameda and San Mateo counties. For comparison, the entire U.S. may have as much as 4,500 MW of industrial-scale wind generation installed by the end of 2001.

The past year has left Californians reeling as skyrocketing energy costs and iffy power supplies threatened to bankrupt the state treasury. The City of San Francisco's expenditures on electricity jumped from US$7 million in 1998–1999 to US$39 million in 2000–2001. As a result, San Franciscans have come to realize the value of locally owned and operated electricity generation.

If San Francisco's overwhelming commitment to renewable energy is well administered and skillfully implemented, the city could serve as a model for large cities across the U.S. Above all else, the San Francisco vote signals that mainstream America is ready for renewables.

–Joe Schwartz for the *Home Power* crew

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Allan Sindelar
Randy Udall
Michael Welch
Simon Wheaton-Smith
John Wiles
Dave Wilmeth
Jennifer Wine
Ian Woofenden
Rue Wright
Solar Guerrilla 0018

"Think about it…"

"Is there any man,
is there any woman,
let me say any child here
that does not know that the seed
of war in the modern world
is industrial and commercial rivalry?"

—President Woodrow Wilson,
a year after the first world war ended

Solar Powered Chocolate Factory

Moth Green

Local kids get a taste of local chocolate and local energy.

While doing PV and intermediate technology volunteer work on the island of Grenada, I became fascinated with the cocoa tree. My favorite pastime became simple, kitchen-style processing of cocoa beans into luscious hot chocolate. After a while, I began to dream of creating a solar powered chocolate factory in the lush, cocoa-producing southern Caribbean.

Grenada Chocolate Co. founders Edmond Brown, Moth Green, and Doug Browne in front of their cottage factory.

Sixteen, 120 watt AstroPower modules provide power directly to DC-driven, chocolate making machines.

The price for cocoa beans paid to Grenadian producers is marginal compared to the price of fancy chocolate. So I began to fantasize about making dark chocolate with a cooperative that would actually benefit the cocoa farmers. Grenada's world famous cocoa would be used to create top quality, nonexploitive chocolate bars right in Grenada. Four years ago, together with two partners and a startup loan, I embarked on this chocolaty journey.

Fine chocolate making is a rather complex process involving several different machines. Fresh, pulpy cocoa beans are first harvested from the pods growing on cocoa trees. They are then fermented in a large wooden box for about seven days, and sun dried. The fermentation gives rise to all the chocolate flavors.

The dry cocoa beans are roasted, shelled, and ground together with sugar into a "liquidy" paste. Pure cocoa butter, pressed from other roasted cocoa beans, is added to this paste, and the mixture is further ground, tumbled, and slow-cooked for up to 48 hours. The resulting finished liquid chocolate is then tempered, molded, and cooled into chocolate bars.

The machines used in the process are the roaster, winnower, melangeur (chocolate grinder), cocoa butter press, refiner/conche, tempering kettle, and vibration table.

The melangeur is a refurbished antique chocolate grinding machine with two, 500 pound (227 kg), solid granite rollers. It has a retrofitted, 24 volt permanent magnet motor, and crushes the roasted cocoa beans.

The Research Stage

The first step in our chocolate odyssey was to convince a couple of big U.S. chocolate factories to allow us to see their process and machines. Later, we located a couple of textbooks on chocolate manufacturing. Quickly it became clear to us that small-scale machinery for quality chocolate making is no longer manufactured. The conversion of cocoa beans to bulk chocolate is only done at very large factories with very large machines these days.

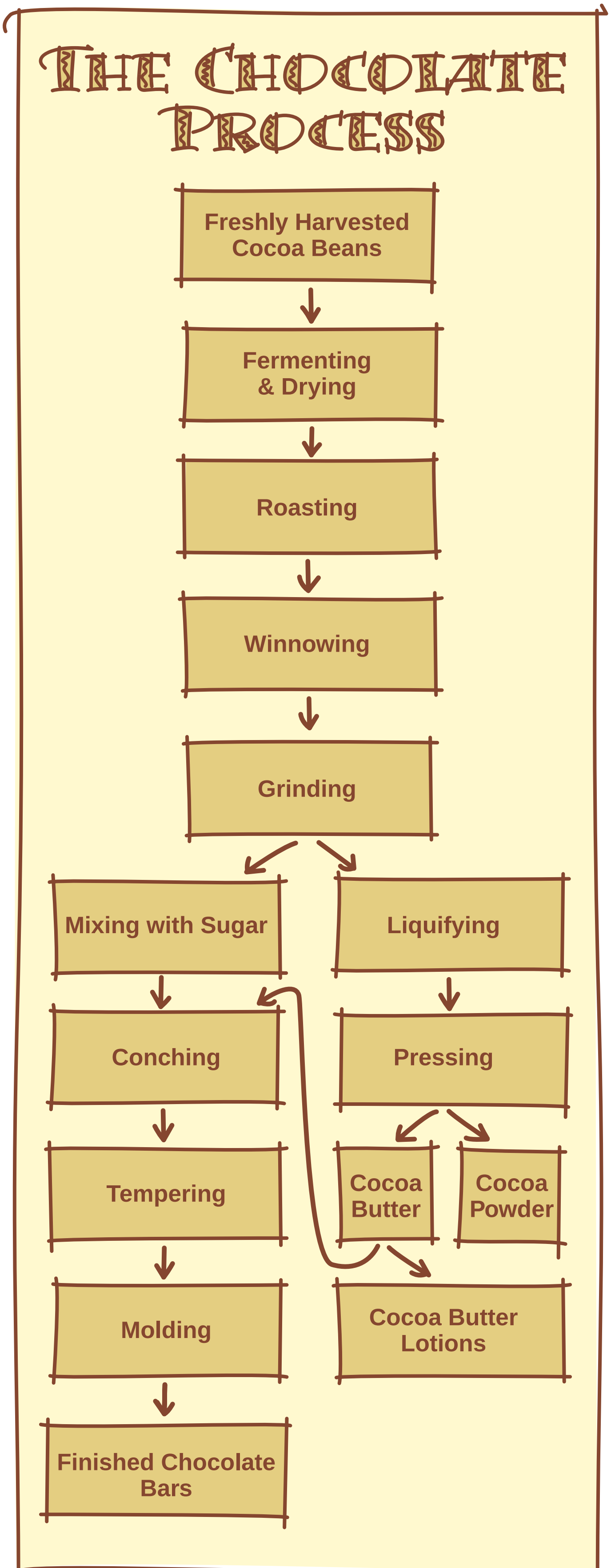
My chocolate dreams and my renewable energy instincts inevitably collided. My new vision was to build a solar powered chocolate factory. We wanted the most efficient machines possible, because chocolate making is a very energy-intensive process for a PV system to handle. For over two years, we experimented with designing our own chocolate making machines, as well as refurbishing a couple of antique machines.

On all these machines, we used DC, permanent magnet motors, which allow efficient direct powering from the PVs or batteries. In my partner Doug's barn in Oregon, we built and tested several generations of machines, including wood-fired roasters, winnowers, grinders, and cocoa butter presses. We tested them by processing cocoa beans we imported from Grenada.

After many months, lots of brainstorming, and a few dead ends, we had a machine line we were happy with, and chocolate we were addicted to. We packed up all our machinery and solar-electric equipment, and sent it on a ship to Grenada about two years ago.

Building the Factory

It was natural to create our little factory in the countryside village that I had lived in over the years. I built a bamboo house in this village, and had created independent appropriate technology projects here, such as teaching solar cooker and hand-powered water



The author pouring cocoa beans into a homemade roaster. A 24 volt DC motor powers the tumbler, which allows the beans to roast uniformly.

pump design in schools and to farmers. I also helped several far-from-the-grid people get acquainted with small photovoltaic power systems for lighting and radio playing in their houses. This village, Hermitage, is also in the heart of the cocoa-growing belt of Grenada.

Together with my two partners, one from Oregon and one from the same village, I started the Grenada Chocolate Company. We began the transformation of an old, abandoned, concrete building into our chocolate “cottage factory.” We redesigned the interior of the building to suit our needs piece by piece, simultaneously assembling and wiring our machines.

Because of the hot, humid, tropical climate here, we required air conditioning in two special rooms, one for molding and wrapping chocolate bars, and one for storing chocolate for its crucial aging period. We used efficient, mini-split, ductless-type air conditioners (Lennox LX WM 10F-AFAB).

This type of room air conditioner is common in Asia and Europe. They are relatively efficient because the compressor is located outside the building. They are similar to central air conditioning systems, but are ductless. The coolant simply circulates through pipes in and out of the building, expanding and getting cold in front of a blower inside, but losing its heat in the compressor outside the building.

Refurbished antique winnowing machine, retrofitted with 24 volt DC motors (one motor for vibration and one motor for a powerful fan), removes the outer shell of the roasted cocoa beans.

One interesting thing about designing and implementing our electric system was that we did not have to worry about following codes here in Grenada. There are codes for regular AC wiring, but DC systems are so rare that they never made or adopted any codes for DC wiring and PV installation. We simply did a solid and safe job by our own standards, and we were able to create a suitable system for our unique situation.

Power System

The chocolate factory is on the grid, and there is no provision in Grenada to sell power to the utility. But the grid power is not reliable enough to count on. It can go off for an entire day once or twice a month, and it goes off for fairly brief periods every couple of days. Not only does the grid go off unexpectedly, but the grid transformers around the country are often overloaded. The electric grid in Grenada is designed to run at 230 VAC, 50 Hz. But overloading regularly brings line voltage down as low as 195 V.

Sometimes we need to run the generator even when the grid is on to get a sufficient voltage to run our battery charger and refiner machine effectively. We also have to watch out for very low voltage when the grid first comes back on. We had to replace an electronic temperature control unit on our refiner/conche machine, which we suspect died this way.

We designed most of the factory's loads to run on DC power directly, using the grid to charge our batteries when the PVs cannot provide sufficient energy. When the grid fails unexpectedly, we don't have to worry about any type of backup system switchover to keep our machines moving and prevent our chocolate from burning. Unlike the grid, the batteries won't fail abruptly. We also have some AC loads, such as lights and the air conditioners, which we power either with an inverter, the grid directly, or an engine generator.

PVs & Wiring

We installed sixteen AstroPower, 120 watt PV modules (1.9 KW rated total, at 25°C; 77°F) on our roof, configured for 24 volts. We made our own mounting system out of treated 2 by 3 lumber. Essentially, we installed another set of rafters on top of the corrugated metal roofing, directly over the actual rafters underneath. We lag bolted them together through the metal.

The PVs were first mounted on 1 by 3s the length of the modules, and then laid down and lag bolted across the 2 by 3s. This provided a sturdy mounting and a cooling air gap underneath the modules. It does have the disadvantage of making it less convenient to check the connections in the PV junction boxes.

The PVs are interconnected with #10 (5 mm^2) stranded wire that is tucked underneath the panels to hide it from

Wendy-Ann Edgar pouring sugar into the antique melangeur.

**Edmond Brown works the cocoa butter press.
A 24 volt homemade blender (not shown) blends up hot, ground liquid cocoa to feed the press.**

the extreme UV. The array is split into two separate 24 V subarrays, each with two #4 (21 mm^2) wires attached. The subarrays each have their own 45 amp DC breaker going into the charge controller in the load center.

The dual breaker system offers the convenience of comparing the total number of incoming solar amps from the two subarrays by turning one off at a time. This is a nice way to gain some instant reassurance that all the PVs are functioning the same and, therefore, properly.

Because the chocolate factory is wired for DC as well as AC, a variety of wiring was used. Several 24 VDC and a couple of 12 VDC circuits for the machines are wired using single conductor, stranded #12, #10, #8, and #6 (3, 5, 8, and 13 mm^2) wire from the load center. Romex type wire was used for the two different kinds of 120 VAC and the 230 VAC circuits.

Balance of Systems
The system also includes four Trojan L-16 high-capacity batteries (395 AH at 6 VDC each), a Heliotrope SolPan 110 load center/control system with a Heliotrope CC-120, 120 amp charge controller; a Quick Charge 60 amp, 24 volt forklift battery charger: and a Honda propane powered engine generator.

The battery bank capacity is relatively small (395 amp-hours at 24 V) because, for now, we don't have enough solar generating capacity to cover the total consumption of the factory anyway. So the batteries get used as a buffer (a voltage stabilizer), powering loads day and night, while being simultaneously charged by some combination of the PVs and the battery charger.

We use a manual-start 5 KW engine generator that we converted to be fueled with propane with a spud/regulator kit. The 230 VAC (our grid voltage here in Grenada) output of the generator is connected through a homemade isolation/transfer system that uses two 60 amp receptacles and one 60 amp plug wired to the grid panel. With this setup, the 230 VAC loads can easily be manually switched between the grid and the generator.

A 2,400 watt Trace modified square wave inverter is powered by the battery bank. The inverter output is wired to a separate 120 VAC, 60 Hz breaker panel. We wired special inverter-powered 120 VAC receptacles from this panel at various places around the building where we need them.

Controls & Warnings
The battery charger cycles on and off automatically as needed, using a power relay and a commercial voltage sensing switch. This sensing switch has two setpoints. We set it to turn the charger on when the battery

Chocolate Factory Loads

DC Load	*Volts*	*Amps*	*Watts*	*Average Hrs./Day*	*Average WH/Day*
Granite stone chocolate grinder	24	40.0	960	8.0	7,680
Inverter (for AC loads)	24	19.0	456	11.0	5,016
Chocolate temper kettle	24	43.0	1,032	4.0	4,128
19 DC CF lights	24	10.5	252	10.0	2,520
2 Vent fans	24	1.3	30	24.0	720
Cocoa bean winnower	24	33.3	799	0.8	599
Cocoa butter press	24	4.0	96	2.0	192
2 Mold cooling fans	24	2.0	48	4.0	192
Cocoa bean roaster	12	5.0	60	2.0	120
Chocolate mold vibrator	12	1.5	18	3.0	54
				Total	21,221

The power wall including the SolPan 110 DC load center, which contains a Heliotrope CC-120 charge controller.

voltage drops to 23 volts DC, and to shut off when the voltage reaches 26 volts DC.

Because some of the loads are running constantly, we don't try to use the AC charger to top off the batteries. The energy used to raise the voltage of the system higher than necessary for powering the loads would just be lost as heat in the motors and batteries.

We also don't want the charger to come on at too high a voltage, so the PVs always get the first chance to power the factory. The batteries seem to stay healthy because, naturally, once in a while we stop making chocolate. Then the PVs get a chance to top off the batteries.

The Heliotrope charge controller has an adjustable voltage regulation setpoint, over which it switches to pulse width modulation mode to keep that voltage steady by controlling the current. Below this setpoint, the charger allows the full current from the PVs to enter the batteries. For the first six months, we had the setpoint at 29 volts. This seemed safe and practical for our Trojan L-16 deep-cycle batteries.

But we found that the batteries were drying fast, needing watering quite often, presumably due to the very high average ambient temperature here. We have since lowered the setpoint to 28 volts to avoid

The AC charger, used for grid backup, sits atop the vented battery box that holds four Trojan L-16Hs.

shortening our batteries' lives. We put in an override switch as well, so we can also use the battery charger to top off the batteries in case of bad weather.

An alarm, powered by the battery bank, of course, warns us when the grid goes down. It is activated by a

Two 230 V receptacles allow a choice between utility or generator power. The LED and stereo indicate a hot grid.

The voltage sensors and controls for the low voltage disconnect and AC battery charger.

normally closed relay that is usually held open by power from the grid panel. When the grid goes off, the relay closes the alarm circuit, telling us that we need to watch what is going on and start the generator if necessary.

If a grid outage went unnoticed, the battery bank could be depleted after some hours, and our low voltage disconnect system (LVD) would come into play. For our LVD system, we use another voltage controlled switch and an electric car contactor. After the low voltage dsconnection, if it gets sunny enough or the generator is started and the battery charger comes on, the voltage goes right up, and the contactor turns on the factory.

Not only do we have to be alerted when the grid goes off, but we also need a "grid-back-on-alarm." Without it, we wouldn't know when we could stop the generator and save propane. So we installed a fused, 230 V LED outlet directly to the large, grid powered receptacle of the transfer system. When the grid comes back on, this special outlet turns on. Either the lit LED or a radio plugged into the outlet alerts us that the grid is on again.

The Loads

We use several types of electricity at the factory. Our larger DC loads, including the chocolate grinder (melangeur), the tempering kettle, the cocoa butter press, and the winnowing machine, are routed through 75, 75, 45, and 30 amp DC-rated breakers, respectively, in the load center.

We also added two, five-circuit fuse blocks inside the load center. One is used for additional, low power 24 VDC loads such as the roaster's rotation motor and DC lights. A Solar Converters, 24 to 12 volt buck converter (DC-to-DC voltage converter) powers a few small 12 VDC loads via the second fuse block. The inverter's DC input is routed through a 175 amp breaker, which is also located inside the load center.

The generator produces 230 VAC at 60 Hz. The air conditioners are 230 VAC, 50 Hz. The AC compact fluorescents (CFs) are 120 VAC, 60 Hz. We are mixing and matching frequencies between several of our appliances except for the AC CFs, which are always powered by the 120 VAC, 60 Hz inverter. Our loads don't seem to care.

In Grenada, tools and appliances and the like are imported from both the U.S. and Europe, so you never know what you might find. Many houses have 230 to 120 VAC transformers to run their fridges, TVs, stereos, etc. Some of our tools, as well as some of the components we put into our chocolate machines, need 120 VAC.

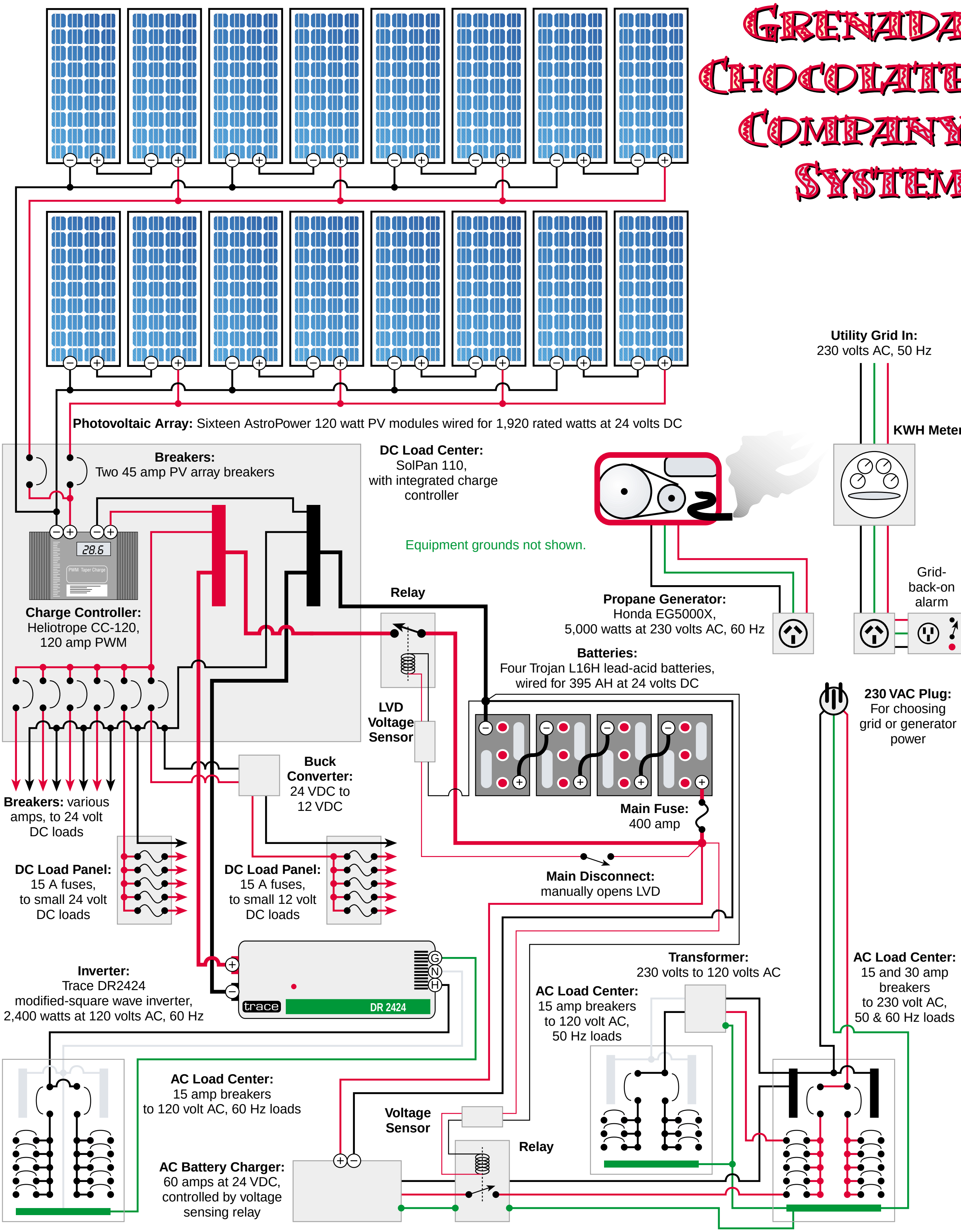
To cover all situations, we wired the factory with two types of 120 VAC. Some 120 VAC outlets are powered by the inverter, and others are powered by the grid or the generator through a step-down transformer (so we have 120 volts at 50 Hz from the grid or 60 Hz from the inverter).

Some of our lights in the factory are powered by the inverter. Other lights are DC. All the lights are compact

Chocolate Factory System Costs

Item	*Cost (US$)*
16 AstroPower 120 W modules	$8,640
Trace DR2424 modified square wave inverter	1,285
Honda EG5000X generator	1,200
Heliotrope load center w/ controller	1,175
4 Trojan L-16H batteries, 395 AH	840
Quick Charge battery charger	520
2 Solar Converters voltage-sensing switches	300
U.S. Carburetion propane fuel adaptor kit	275
KTA Services electric car contactor	145
Solar Converters buck converter, 24/12 V	140
Charger turn-on relay	32
Alarm activation relay	11
Total	$14,563

Grenada Chocolate Company System



fluorescents, of course. Our chocolate refiner (conche) machine, the battery charger, and the air conditioners run on 230 VAC directly off the grid or generator.

Four Voltages

With all the various requirements for our factory's equipment, we actually ended up having four different voltages and two frequencies of 120 VAC! The grid and our air conditioners are 230 VAC. Our inverter and our transformer provide us with 120 VAC modified square wave 60 Hz, and 120 VAC sine wave 50 Hz, respectively. We have various components, controls, and tools that use 120 VAC. Some of them prefer 60 Hz, while others would rather have a true sine wave at 50 Hz to operate properly.

Most of the machines and lights use 24 VDC, our system's nominal voltage. But one of the permanent magnet gear motors that we needed was only available in 12 VDC. That's why we installed the 12 VDC fuse block inside the load center. It is handy anyway because a lot of the DC tools and appliances we can find, such as fans, are 12 V.

Being situated on a little island in the sea causes us to end up with motors and other devices imported from all over the world with various voltages. By having all the common voltages, we can cover almost any situation as we continue to tinker and figure out the best way to expand our operation's output. It's a complicated system, and not something I'd recommend in most cases.

Future Solar Plans

Who said it's not practical to power air conditioners with PVs? The mini-split type we use is quite efficient. Our 9,000 BTU per hour unit only draws 970 watts, and cycles off quite often in our small insulated room.

My ballpark estimate is that each air conditioner is on about a quarter of the time on the average, or a total of twelve hours per day for the two units. This gives an approximate total of 11.6 kilowatt-hours per day. With a large 230 volt inverter and another 6 kilowatts of PV, we should be able to solar power the entire factory, including the air conditioners, most days of the year down here in the sunny Caribbean.

Solar Powered Chocolate Cooler

We needed a way to keep our chocolate at about 70°F (21°C) when selling at beach parties. Thermoelectric coolers, commonly used by truck drivers to keep drinks cool, are perfect for use with PVs because they cool mildly and use little power.

A phenomenon known as the Peltier effect causes one side of a thermoelectric module to get hot and the other cold when electric current is applied. When the module is coupled with a heat sink on one side and a heat conductive plate on the other, it acts like a heat pump, keeping the inside of the cooler cool.

We added thermoelectric cooling to a regular cooler (Coleman, US$55) by incorporating an aluminum plate (scrap yard, US$8), a Peltier cooling module (US$15), a block of aluminum (scrap yard, US$6), a heat sink (US$10), and a 12 V muffin fan (US$9) into one wall of the cooler. A square chunk of the cooler wall and insulation was cut out to accommodate the unit. The 2 by 2 inch (5 x 5 cm) Peltier module and the block of aluminum were placed where the insulation was, with the cold side of the module facing in against the aluminum plate, which was mounted on the inside of the cooler.

The hot side of the module faces out against the aluminum block. The other side of the aluminum block contacts the heat sink, mounted on the outside of the cooler, with the fan attached. Thermal conductive compound was applied to all meeting surfaces. A 55 watt Siemens PV module (US$330) is connected directly to the positive and negative terminals of the thermoelectric module and the fan in parallel, using #12 (3.3 mm^2) wire.

The nice thing about a PV powered thermoelectric unit is that the more current available to the module, the colder it will get. When it is sunniest and hottest, we get the most cooling power. The maximum cooling happens at 5.5 amps for this thermoelectric module. So we get less than half its full effect from the single 55 watt PV module, which seems to be enough if we are in the shade. If we need extra cooling power, we could just add another PV module.

Peltier effect cooler and PV panel.

Another difficulty is that we have to store sacks of cocoa beans for months during the off-season. They spoil quickly in this very hot, humid, tropical environment. There is certainly not enough space in our little air conditioned rooms to store cocoa beans. So we plan to get a small cargo ship container and convert it into an independently PV powered, air conditioned, cocoa bean storage unit.

We'll need approximately 2 kilowatts of PV (which will shade the roof of the container as well), another 230 volt inverter, a separate set of batteries, and another mini-split air conditioner. Large PV systems like this are expensive, of course, but if the loans to acquire them are attainable, we see them as buying our chocolate making energy long in advance.

Chocolate Power!

Finally, after years of tinkering, munching on chocolate, and sweating profusely, we have completed the factory and successfully tested all systems. Our little chocolate making cooperative can crank out about 300 pounds (136 kg) of chocolate and cocoa powder every week, enough for the local and tourist markets.

One month after our product launching, we are feeling very encouraged. The foreigners and tourists are impressed with our products, since they are used to dark chocolate. Grenadians themselves are just getting used to the idea. Only low quality milk chocolate has ever been imported, and we are the first chocolate company in Grenada. It's fun that people here can finally enjoy the luxury of high quality chocolate after supplying the fancy European chocolate companies with cocoa beans for over a century.

Grenada's cocoa is some of the strongest in the world. It is also particularly clean cocoa, very rarely sprayed with pesticides. Eventually we will export our chocolate, but for now, we will just be keeping up with the local market. We are probably the smallest chocolate factory in the world, and perhaps the only solar powered one.

Access

Moth Green, The Grenada Chocolate Company, Ltd., Hermitage, St. Patrick's, Grenada, West Indies
473-442-0050 • moth@grenadachocolate.com
www.grenadachocolate.com

AstroPower, Inc., Solar Park, 461 Wyoming Rd., Newark, DE 19716 • 866-218-2797 or 302-366-0400
Fax: 302-368-6474 • sales@astropower.com
www.astropower.com • PV modules

Trojan Battery Company, Inc., 12380 Clark St., Santa Fe Springs, CA 90670 • 800-423-6569 or 562-946-8381
Fax: 562-906-4033 • marketing@trojanbattery.com
www.trojan-battery.com • Batteries

Doug Browne and Wendy-Ann Edgar wrap finished solar powered chocolate, and try not to eat too much.

Xantrex Technology, Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-2229
inverters@traceengineering.com • www.xantrex.com
Inverter

Solar Converters, Inc., C1-199 Victoria Rd. S., Guelph, ON, Canada, N1E 6T9 • 519-824-5272
Fax: 519-823-0325 • info@solarconverters.com
www.solarconverters.com • Voltage controlled switches (model VCS-2) and buck converter, 24 to 12 volts (model EQ 12/24-20)

KTA Services, Inc., 944 West 21st St., Upland, CA 91784 • 909-949-7914 • Fax: 909-949-7916
www.kta-ev.com • Electric car contactor and main battery fuse.

Quick Charge Corp., 1032 S.W. 22nd St., Oklahoma City, OK 73109 • 800-658-2841 or 405-634-2120
Fax: 405-632-5667 • contact@quickcharge.com
www.quickcharge.com • Forklift battery charger

Honda Power Equipment Group, 4900 Marconi Dr., Alpharetta, GA 30005 • 800-426-7701 or 770-497-6400
Fax: 678-339-2670 • www.honda.com • Generator

U.S. Carburetion, Inc., HC79, Box 130, Building B-1, Canvas, WV 26662 • 800-553-5608 or 304-872-7098
Fax: 304-872-3359 • sales@uscarburetion.com
www.propane-generators.com • Propane fuel conversion spud kit

Leeson Electric Corporation, PO Box 241, Grafton, WI 53024 • 262-377-8810 • Fax: 262-377-9025
leeson@leeson.com • www.leeson.com • Motors

Scott Motor Company, 2401 S. Virginia St., Reno, NV 89502 • 888-550-0270 or 775-332-4000 Fax: 775-332-4005 • info@scottmotors.com www.scottmotors.com • Motors

W. W. Grainger, Inc., 100 Grainger Parkway, Lake Forest, IL 60045 • 847-535-1000 postoffice@grainger.com • www.grainger.com Dayton motors

McMaster-Carr Supply Company, Inc., PO Box 740100, Atlanta, GA 30374 • 404-346-7000 • Fax: 404-349-9091 atl.sales@mcmaster.com • www.mcmaster.com Various relays, pulleys, sprockets, and other assorted machine-building supplies

Lennox Air Conditioning, PO Box 799900, Dallas, TX 75379 • 800-9-LENNOX or 972-497-5000 Fax: 972-497-5331 • www.lennox.com • Mini-split ductless air conditioners

Backwoods Solar Electric Systems, 1395-HP Rolling Thunder Ridge, Sandpoint, ID 83864 • 208-263-4290 Fax: 888-263-4290 • info@backwoodssolar.com www.backwoodssolar.com • Siemens PV module for solar cooler, SolPan load center, and CFs

Marlin P. Jones & Assoc., Inc., PO Box 12685, Lake Park, FL 33403 • 800-652-6733 or 561-848-8236 Fax: 800-432-9937 • mpja@mpja.com • www.mpja.com Thermoelectric cooling module, muffin fan, heat sink

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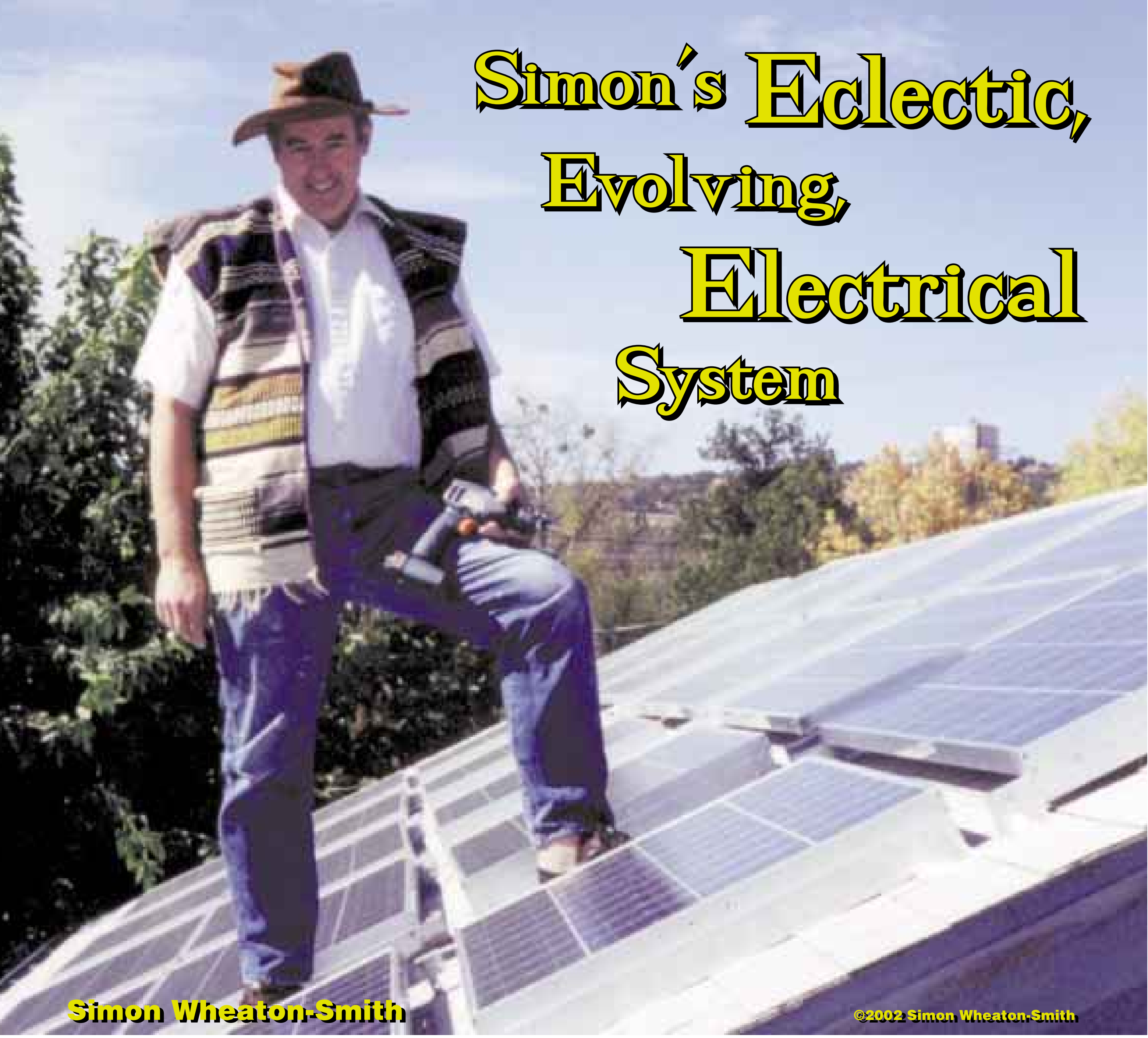


**Simon Wheaton-Smith checks the mounts on his system's PVs.
He started his system with gear he found at a local junk store: three Kyocera panels and a Trace inverter.**

I dabbled with solar hot water back in the early '70s, and it worked. I often thought about solar electricity, but decided it was too expensive. Then in early November 2000, the leaves were still green, and it snowed. Down came the branches, and next the utility lines. Amid the arcing of shorted grid wires, out went all the lights.

My 1880 house has adobe interior walls, so the heat was retained. I have hydronic heating using natural gas, but my wonderful gas boiler has a tiny little pump. It draws about 115 watts when running, but with no grid, there was no heat. Slowly the house started to cool as the hours ticked away. My three nonelectric gas heaters were fired up, and life continued. But I was determined that this was not going to happen again.

A UPS Is in Order

My solution was a UPS (uninterruptible power supply). I got the biggest and best, and the tiny little pump exhausted the UPS' small battery in a short time. "No problem," I said, thinking of *Home Improvement's* bumbling Tim the Toolman, "I will build my own."

So I got a cheap battery and a small Maxwatt 400 watt inverter, and looked for a charger. I educated myself on battery technology and charging methods. And, lo and behold, I found three Kyocera 80 watt panels in the local junk store, as well as a Trace Tiger TS512 inverter. I thought I was in business, but it was only the calm before the storm.

Modified Watt Wave?

My earlier system expanded to several Trojan T-105 batteries, a Trace C30A+ charge controller, and a Trace DR1512 inverter to power my chest freezer. The TS512 ran the security lights. Everything was running on modified square wave. I added a couple of Kyocera 120 watt panels, followed by two more.

It was at this point that I learned that my security motion detector would burn up when presented with a modified square wave from the Trace TS512 inverter. The chest freezer ran fine when the batteries were full. But as the source DC voltage got lower, the Trace DR1512 inverter wave was indigestible to my chest freezer, and it shut down. Compared to sine wave inverters, the AC output voltage of most modified square wave inverters is not as precisely regulated. So as the battery voltage drops, so does the voltage of the inverter's AC output.

Was Darwin Right?

Before you get the impression that I can't plan my way out of a paper bag, and know nothing about electricity, perhaps you need to learn a little about me. I got my first amateur radio license in 1962 (G3ROW), and later an American one (WB7ULT), and was a brass pounder (morse code operator) in the Royal Naval Reserves. While I was encouraged to complete my degree in special physics elsewhere than the college in which I was enrolled, I am not without forward-thinking skills. My masters is in computer science, and I have spent thousands of hours planning systems and the like.

I switched careers about twenty years ago and flew freight Merlins and Falcons, and finally B737s for one of the top ten airlines. After that, I became an inspector for a federal agency charged with air transportation certification and surveillance. I can't mention their three-letter name, since they think I am a bit of a maverick.

I have spent so many years planning things to the nth degree that I decided, "To hell with all that, let's build a solar-electric system." This is a system that proved Darwin was right—it evolved. And that took bucks—the dear kind of bucks, not the deer ones.

Conservation

I went through load measurements with a Watts up? meter, and that convinced me to switch to compact fluorescents. I also eliminated many phantom loads, such as the satellite TV receiver, VCR, several televisions, and so on.

I added external insulation to some adobe walls, triple glazed windows, and crawlspace insulation. Clothes drying is now done on a clothesline just like when I was a kid, and a crockpot works well for stews. I have a solar oven, but it doesn't do all I would like it to do. I might use its baked bread for building blocks or solid insulation, I suppose.

I have also installed a solar air heater for the offices in the garage, and will be converting to diversion loads to use excess collectable solar electricity. The diversion load will probably either heat batteries if needed, or supplement the gas water heater.

PVs & Inverters Galore

I now have sixteen Kyocera 120 watt panels, seven Kyocera 80 watt panels, and two Siemens 75 watt

The Weil-McLain furnace with its little pump.

Part of the system's power wall, including Trace C40 and C60 charge controllers, instrumentation, and overcurrent protection.

Eighteen Trojan T-105s make up this battery bank. The battery system is insulated, fused, and vented.

Three of the twelve Rolls batteries. The #4 (21 mm^2) wiring shown is from the C60 controllers.

panels. Total rated PV output is 2,630 watts. PV manufacturers rate module output using an operating temperature of 25°C (77°F). But PVs often operate at temperatures closer to 50°C (122°F). And PV output drops as module temperature increases. Realistic PV output is usually about 85 percent of the manufacturer's rated output on a yearly average, or 2,200 watts in my case.

The PVs are regulated by four charge controllers. A Trace C40 handles 320 watts, two C60s handle 720 watts each, and the last C60 handles 870 watts. The C40 and a C60 regulate the charge to eighteen Trojan T-105 batteries, 2,025 amp-hours at 12 volts. These subarrays total 1,040 rated watts, and the remaining subarrays total 1,590 rated watts and charge twelve Rolls 4KS21PS batteries.

The T-105 system runs a PROsine 1,000 watt inverter for the chest freezer, which is happy now that it has a sine wave. The Trace DR1512 inverter runs the well and pressure pump, and shop tools. They are OK with the modified square wave.

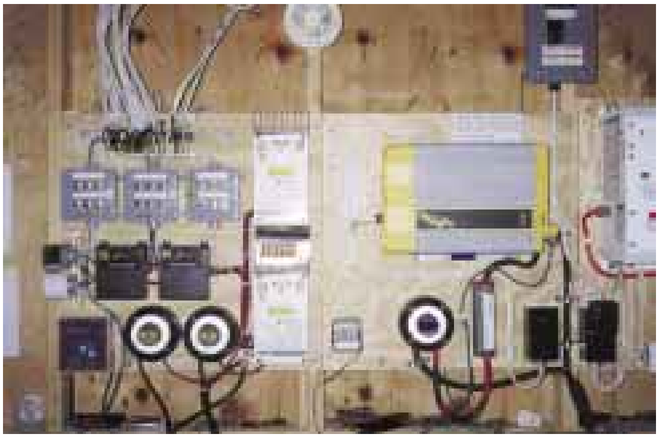
The 4 volt Rolls batteries are wired three in series for 12 volts, and four sets in parallel for 4,400 amp-hours.They run an Exeltech XP600/12 true sine wave inverter, which powers the boiler pump, security lights, and some frequently used house lights. A PROsine 1800 sine wave inverter is backup, and a Trace PS2512 inverter runs the fridge, microwave, toaster, and the rest of the house lights. The batteries all have Hydrocaps to recombine gasses, and there is an exhaust fan powered by the Trace PS2512 inverter auxiliary relay.

One of the 720 watt C60 charge controllers can be switched between the Rolls and the Trojans. The inverters have excess capacity so they can back each other up.

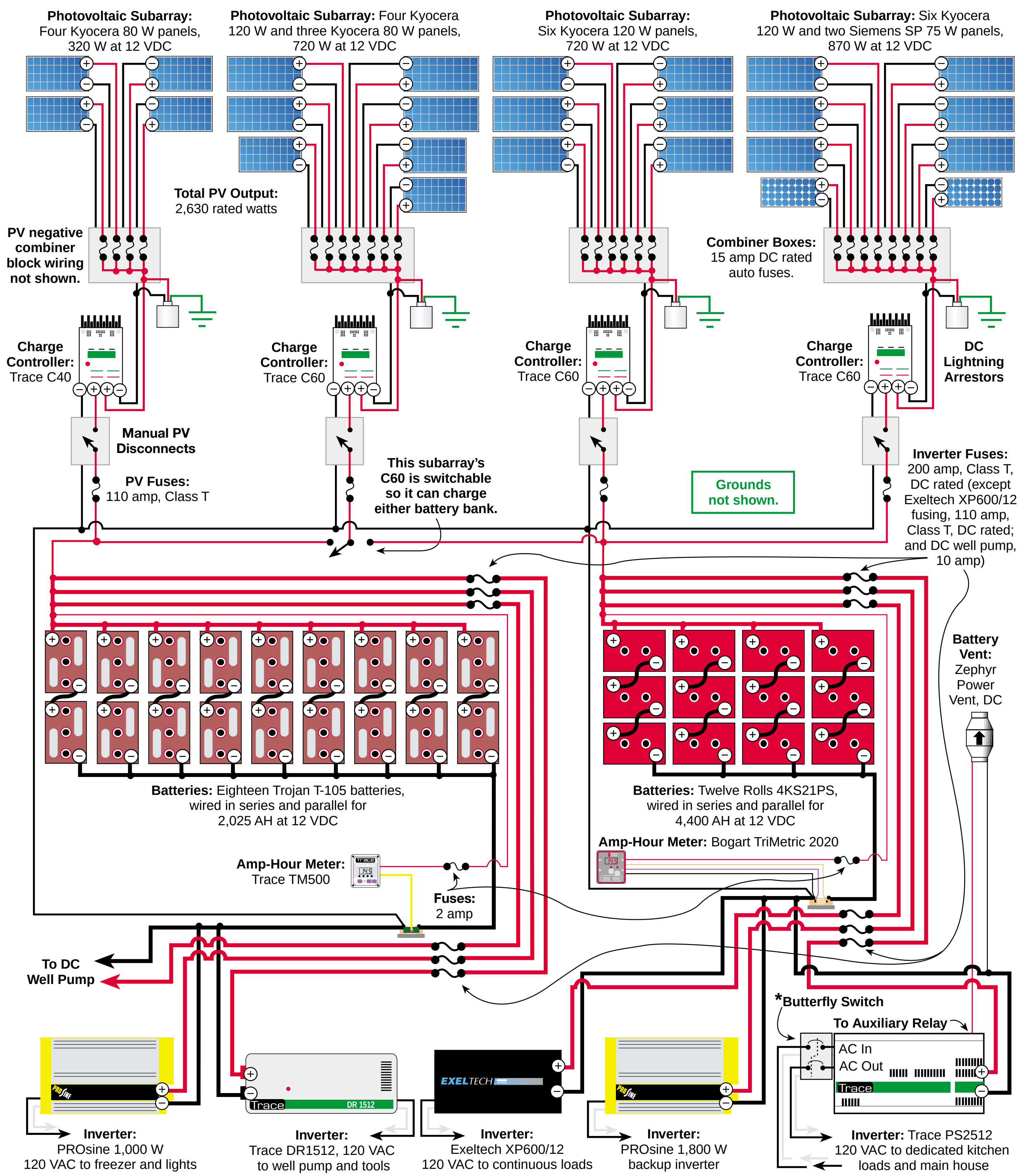
In short, this is a system with significant reserve capacity and redundancy. It's also designed to be easily reconfigurable. I would love to say I designed it from scratch that way. I didn't—it just grew and grew. And it still is growing.

The Trojan system's inverters: XP600/12, PROsine 1,000 watt, and DR1512.

The Roll's C60 system with PROsine 1,800 watt and Trace PS2512 (off to right) inverters.



Simon's Evolving PV System



*AC input from the utility grid allows the Trace PS2512 to charge the Rolls battery bank. The butterfly switch assures that the grid is only used for battery charging. This system isn't utility-intertied.

My Friend Has a Bass Fishing Boat
And US$30,000 later, it is a system fully charged by solar noon, running 75 to 90 percent of my electric usage. My last grid bill was US$9.37.

What does this have to do with bass fishing? One of my colleagues asked me how I could justify this system with its switches, gadgets, meters, flashing lights, and redundancy? I knew he had just bought a bass fishing boat. So I asked him what it cost.

"$21,000," he said.

"And how many bass have you eaten?"

"Seven fish," he said.

"So," I said, "you are running $3,000 per fish."

To be honest, my solar-electric system is more of a hobby that runs the house, and not a cost-effective operation. However, my early unused purchases were sold as surplus to others also doing their solar thing, so my learning curve wasn't too costly.

Net Metering
While my state allows net metering, our utility company chooses to require separate meters for buying and selling, and that creates problems. They like to charge for their transmission lines, and they pay almost nothing for electricity produced by intertied systems. So while I am equipped to sell back, I am choosing instead to use all of my surplus that I can. Being fully charged by solar noon, and with very few cloudy days, I have excess to use. I am working on it.

My batteries can go five days with no sun, and three is the normal worst case here. Even when slightly overcast, I still get about 20 percent of the rated output from the PV panels.

The Trace PS2512 inverter, the AC-in breakers and isolation box. A PV amp-hour log is kept on the clipboard.

Wheaton-Smith Systems Costs

Items	*Cost (US$)*
16 Kyocera KC120-1 120 W modules	$8,720
12 Rolls 4KS21PS batteries, 4,400 AH at 12 V	6,600
7 Kyocera KC80 80 W modules	2,723
Trace PS2512 inverter & SWRC	1,825
PROsine 1800 inverter	1,015
18 Trojan T-105 batteries, 2,025 AH at 12 V	1,008
Miscellaneous wire & hardware	1,000
Trace DR1512 inverter	800
2 Siemens SP75 75 W modules	700
78 Hydrocaps	624
PROsine 1000 inverter	600
Exeltech XP600/12 inverter	570
3 Trace C60 charge controllers	555
4 Trace C-series digital displays	316
Trace TM500 meter	200
Bogart TriMetric 2020 meter	190
Trace C40 charge controller	149
Total (plus shipping & handling)	$27,595

My Safety Systems
I have fire extinguishers for electrical fires at all doors to the garage, which is where this Frankenstein laboratory is. Other safety equipment includes baking soda, bottles of distilled water, eye goggles, first aid kits, and a smoke alarm.

A 12 volt, low wattage fan sucks air through a 1-1/2 inch (38 mm) duct from the two battery banks, which are in separate boxes insulated with two layers of R-19 fiberglass insulation. All connections are coated with a battery corrosion preventative spray. In addition, each cell has a Hydrocap.

Each positive inverter cable has a Class T fuse located in the battery box for overcurrent protection. Then #2/0 (67 mm^2) and #4 (21 mm^2) wire exits to cable quick-disconnects, bolted disconnect switches, and other fuse systems. There is a common ground bus bar, and all equipment grounds are terminated at that bus. The bus is in turn connected to buried ground rods. The battery negatives are also common; only the positives of each battery bank are isolated.

Lightning arrestors are installed in the PV output circuits before they go to their charge controllers, and each panel is individually fused. All AC systems, of which there are four, have lightning protection as well.

Measurements & Code
One of the measurements I'm really interested in is how many DC watt-hours the PVs are producing. So I

From three panels to twenty-five—the system keeps growing, and growing, and growing! The sixteen KY120, seven KY80 and two SP75 PV panels.

decided to purchase Trace's digital AH displays for each charge controller. At 8 AM every Sunday, I log the amp-hours each of the four subarrays has produced. Multiplying the total AH figure by 12.5 volts gives me the estimated collected watt-hours for the past week.

I also have a Trace TM500 amp-hour meter for monitoring the Trojan battery bank, and a Bogart TriMetric 2020 amp-hour meter for monitoring the Rolls bank. These meters compare incoming amp-hours from the PVs to amp-hours being consumed by the loads. Amp-hour meters are the most accurate and convenient way to keep track of the state of charge (SOC) of each battery bank.

Well, this is purely an experimental, evolving system. Having said that, some things are not code compliant. The positives coming in from the panels are not in conduit. And they are white wire with red tape, and black is negative. Having held two country's amateur radio licenses for forty years, I am used to that wiring convention.

For the most part, this system is code compliant, if not pretty. While it runs itself, if I ever sell the house, there will be a lot of training.

System Details

Beginning at the far east end of the garage is my 320 watt system of four Kyocera 80 watt panels. The panels are fused individually. PV output is routed through DC rated automotive fuses and then paralleled up at a combiner block. A lightning arrestor is also installed at the combiner block. From there the combined juice goes to a C40, and then to a switch and to the Trojan batteries.

The next subarray is 720 watts—three Kyocera 80 watt panels and four Kyocera 120 watt panels, controlled by a Trace C60. These two PV systems go to a bank of eighteen Trojan T-105 batteries with Hydrocaps. Covering the batteries are sheets of Plexiglas, so that if I drop a wrench on them, there is no nuclear meltdown.

This battery bank powers the Trace DR1512 modified square wave inverter and the PROsine 1,000 watt true sine wave inverter. Each inverter powers a separate breaker box.

The next system, continuing west along the garage is the Rolls 4KS21PS battery bank, its PV array, and its inverters. These batteries use two C60 controllers, and two subarrays. One is for six Kyocera 120 watt panels, the other has six of the same panels as well as two Siemens SP75 panels. These collect a rated 720 watts and 870 watts, respectively. The ratios of PV output and the battery amp-hour capacities of the systems match the daily inverter usage.

Inconspicuous PVs

And where are the panels? They are on the garage roof at a roof pitch of 20 degrees. This is not efficient, but I wanted the system to be pleasing to the eye. The panels were not a significant roof load. But where the bolts didn't meet solid wood beams, I attached braces to reduce wind lifting problems.

Just in case of another sort of "lifting" problem, I added an alarm system to protect the solar panels from sprouting wings. I have a continuous loop of stranded insulated wire going through at least one unused mounting hole in each panel. That closed loop goes to the normally-closed input of an old Radio Shack alarm controller, powered by the Rolls batteries.

I used the roof angle of 20 degrees for the PV arrays. Afterwards, a friend asked me if I would have sun in the winter, given the fact that the house is south of my garage roof, which has the PV arrays, and the fact that there are three large trees. My heart sank—actually stopped would be a better description.

With my solar powered computer, I went to http://mach.usno.navy.mil, which gave me azimuth and

Wheaton-Smith Critical Loads

Item	*Phantom Watts*	*Normal Watts*	*Peak Watts*	*KWH per Day*
Sears fridge		140	450	1.78
Chest freezer		130	130	1.12
Furnace pump	7	115	115	0.59
CF lights		25	25	0.25
Well pump		910	1,050	0.14
Security light	5	5	150	0.10
Microwave	10	1,200	1,200	0.10
Toaster		1,000	1,000	0.10
Pressure pump		360	310	*
			Total	4.17
			Total Weekly	29.19

*Pump only runs one minute per week.

zenith settings for any day of the year at any city. Wisely selecting my own city, I got the azimuth and zenith figures, and made a cardboard model. With a compass adjusted for magnetic variation, I found that I had a clear solar path in the winter. My heart resumed normal function.

In doing this project, I have had *no* assistance from engineers or electricians. This has been designed, built, fixed, rebuilt, modified, and installed, tested, repaired, and monitored by me.

Runs Itself

What is the system like to live with? It runs itself. I can leave it alone and it does just fine. But I like to sit and watch the flashing lights and hear the inverters hum, like the buzzing bees of summer. Nothing has failed yet, but if it does, it is very easy to reconfigure while failed items are repaired.

The AC systems use their own wiring in the house, and each is color coded. The yellow system is the Exeltech XP600/12 inverter—only plugs with yellow tape can go there. The PROsine 1000 system has red wall sockets, and only plugs with red tape can go there. Similarly with the Trace PS2512 or PROsine 1800, which run the blue system. The Trace DR1512 is the white system, similarly marked. Some plugs have several color bands, meaning they can go to different inverters.

The color coding for plugs is based on whether they need continuous power (from the XP600/12 inverter), the type of wave they can accept, and the net aggregate load for that inverter.

Critical Loads

Home Power likes to have a table of loads for system articles. That's fine if you actually planned anything. I didn't. So I grabbed my Watts up? meter and confirmed the loads after the fact. The figures from this meter were about what my TM500 and TriMetric 2020 meters implied.

The daily KWH column adds up to 4.17 KWH a day, although I actually run below that. My most recent weekly statistics showed I used a total of 27.0 KWH (11.7 + 15.3), and the deduced depth of discharge matches my daily low voltage at rest readings. While it may appear that I use more KWH from the batteries than I put in, that is because I use 12.5 volts to derive KWH. In reality, the collection voltage is above 12.5, and the nightly load voltages are less.

The 11.7 figure above is the KWH usage from the Trojan T-105 battery system, and the 15.3 figure is the KWH usage from the Rolls battery system. The Trojans are being charged by the 320 watt array, controlled by the C40, and the 720 watt array, controlled by the C60. The Rolls batteries are charged by the 720 and 870 watt arrays via the remaining two C60s.

The daily load usages were measured over several weeks to get good daily averages. The 1,000 watt well pump when running has such a high surge load that the sun seems to grow dimmer as my well pump starts up!

The microwave from Wal-Mart said it was 650 watts, which was why I bought it. But it draws about 1,200 watts. The microwave doesn't trigger the inverter, so it is on a distribution switch with a lamp that will load the inverter out of search into running mode.

My grid usage runs around 12.8 KWH a week, and is reflected in my monthly electricity company bill. I will be running the entire house off the system when I get my transfer switch installed at the main panel, and will only use the grid for the electric oven and the clothes dryer if needed.

The author's first try at the house's east wing monitoring and distribution panel—before he added conduit.

Utility Costs & Usage

Date	*Cost (US$)*	*KWH Used*
02/27/01	116.31	974
03/01/01	97.27	785
04/28/01	64.95	515
05/28/01	47.58	376
06/04/01	39.83	311
07/04/01	32.08	246
08/12/01	19.90	135
09/07/01	12.41	71
10/01/01	11.40	63

**The AC well pump moves water to this tank.
A sump pump pressurizes the irrigation water for distribution.**

I eliminated phantom loads, use high-efficiency appliances and lights and a clothes drying line, and got lucky buying a Sears fridge that is fairly energy efficient. My annual grid usage has dropped significantly. March and April saw the chest freezer go off the grid, May and June the fridge, with the microwave and toaster following in July. I was running one resistive heater that I replaced with gas, and the insulation and multiple glazing reduced those loads.

Good Things, Bad Things
There are always things that could have been better. Cheaper combiner boxes that meet code would be nice, because mine are auto fuse systems. I wish the PROsine and Trace inverters had DC insulating caps for their inverters that would go around most common DC lugs.

I would like it if Statpower and Trace would respond to e-mail in the same century that I e-mailed them. Having said that, while Statpower has not been helpful over the phone, Trace has been excellent, which is strange since they are both owned by Xantrex.

Sunelco was excellent in handling door-to-door Rolls battery deliveries. No one else would do door-to-door with a truck with a lift-gate. I used a 4,000 pound (1,800 kg) capacity engine hoist costing US$190 to move the batteries, and that same hoist lifted the Trace PS2512 to a table. I have a ceiling winch to lift the PS2512 and its wall mount panel up to the wall for fastening.

All this equipment works very well. The Exeltech XP600/12 had a problem with the remote on/off switch, and Exeltech was excellent both via e-mail and phone. I bought the Exeltech XP600/12 from RMS Electric in Boulder, Colorado, and they were very helpful. The Rolls battery people were also helpful over the phone and by e-mail on battery specs, settings, and other refinement issues.

Before getting the Trace PS2512 from Earth Solar, I got a PROsine 3000 inverter. It wouldn't run right out of the box; it kept going to "power down." When I found a sequence of keys to hit within five seconds to stop that, it ran fine for twelve hours when for no reason it again went to "power down." In this state, nothing will wake it up except resetting the inverter. No faults were shown and temperatures were normal.

My e-mails to Statpower, which makes the PROsine 3000, were never answered. One phone call was of no help, the rest were never returned. I later found that the PROsine 3000 burns 60 watts of overhead, the Trace PS2512 only draws 20. This is something the marketing specs didn't highlight. Earth Solar was very helpful here.

Cake with Icing
I love seeing the lights flash, hearing the inverters hum, and eating solar powered, microwaved beef stew on toast from a solar powered toaster, washed down by cold lemonade chilled by a solar powered fridge, relaxing under solar powered patio lights, while enjoying reading my most recent utility bill of US$9.37. Knowing that it all works, is safe, and doing its bit to keep the air clean, that's the icing on the cake!

Access
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www.sunelco.com • Rolls batteries, Xantrex products, Kyocera modules, disconnect switches, battery cables.

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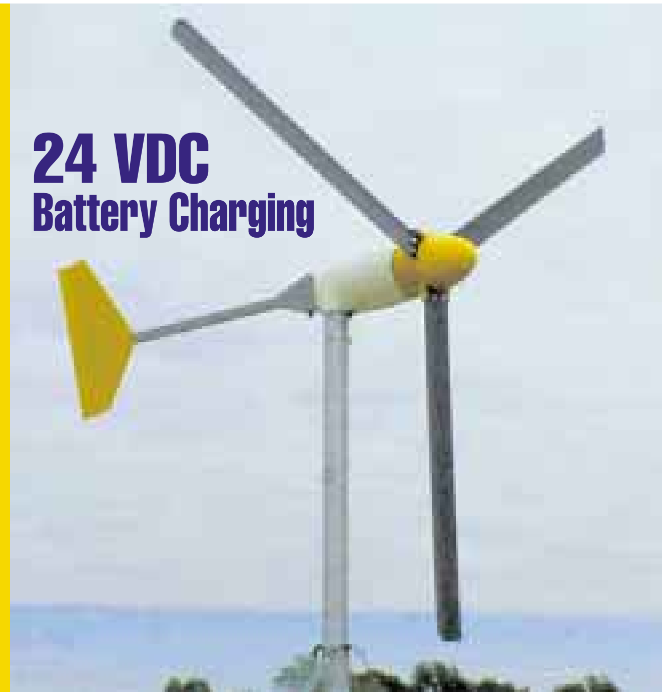

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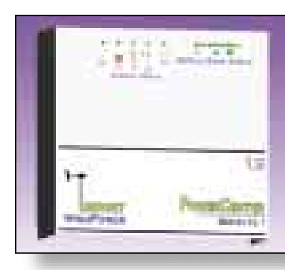

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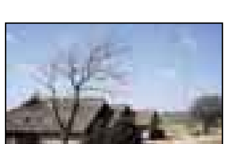

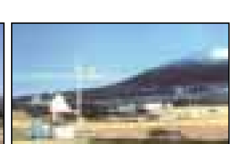

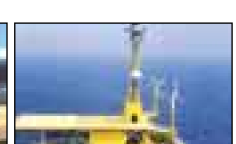

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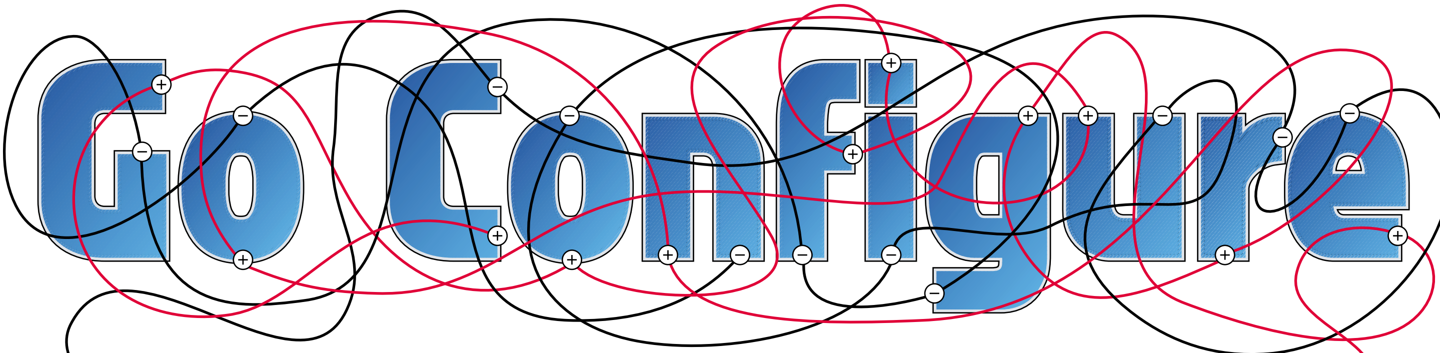


Configuring Your PV Array

Joe Schwartz

One of the most user friendly aspects of photovoltaic (PV) technology is that it's a modular energy source. Individual PV modules can be wired together in different configurations to meet the voltage, current, and power requirements of a specific system.

The big benefit of this modularity is that an increase in energy demand can easily be met with an increase in solar production. This represents a 180 degree shift, both technically and conceptually, from the large, centralized energy sources that provide electricity to most folks' homes and workplaces.

To understand different PV configurations, or how individual PVs can be wired together, you need to have a few principles of basic electricity under your belt. Getting a handle on these concepts is an indispensable step toward designing and installing your own PV system.

Making Sense of Series & Parallel

Many electric components can be wired together in two basic configurations—series and parallel. The PVs and batteries used in renewable energy (RE) systems are typically wired together using a combination of series and parallel connections between the individual components.

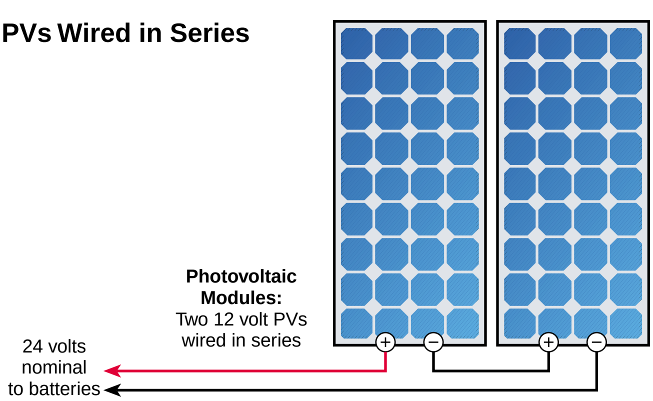
The circuitry in your home appliances also relies on networks of series/parallel connections. And series/parallel configurations are not limited to electricity. For example, the collectors and tanks used in solar thermal (hot water) systems can be plumbed in series or parallel configurations, depending on the application.

Let's take a look at a couple of simple electrical circuits to illustrate the difference between series and parallel configurations. A series configuration places all the components in a single electrical path. So the electrons flowing through a series circuit must pass through each individual component.

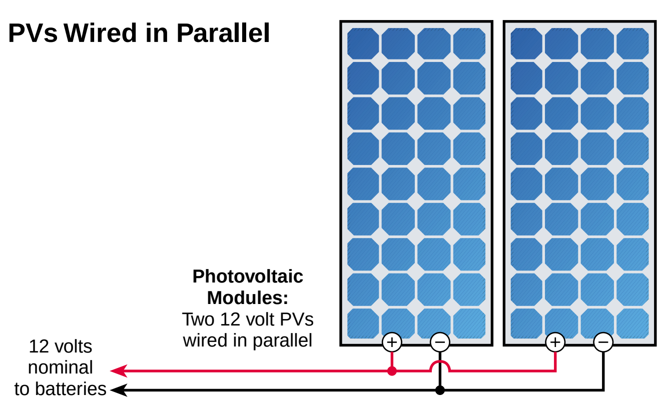
Series electrical connections are made by connecting the positive terminal of one component to the negative terminal of another. If we connect the positive terminal of one PV to the negative terminal of another, the output of one module is electrically tied to the output of the other. Like links in a chain, the modules are working in series to charge the battery. See the diagram below, on the left.

A parallel configuration creates multiple paths for the electrons to flow through. Once again, let's use a couple of PVs as an example. A parallel connection between two PV modules can be made by running the positive and negative output wires from each PV to combiner

PVs Wired in Series



PVs Wired in Parallel



blocks. Here the positive output wires are paralleled or connected together. The negative output wires are also wired in parallel using a combiner block that's electrically isolated from the positive parallel block. See the right-hand diagram on page 36.

The positive and negative output wires from each PV run to the combiner block independently. In this case, the PV panels are working side-by-side, or in parallel, to charge the battery.

If these are new concepts to you, Ian Woofenden wrote some great descriptions of series and parallel circuits in his *Word Power* columns in *HP83* and *HP84.* Check them out.

A Simple Equation

Now that we have a basic, conceptual idea of series and parallel configurations, let's run through a simple equation that allows us to mathematically compare the results of series and parallel electrical configurations. The main thing you want to remember is that in an electrical circuit, a series connection increases voltage and a parallel connection increases current (electron flow rate). If you're a visual learner, hang in there—the illustrations are coming right up!

The power formula defines the relationship between power (watts), voltage, and current (amps). The formula goes like this:

P = V x A, or

V = P ÷ A, or

A = P ÷ V

Where P is power; V is volts; and A is amps.

In residential electric systems, power is usually measured in watts (W) or kilowatts (KW). A KW equals 1,000 watts. Amps are sometimes abbreviated using an I rather than an A. And voltage is sometimes abbreviated with an E rather than a V. So if you see these abbreviations somewhere, don't let them throw you for a loop!

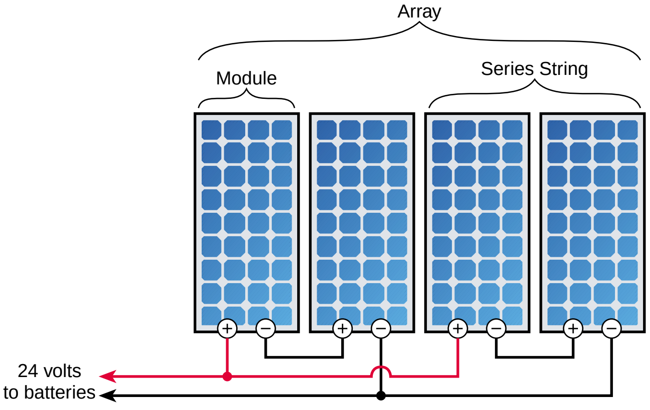
Again, the main thing you want to remember is that a series connection increases voltage and a parallel connection increases current. If we plug some numbers into the power formula, the relationship between voltage and current becomes pretty clear. If you double the voltage of the system, the current is cut in half, but power remains the same.

12 volts x 10 amps = 120 watts

24 volts x 5 amps = 120 watts

The power formula demonstrates that with a constant power supply (watts), voltage and current have an inversely proportional relationship—if voltage increases, current decreases, and vice versa. The fact that you can make series and parallel connections allows you to specify the voltage and current of your PV system. It gives you some control over the power formula.

Elements of a PV Array



Many Pieces, One System

When you're wiring up your PVs, a single PV module represents the building block of the total power source. Once a nominal system voltage is decided on, the PVs can then be wired together to meet your system design parameters.

PVs wired in series with one another are referred to as a series string. The output of each series string is run to a combiner box. In the combiner box, the series strings are paralleled together, and make up what's called a PV array. An array is the largest unit in PV configurations. Large PV arrays can also have a number of subarrays that make up the total array.

PVs for Free!

To better understand common PV configurations, let's imagine that the U.S. government, in a display of true leadership, provided every American man, woman, and child with four PV modules to help foster America's energy independence. When your PVs arrive, you unbox one of them and check out the label on the back of the module. Not only was the government forward thinking on this groundbreaking occasion, but they were also generous. The panels they provided are rated for a 100 watt output, a nominal operating voltage of 12 volts direct current (VDC), and a rated current of 5 amps.

Since you're hip to the power formula, you're probably thinking, "Wait, 5 amps multiplied by 12 volts doesn't equal 100 watts!" Actually, a 12 VDC nominal PV rarely if ever operates at 12 VDC. With few exceptions, it will always be operating at a voltage a little higher than the battery voltage, which in this case ranges from about 12 to 15 VDC. This higher operating voltage enables the PV to fully charge a 12 VDC lead-acid battery bank to 14.2 to 14.8 VDC, depending on battery type.

Combiner Box

The output of individual series strings of PV modules should be run to a combiner box. Using a combiner box results in a code compliant and organized PV wiring network that is easy to troubleshoot and maintain should problems ever arise.

Inside the combiner box, positive and negative bus bars or combiner blocks are used to parallel the output of the individual series strings. Each PV output wire is connected to a dedicated terminal on the bus bars or combiner blocks. This allows for testing of individual series strings. It also allows for the use of overcurrent protection for each series string of PVs.

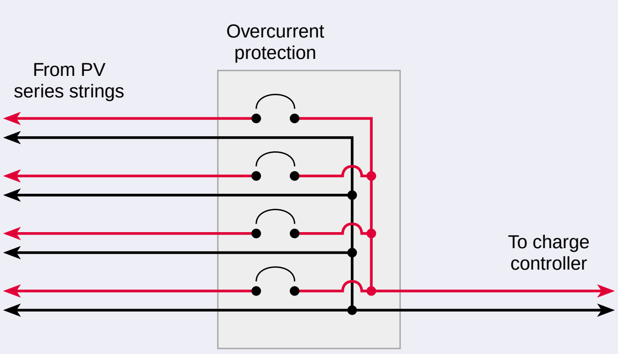
The *National Electrical Code (NEC)* requires a breaker or fuse in the positive lead of each series string of PV modules for overcurrent protection. These DC-rated breakers and fuses are typically rated at 5 to 20 amps depending on the type of modules you're using. PV manufacturers provide a specific series fuse amperage rating for each of their PV models. The fuse information is typically printed on the label on the back of the module.

Series fusing prevents the possibility of individual series strings of PVs backfeeding another paralleled series string that develops an electrical short circuit. This short circuit could theoretically develop between the string's positive and negative leads, or as a direct short within an individual module.

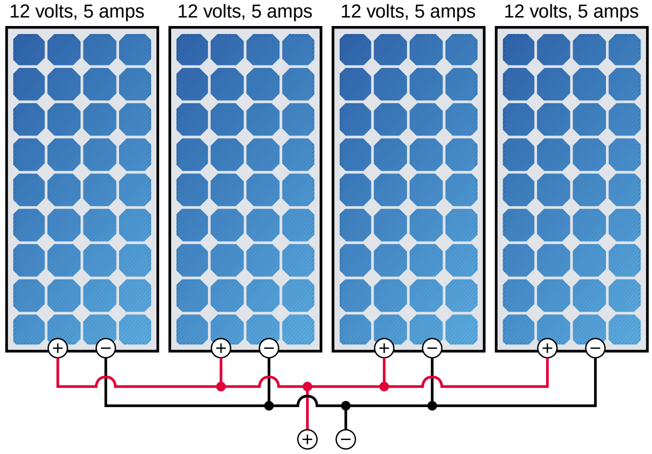
For years, most PVs were wired without the benefit of series fusing. And the instance of an entire array feeding a shorted series string is rare. However, the *NEC* now requires series fusing in all systems with more than one series string of modules.

Outback Power Systems and Xantrex both manufacture PV combiner boxes. You can also assemble one on your own. For a great tutorial on building your own combiner box, check out Dennis Scanlin's article in *HP78.*

Combiner Box Wiring



Four PV Modules Wired for 12 Volts



PV modules are factory rated at 25°C (77°F). But normal PV operating temperatures are often twice that, and PV voltage drops off as the operating temperature increases. The higher operating voltage allows some headroom for the voltage drop associated with realistic module operating temperatures.

In the real world, even in a well designed system, a 100 watt PV typically produces about 75 to 90 watts depending on module temperature, battery voltage, wiring losses, and whether a maximum power point tracking (MPPT) charge controller is being used.

So the actual operating current and voltage specifications of a 12 VDC nominal, 100 watt PV would be more like 5.6 amps at 17.7 VDC. But for the following examples, let's keep the mind boggling to a minimum by simplifying the numbers to 5 amps at 12 VDC.

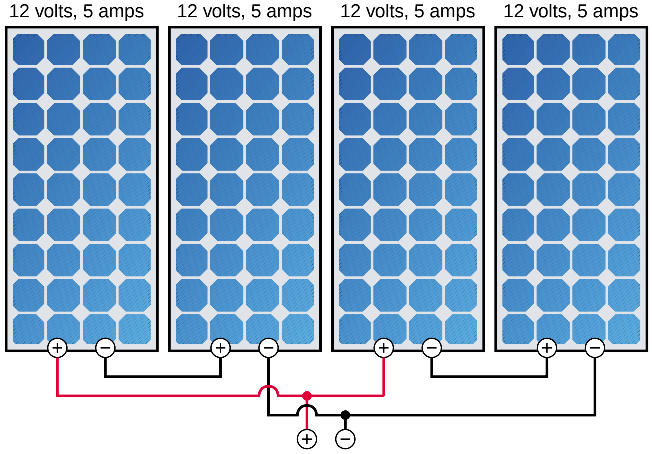
To better illustrate the electron flow, the parallel connections in the following diagrams are shown in the junction or wiring terminal boxes. In the field, parallel PV connections should be made in a combiner box and protected from overcurrent with a series fuse or breaker. The sidebar at left provides an overview of combiner boxes.

Wire 'Em Up!

It's a sunny day outside, and you're feeling patriotic. You want to get your free PVs wired up and making electricity. Armed with a pencil and paper, you use the power formula to compare the output of your four PV modules in different configurations. Before you set to work wiring them up, you want to run the numbers for three different voltages: 12, 24, and 48 VDC nominal.

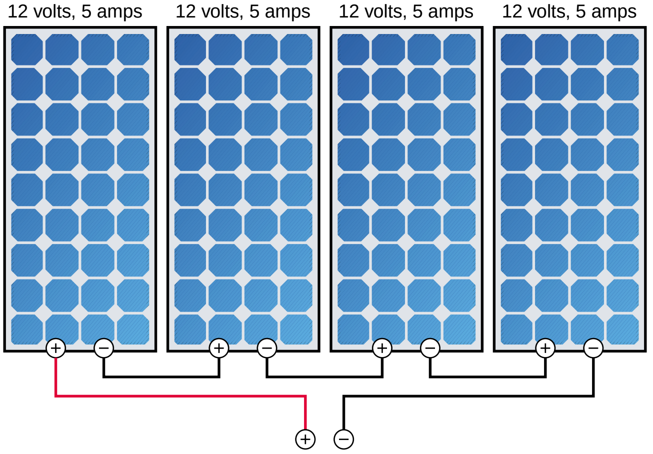
For starters, you decide to keep it simple and wire all four of your PVs together for a 12 VDC output. You know that each of your PVs operates at 12 VDC nominal, and that you need to wire the PVs in parallel to increase the

Four PV Modules Wired for 24 Volts



24 volts X 10 amps = 240 watts

Four PV Modules Wired for 48 Volts



48 volts X 5 amps = 240 watts

current but keep the voltage at 12 VDC. You sharpen your pencil and bust out some easy math to see how many amps you'll be moving at 12 VDC and how many watts the array will produce.

In a parallel configuration, four 12 VDC PVs, multiplied by 5 amps each, equals 20 amps at 12 VDC. Using the power formula, this 20 amps multiplied by 12 VDC equals 240 watts total.

You're thinking, "Hey this is pretty fun!" and decide to wire your PVs up for 24 VDC nominal. You scratch your head a bit because this is more complicated. Two 12 VDC panels wired together in series (positive to

Choosing System Voltage

People often ask, "What system voltage should I choose?" The answer depends on two main factors—how large the system will be and how far the generating sources (PVs, wind generator, hydro turbine) will be from the battery bank. Most off-grid systems run at 12, 24, or 48 VDC nominal.

On the grid, most batteryless, utility intertied inverters have a 48 VDC or higher DC input voltage requirement. So for a grid tie, the system voltage will be dictated by the inverter you choose.

Current is a measure of the rate of electron flow through a circuit or wire. Copper (CU) wire is the standard wire type used in electrical systems. And even though copper is a great conductor, it still presents some resistance to the electrons flowing through the circuit.

Resistance results in the loss of power in a system. And the greater the rate of electron flow (amperage) through a wire, and the smaller the wire gauge, the greater the power loss in the wire. The length of the wire has a big effect on power loss as well. So the main variables affecting power loss in a transmission line are voltage, current, the resistance of the wire itself (which is determined by the type and diameter of the wire), and the overall length of the wire.

Since we have several variables at work, the appropriate transmission wire size needs to be specified for each individual system. In PV systems, the rule of thumb is to keep the transmission line loss under 2 percent. You can get a wire sizing spreadsheet from the "Promised" section of the downloads page of *Home Power's* Web site at: www.homepower.com. It will help you with your wire size calculations.

The power formula shows us that if you double the voltage of the system, the current is cut in half, but power remains the same. As a result, the majority of residential scale PV systems today are being wired at 48 VDC nominal.

In a smaller system, 12 or 24 VDC nominal operating voltages still often make sense, especially if you plan to run DC appliances. For folks on a budget, another advantage of low voltage PV systems is that modules can be added in smaller increments.

Imagine a PV system with eight, 100 watt panels located 50 feet (15 m) from the batteries. The PVs have a rated output of 5.6 amps at 17.7 VDC. If the PVs were wired at 12 VDC nominal, #4/0 (107 mm^2) CU wire would be required between the PVs and batteries to keep voltage drop under 2 percent. If the panels were wired at 24 VDC nominal, #3 (27 mm^2) CU wire would satisfy the two percent voltage drop requirement. At 48 VDC nominal, #8 (8 mm^2) CU wire would do the trick.

To put things in perspective, at 12 VDC you'd need wire the diameter of your thumb. At 48 VDC you'd need wire the diameter of a pencil!

negative) will give you 24 VDC, which is the voltage you're after. Since a series connection increases voltage, not current, wiring two of your 5 amp, 12 VDC PVs in series equals 5 amps at 24 VDC. You multiply 5 amps by 24 VDC and come up with 120 watts, which makes sense because you've wired together only two of your PVs.

You take the other two PVs and wire them in series as well. Now you have two series pairs running at 24 VDC each. If you series these two pairs together, you'll end up with 48 VDC, which isn't the voltage you're after. So to keep the voltage at 24 VDC, you wire the two series pairs together in parallel for a series/parallel configuration. This doubles the current, but keeps the voltage right where you want it, at 24 VDC.

The two, 5 amp at 24 VDC series pairs wired together in parallel give you 10 amps at 24 VDC. You do the math and are pleased to find out that 10 amps multiplied by 24 VDC equals 240 watts total.

After wiring your PVs up at 24 VDC, you're thinking that a 48 VDC configuration will be a snap. You know that series connections increase voltage, and that's what you want to do. You run some numbers...12 VDC multiplied by four modules equals 48 VDC. And 48 VDC multiplied by 5 amps equals 240 watts. So all you need to do is connect the four PVs in series (positive to negative), and you're set.

Power Is Power

You've spent a fun afternoon in the sun bonding with your PVs. And you've decided that wiring up your four PVs in different configurations is no problem. The main features are that series connections increase voltage, and parallel connections increase current. As long as the PVs are wired correctly, the combined power (wattage) is always the same, no matter what configuration you choose.

As you start to pick up your tools, the dog barks and the UPS truck rolls in. The driver hops down from his rig and happily informs you that the feds have decided to increase the free PV program to eight modules per citizen! He seems even more exited than you are. As you help the driver unload the truck, you confidently ask him, "Hey, how many amps will you get if you wire up your eight, 5 amp, 12 VDC modules in series/parallel for 24 VDC nominal?" (Answer below.)

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www.outbackpower.com

Xantrex Technology, Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-2229
inverters@traceengineering.com • www.xantrex.com

Answer: 20 amps at 24 VDC for 480 watts total output.

PAYBACK On RE?

How Wrenches Respond

Allan Sindelar

Professional designers of solar-electric and solar thermal systems are routinely asked about the payback for solar energy. "How many years before the solar water heater you are selling pays for itself?" has been heard since the first solar boom in the 1970s. Now, "How long will it take this PV system to pay back my purchase price?" has been added to the questions that system designers are expected to answer.

Joel Davidson,
SOLutions in Solar Electricity

William Miller,
SLO Communications

Phil Undercuffler,
Positive Energy

John Veix,
Solar Electric Specialists

Todd Cory,
Bald Mountain Solar

Steve Willey,
Backwoods Solar Electric Systems

Payback can mean many different things. In *HP80,* Karl Knapp and Teresa Jester analyzed the "energy payback" of PV modules. Energy payback time is the amount of time a PV module spends converting light to electricity just to make up for energy used to manufacture the module. Knapp and Jester concluded that PVs recoup their production energy in two to four years, and go on to produce clean energy for thirty years or more.

Another angle is "economic payback." This is the projected amount of time until the total energy savings achieved by using a renewable energy system equals the cost of the system. This payback question is often posed by a prospective renewable energy user who is trying to justify by conventional terms an investment having benefits that can't be measured in conventional terms.

A Wrenches Discussion

More than one hundred and fifty "wrenches" (experienced installers of home-scale renewable energy equipment) participate in an e-mail discussion forum. The forum, hosted by *Home Power,* is used for community building, problem solving, and ongoing discussions of installation techniques, *National Electric Code* issues, and business issues specific to the renewable energy (RE) industry. Participation is strictly limited to qualified wrenches.

In early September 2001, one wrench asked how others address questions about payback from customers. The question generated a rich discussion for several weeks following. What follows is an edited set of responses to that question by RE wrenches around the world.

Almost all of us have been asked, "What's the payback?" and "Is it cost effective?" Almost all of us have been told, "I'd rather put my money in the stock market and pay my electric bill with the profits." The average American now knows that the stock market giveth and taketh away unmercifully, but we still get the questions. I've been trying to put together a short response to get skeptics to shut their mouths, open their minds, and think. What do you all think?

My thoughts? Selling stuff, even good stuff, is not my idea of living the good life. I challenge people to reduce their energy consumption by at least 50 percent without buying more stuff. If everyone in the U.S. would cut his or her consumption at least 10 percent, I'd quit selling PV and start enjoying heaven on earth.

The bad news is, Americans are not going to consume less, and billions of people in developing countries aspire to consume like Americans. So I guess I'll just have to keep selling PV until everyone becomes a net energy producer, or all of the planetary resources are used up.

Joel Davidson, SOLutions in Solar Electricity, Culver City, California
joeldavidson@solarsolar.com

Friends, I tell prospective clients that installing PV (or any RE source) is something you do not do just for the payback. Installing an RE system is a great hobby, it promotes the industry, it allows independence from gouging producers, and it's a great conversation piece.

William Miller, SLO Communications, Santa Margarita, California
wrmiller@slonet.org

I remind "payback" questioners that we think nothing of investing thousands of dollars into a vehicle that plummets in value the moment it leaves the dealer's lot. We then follow that with huge investments in fuel, oil, maintenance, and repairs—not to mention the "investment" in fighting wars in foreign lands to keep the pipeline open.

What is the payback on that? The ability to go where you want, to do

Larry Elliott,
Ion Technologies/Solar Tech

Carl Emerson,
Freepower, Ltd.

Travis Creswell,
Ozark Solar

what you want when you want to. Maybe not such a hot investment, but we all do it; we all take it for granted; we think nothing of it.

By comparison, an investment in efficiency (the first and best investment) or a renewable energy system provides the ability to live just as comfortably as the neighbors, without mining energy, emitting CO_2, or damming rivers.

When I prepare a solar thermal quote, I always give focus to the energy output of a system in terms of BTUs of fossil fuel replaced each day. I remind the client that the real *payback is fossil fuel that isn't mined, burned, or released into the atmosphere, while their house is still nice and warm and toasty.*

We all make investment choices each day. Those investments can be positive, or they can be the status quo.

Phil Undercuffler, Positive Energy, Santa Fe, New Mexico
phil@positiveenergysolar.com

I turn it around and ask them when was the last time they worked out the "payback" time on their fridge, TV, or car. Like Phil's comments about buying and maintaining a vehicle, it puts things in a better perspective. I usually find that if they are only concerned about "payback," they are doing the right thing for the wrong reason.

John Veix, Solar Electric Specialists, Christchurch, New Zealand
john@gosolar.co.nz

Good thread. Another reply I have come up with to the usual payback question is to ask them why they think with energy that "Cheaper is better." When they bought their vehicle or home, did they look for the rock bottom, cheapest thing they could get? Of course not, so I point out that likewise, some kinds of energy are different (and better) than others.

Yes, that $500 used, rusted out, 1967 pickup will move your body from point A to B, just like brown, carbon-based power will light a bulb or run the TV. But green power is different and better because it is clean. Like a Lexus, it does cost more.

I also point out how the current cost of brown power does not begin to include the long-term environmental consequences of using it. I tell them that their children's, children's, children will get to pay that bill. I encourage them to be a leader, be an example to others, and make the only intelligent choice for the health of future generations on our planet.

We are dealing with a consciousness shift here, folks. That is why the change to renewables is so much more complicated than what seems to be so obvious to us. Again, 70+ percent of what I end up doing is education of the customer. Too bad the schools don't teach people to think outside the box better.

Todd Cory, Bald Mountain Solar, Mt. Shasta, California
toddcory@jps.net

Another angle on payback is to ask people how much they paid for their car (often about the same as a PV system). Then ask how many hours a day they operate their car. And how many hours a day they plan to operate electrical items in their home (if it's stand-alone), or how many hours the sun shines (if it's intertied). Further, you can ask how long their car will last, and how long the PVs will last...

Steve Willey, Backwoods Solar Electric Systems, Sandpoint, Idaho
steve@backwoodssolar.com

To hell with all this pandering to customer queries on payback. When they say that PV is too expensive, I simply ask, "Compared to what?"

Larry Elliott, Ion Technologies/Solar Tech, Bonanza, Oregon
director@kattel.org

Kurt Nelson,
SOLutions

Mo Rousso,
Urban Refuge

Jay Peltz,
Peltz Power

Looking at the bigger picture, short-term thinking for financial gain, largely driven by bean counters, has landed the world in an environmental mess. Those who look for payback continue to perpetrate the same ethos that caused the problem in the first place. Those who choose solar energy regardless of the short-term benefit (or lack thereof) take a responsible position, and break the cycle of greed that has driven environmental irresponsibility.

In New Zealand, with no government subsidies, the systems take 100 years to "pay back" if you simply compare current KWH value generated to all the costs associated with putting in, commissioning, and maintaining a system. I point out that a roof-integrated, solar-electric system requires minimal maintenance and will pay for itself more than twice over during its lifetime. The rest of the roof will never pay for itself, will have one-third of the life, and will require considerable maintenance.

Carl Emerson, Freepower, Ltd.,
Auckland, New Zealand
emerson@freepower.co.nz

Very good thread indeed! I'll tell you all something I realized the other day, as I was flying over Kansas in a single engine plane at about 1,000 feet. We flew over house after house with pools in the backyard. I couldn't help but notice that it's things like those backyard pools that we are competing with.

We are asking the average guy with a wife and 2.3 kids to make a choice between a solar energy system, with its very intangible benefits, and that pool—something his entire family can enjoy. I doubt many "average" families can afford both. As a father of a young child with another on the way, I realized that given the choice between the pool and more solar panels, I'd choose the pool every time, and I'm pretty green. What does that say about "average Americana"?

Travis Creswell, Ozark Solar,
Neosho, Missouri • ozsolar@ipa.net

I stick with the fact that renewables are *cost effective right now. The reason they don't seem to add up economically is that they are being asked to compete on an unlevel playing field. Fossil and nuclear fuels are heavily subsidized, and neither are paying the environmental costs associated with them.*

These aren't just make-believe numbers. We are all paying for those cheap watts and gallons in places other than the meter and the gas pump. Acid rain alone is estimated to cost over eight billion dollars every year, and what price can we put on Desert Storm? Add to this the fact that our reliance on fossil fuels has long been referred to as a giant pipeline of dollars out of our country, while dollars spent on renewable energy remain at work in our local economy.

Kurt Nelson, SOLutions,
Cornucopia, Wisconsin
sunwise@cheqnet.net

Here's my question: Sure I give the customer many angles to make the system cost effective. But how many people run into problems when you suggest, "Well, it's cheaper to reduce than to produce. We need to get you a new fridge, washer, lights, etc." Then I show them the math, and it's like major blank time. Just wondering what you all have run into.

Jay Peltz, Peltz Power, Redway,
California • jay@asis.com

I did my first project, a 3 kilowatt, batteryless, grid-tied system, for an 89-year-old woman. She did not do this because of "payback." She did it because she wanted to stick it to San Diego Gas & Electric, and she derived the value of her money from how she used it.

Mo Rousso, Urban Refuge, Inc.,
Fallbrook, California
mrousso@urbanrefuge.com

Holt E. Kelly,
Holtek Fireplace & Solar Products

Bob Maynard,
Energy Outfitters

Allan Sindelar,
Positive Energy

I think the task at hand in defining payback is not economic but cultural. This from a letter a potential client wrote explaining why he and his family decided not to install a renewable energy system: " ...we have decided that we do not want to make the changes necessary."

The "changes" were efficiency measures to reduce loads. They did not want to "sacrifice" an electric water heater for a solar one, and did not want to look at that "ugly color" of compact fluorescent light. Payback? Just remember: "We do not inherit the earth from our parents, we borrow it from our children." (Chief Seattle)

Holt E. Kelly, Holtek Fireplace & Solar Products, Waco, Texas
hkelly6@msn.com

With PV being called "too expensive" by many in this country, I ask them to look at the September 11 attack on the WTC and tell me: "What is the real cost of a barrel of Middle Eastern crude oil"?

Bob Maynard, Energy Outfitters, Cave Junction, Oregon
bob@energyoutfitters.com

A typical, PV powered, off-grid home uses five to fifteen percent of the electricity of a conventional home that has utility power. This is not accomplished by forgoing modern conveniences. Our off-grid home has hydronic heat, a microwave, a Maytag refrigerator and Jenn-Air dishwasher, a computer, an entertainment system, a well pump, and shop tools. We achieve this efficiency by closely adhering to two basic rules: use the right form of energy for the job, and minimize the amount that's wasted.

If all of us in the U.S. lived as though we got our heat and power directly from the sun, we wouldn't be reeling from a terrorist attack on "our way of life." We wouldn't have gone to war to keep our supply of Middle Eastern oil flowing. We would leave the Arctic National Wildlife Refuge alone. We could see the stars in the night sky.

Allan Sindelar, Positive Energy, Santa Fe, New Mexico
allan@positiveenergysolar.com

I think that this is really important stuff—it goes deep. What if we were to live as though all of our energy came directly from the sun, wind, and modest use of falling water? This would have profound and positive impacts on so many aspects of our lives.

Recent events give us an opportunity to consider how some things might be different if we were wiser in our use of energy and the sources we tapped. Would we have a military presence in Saudi Arabia? Would we give Israel, and a select "club" of other countries, money? Would we be in the mess we are in now? Middle Eastern politics are complex, to be sure, and the connections to oil may not seem obvious. But I do think that oil security (the enabler of "The American Way of Life") is a huge factor in our Middle Eastern affairs.

The real costs of "our way of life" are extremely high—to all of our brothers and sisters all over the planet, including those people who were and are victims of the war we've been waging for a long time, as well as those who fly, swim, crawl, and stretch their graceful, leaf-clad limbs into that beautiful starlit sky.

Despite my short-term pessimism, I feel threads of possibility amid the recent and ongoing tragedies. I sense that we are waking up a bit. Many have said "everything has changed," but I think what we are really saying is that we have changed. There is a hint of a new awareness, which colors how the world feels to us. It is scary feeling this tug at the blinders, yet the birth of a new consciousness can be an extraordinary thing.

It is said that in times of crisis, there is also opportunity. I think this is so true. The path ahead will be

Gary Higbee,
Gary Higbee Technical Services

Jeffery Wolfe, P.E.,
Global Resource Options

dangerous, and will also be full of opportunities to grow. This can be a rich time as we look for new possibilities. The old, dysfunctional model of "the American way of life" can give way to a much more enlightened vision. I'd like to think that we could all be a part of offering inspiring examples.

Gary Higbee, Gary Higbee Technical Services, Eugene, Oregon
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When asked either, "What's the payback?" or "How does this compare to utility power?" I simply say, "It's the cheapest clean energy you can buy." This completely stymies some, and causes all to pause. It helps convey three ideas in a single sentence: 1. It's not expensive, 2. It's clean energy, and 3. (if they're savvy) You can't buy clean energy any other way (at least in Vermont at this point). If they miss the point, and thought it was cheaper than utility power, well, that's the point.

We are cultural educators. Our biggest barrier is not cost—it is culture. The fact that people rely on the cost of electricity in making their decision is due to their cultural indoctrination. That's why the same person who buys an SUV for city driving can say, and believe, "Solar energy doesn't make economic sense." Culture is the most powerful influence on all our lives and actions.

In trying to do the right thing, and make a living by selling systems, I note that having a PV system installed is a major consciousness raiser in further reducing energy use after installation. People want to see that meter turn backwards, and they do start to pay attention.

I also use the story of the apple grower who has an apple for sale for fifty cents. It is a beautiful apple, organically grown, very beneficial to your health, not harmful to the soil it is grown in, nor harmful to the workers who produce it.

What? Too expensive? The grower also has an apple for sale for twenty-five cents. It is also a beautiful looking apple. It is grown with pesticides, harms the soil around it and the water through runoff, and causes disease in the workers who produce it. Oh, and it is poisonous to you. Which apple would you like to buy?

Jeffery Wolfe, P.E., Global Resource Options, Strafford, Vermont
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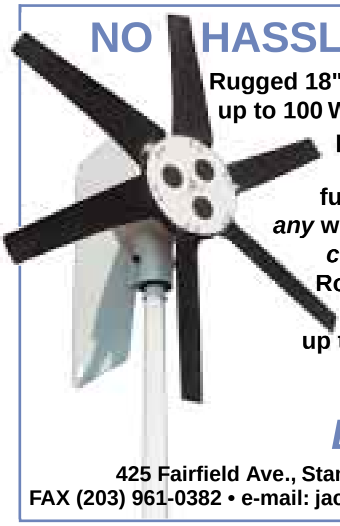


U.S. ENERGY FLOW— IN THE BELLY OF THE BEAST

Randy Udall

From a biological perspective, think of the U.S. economy as the largest "animal" the planet has ever seen—a living, breathing *T. Rex Americus,* whose energy appetite is gargantuan. If we dissect the beast to study the energy flows that sustain it, we end up with this chart, produced at Lawrence Livermore National Laboratory.

At first glance it may seem laughingly obtuse, a bizarre eye exam. But if you are interested in America's energy realities, challenges, and opportunities, it's worth studying.

Looking at the chart, energy flows into the economy from the left. It is consumed by power plants, boilers, furnaces, aircraft turbines, and automobile engines in the middle. The energy services provided by those prime movers are used in the residential, commercial, industrial, and transportation sectors on the right.

In 1999, the U.S. economy devoured 97 "quads," or 97,000,000,000,000,000 British thermal units. More than half of the energy was, as the chart demurely puts it, "rejected" at the upper right. The remainder did useful work.

The Oil Tribe

Petroleum provides 39 percent of U.S. energy. Some oil is converted to electricity, some fuels home furnaces, some is used to make petrochemical products, but most moves cars, SUVs, trucks, planes, tractors, snowmobiles, etc.

Since September 11th, we have been reading about Uzbeks and Pashtuns—exotic tribes in central Asia. But we Americans are the Oil Tribe, consuming 150 pounds (68 kg) of petroleum per person each week. Domestic production peaked in 1970, and we now import nearly 60 percent of the oil we demand.

Transportation is a petroleum monoculture; alternative fuels like biodiesel, ethanol, natural gas, and propane barely register. Note too, how terribly inefficient our transportation system is, wasting four of every five units of energy it consumes.

Coal Makes Kilowatts

Coal provides nearly one-fourth of U.S. energy, and most of it is burned in electric power plants. One pound (0.45 kg) of coal will produce one kilowatt-hour, plus two pounds (0.9 kg) of carbon dioxide, as the carbon in coal combines with oxygen in the air.

A typical coal plant wastes two out of every three units of energy it consumes. Nonetheless, coal has been the backbone of our electricity system for a century, and climate concerns aside, is likely to be the dominant fuel used for electrical generation for decades to come. The reason? It is cheap and abundant, our most plentiful domestic fuel.

Methane Madness

Each year, 280 million Americans use as much natural gas as 3 billion people in Europe and Asia. What we call gas is mostly methane, a wonderful molecule that can heat your home, dry your clothes, grill your steak, and run a car or a power plant.

Nearly all new power plants are gas fired. Gas is also critical to agriculture, since it is the key feedstock for fertilizer. Per capita, we use a dumpster's worth of gas each day. U.S. gas production peaked in 1973, and imports have grown sharply since 1990. Indeed, we are now the world's largest importer.

When Canadian gas production peaks in the next decade, they may decide to cap exports to the "damn Yanks." Sooner or later, expect to see a US$15 billion gas pipeline to Alaska. We will also need to import increasing amounts of liquefied natural gas. It is cooled to –260°F (–162°C), and shipped in on special tankers, which have the energy density of a tactical nuclear weapon.

Bit Players

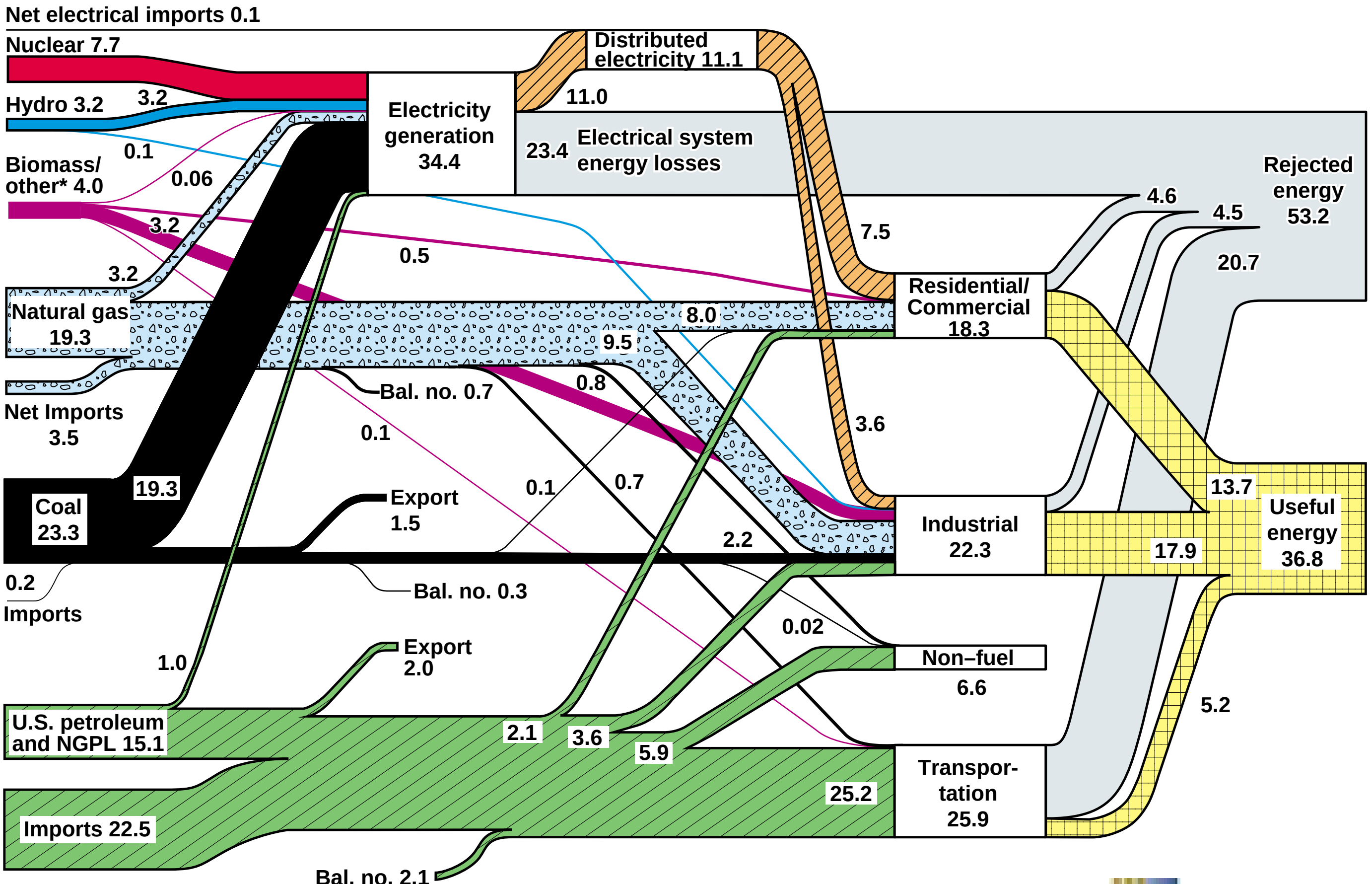
The purple band dubbed "biomass," and the hydropower band above it include water, wood, wind, solar, geothermal, landfill gas, and other forms of renewable energy. Renewables are about 7 percent of the energy pie. Wind and solar are, in percentage terms, the world's fastest growing energy sources. But in the grand scheme of things, they remain dwarfed by fossil fuels.

Pick Your Poison

Many people have no love for nuclear reactors, but they provide 20 percent of the nation's electricity, and about 8 percent of total energy. No nuclear plants have been ordered since 1980. We haven't figured out what to do with the radioactive waste.

On the other hand, nukes don't produce greenhouse gases. Is a nuclear "renaissance" on the horizon? The Bush administration would like to see it happen, but most utility experts think it's highly unlikely.

Net Primary Resource Consumption 97 Quads



Source: Production and end-use data from Energy Information Administration, *Annual Energy Review 1999*
*Biomass/other includes wood and waste, geothermal, solar, and wind.

March 2001
Lawrence Livermore
National Laboratory

Excreta

Our economy is not, metabolically speaking, a thrifty creature. About 55 percent of the energy that flows into the economy is ejected as *T. Rex* dung. This waste carries with it a huge pollution and climate burden.

Vice President Cheney said that "conservation may be a sign of personal virtue, but it is not a sufficient basis for a national energy plan." Despite this belief, it is obvious that *T. Rex Americus* must become more efficient if it wishes to continue growing. As Amory Lovins and others have noted, more efficient appliances, lightbulbs, or cars that save one unit of energy on the right side of the chart, avoid the need to pump in three or four or five additional units of energy on the left.

Looking Ahead

Energy systems change slowly. History shows that none of the existing energy flows or prime movers will cede its position without a fight. If fuel cells aim to displace internal combustion engines, they will have to battle for market share. Likewise for hydrogen, which today does not appear on the chart.

In the long run, of course, renewable energy is destined to supply a bigger share of the load. But despite the depletion problems that face both oil and natural gas, fossil fuels will remain dominant for decades to come. Of course, that's at a national level. At a household level, anyone can begin to embrace energy efficiency and wind, solar, or geothermal energy. And tens of thousands of families have begun to do just that.

Access

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Credit for the energy flow chart is given to the University of California, Lawrence Livermore National Laboratory, and the Department of Energy, under whose auspices the work was performed. This and charts for previous years are available at http://en-env.llnl.gov/flow. A chart for the year 2000 will be available sometime in 2002.

No Power? No Problem!

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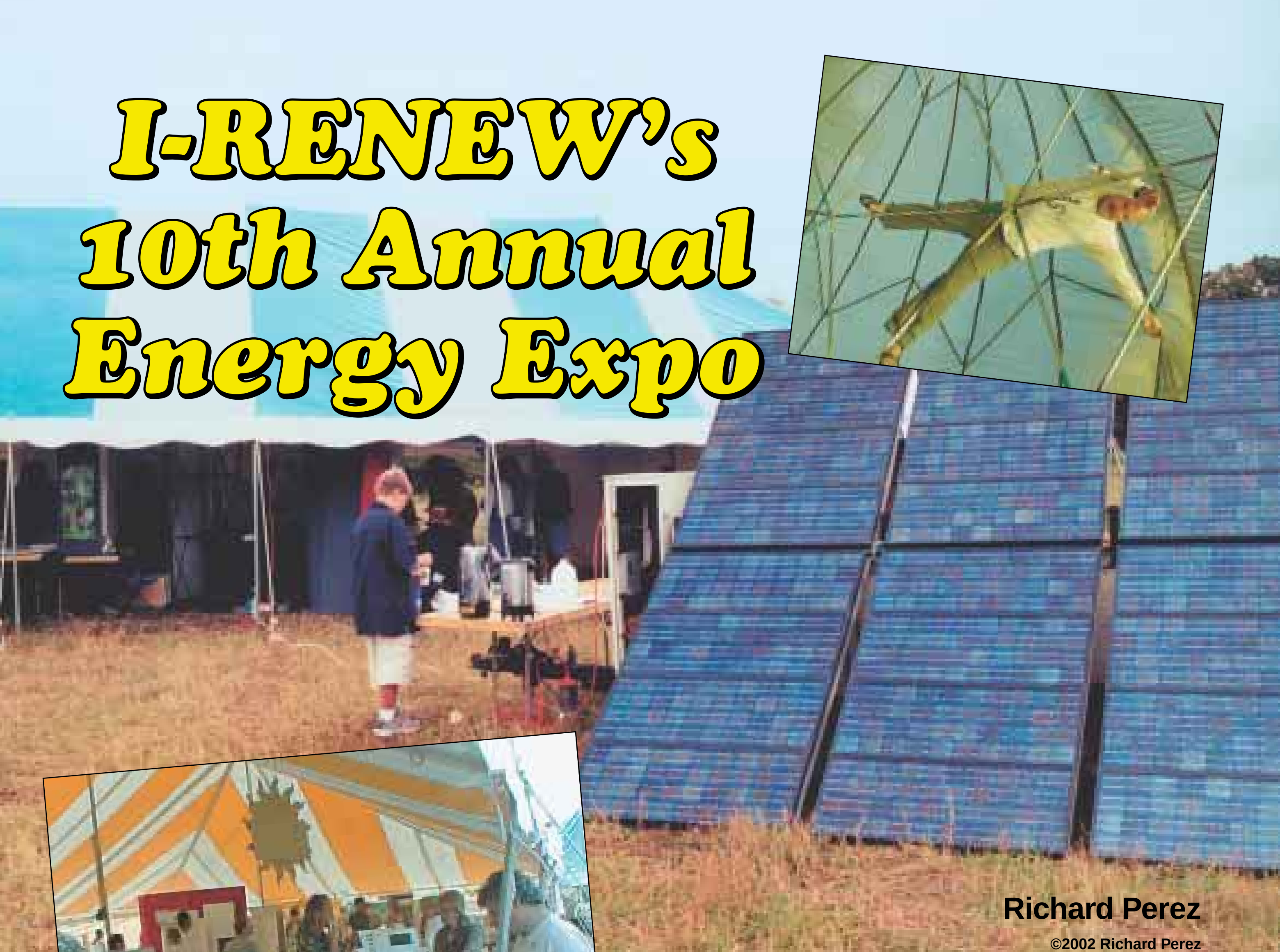
I-RENEW's 10th Annual Energy Expo



Richard Perez

It's a bird, it's a plane... No it's I-RENEW President Rich Dana assembling the geodesic dome (top inset photo).

A young fairgoer enjoys solar powered hot cocoa from I-RENEW's 1 KW, mobile PV trailer (main photo) .

Inside the fair's tents, there were deals to be had at the exhibitors' booths (bottom inset photo).

On September 8 and 9, 2001, the Iowa Renewable Energy Association (I-RENEW) held its tenth annual Energy Expo in Hiawatha, Iowa. This was the first time that *Home Power* attended this fair. We were amazed with the event, and gave ourselves a good butt kicking for all the previous ones we had missed.

It Was Free!

One of the unique features of I-RENEW's Energy Expo is that it was free. There was no admission charge, while camping on site was just US$5. Exhibitors secured booth space by donating a US$50 product to I-RENEW's silent auction. This auction was well attended, and many people took home terrific deals on everything from RE gear to educational materials.

In spite of a constant drizzle on Saturday and part of Sunday, over 2,000 people came from Canada, Colorado, Georgia, and thirteen other states to attend this fair and meet with the more than 60 exhibitors. These are wonderful folks, and they packed the 64 workshops held during the fair. The educational nature of this fair overflowed onto the exhibit grounds. I remember one instance where at least a dozen folks started an unplanned workshop at *Home Power's* booth. The topic was using RE to make hydrogen, and using this hydrogen to power all of America. I was surprised at the knowledge these folks had.

"What was that?"
This electric racer piqued the interests of surprised fairgoers.

I-RENEW had their mobile solar-electric system on site. It was a real treat to check out this system firsthand. It is a large trailer with a deployable 1 KW PV array, batteries, and a 4 KW inverter. I-RENEW has powered many events and concerts with this trailer. See *HP68,* page 50 for a complete write-up of this cool "Solar-Powered Bluesmobile." Transportation using RE was also well represented, with Electrathon racers and the Iowa State University's PrISUm, a purely PV-powered race car.

Prairiewoods Franciscan Center

Hiawatha is a suburb of Cedar Rapids, Iowa. So I expected the I-RENEW Energy Expo to be in a suburban setting. I was wrong. Perhaps the most wonderful thing about this fair was the venue.

Energy Expo organizers Tom Snyder, Tim Schulte, and Martin Smith had collaborated with the Franciscan Sisters and staff at Prairiewoods to have this fair at their center. The Franciscan Center already had a huge head start with renewable energy. Through previous I-RENEW workshops, the center has two PV powered straw bale buildings, solar hot water, and passive solar architecture, complete with a Trombe wall to store heat.

One of the two, PV powered straw bale hermitages at the Prairiewoods Franciscan Center.

The Franciscan Center is a beautiful location, not at all the suburban situation I had imagined. The 70-acre grounds are green and spacious, with more than enough room for the Energy Expo and for the many folks who were camping on site.

Instead of manicured lawns, the Sisters opted for what they call "wildscaping." The grounds are filled with the native plants that have inhabited the Midwest prairies for centuries. Just strolling though the grounds was an education in natural history. And the people were not the only ones appreciating this beautiful site. The grounds were filled with hundreds of monarch butterflies that were our constant companions during this magical weekend.

Karen and I are not big fans of organized religion, but the Franciscan Sisters at Prairiewoods wiped prejudices and stereotypes from our minds. These Sisters are very involved with their local ecology and using renewable energy.

Karen attended the "Blessing of Animals" that the Sisters held. It was a wonderful and touching scene, as fair attendees brought their dogs forward to be blessed. We're not talking a dab of holy water and "hit the road" here. Each animal was petted, talked to, and made to feel as special as they really are. St. Francis of Assisi would have felt entirely at home during this fair. The love and devotion of these Franciscan Sisters added immensely to this Energy Expo.

Solar Domestic Hot Water (SDHW) workshop at the Prairiewoods' guest house. Three of the Franciscan nuns participated in the workshop.

A Success?

Over the last eleven years, I have attended more than fifty energy fairs. Some are large with tens of thousands attending, others smaller. All have one thing in common—people come because they want to learn about renewable energy and sustainable living.

The 2001 I-RENEW Energy Expo was a huge success. Folks came and they learned. It was a weekend of nonstop good energies and wonderful people. I don't know when I've had a better time. Next year's I-RENEW Energy Expo will be held on September 7 and 8, 2002. The location will be the same place—Prairiewoods, Hiawatha, Iowa. Come and join us!

Access

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2001 Texas Renewable Energy Roundup

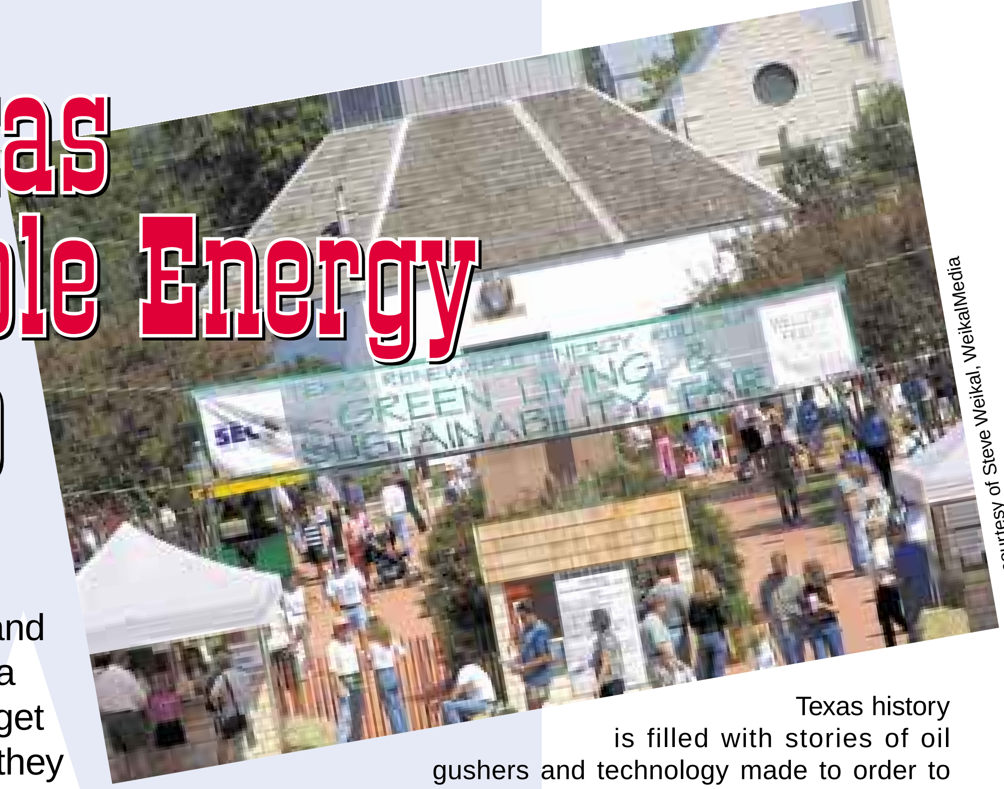

Photo courtesy of Steve Weikal, WeikalMedia

Tom Bishop

Texas is a big state, and Texans do things in a big way. When they get excited about something, they jump in with both feet, boots and all. Renewable energy is no exception. The interest and enthusiasm in Texas for homemade energy turned Texans out in herds on September 28–30, 2001 to take advantage of presentations, workshops, and an opportunity to talk green energy with vendors and other fairgoers.

Texas history is filled with stories of oil gushers and technology made to order to meet the energy needs of a hungry (or should we say thirsty) nation. If the enthusiasm of the people I met at the Texas Renewable Energy Roundup, Green Living, and Sustainability Fair in Fredricksburg is any indication, the state of Texas will again be rising to the occasion.

Tech in Texas—impressed by PV.

Photo courtesy of Steve Weikal, WeikalMedia

Yesterday's Oil Patch Becomes Today's Wind Farm

Many large wind farms are being sited in Texas due to the abundance of wind and open land. Most of the citizens see this as a chance to renew their status as the energy capital of the country. I won't disagree.

One gentleman I met was poised to sign a lease to place 135 megawatts of wind machines on his ranch. That would be more than ninety 1.5 megawatt machines. Admittedly, not everyone at the fair was situated so nicely. But there was plenty of enthusiasm

Water pumping windmills still make good RE sense.

Photo courtesy of Steve Weikal, WeikalMedia

Photo courtesy of Steve Weikal, WeikalMedia

Adult fairgoers weren't alone in their quest for knowledge.

for the smaller generators, which can supply individual residences.

Energy Independence in the Lone Star State

Texans take independence very seriously. That lone star on the Texas flag is a symbol of their independence. It was put there shortly after Sam Houston "opened a can of whup ass" on old General Santa Anna while yelling "Remember the Alamo!"

This independent spirit was evident in almost everyone we talked to about the stranglehold OPEC has on the family pocketbook. They express their indignation with a soft southern drawl, but from the looks of it, they are ready to back up their complaints with action. Texas is a place that is poised to break the renewable energy market wide open. With plenty of wind and sun at their disposal, it shouldn't be very long.

Fair Highlights

Some very good workshops were available, both free and by paid enrollment. I would like to have attended many of them, presented by some very knowledgeable individuals. But due to the large number of people passing through our booth, there just wasn't enough time. Just a few of my favorites were:

- Fun with Fuel Cells, by Steve Wiese
- Building with Straw Bales, by the Straw Bale Association of Texas
- Installation and Code Compliance, by John Wiles
- Solar Cooling, by Dr. Gary Vliet

There was no shortage of renewable energy vendors and manufacturers represented. You could get your hands on the latest and greatest gizmo for supplying independent electricity, cool air, hot air, compost, clean water, and just about anything else you can imagine related to clean, independent living.

Natural building techniques, like straw bale construction, were demonstrated.

Photo courtesy of Steve Weikal, WeikalMedia

In addition, the local utility authorities had some attractive booths showing what they are doing to provide locals with nonpolluting electricity. This was a good indicator that they know folks around Austin and San Antonio want something other than nuclear and fossil fuel generated electricity.

One of my favorite attractions was Sunny, the 7 foot (2.1 m) tall remote-controlled robot that traveled around the fair telling corny jokes and advocating renewable energy—solar, wind, and especially biomass. There was also a long-horned steer with a saddle. You could have your photograph made on the steer for a small price. From the smell of the steer, I believe he was powered by methane.

See You in Fredricksburg—2002
The historic town of Fredricksburg is one of the prettiest towns I have ever seen. The architecture is predominantly "west Texas genteel," of white native limestone and granite. The people are friendly, chatty, and a joy to be around. Hotel accommodations were inexpensive and very comfortable, and the weather was a balmy 80°F (27°C) during the day.

Fair organizers, Russel Smith of Texas Renewable Energy Industries Association and Kathryn Houser of Texas Solar Energy Society.

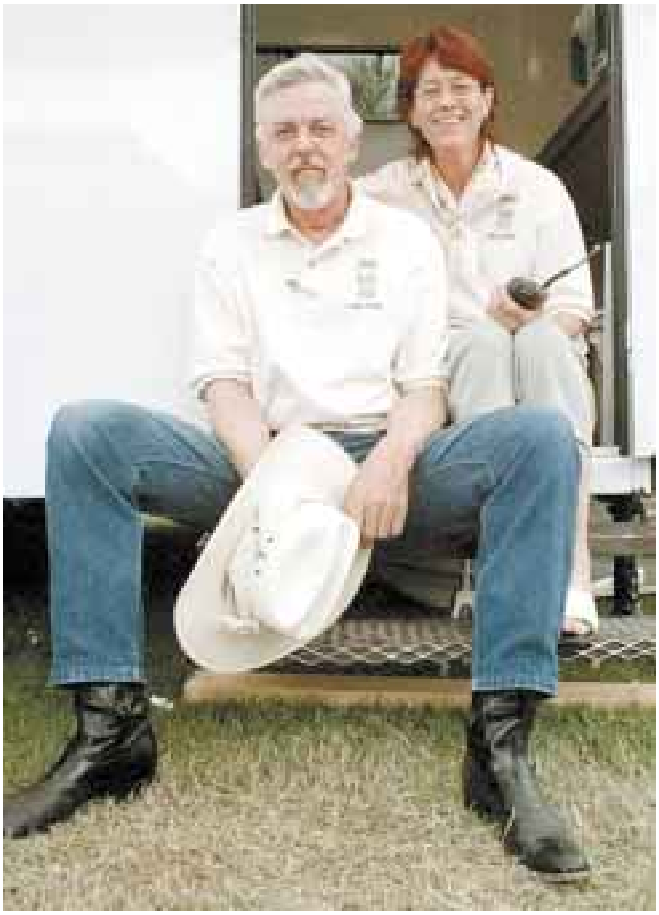

Photo courtesy of Judy Pearson

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Electric vehicles rounded out the RE scene in Fredericksburg, Texas.

The nightlife was an extra bonus. Pearl, Shiner, and Lone Star beers were ice cold and on tap at the local taverns, and the local music was hot. It was a top notch renewable energy fair with all the trimmings. I can hardly wait till next September to go back and take that longhorn out for a spin!

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Solar Fiesta Combines Sustainable Living with Southwestern Culture

Rose Marie Kern

Bright sunlight greeted the day as the New Mexico Solar Energy Association (NMSEA) hosted their annual Solar Fiesta over the weekend of the fall equinox. A record crowd of 2,275 people came to the two-day event held at the Indian Pueblo Cultural Center in Albuquerque, September 22–23, 2001.

Solar Fiesta, a renewable energy and sustainable building educational fair, featured 42 speakers and classes, 33 booths, a solar scavenger hunt for kids, and a raffle for a 160 watt PV system. Solar Fiesta was sponsored by the Sandia National Laboratories, the Public Service Company of New Mexico (PNM), *Home Power* magazine, and the Alliance for Green Development.

Native Energy

This year's Solar Fiesta was enhanced through cultural participation by the Indian Pueblo Cultural Center (IPCC). It featured performances by Native American dancers in the courtyard of the beautiful adobe style building. With their eagle dance, the Laguna Pueblo Elementary school dancers created a dust devil out of a calm day, sending shade umbrellas flying over the tops of outbuildings.

The Sacred Power 1.2 KW PV system that powered the exhibitors tent and stage.

The IPCC building is powered by a 10 KW PV system. The system is grid tied and net metered through PNM. It was designed by Dave Melton, a Native American engineer, and installed by his company, Sacred Power. This is the largest PV installation on native land in the United States, and the largest commercial array in New Mexico.

Fun & Food

The kids' booth boasted a solar scavenger hunt, where children could pick up a card with questions to answer by visiting many of the exhibits. They had to record the

This industrial-sized solar cooker baked cookies for fairgoers—seven trays at a time.

temperature in the Solar Villager sun oven, visit the Sunchaser educational trailer, watch adobe bricks being made, and then take the completed card back to the booth to receive a prize.

La Mantanita Organic Foods Co-op hosted a solar cooking contest on Sunday, with the winners receiving gift certificates to their store. The first place winner was Michele Godwin of Albuquerque, who baked a rosemary chicken casserole.

Jeanette Moore brought the Sandia National Labs' Solar Villager, a trailered sun oven that stands 12 feet (3.6 m) high and can cook six turkeys, or seven trays of chocolate chip cookies at once! With help from Dave Patterson, Amanda Hodson, and Alisha Hodson, Jeanette was making chocolate chip cookies for two days!

Education

The Solar Fiesta also saw the debut of NMSEA's new energy education trailer, the Sunchaser3. Their program has been so popular that their Sunchaser2 trailer couldn't meet the demand from one end of the state to the other. Both SunChaser trailers contain examples of solar hot water heating, PV and wind electric systems, solar cooking, fuel cells, passive solar home features, and other sustainable technologies.

Sunchaser3 contains a complete 300 watt PV system, a wind generator, and a stationary bike. All of these tie into output monitors, batteries, and an inverter. Mike Prine has brought the systems up to date, and displayed them for the crowds.

Solar Fiesta included forty classes and two panel discussions. The classes were US$5 each, or US$20 for an all day pass. Most of them were set up classroom style, with a few of them including an outdoor demonstration immediately following.

The classes covered all aspects of renewable energy technology, solar building design, and green building techniques, as well as permaculture and organic issues. All of the classes were taught by people who are actively working in these fields.

The Solar Raffle was first seen last year when the grand prize was a small, home photovoltaic system. This year's grand prize was a Firefly plug n' play 160 watt PV system. The winner, Gene Sydoriak of Santa Fe, told us that he was just getting into solar energy, and couldn't wait to experiment with his new Firefly. It features four 40 watt PV panels donated by Matrix Solar Technologies, a Cool Cell battery box donated by Zomeworks, a Sundog battery donated by Industrial

Tire pounding 101—the beginnings of an earthship home.

Battery Specialists, and a Trace inverter purchased at reduced cost from Xantrex. Ron Orozco and Steve Durand of Energia Total donated labor to put the system together.

Energized in the Southwest

I spent eight months of my spare time organizing the Solar Fiesta. Robert Griffin directed the volunteers, and grounds manager was Don Miller. Sunchaser2 was managed by Joe Griffin, with help from Ben Luce. The NMSEA booth was organized by Elaine Prine and Pat Miller.

New Mexico is rich in sunshine, and blessed with wind. The Solar Fiesta is designed to reach out to people who've heard about solar energy and sustainable topics and are hungry to know more. It gives them a taste of what is possible to do right now.

It brings confidence about sustainable living to those who have never before had an arena in which to experiment. Chuck Marken of AAA Solar stated, "This Fiesta was simply the best solar happening I have ever seen in New Mexico, and rivaled the early Midwest fairs in Wisconsin." With enthusiasm like that, we guess we'll just have to do it again!

Access

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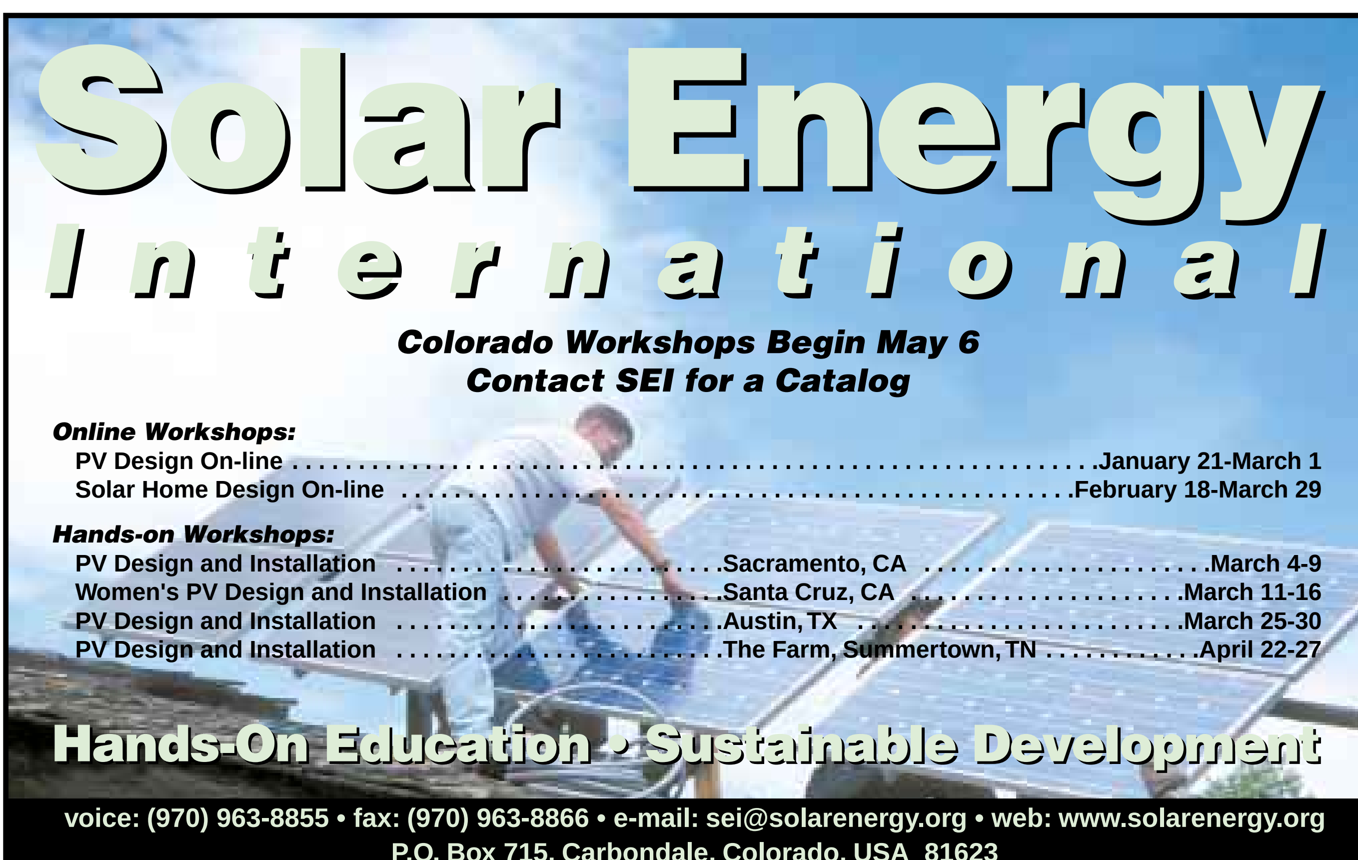
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Good Things in Small Packages

Shari Prange

The Th!nk City has a fairly conventional appearance compared to some other city cars.

Bigger is better, right? It's the American way. Supersized fast food, big screen TV, monster trucks. We set records for the tallest, the biggest, the longest, the most....

But sometimes, less is more.

"Overdesign" is a concept that can be good or bad. Some things are deliberately overdesigned for their intended use to include a built-in safety margin. This is good. But some things are overdesigned to meet peak demands, even though most of their useful life is spent at much lower levels of demand. Electric power systems, for example, have to be designed to meet expected worst case draw, even though off-peak demand, such as overnight, will be very low.

This can be wasteful. Often, systems operating below their peak are inefficient, which wastes fuel. It wastes resources that are tied up in the oversized equipment. In some situations, such as cars, it also wastes the energy needed to carry around the weight of the oversized equipment, just so it will be there for those occasional times when you actually need it.

Sometimes this waste is unavoidable. But other times, a little thinking outside the box can provide a solution. For example, a busy family might really need two cars. But is it necessary for both cars to be capable of carrying the whole family, reaching freeway speeds, and travelling long distances? Or could one car be a special purpose, efficient vehicle for local use only?

Even a one-car household, such as a couple in a retirement community or a single person living in a city, may not need a conventional car 90 percent of the time. For them, it might make more sense to have a minimalist vehicle, and rent a "regular" car only when absolutely necessary.

City Cars

Last issue, we talked about neighborhood electric vehicles (NEVs). These are very small, four-wheeled electric vehicles, often resembling golf carts. They have a top speed of 25 mph (40 kph), and are perfect for many drivers. Other people want something a little more car-like in appearance, convenience, and performance, but more specialized, compact, and efficient than a conventional car.

The vehicle that fills this gap is the city car. This is a loosely defined term. In general, it means three or four-wheeled electric vehicles that are much smaller than standard cars, but have fully enclosed bodies, and top speeds that often reach freeway levels—well, at least on some freeways, in the slow lane. There are several versions of city cars currently or soon to be available. Let's take a look at some of them.

Th!nk City

The little car from the big company is the Th!nk City from Ford. This is the "big" brother (relatively speaking) of the Th!nk Neighbor we looked at last time. While the Neighbor clearly showed its golf cart heritage, the City looks pretty much like an ordinary car, only smaller. The two-seater is only 9.8 feet long by 5.3 feet wide and 5.1 feet high (3 x 1.6 x 1.6 m). The hatchback opens on 12.4 cubic feet (0.35 m^2) of storage room.

The entire car weighs 2,112 pounds (960 kg), including batteries, and can carry up to 451 pounds (205 kg) of passengers and cargo. The car is built on an aluminum space frame, clad in thermoplastic body panels. A space frame is a type of chassis using a lightweight structure of tubing arranged in cross-braced open cages enclosing the various sections of the vehicle, such as the engine and passenger compartments. As a bonus, the Neighbor's plastic body is resistant to the kinds of minor dents, scrapes, and dings that ordinary cars collect. Overall, the car is 98 percent recyclable.

Safety is always a question in a small car like this. The Th!nk City has seat belts, a driver side airbag, and side intrusion beams in the doors to protect passengers in a collision. The Th!nk currently available meets all European safety standards, but not yet U.S. standards. However, starting in March 2002, a fully certified and crash-tested U.S. version will be available. It will be legal on all streets and highways. Customers who are leasing European standard models will be upgraded to the U.S. model at that time.

The car is powered by a liquid-cooled, 3-phase AC induction motor, mounted as a "direct drive" system. Essentially, this means that it uses a gearbox with only one gear, and never shifts. It draws energy from a 114 volt, 100 amp-hour pack of nickel-cadmium batteries. The U.S. version will incorporate some changes, including different gearing and a shift to sealed, lead-acid batteries, as well as some reprogramming of the battery management system. These changes are intended to improve the efficiency, range, and top speed of the vehicle to make it fully highway capable.

The current pack is recharged on 230 volt power only, since this is the European standard. The U.S. model will carry an onboard charger that plugs into a normal 120 volt outlet, with the option of a wall-mounted 240 volt charger for faster charging. A depleted pack can be charged to 80 percent in 4 to 6 hours, or fully charged in 6 to 8 hours on 120 volts.

The City has a top speed of 56 mph (90 kph), with a 0 to 30 mph (0–48 kph) time of 7 seconds. Its maximum range on a charge is 53 miles (85 km). The U.S. version will expand this to about 70 miles (112 km) range and 65 to 70 mph (104–113 kph) top speed. At present, the City is only available for lease, since the current model is not fully U.S. certified. The U.S. model will be available for sale, but the price is not yet known.

Smart

Another four-wheeled city car is the Smart Car from eMotion Mobility in Atlanta, Georgia. The Smart began life in Europe known as the Swatch car. It was created by Nicolas Hayek, the designer of the Swatch, the color swapping wristwatch that became a fashion craze in the 1980s. The car was intended from the beginning to be electric, but marketing considerations in Europe forced production of the Smart as a conventional gas car. It has been available in Europe since 1998.

Now DaimlerChrysler has formed a strategic partnership with eMotion Mobility to bring the Smart to the U.S. as an electric car. Donald Panoz, owner of eMotion Mobility, is well known in the automotive world as founder of Panoz Motorsports, one of the major players in LeMans style racing.

The Smart will use the same two-seat chassis as the European model, which measures 8 feet long by 5 feet wide by 5 feet tall (2.4 x 1.5 x 1.5 m). The body is a combination of metal and thermoplastic, but unlike the Th!nk's pebbly finish, the Smart is polished, shiny, and smooth.

The Smart Car is shown at a Georgia charging station (left) and flashing its smiley front side (right).

Photos courtesy of eMotion Mobility.

It also will be fully U.S. safety certified, crash tested, and highway capable. The chassis incorporates a sturdy cage for passenger safety. Top speed will be about 70 mph (113 kph), with a range of 60 to 70 miles (97–113 km).

The air-cooled AC induction drive system will be supplied by Solectria, a U.S. company that has been providing drive systems for electric vehicles since 1989. It will be a single-gear, direct drive system. The battery type and pack voltage are still being determined. The car will have an onboard charger capable of accepting either 120 volt or 240 volt input.

There are no plans at this time to make the Smart available for sale or lease to individuals. Instead, it will be used in station car projects in major metropolitan centers across the U.S., starting with Atlanta in 2002. Within five years, eMotion Mobility plans to have 16,000 Smart cars in programs throughout the northeastern U.S. and California. Since the Smart will be marketed only as a station car, it will be sold to metropolitan transit systems, which will acquire a few hundred to a few thousand to service their entire areas.

Something Completely Different

Some city cars fall into a different subcategory of the genre. These are three wheelers. They are generally configured with two wheels in front and one in the rear. One reason for a three-wheeled design is that it increases energy efficiency by reducing both weight and rolling resistance. It also, of course, reduces the cost of manufacturing by one wheel.

Probably the most persuasive argument in favor of three wheels, however, is the reduction of red tape. These three-wheelers are legally classified as motorcycles. In some areas, this has advantages to the owner in the form of cheaper registration, and access to carpool lanes or motorcycle parking. But the bigger advantage is to the manufacturer. The regulations on manufacturers of motorcycles are much easier and cheaper to meet. This allows small companies into a niche of the automotive market that they could not otherwise afford to reach.

Most states with motorcycle helmet laws have exemptions for these enclosed three-wheeled “motorcycles,” so you don’t have to wear a helmet. Let’s look at some of these three-wheelers.

Sparrow

The closest to a “normal” car among the three-wheeled set is the Sparrow from Corbin Motors in Hollister, California. (The Sparrow was profiled in *HP67.*) The Sparrow is kind of a single-seat jelly bean, a rounded shape in bright colors.

Corbin began taking orders for Sparrows in 1997, but startup hurdles delayed delivery of the first units until the end of 1998. Since then, the little bird has undergone changes in appearance as well as drive system.

First, let’s look at the outside. The Sparrow is only 8.3 feet long and 4.2 feet wide (2.5 x 1.3 m). You can park four of them in a normal parking space. However, it stands 4.8 feet (1.5 m) tall, giving the driver reasonable visibility. It weighs in at 1,250 pounds (567 kg), and can carry up to 350 pounds (160 kg) of driver and cargo.

The bodies on the first Sparrows ended in a smoothly curved line that extended from the roof down to the rear wheel. While aesthetically pleasing, this did leave the cargo area behind the seat somewhat cramped and oddly shaped. When a pizza franchise wanted to use Sparrows as delivery vehicles, Corbin redesigned the rear by expanding and squaring off the cargo area. The new style was a hit, and became the standard.

More recently, the Sparrow has developed large dimples on its fenders, giving it a resemblance to a neon golf ball designed by artist Salvador Dali. Actually, the Sparrow has dimples for the same reason a golf ball does: aerodynamics. The dimples break up negative pressure zones that create drag.

All of these variations are still considered the Sparrow I. The Sparrow II, due for release in mid-2002, is a major

Evolution provided a longer tail and dimples for the Sparrow I.

departure, with a long, raked windshield and more aggressive, sporty styling. The new version will be roomier, with better handling, and will lend itself to higher volume production techniques.

The Sparrow has a single door, which is placed on the right side for safety reasons. In addition to allowing access from the curb side instead of the traffic side of the car, it also makes the left side—which is more prone to collision damage—stronger. On the Sparrow II, the door opens on a scissors hinge that rotates it upward instead of out into pedestrians or obstructions.

The Twike comes in electric and and electric/human powered versions.

Photo courtesy of SwissLEM.

Tom Corbin likes to describe the Sparrow as a motorcycle helmet for your whole body. As a legal motorcycle, the Sparrow is not required to be crash tested, but Corbin is planning to do just that anyway, once production of the Sparrow II is up to speed. Informally, the Sparrow has already been crash tested a couple of times by customers—one of whom was hit by an SUV and rolled twice. In both cases, the Sparrow body shell was scratched but remained intact, and the driver walked away.

One “problem” (if it can be called that) with the Sparrow I involved the production line rather than the car itself. Corbin was unprepared for the number of orders placed for the little cars, which were built one at a time, with the fiberglass hand laid up. By first quarter of 2002, they will have delivered 355 of the vehicles, though many other orders have gone unfilled because Corbin could not keep up with the demand.

With the Sparrow II, Corbin is partnering with SLP Canada in Montreal. SLP will produce the body parts through compression molding with large multipiece molds. The Hollister facility will be the assembly plant. However, there are plans in progress for a completely solar-powered geodesic factory in Florida further down the road.

The Sparrow is powered by a series brushed DC motor and controller system, much like those used in electric vehicle conversions. The battery pack consists of thirteen, 12 volt, sealed, lead-acid batteries for a total of 55 amp-hours at 156 volts. This will carry the vehicle up to 60 mph (97 kph), with a 40 to 60 mile (64–97 km) range.

The Sparrow I was priced at US$12,900. However, only a few may be still available in the showrooms of dealerships. The factory will not build any more after it fulfills its current list of orders. The Sparrow II will sell for US$16,900 from the factory or from a network of more than fifty dealerships.

Twike

Although commonly called the Twike, the full name of this vehicle from SwissLEM AG in Switzerland is the Twike.You. There are immediately visible differences between this and other city cars, even three-wheelers. For a start, the Twike has two wheels in the rear and one in the front. It’s a two-seater, but the seats are front and rear rather than side-by-side. Also, the wheels resemble motorcycle wheels more than car wheels.

The Twike is 8.7 feet long by 3.9 feet wide and 4.1 feet tall (2.7 x 1.2 x 1.3 m). It weighs 542 pounds (246 kg) empty, and 992 pounds (450 kg) fully loaded. The chassis is an aluminum space frame with a thermoplastic body.

When you look closer, more differences become apparent. The most noticeable is the steering joystick instead of a wheel. The next difference you notice is the pedals. I don’t mean throttle and brake pedals. I mean bicycle pedals.

You see, the Twike comes in two versions. The Twike.You “Easy” is for lazy souls who simply want to sit back and let the electric motor do the work. For those who would like to save the cost of joining a gym, there’s the Twike.You “Active,” in which you can add your own muscle power to that of the electric motor when you feel the need, through a 5-speed hub gear and an automatic pedal clutch. This gives you a bonus cardiovascular workout whenever you glance in the mirror and see an SUV bearing down.

The electric drive is an asynchronous, 3-phase AC motor. The battery pack is 360 volts, and consists of two or three nickel cadmium modules at 360 volts and 1 amp-hour capacity each. These are connected in parallel, so the total voltage remains 360 volts, while the amp-hour capacity increases to 2 or 3 amp-hours. (The basic setup has two modules, and a third is optional for more range.) These are recharged from a 230 volt, 10 amp socket in about two hours.

This setup can propel the Twike up to 53 mph (85 kph), with a range of 25 to 56 miles (40–90 km), depending on the number of battery modules and your muscle-power contribution. It can tackle gradients up to 22 percent. The Twike is just completing U.S. DOT certification, and should be available in the U.S. in the spring of 2002. Selling price is reported to be about US$20,000.

Gizmo

Even further afield from "conventional" transportation is the Gizmo, from the Neighborhood Electric Vehicle Company (NEVCO) in Eugene, Oregon. Despite the name of the manufacturer, I'm grouping this with "city cars" because it does not meet the strict federal definition of an NEV, which must have four wheels, and a top speed of no more than 25 mph (40 kph).

The Gizmo has a front two-wheel, rear one-wheel configuration like the Sparrow, but the shape is almost impossible to describe. The cab has removable fabric side and rear panels, for a quasi-convertible effect. To paraphrase Henry Ford, you can have it in any color you want, as long as it's white, although the fabric panels come in several colors.

The fiberglass body stands 8 feet long, 4 feet wide, and 4.5 feet high (2.4 x 1.2 x 1.4 m). It weighs 660 to 860 pounds (300–390 kg) depending on the battery pack, and has a payload capacity of 250 to 500 pounds (110–225 kg kg) and 10 cubic feet (0.28 m^2). It seats one.

The Gizmo doesn't have a door. To enter, you unlatch and tilt open the entire front canopy of the cab, and step inside. You can do this because there is no steering wheel in the way. The Gizmo is steered by a pair of push/pull levers that rise on each side of the seat.

Now put the key in... where? Oh, on the floor to the left. This will feel really weird, except to some Saab drivers. Next, you look for the pedals. There aren't any. The accelerator is a trigger, and the brake is a motorcycle-type squeeze lever, both mounted on the right steering handle. The left handle has the parking brake.

As you might guess, it's recommended that you spend some time driving around an empty parking lot before venturing into traffic. If manual coordination and multitasking are not your strong suits, the Gizmo may not be for you.

It uses a series DC motor, driving a single-speed, chain-driven transmission, with a forward/reverse switch on the right side of the cockpit. Since it only has a 48 volt battery pack, it is limited to about 40 mph (64 kph) top speed. This is not one of the city cars that can be taken on the freeway.

There are two primary choices for the battery pack: eight, 6 volt, flooded, lead-acid Trojan T-105s at 225 amp-hours; or eight, 12 volt, sealed Optima Yellow Tops at 110 amp-hours. Both systems are 48 volts, but the flooded pack is a single series string, while the sealed pack is two series strings wired together in parallel. The sealed batteries are lighter, 350 pounds (160 kg) for the pack, and give better acceleration and uphill speed. This is due to the internal design of the sealed batteries, which have lower separator resistance between the plates. The lower resistance allows the batteries to release their energy more quickly. The flooded batteries are heavier, 480 pounds (218 kg) for the pack, but give 45 miles (72 km) range compared to 35 miles (56 km) for the sealed batteries.

The main difference is durability in use. The sealed batteries are much fussier about their charge/discharge profile, and improper driving and charging habits can drastically reduce their cycle life. Even under perfect conditions, they are only good for about 350 cycles, as opposed to 1,000 cycles for the flooded batteries. This is especially relevant since the sealed pack and its attendant charging management system adds US$1,000 to the price of the vehicle.

With a top speed of 40 mph (64 kph), the Gizmo is appropriate for in-town driving rather than freeways.
Photo courtesy of NEVCO.

The car gets a full recharge from a 120 volt charger in about 8 hours. A 240 volt charger is also available for an extra US$400, and this reduces charging time by almost 75 percent. According to Ray Holan of Midget Motors, the midwest distributor for the Gizmo, off-grid users can charge the car with about 600 watts of PV panels. The

Gizmo sells for US$8,650 with the flooded battery pack, and US$9,650 with the sealed battery pack.

Different Strokes

This has been a sampling of some of the city cars that are or will soon be available. It is not an exhaustive list. If you come across another city car that interests you, a little research would be prudent. There are many "wannabe" and "gonnabe" EVs out there, and some never survive gestation to make it into the real world.

The thing to remember is that not all "cars" are created equal, nor should they be. A Ferrari is lousy for hauling a soccer team, and a minivan lacks a certain thrill, but each is great at what it was designed to do. Any vehicle that attempts to be everything for everybody will be a collection of compromises, and will not be really outstanding at anything.

We each need to take a realistic measure of our own driving needs, and tailor our cars to suit. If you live in a major metropolitan area, ask yourself whether public transit would be an attractive option for you if you had access to a city car at your destination. If so, find out if your area has a station car project. If they don't, ask them why not.

If you think owning a city car might work for you, try keeping a driving log for a month. Record your daily mileage, with notes about road or traffic conditions, passengers or cargo, and top speeds needed. At the end of the month, review it and mark the trips that would not have been possible in a city car. Then think about how often you make those trips, and whether another option, such as a rental car or taxi, might make economic sense for those times.

If you have a multicar household, try designating one car the city car for a month, and don't use it for anything a city car couldn't do. At the end of the month, you'll know a lot more about your *real* driving needs. For some people, a city car might be a perfect fit.

Access

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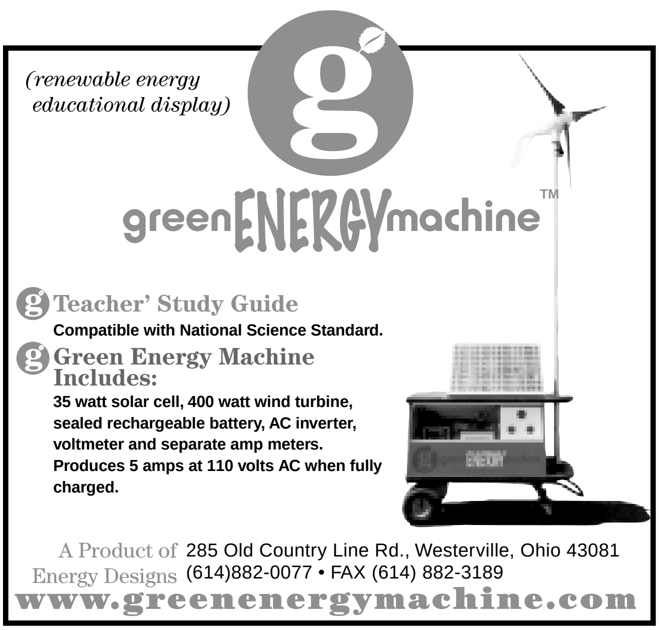
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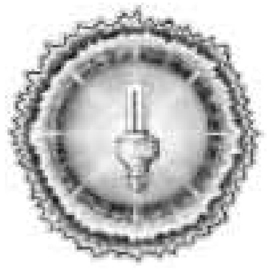

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TOP SECRET

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

PROFILE: 0018

DATE: December 2001
LOCATION: Northern Hemisphere
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 960 watts of PV
PERCENT OF ANNUAL LOAD: 25%
TIME IN SERVICE: 18 months

Strong environmental concerns have driven me to go solar. Oil is much too precious to be burned for heat when trees fall over in the forest and rot away. Here in my area, a good percentage of electrical energy is generated from nuclear plants. They still don't know what they're going to do with the waste from that.

I'm a telecommunications networking engineer. On the roof of my typical suburban home, there are eight Solarex MSX 120 solar-electric panels, with a peak rated output of 960 watts. I use a Trace C40 controller and a bank of eight Interstate, deep-cycle, marine batteries to store the energy. System voltage is 24 VDC. I use an APC Smart-UPS to convert the DC to usable AC. The UPS was going to be discarded due to the fact that its internal batteries were in need of replacement. I removed the internal batteries and wired the UPS to my marine batteries. I now have a constant source of about 600 watts of AC power. I estimate that I'm getting anywhere from 2.5 to 3 KWH of AC electricity from the PV system on sunny days.

Much of the energy stored is used for lighting, phone answering machines, and small devices that are usually on 24 hours a day. In fact, the energy necessary to run the computer monitor I'm using right now comes from the sunshine that falls on those panels.

The heating system in this residence is fueled by biomass (wood) and sunshine. Augmenting the woodstove are five solar hot water panels. All energy for pumps and fans is provided by the PVs on the roof.

The guerrilla part of my system is very simple. I have a MicroSine 100 watt inverter that is tied to the grid. When my storage bank of batteries reaches full charge, the MicroSine inverter feeds the grid with some of the excess energy I generate. The PV panels are directly connected to two devices. One is a Trace C40 charge controller and the second is the MicroSine. They are connected in parallel. The C40 is set to bulk charge to 29.6 volts, and float at 26.8. When the batteries reach full charge, the voltage on the panel side of the charge controller rises and the MicroSine begins to function. There is no switchover, and it is fully automatic. The MicroSine doesn't draw down the batteries because it is on the PV side of the C40.

I went guerrilla because I am reluctant to pay someone for something I can get for nothing with a calculated investment in the proper equipment. If you drive by the front of my house, you'd notice nothing, and I hope the tax assessor feels the same way. They won't even give me a tax break for my investments...

Guerrilla Solar Defined

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

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

A PV Education— One System at a Time

Cliff Millsapps

I'm a do-it-yourselfer sold on PV power. During the past twelve years, I've been blessed with a positive PV experience. Most of the credit goes to the forgiving and adaptable nature of PV. The rest goes to letting my experience and confidence grow in steps.

My start with PV was an accident. Initially, I was determined to use the wind. I lived in windy South Dakota at the time, so I was going to get a wind generator. I read and thought, and read and thought, but I never got anything done. Wind generators and towers just seemed like a big step to a complacent grid-fed novice.

First System: A Simple PV Powered Water Pump

While I dreamed about wind generators, I bought a PV panel, a linear current booster (LCB), and an inexpensive, 12 volt diaphragm pump. I pumped water to a pond, had backup garden irrigation, and made a stream demo table for an educational science display. These systems were simple and DC—just a nice step beyond my understanding of basic automotive DC.

I was fascinated by how the little LCB started the pump early in the morning and kept it running well into the afternoon, and right through periods of thin clouds. Without the LCB, the pump would only run in the middle of the day, in full sun.

The power (watts) a PV produces is equal to the module's voltage multiplied by its current (amps). Motors need a certain amount of current to start. An LCB uses voltage beyond what the pump needs to make more current (amps) available to start a pump motor. And it keeps the pump running in low light conditions. An LCB also increases pump output in full sun.

Second System: Grid Backup

I soon discovered *Home Power* magazine. *HP,* along with a Solar Energy International (SEI) PV course, gave me the confidence to buy five more PV panels, a 24 VDC Sun Frost refrigerator/freezer, a prototype inverter (PowerStar UPG, 900 watt), a meter (Omnimeter), and a couple of Todd chargers. I found a free set of telephone company batteries, put it all together, and casually continued my education.

The system used six Kyocera, 51 watt PV modules. These and the Sun Frost were quite an investment for my wife and I at the time, but we were excited to put our dollars into something we believed in. Knowing that our refrigeration was solar powered was a good feeling.

Besides being partially renewable energy (RE) powered, I had a good backup system to the grid. When the grid went down in the middle of a good old South Dakota blizzard, we still had electricity.

Forgiving & Adaptable

The idea that you can temporarily short circuit PV modules, and leave them open circuited without damage, makes them ideal for novices. Another beauty is that you can start with one panel, and just add on as you gain confidence and cash.

But keep an eye to the future size of your system. If you plan to increase the size of your system, buy inverters and charge controllers and size your wire with expansion in mind. These are things that are both easier and cheaper when done just once, rather than with each upgrade.

Cutting Corners

I wanted the PV system to pencil out, and I cut corners trying to make it pay back quickly, and be cost competitive to the subsidized grid system. I did this with my initial Sun Frost system (described in *HP39*). I felt that with my new-found knowledge, I could skip a lot of the idiot proofing that added expense to the system.

My decision to skip a charge controller was based on the "knowledge" that I had a small PV system (six, 50 watt panels) and a relatively big battery bank (about a ton) with a fairly consistent load (Sun Frost). The batteries were twenty-four, 2 volt, telephone company type, lead-acid cells. The stored energy was regularly being removed by the Sun Frost, and the capacity of the battery bank kept it from being overcharged by the comparatively small PV array.

The PVs' top-of-pole mount eliminated the potentially dangerous roof mount.

from high current, not high voltage. I fried at least one compressor and one electronic control unit. I replaced both compressors, and had a refrigeration guy recharge the system. I replaced the electronic control unit myself.

Do your system right! I'm still not code pure, but I think it is smart to work toward a code-compliant system, and build all new systems to code. If you can't afford to do the system you are hoping for correctly, do a smaller PV system first. Start with a vanilla system, and take on the complexities, one step at a time.

Good Batteries

The free batteries in my initial system were messy, prone to corrosion, and didn't have very much capacity for all that weight. Their only redeeming value was what I learned while attempting to salvage them. I later got a new set of eight Trojan L-16s (700 AH at 24 VDC), which was a real luxury. They have more capacity in a much lighter package, with a fraction of the terminals, and hardly any corrosion per terminal. In fact, when I finally got the L-16s, I was too careful with them.

Never pamper your battery bank more than your sweetheart! After we moved off the grid later on, and were looking at cloudy weather and a battery bank not even drawn down 25 percent, I was over cautious and started to curtail our already basic (relative to middle America) use of electricity. Darlene was all for cutting back, but when there were unexpected cutbacks, on top of the expected cutbacks, it became too much like camping.

Then one day after a fresh snow, the sun came out. The cold temperatures, crystal clear atmosphere, and highly reflective snow provided a combination that supercharged my PV system. We were really cranking out the juice. By noon the next day, I noticed the voltage creeping up toward the high end of the range recommended for the Sun Frost.

This was a little unexpected, but I said, "Ha, I'll just disconnect the Sun Frost to play it safe." Well... at a common junction, the wire terminal end to the battery was pulled off the connecting bolt a second or two before the terminal end to the Sun Frost was pulled free. The instant the voltage-buffering battery was removed, the voltage in the line to the amp-sipping 24 VDC Sun Frost jumped to more than 30 volts.

Even DC Sun Frosts have sensitive electronics, and the automotive type fuses they use only protect them

The tall pole is steadied just below the deck with cables.

Balcony Solves Roof/PV Hassles

Another thing I found to be a real hassle with my original system was where I chose to mount the panels—on the moderately steep roof of our story-and-a-half farmhouse. The roof is often the place people go to reach that solar window above the trees and other obstacles. The downside is cleaning snow off the panels in the winter, readjusting panels, and revamping the panel setup. These all were uncomfortable, dangerous, and frustrating experiences.

I built a balcony off the upstairs bedroom. By using a 5 inch pipe as one of the supports, and allowing it to extend up high enough, I had a mast for my PV rack. Steel pipe comes in 21 foot (6.4 m) lengths, which got the top of the mast up about 8 to 9 feet (2.4–2.7 m) above the balcony deck. The wind load on a rack of several panels, on top of a tall pole, can create a lot of leverage, so I cabled the pole to the house. I included turnbuckles so I could easily adjust cable tension.

The rack was attached to a 3 to 4 foot (0.9–1.2 m) length of 6 inch pipe, with a cap welded on it. It is easy to loosen three set-bolts and rotate the 6 inch pipe with its attached PV rack, on the 5 inch support mast. This is handy if you have a day when you really need to track the sun and produce all the energy possible. You can use separate bolt holes in an adjustment arm to seasonally change the slope or inclination of the panels.

Moving the PVs wasn't too hard with the help of this cherry picker.

Before building my own, I called the main manufacturer of similar mounts. I was ready to buy. I just needed to find out the offset, the center point, and the radius that the panel moved through. Then I could make sure that the rack wouldn't hit, or be shaded by the edge of the roof. The manufacturer didn't have time to answer my questions, so I got huffy and decided to build my own rack. It was educational and came out fine, but it seemed a waste to do the engineering for just one rack. I would encourage the next guy to push the mass manufacturer a little harder than I did.

Third System—PV for Off-Grid Construction

The rack I built had expansion potential to ten panels, which was farsighted, since we eventually packed up everything and moved to an off-grid property in Tennessee. Ah yes, PV is portable. Middle America didn't want my solar-assisted rural acreage in South Dakota, so I just took the PV system with me. (No, I never did get that wind system working up on the windy plains. I had bought a little Air 303, but never settled on what to do for a tower.)

In moving our PV system south, its modest size made things much less formidable. I had the electronic components and component wiring all mounted on a sheet of 3/4 inch (19 mm) plywood. All I had to do was disconnect the Sun Frost, the PV panels, and the AC circuit from the inverter, and take the sheet of plywood off the wall.

To pluck the rack mount off the balcony mast, I got a tree trimmer to bring in his big bucket truck. I had originally put the mount onto the pole with a makeshift extension on the loader bucket of my farm tractor. But the ease and peace of mind was worth the US$60 for the bucket truck.

When we got to Tennessee, we immediately wanted to crank the solar-electric system back up. All we had to do was provide some temporary shelter for the batteries and the components on the plywood sheet, slide the rack of PV panels off the trailer, turn them to face south, and hook everything back up. Don't give me grief about code compliance. It was this or use a hand saw or a noisy rented generator. I accepted the risks, and everything went fine.

Inverters

Three months prior to leaving South Dakota, I had sent my old modified square wave inverter in for an upgrade. Move time came and it was not back, so I bought a Trace DR2424 modified square wave inverter. It was just as well, since I don't believe that the old inverter would have given the desired service. I kept it for an emergency backup.

PV is portable!
The upgraded system at its off-grid location in Tennessee.

Millsapps Systems Costs

First System

Item	*Year*	*Cost (US$)*
Kyocera PV panel, 51 watt	1990	$295
Bobier Electronics LCB, 7 amp	1990	100
Flojet pump, 12 V, diaphragm	1990	93
	Subtotal	$488

Second System

Sun Frost RF19 refrigerator, 24 V	1993	2,275
5 Kyocera PV panels, 51 W	1993	1,500
Todd charger, 12 V, w/ adjustable pot	1993	157
Todd charger, 12 V	1993	116
Education: Sun Frost repair	1994	500
PowerStar inverter, 24 V, 900 W	1994	500
Omnimeter (meter w/ very fuzzy logic)	1994	350
4 Shunts, 100 A, 100 mV	1994	96
Trace C30 controller	1994	80
Heinemann breaker, 100 A	1994	40
Pole mount with adj. rack, 22 ft. tall	1996	500
8 Trojan L-16 batteries	1997	1,400
	Subtotal	$7,514

Third System (Water)

Dankoff Slowpump, 12 V	1998	$485
PVC pipe, 250 ft., fittings, valves, hydrants	1998	320
Poly repairable tank, 1,000 gal.	1998	245
Backhoe	1998	175
Trencher	1998	160
3 Concrete culverts	1998	75
Bobier Electronics LCB, 7 amp (replacement)	1999	85
	Subtotal	$1,545

Going Gridless Upgrade

4 Kyocera PV panels, 51 W	1998	$1,625
Trace DR2424 inverter, 24 V	1998	934
Welding cable, 20 ft., #2/0, plus lugs	1998	35
	Subtotal	$2,594
	Grand Total	$12,141

Trace developed a sleep or search mode for its inverters, which substantially reduces the power drawn by the inverter when it's just sitting there idling, waiting for a load. In search mode, the inverter's output is limited to the small pulses it sends out about once a second.

These pulses are "looking" for a load. If a load is sensed, the inverter's output comes up to full voltage to power the load. The sleep threshold, or size (wattage) of a load large enough to bring the inverter out of sleep mode, can be set by the user.

On the DR inverter, the sleep threshold can be set between 0 watts (always "awake") and about 100 watts. But household wiring has resistance. So do appliances, even when they're turned off. The inverter's sleep circuit senses this combined resistance as a tiny "load." And the amount of this combined resistance varies with changes in temperature and humidity. As a result, I periodically need to fine-tune the DR inverter's sleep threshold so that it starts up with a real load, but doesn't stay on (humming) because of changes in resistance in the household wiring and appliances.

My unit would benefit from having a larger knob with more sensitive tuning capability. You can turn the knob all the way in one direction to make the inverter stay on all the time, which is necessary for running some fluorescent lights and charging cordless tool batteries. The Trace has charged my DeWalt cordless drill many, many times, but the one time I forgot to shut the sleep mode off, it fried the battery I was recharging.

Also, if the sleep mode is on, and nothing else is pulling juice, there is a momentary lag between pulling the trigger or flipping the switch, and the next time the Trace checks and sees a load. This takes some getting used to.

Fourth System—Water Pumping Again

After getting some basic shelter squared away on our new property in Tennessee, the next project was the water system. The water system taps a spring that is at a lower elevation than the building site. I used a concrete culvert as a stilling well, and used a 12 volt Dankoff, vane-type, Slowpump to push the water to a 1,000 gallon (3,800 l) poly holding tank. The tank is about 60 feet (18 m) higher elevation than the well, and 25 to 30 feet (7–9 m) above the building site.

I buried 3/4 inch PVC from the stilling well to the house, and 1-1/2 inch PVC from the house to the tank. I like the idea of a gravity pressurized water system, and the big line can really put out the water at the the building site (great for fire protection). Again, pumping water is a nice PV project. The components are few, it's reliable, it doesn't take an electronic wizard to set it up, and often it is the most cost-effective means.

For power, I used a couple of old hammered panels. One was a "bronze quadlam" that had the glazing caramelized by concentrated sun in an early utility-scale PV installation. I dragged it around for years on a mobile electric fence charger. The sheep ran over it, and the tractor banged into it, busting the trim loose.

The other panel had the glass honeycombed years ago, by me whapping the edge with a stick trying to get the 1/2 inch of ice glaze off. It is really hard to kill a PV panel. Considering the abuse these had, it is amazing that they work at all. I'll guess that these panels have lost less than 30 percent of their output compared to when they were new.

I wired the PVs in parallel and mounted them on a makeshift cedar rack. I found a hole in the tree canopy, wired the PV panel to the pump with an old hefty extension cord, and I was pumping water.

Of course I used an LCB, but learned that inside the humid concrete stilling well was a poor location for it. My LCB quit working after a couple of months. I left it sitting out in the sun for a few days and it started working again. It was probably moisture that caused the failure, although it died for good after another month in a drier location.

Moving Again

Before we could get started building the real house, we ended our gridless experience. We moved to a started home (exterior shell completed) with the grid attached, and the previous cabin, shop, and property sold. The lender for the buyer seemed willing to loan an additional amount for the solar-electric system, but didn't have an appraiser that could provide an evaluation. There's a service business opportunity here for someone willing to establish agreements with lenders, and do some traveling.

At any rate, the new cabin property owner opted to start out with a generator. I left all the components of the water pumping system, but moved the main PV system to our new location to eventually be used for grid assist. For the present, I have just set the system up as a grid backup. I am waiting to get and try a new experimental transfer switch that will watch the battery, and will seamlessly and automatically switch between grid and RE, relative to programmed conditions. This will save me many headaches if it works.

PV for Plain Communities

We've moved into an area where there are Plain communities (Amish and Mennonite) living largely without electricity. They are a disciplined group of families who take a strong stand against forces they see as potentially damaging to family and children. They want interdependence within their families and their communities. Horses are the primary source of farm power, and horse and buggy the primary means of travel.

These people can get along quite reasonably without electricity most of the time, so why couldn't we do with less until I expanded our system? My wife Darlene tried my idea, bless her heart, but she led me to see that this wasn't a camping trip. She pointed out that the Plain families had accustomed themselves to other means of providing lighting, refrigeration, clothes washing, etc.

Traditionally, kerosene lights and the Honda gas engine have been the mainstay for nondraft power around the Plain farmstead. The Honda can be used mechanically for most everything, including running the washing machine, irrigation pump, and grain grinder, and yes, it is even occasionally used to drive an electrical generator. Their beef isn't with technology in general, but has to do with a concern for the family and community unit. If they feel that a certain technology pulls members of their family or community away, or reduces their need for each other, they say no to that technology. Hmm.

At any rate, the PV panels' reliability, durability, and improving relative cost, have made them attractive to the Plain communities around here. They are a sensible means of getting rid of the smell and fire hazard of kerosene lights. I've seen PVs sprout up in several yards of Plain families during the past year.

These systems are usually just a single panel or two. They provide modest lighting, charge up the buggy's signal light battery, or power a cordless drill. It's only a matter of time until the noisy, smelly Honda gets a rest, and a handful of panels takes on the load.

The Future

Looking down the road with a global perspective, I hope we move toward millions of small grid-tied RE systems. The place to put these preferable, but still ugly, power producers, is alongside, or on top of the blemish of our own homes.

I used to preach about the merits of wind farms, until they started wanting to put one up close to some farm ground I own in northeast South Dakota. The rugged, open, and uncluttered nature of the area is dear to me. I want the raw landscape, the huge skyline, the sunrises and sets, just the way they are.

No, I wouldn't rather have a nuclear power plant to make up the shortfall. What I would rather have, as soon as possible, are cheap PV roofing panels. Make up the shortfall with PV electricity, made where it is used, during the day when most of it is used. It's certainly worked for my family, in a succession of homes.

I started with just a small amount of equipment. As I learned, I expanded and improved my systems. I was able to apply the lessons I learned from one system to the succeeding systems. And I used some components from each system for the next generation. I'm still using some of the equipment I started with back in South Dakota. You, or anyone, can start with the basics, grow a system as you learn, and adapt it as necessary. So why not get the rest of the population hooked on PV?

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Installing EV Gauges, Part 2—Wiring

Mike Brown

In my column in *HP85,* I covered electric vehicle (EV) gauge selection. Last issue, I covered mounting the gauges in your vehicle. Now that you have the gauges mounted, you need to wire them to the parts of the EV drive system that they are monitoring.

This wiring involves both the high voltage traction battery pack and the vehicle's original 12 volt electrical system. So we should take another look at some wiring basics.

Never the Twain Shall Meet

The vehicle's existing 12 volt electrical system powers the lights, turn signals, wipers, radio, and the low voltage part of the drive control system. It uses the chassis of the car as its negative or ground path.

On the other hand, the traction battery pack and the high voltage components of the drive system must be isolated from the chassis of the car for proper operation, as well as safety. The motor, controller, battery charger, and all the other high voltage components do this internally.

The wires and cables that connect the parts of the high voltage system make up both the positive and negative paths of the high voltage circuit. They "float" above the chassis, with no electrical connection to it. The gauges you are installing are an instance where both systems come together in a small area, and the potential for problems exists.

The Right Wires & Connectors

Smaller gauge wires are usually where mistakes are made, failures occur, and accidents happen. It is a mistake to use any wire size less than #16 (1.3 mm^2) in a conversion. Smaller gauge wires have less physical strength and thinner insulation. It is also harder to crimp a crimp-on connector on smaller gauge wires, due to the difference between the wire's outside diameter and the inside diameter of the connector's barrel.

Another common mistake is using the wrong connector size, usually by trying to crimp too large a connector on too small wire. The result is a mangled connector barrel from over-crimping the connector to get a tight crimp on the small wire.

The insulation on the connectors is color coded to tell which gauge wire it should be used on. A red insulated connector is made for wires from #22 to #18 (0.3–0.8 mm^2), but I find it to be a perfect fit for #16 (1.3 mm^2) as well. A blue insulated connector is nominally for #16 to #14 (1.3–2.1 mm^2) but I find it a little big for the #16. It will also accept two #16 wires twisted together if you need to daisy chain several components to a common power source or ground. A yellow insulated connector is for #12 to #10 (3.3–5.3 mm^2) wires, or two #14 (2.1 mm^2) wires twisted together.

Connectors are sold with different insulating materials (vinyl and nylon), and different barrel styles (single crimp and double crimp). I prefer the connectors that have a metal barrel over the bare wire, and a longer metal sleeve that covers both the connector barrel and the wire's insulation. The whole barrel and sleeve assembly is covered by molded-on, color-coded nylon insulation.

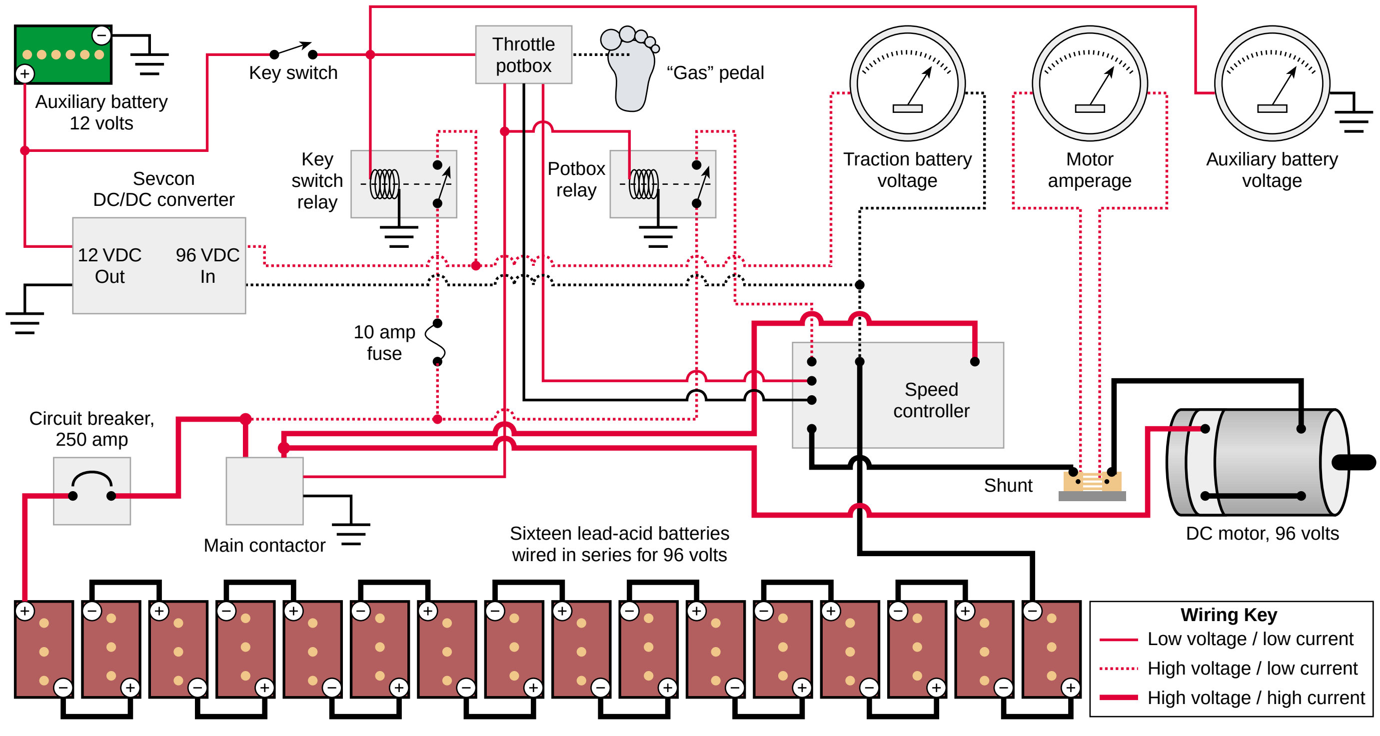
This connector has to be crimped twice—once to crimp the barrel and sleeve to the wire, and once to crimp the sleeve to the wire's insulation. I've found that the nylon insulation holds up better during crimping than the vinyl, and I like the extra strength the second crimp on the wire's insulation gives the connection.

Recycling Original Wiring

There are a lot of surplus wires left over from the old gas or diesel system that could be used to connect the gauges to the places in the electric drive system where they pick up their signals. But finding them under the dashboard and pulling them out of the wiring loom is a lot of work. Once found and separated, they will probably not be long enough to reach the location of the new EV gauges. In general, I have found it easier to run new wires between the gauges and their pick-up points.

If your donor vehicle has warning lights that indicate trouble with the charging system or oil pressure, these lights and the wires between them and the former engine compartment *can* be adapted to EV use. Both of these lights come on when the ignition key is turned on. The charging light goes off when its ground is removed

EV Wiring, Including Gauges



by the alternator starting to charge the battery. The oil pressure light goes off when the oil pressure switch is opened by pressure in the engine's lubricating system.

You can rewire the alternator light so that the wire that used to go to the alternator now goes directly to a chassis ground, which will turn on the light with the ignition key. Since the ignition switch also supplies power to the low voltage side of the EV control system, you now have a light in the dash telling you that your silent EV is turned on.

The former oil pressure light can be turned into a motor overheat warning light. Most of the electric motors used in conversions have two small wires coming from a hole in the side of the motor. These wires are attached to a temperature switch mounted inside the motor between the field coils. This is a normally open switch that closes at temperatures ranging from 120 to 180°C (248–356°F). The closing temperature varies from manufacturer to manufacturer.

If you connect one of the motor wires to the oil pressure light wire, and the other motor wire to a chassis ground, you will have a light in the dashboard that will warn you if your motor is in danger of damage from overheating.

Bench Work

The place to start the wiring process is with the gauges themselves. Because working in the confined space under and behind a car's dashboard is no fun and likely to cause wiring errors, I prefer to do the wiring of the gauges themselves on the workbench.

As we determined in the first article of this gauge series, the gauges you will be installing are a battery pack ammeter, a battery pack high voltage meter or state-of-charge gauge, and maybe a voltmeter for your 12 volt accessory battery.

On the workbench, install the gauges in the mount so you have the best view of the ammeter. Next, pick out the wire insulation colors you are going to use for the high voltage positive and negative wires, the two ammeter wires, the wires to the auxiliary battery voltmeter (if you are installing one), and the 12 volt positive and ground for the gauge lights. Record these color codes in your project notebook.

Try to follow the car's original color protocols when possible. For example, on German cars, the ground is usually brown, while on American cars, it's black. For wires that have no corollary in the car's original system, arbitrarily pick a color for each part of the circuit, and be consistent. I use blue for high voltage positive, yellow for high voltage negative, and green and white for the shunt. Pick something that matches your decorating scheme.

Now you can hook up the gauges, following the manufacturer's instructions. When cutting the wires for the high voltage voltmeter and the ammeter, cut them long enough to go through the firewall and extend out into the engine compartment a couple of feet. The wires for the auxiliary voltmeter and the gauge lights don't have to be as long because they will be hooked up under the dashboard.

In the Car

Install the wired gauge and mount assembly in its place. Run the four wires for the high voltage voltmeter and the ammeter through a factory original grommet in the firewall or through a new grommet in a hole drilled for them. The grommet is a rubber donut that protects the wires from sharp cut edges of sheet metal. There is often enough room in factory grommets to squeeze through one or two more wires.

Now you can go back under the hood and finish connecting the gauges to what they are measuring. Locate a convenient place on the firewall, and install a terminal block that has enough spaces to accommodate the wires from the gauges. Run the wires coming out of the grommet in the firewall up to the terminal block and cut them to length. Next, crimp suitable connectors to the wires and fasten them to the terminal block. As a finishing touch, gather the wires into a loom, and tie them together with tie wraps at regular intervals.

Now you can run the wires from the terminal block (which you can see and reach easily), along existing wiring looms that you can secure them to, and to the terminals on the components where they pick up their signals. Dividing the gauge hook-up wires into two parts with the terminal block makes the job easier and more accurate. It also cuts down on the amount of wasted wire, since you don't have to run a lot of extra "just to be sure."

Ammeter Connections

The ammeter measures the electrical current passing between the batteries and the motor. It gets its signal from a device called a shunt. A shunt is a precision resistor. The 50 millivolt, 400 amp shunt or the 50 millivolt, 500 amp shunt used in electric vehicles drops 0.125 or 0.1 millivolts, respectively, for each amp passing through the shunt. The amp gauge is scaled to show this millivolt drop in terms of DC amps.

The shunt allows us to measure 400 to 500 amps running through #2/0 (67 mm^2) cable from the batteries to the motor, without actually having a current through the gauge. The millivolt signal being taken off the shunt can easily be run through two #16 (1.3 mm^2) wires.

The shunt should be located in the power circuit between the motor negative terminal of the controller and the negative terminal of the motor itself. In this position, it reads motor current, which is the most accurate measurement of energy use. It is also the first thing manufacturer's motor and controller technicians want to know when they are trying to troubleshoot a problem.

When cutting the ammeter wires at the shunt end, make sure that each wire will reach either small terminal on the shunt in case you have to reverse them to get the gauge needle to move in the right direction. Some gauge manufacturers aren't very clear on which hook-up pin goes to the load side of the shunt. So you have a 50/50 chance of getting it right the first time, with no harm done if you get it wrong. Due to the size of the signal and the fact that it is attached to only one leg of the high voltage circuit, it is not necessary to fuse these wires.

Battery Pack Voltage

The battery pack voltmeter or state-of-charge meter needs to be attached to the battery pack's most positive and most negative terminals. This does not mean directly to those terminals on the batteries themselves. Connecting to the battery terminals can be impractical and unreliable.

In most EVs, the battery pack is split into two or more individual packs at different ends of the vehicle. Either the most negative or most positive battery terminal ends up at the rear of the car. This would make for a long wire run for one leg of the voltmeter wiring.

Another reason for not connecting the voltmeter leads directly to the battery terminals is corrosion. It has been my experience that any small gauge wire and connector attached directly to a battery terminal attracts corrosion that wouldn't form if there was only a #2/0 (67 mm^2) lug attached to that terminal. It doesn't take much corrosion to eat through a #16 (1.3 mm^2) wire.

The cable from the most positive terminal of the pack always ends up at the positive side of the main contactor. This is the place to connect the positive wire for the voltmeter. The only problem with this location is that it is always connected to the battery pack, and a voltmeter hooked to it will always be on. Since it is neither necessary nor desirable that the voltmeter be on at all times, use a small relay that is closed when the EV is turned on to connect the meter to the contactor. Due to the high voltage involved, you should add a fuse in the #16 (1.3 mm^2) wire that runs from the positive main contactor terminal through the relay to the meter.

I usually connect the voltmeter's negative lead to the battery negative terminal of the controller, which is where the cable from the battery pack's most negative terminal ends up.

Accessory Battery Voltmeter, Lights, & Tach

The accessory battery voltmeter, if you are using one, gets its positive voltage from the key switch when the key is turned on. The best place to pick this up is at the vehicle's existing fuse block. Use your factory shop manual's wiring diagram to determine which fuses are controlled by the key switch, and hook your positive gauge lead to a terminal on the load side of the fuse. Like all 12 volt accessories, this voltmeter gets its ground from the vehicle's chassis.

One of the advantages of automotive style gauges is that they can be lighted. To do this, the positive wire for the bulb is piggybacked onto an existing dash light to take advantage of the dimmer feature of the car or truck's dash light system. The negative side of the circuit goes to a chassis ground.

If you have a tachometer you want to use, tach drives are available for sale. If you want to build your own, I have a circuit diagram I can send you. These are optical drives that count the blades of the motor's cooling fan, and turn that count into a signal that your existing tachometer thinks is coming from the original engine. They are powered by the car's 12 volt system.

As always, if you want to discuss this subject further or have any other technical questions, feel free to phone, write, or e-mail me. This column is meant to be a two-way conversation. Talk to me.

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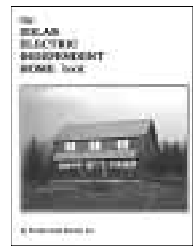


Wŏrd Pow´ẽr

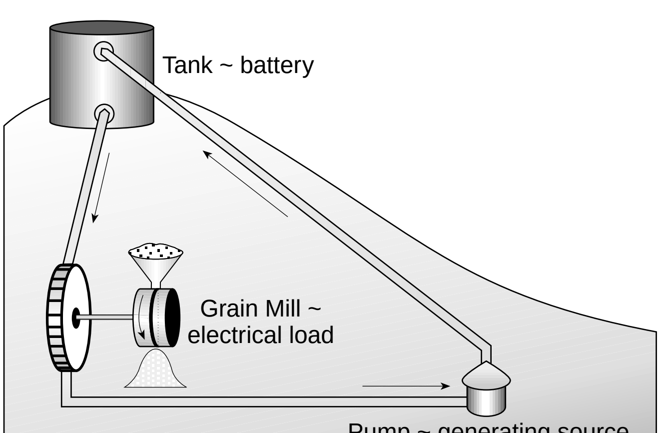
Renewable Energy Terms

Electricity: An Analogy

Ian Woofenden

For a long time, folks have been wrestling to come up with a comprehensive analogy for basic electrical terms and functions. With help from a variety of smart people, I think I've come up with something. I hope it helps you visualize things, and clears up some of the confusion caused by the misuse of electrical terminology.

Volts ~	water pressure
Ohms ~	resistance of the pipe, fittings, and mill
Amps ~	gallons per minute
Amp-hours ~	total gallons through the mill
Watts ~	grain ground per minute
Watt-hours ~	total grain ground



In the diagram below, the pump is analogous to the generating source—PV, wind generator, etc. The tank is analogous to the battery in a simple DC system. The plumbing represents the wires, and the water represents the charges or electrons that flow in the wires.

Volts are analogous to pressure in the water pipe. It's the "push" that gets the water up to the tank, and the same "push" that the water in the tank exerts on the pipeline down to the mill. Ohms are analogous to the resistance of the pipe walls and fittings, and of the pump, battery, and mill.

Amps are analogous to gallons per minute of water flowing in the pipe. An amp is the rate of charge flow (coulombs per second). Amp-hours are analogous to the total gallons pumped through the system. An amp-hour is accumulated charges over a period of time.

Notice that this is a closed loop system. There's a certain amount of water in the system, and it just flows around and around. In the same way, charges in an electrical circuit flow around and around. They are not "used up," nor do they flow out the end of the wire like water out of the end of a hose.

Two things flow in an operating electrical circuit—charges and energy. In this analogy, the water system is showing only the flow of charges (you can think of them as electrons). To get to the flow of energy, I've introduced a grain mill, powered by water (representing an electrical load, powered by charges).

Watts are analogous to the grains per minute being ground by the mill. It's the rate of energy transfer. The energy is transferred by the charges, but it travels instantly from source or battery to load in a one-way trip. Energy is applied to the system at the generator, and the grain mill instantly grinds some grain. A watt is the rate of energy flow (joules per second).

Watt-hours are analogous to the total grain that has been ground—energy used. The charges drive the mill, and the energy is instantly transferred from the pump (generating source) or tank (storage device) to the grain mill (electrical load). A watt-hour is energy generated or used over a period of time.

All analogies are imperfect in one way or another. Or as one scholar said, "All models are wrong. But they're useful." I hope this one helps sort out a few of the mysteries of common electrical terms.

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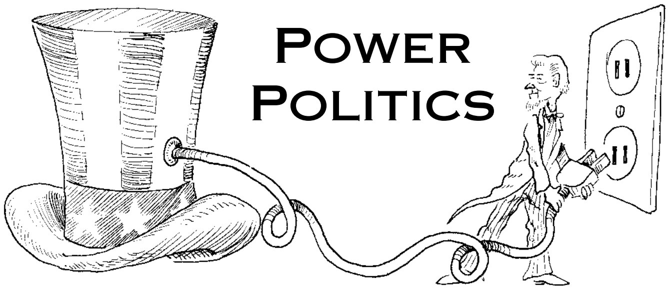

Nuclear Cities & A Pipeline War

Michael Welch

Early in November, forty-one tons of high level nuclear waste, in the form of irradiated reactor fuel, were delivered to Zheleznogorsk in the Krasnoyarsk territory of Siberian Russia. The fuel came from an electric power reactor in Kozlodui, Bulgaria.

Bulgaria is on the southwest shore of the Black Sea. While the routing details are considered a state secret, antinuclear activists are certain that the irradiated fuel rods were shipped by rail around the Black Sea, through Ukraine, and across much of Russia to south-central Siberia. This is the first shipment of many intended for this and one other formerly secret Siberian "nuclear city."

Nuclear Cities
The cold war left a lot of problems for Russia, especially for its secret weapons outposts. Several cities like Zheleznogorsk were so secret that they appeared on no maps. Mail to entire cities was quietly routed through postal boxes in nearby, publicly known towns. The cities were kept secret because they contained the nuclear and chemical facilities that we so often hear about in the former U.S.S.R. They became known as nuclear cities.

Entire regions were supported by big spending on these facilities and other Cold War projects. But then the Soviet Union collapsed from that same overspending and other political pressures. The collapse of the system left behind a legacy of unemployment, contaminated ecosystems, and the possibility of terrorist groups obtaining nuclear scientists and nuclear materials.

Similar Danger for the U.S.?
It is scary to consider that our own economy may be only a few decades behind the failed Soviet economy. U.S. politicians continue to buoy up our nonproductive war economy through exorbitant spending on the military, which produces no net gain for our society. It may be only a matter of time before it comes back to bite the citizens of the U.S. and other nations, just as it did in the former U.S.S.R.

Our apparent prosperity is not lost on Russian politicians as they look for new ways to bring money into their cities. They figure that as long as they have places like their already contaminated nuclear cities, there must be some way to cash in. That same concept of cashing in extends to the displaced scientists, bringing us the fear that they will sell out their knowledge and weapons to terrorists with ill will towards the U.S. That, of course, would be illegal, and would have potentially devastating consequences.

What isn't illegal is that Russia last summer began to set itself up to become a repository and reprocessor of nuclear waste from the rest of the world. While eastern European nations had long sent their radioactive waste to the Soviet Union, a 1992 law banned expansion of those arrangements. A 1997 agreement allowed that recent Bulgarian shipment, supposedly still under the 1992 law.

In the Russian Backyard
But this summer, the Russian Parliament passed a new law that would open the country to accepting waste from countries not included in the old law. Now Russian and international environmental and antinuke activists fear that lots of nuclear nations will try to take advantage of this situation.

The fears are not unfounded. There is hardly a nuke nation in the world that is not worried about what to do with their reactor and weapons waste. There is even speculation that the U.S. nuclear industry is interested, since their own Yucca Mountain, Nevada nuclear waste repository may never be opened.

As you might imagine, the Russian citizenry is dead set against importing nuke waste. Politicians are largely ignoring polls showing that 80 to 90 percent of Russians are against the importation plan. Even though this recent shipment was approved under the old law, Russian environmental activists saw it as a symbol of things to come, and an opportunity to protest the law before newly approved waste shipments began rolling in.

Russian politicians argue strongly in favor of the economic benefits of dumping the world's waste in Siberia. They estimate that two sites can be made ready for storage within three years, and that a reprocessing facility could be completed by 2020. They claim that they can make an estimated US$20 billion by importing 20,000 tons of waste in the next decade. And they talk about using those profits to clean up the Russian environment. Yeah, right.

Greenpeace calculated that by the time the money is collected and the facilities paid for, there would be only US$10 left per Russian citizen from the multibillion dollar deal. Meanwhile, about 140 grams (5 ounces) of deadly nuclear waste per capita would be accumulated under the plans. Russians know that they and the environment are getting screwed.

According to a November 10 article in the *Moscow Times,* Greenpeace activists participated in a protest of the plan and the government's unwillingness to discuss the shipment routes. They gathered in front of the Nuclear Power Ministry building, demanding a halt to nuclear waste imports to Russia. They installed a symbolic gravestone and put up a 10 meter (33 foot) banner reading in Russian, "Stop Nuclear Slavery in Russia."

Edited map courtesy of U.S. Central Intelligence Agency as found at www.lib.utexas.edu/maps/

Activists also gave ministry officials a fake nuclear waste container. And a model of a section of the Trans-Siberian Railway was shown to point out that there was a 14 car train derailment on the railway around the time the 41 ton shipment was coming through.

Of course, Russian officials would not release the train schedule so that an accident with the nuke train could be confirmed or denied. Other reports from Russia had the train accident occurring three days after the nuke train came through. Either way, it shows how serious a problem it is to transport such dangerous materials over those vast distances.

Pipeline through Afghanistan?

While we're in the Asian neighborhood, I want to comment on what is beginning to be uncovered as one real reason we are fighting in Afghanistan—the placement of an oil pipeline. Such a pipeline could open up a huge reserve of oil in the Caspian Sea area to the largely oil-starved areas of south-central Asia. And U.S. oil companies want to build and operate the pipeline.

According to the U.S. Department of Energy's Energy Information Administration, "Afghanistan's significance from an energy standpoint stems from its geographical

Caspian Region Oil Production, Exports, & Reserves

Country	Production (1,000 BBLs per Day) 1990	2000 Est.	2010 Possible	Net Exports (1,000 BBLs per Day) 1990	2000 Est.	2010 Possible	Oil Reserves* (Billion BBLs) Proven	Possible	Total
Azerbaijan	259	280	1,200	77	155	1,000	4 - 13	32	36 - 45
Kazakhstan	602	693	2,000	109	452	1,700	10 - 18	92	102 - 110
Russia**	144	11	300	0	7	300	3	14	17
Turkmenistan	125	148	200	69	83	150	1	80	81
Uzbekistan	86	152	200	-168	16	50	1	2	3
Totals	1,216	1,284	3,900	87	713	3,200	19 - 36	235	239 - 270

** Excludes Iranian oil, since it is not politically available*
*** Includes Astrakhan, Dagestan, and the North Caucasus region bordering the Caspian Sea*
Data from United States Department of Energy

position as a potential transit route for oil and natural gas exports from central Asia to the Arabian Sea. This potential includes the possible construction of oil and natural gas export pipelines through Afghanistan, which was under serious consideration in the mid-1990s. The idea has since been undermined by Afghanistan's instability."

There you have it in a nutshell. Years of civil strife and Russian invasion have contributed to Afghanistan being among the poorest and most politically unstable nations. Everyone, Taliban and Northern Alliance fighters alike, wants to see an economic change. (For political/geographic information, see the U.S. Central Intelligence Agency's *World Factbook* for Afghanistan at www.odci.gov/cia/publications/factbook/geos/af.html.)

Afghanistan does not have a lot of gas and oil itself, and local production steadily decreased in the '90s. Its greatest potential for wealth and influence lies in the transport of oil. Oil from the Chardzou, Turkmenistan refinery, and the Russian western Siberian oil fields that it is linked to, needs to be transported to Pakistan's Arabian Sea coast. Other gas and oil pipelines are also being considered. But before any can be built, rule needs to be consolidated into a factionless governing body that is both friendly to the West and stable. It remains to be seen if the Northern Alliance can produce such a government.

Afghanistan's southern neighbor, Pakistan, is as close to a U.S. ally as there is in the region. If U.S. oil interests can pull off the planned 1,000 mile (1,600 km), million barrel per day Central Asian Oil Pipeline Project, Pakistan might become the economic and political leader of the region, and under U.S. control. The demand for oil and gas there is largely unmet.

Incredible profits can be had in the region, much more than by shipping the oil west and north and ultimately to Europe, where demand has pretty much leveled out. Increasing oil availability in Europe would only serve to lower prices and profits. If the oil gets moved through Russia to the west and Europe, it would enhance Russian power and control, while leaving Western oil interests out in the cold. It would also make it more difficult for our ally Pakistan to become a larger Asian force.

Of course, there is no way that the U.S. would allow the oil to be pumped through Iran, another route to the south. The U.S. government is still trying to isolate that regime. Besides, the big point is that more money can be made by piping to the oil-starved south, rather than to the oil-rich Persian Gulf.

War for Oil Profits

In case there is still doubt as to why President George W. Bush and his cohorts are really in Afghanistan, here is what our own Vice President Dick Cheney had to say to oil industry executives in 1998 while he was still an oil company executive: "I cannot think of a time when we have had a region emerge as suddenly to become as strategically significant as the Caspian."

A statement by John J. Maresca, a U.S. ambassador under the previous Bush administration, gives even more perspective on the current war. During 1998 Congressional hearings, Maresca, currently with Unocal Corporation, the leader of the consortium of oil companies calling for the pipeline, said: "The territory across which the pipeline would extend is controlled by the Taliban, an Islamic movement that is not recognized as a government by most other nations. From the outset, we have made it clear that construction of our proposed pipeline cannot begin until a recognized government is in place that has the confidence of governments, lenders, and our company."

There is still plenty to be said for the idea of wiping out a terrorist organization, especially one that is such an immediate threat to U.S. civilians. But it may have been our own oil-tainted politicians and media that pushed us to leap from finding Osama bin Laden to wiping out

Afghanistan's Taliban. Was there really a need to take that extra step, other than for oil company profits? I'm not so sure. We definitely can't rely on this oily administration to be truthful about it.

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Don Loweburg

Economic Payback

In *HP85, IPP* examined how time-of-use (TOU) metering and net metering affected payback time. TOU can significantly reduce the payback time for a PV system if a household can manage its daytime loads.

Back in *HP65* ("Beyond Net Metering"), *IPP* envisioned the possibility of real time pricing and how that would improve the economics of PV. Real time pricing is still not a reality, but changes in California's utility rate structure have improved the economics of PV. TOU and net metering together certainly represent a step beyond net metering alone.

However, most California residential utility customers are not on TOU, but rather are charged according to a multilevel or tiered price schedule. The recent rate hike given to the utilities in California was achieved by significantly increasing the price of the tiers above baseline, while baseline rates remained unchanged. This strategy put the bite on heavy users of electricity.

It is not uncommon when reviewing these customers' electric bills to see third and fourth tier charges as high as US$0.25 per KWH. Since the economic benefits of PV will accrue to the highest tiers first, the economic payback time for a PV system is reduced significantly for customers with high usage. For example, at US$0.12 per KWH, simple payback would happen in about fifteen years. However, at US$0.25 per KWH, the payback happens in about seven years.

These figures do depend on the 50 percent rebate available to Californians. What we can see here is that as utility rates more accurately reflect the time value of energy, and send appropriate price signals based on the volume of energy consumed, opportunities for economic PV develop.

Lovins on California Electricity Restructuring
Amory Lovins' writings may be known to many *Home Power* readers. He is CEO of Research at Rocky Mountain Institute, author of many books on energy efficiency, credited with the concept "negawatts," and designer of the Hypercar. On July 11, 2001 he made the presentation, "Electricity Solutions for California," to the Commonwealth Club of San Francisco. Though commentary about electric restructuring has been generous in *Home Power,* these additional comments by Lovins are edifying and generally amplify points made in past columns.

Amory Lovins began with four statements about electricity restructuring that run counter to common opinion:

- California's electricity demand did not soar. Nor was there a huge increase in demand due to the Internet and the dot com boom.
- California did not stop building generating plants during the 1990s.
- Even during outages, California was not short of generating capacity.
- The current rush of generating plant construction may result in overproduction in the future.

Lovins provides extended dialog on each of these points. Interested readers can get a copy of the presentation by contacting IPP. Besides debunking the four myths cited above, his main conclusions are that market gaming and intentional reduction of plant output by generators created the emergencies, and that flaws in the restructuring legislation made certain that retail competition failed.

Dealer-Installer Certification Programs
Training for installers and dealers of PV systems has been offered by distributors and manufacturers for many years. There's been everything from one-day, topic-specific sessions to longer trainings involving home study and hands-on infield components. For many years, Solar Energy International (SEI) has also offered both short and long classes on a wide range of renewable energy topics.

The North American Board of Certified Energy Practitioners (NABCEP), currently applying for nonprofit status, is organizing and developing a national certification program. The board includes participants from all areas of the PV industry. NABCEP will be incorporating successful elements from existing programs. The goal of the project is to create a national installers' certification standard and test.

The voluntary certification program is targeted to be in place by midsummer of 2002. A menu of work and training options has been developed as prerequisites to taking the certification test. To view the draft of the requirements, go to the NABCEP Web site.

System Output—Xantrex Publishes Study

In the last few columns, I've reviewed Sandia's work on module output and how to make reasonable predictions for system power and energy output. Based on some simple approximations, it was shown that a system's AC power output is about 70 percent of the solar-electric array's STC rating (the manufacturer's nameplate DC rating).

Xantrex, in response to customer concerns about systems producing less than expected, has recently released a white paper on this topic. Titled "Measuring Photovoltaic and Inverter Efficiency and Performance," the paper goes into great detail explaining the instrumentation and methodology of measuring system output.

Other system issues, such as a module's maximum power point (MPPT) variation with temperature and installation site details, are also covered. The conclusions are very close to those of the casual approach used in past columns, but the rigor and detail may be of interest to some. The paper is available on Xantrex's Web site.

Caspian Sea Oil

The popular view of the war in Afghanistan holds that it is about terrorism and the September attacks on New York and the Pentagon. On the surface, this seems like a reasonable conclusion. But looking deeper, I suggest that it's about oil.

Several years ago (*IPP, HP69*), I mentioned the oil fields being developed in and around the Caspian Sea basin. My information came from a series of articles by Frank Viviano written for the *San Francisco Chronicle.* Titled, "New El Dorado," the series began in the August 11, 1998 issue. According to Viviano, the Caspian Sea area holds oil and gas reserves equal to the Persian Gulf.

The author detailed the extreme political instability of the region, and the difficulty of locating the pipelines needed to get the oil to western markets. Certainly the political stability of the region has not improved since that time!

My analysis is that the growing fundamentalist Taliban control of that region was totally unacceptable to the oil cartels and their governments. September 11 aside, it was only a matter of time before the need for western control of this oil rich area would lead to military action. The destruction of the towers provided the green light. Our addiction to imported oil comes at a high price.

Renewable Lab

Drake Chamberlin, wrench and IPP member, is heading up the formation of a Renewable Energy Test Lab. The purpose of the lab is to provide independent testing of both equipment and practices related to the safe installation of renewable energy systems. The lab is envisioned as complementary to existing code writing agencies and other testing labs.

A significant focus of the project is to develop and support techniques that are safe but don't increase the cost of code compliant systems. The lab will be set up as a nonprofit organization affiliated with and sharing IPP's nonprofit charter. Chris Sinton of Alfred University is seeking funding for the lab. Those interested in more information, wanting to provide input, or wishing to support the project with tax deductible donations, can contact Drake.

Net Metering, Again!

Last issue, we reviewed Carl Weinberg's article "Keeping the Lights On." He used the terms "hesitate and hassle" and "snarling dog" to describe utility behavior towards distributed generation. Those terms very well describe the current behavior of PG&E (Carl's one-time employer) regarding the implementation of California's new one megawatt net metering law.

Richard Perez's editorial in *HP85* described the case of Kenneth Adelman. Mr. Adelman recently completed a 31 KW PV system for his home. Being under 1 MW, he planned to be net metered. However, when he applied for net metering, he was told that he would have to pay US$7,000 for an interconnection study and US$600,000 for distribution system upgrades.

Since California's net metering law explicitly prohibits any additional charges being levied on net metering customers, he declined to pay. He was subsequently disconnected from service. After a long battle, he is now allowed to sell back up to 20 KW from his system. The battle with PG&E is continuing, and you can read about it on Ken Adelman's Web site.

PG&E is breaking the law. Section 2827 (d) of the net metering law says, "Any new or additional demand charge, standby charge, customer charge, minimum monthly charge, interconnection charge, or other charge that would increase an eligible customer-generator's costs beyond those of other customers in the rate class to which the eligible customer-generator would otherwise be assigned are contrary to the intent of this legislation, and shall not form a part of the new energy metering contracts or tariffs."

This is pretty clear language. In his editorial, Richard used this situation as a rationale for a federal net metering law. I support this goal. But in this case, we have a law that is clear. What we need is enforcement.

On October 30, 2001, the California Solar Energy Industries Association (CAL SEIA) filed a protest with the California Public Utilities Commission (PUC). Included in that filing is a letter from the author of California's net metering law, assemblyman Fred Keeley, stating clearly his legislative intention that net-metered systems be free of any additional charges. The Office of Ratepayers Advocates has also filed a protest echoing CAL SEIA's comments.

I hope that this level of strong support for Mr. Adelman, and PG&E's blatant violation of the law will persuade the commission to make the right decision. This situation stands as one more example of the fact that utilities are enemies of PV and distributed generation. At the legislative level, the PV industry must spend big money to get legislation allowing PV interconnection. Subsequently the industry must then spend additional efforts and money getting those laws enforced.

The utilities create barriers to PV and distributed generation at every possible opportunity. Carl Weinberg's imagery of the utility as a "snarling dog" (*IPP, HP86*) is right on the mark. California readers should keep in mind that AB29X, the latest net metering law approved this year, will need to be re-legislated next year due to the one year sunset provision attached at the last minute.

Renewable Energy in San Francisco

There's some very exciting news from San Francisco. On November 6, 2001, voters approved a US$100 million renewable energy bond. It provides for the purchase of from 10 to 12 MW of PV and an additional 30 MW of wind. The systems are to be installed on city property and buildings. The bond measure passed with a 73 to 27 percent margin. San Francisco joins Sacramento and Los Angeles as "solar committed" cities.

San Franciscans also voted on another measure on the ballot that would have allowed the city to form a municipal power authority. The municipal power measure lost by a few percent. On the eve of the election, PG&E's parent company announced a 234 percent increase in profit for the year. The two million dollars spent opposing municipalization is pocket change compared to their profits.

Meanwhile, the regulated PG&E cries poor (following a massive transfer of wealth to the unregulated parent corporation last December), and has filed for bankruptcy! After the citizens of Sacramento decided to dump PG&E in favor of forming their own municipal utility, it took another 23 years plowing through the courts to make it happen. These corporate thugs do not let go easily!

California Solar Tax Credit

California taxpayers can now receive a 15 percent state tax credit. Voted into law in October 2001, SBX2 17 is retroactive to January 1, 2001. The credit applies to the net cost of a system. For example, a US$20,000 system after receiving a California rebate would cost the customer US$10,000. That US$10,000 can be reduced another US$1,500 by taking the tax credit, if you are in a high enough tax bracket.

Other California solar legislation recently passed is SBX2 82 (Solar on State Buildings) and ABX2 48 (Solar Training and Certification). The complete bills and their legislative histories are available at www.leginfo.ca.gov/index.html.

Online Information

Tor Allen is moderator and facilitator for the California PV Alliance (PVA). The alliance is an ad hoc working group with members from all elements of the PV industry. The group meets four times a year, alternating between southern and northern California sites.

Tor maintains a Web site, with a section for PVA. The site has up-to-date information about the California solar scene. You can also register for two newsgroups, Solar e-Clips and CalPVAlliance. Tor's site is very well laid out and easy to navigate, in addition to having a wealth of information. This site is valuable to all interested in PV, not just Californians.

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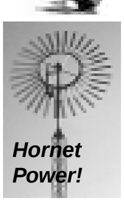

2002 NEC & Beyond

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

The 2002 *National Electrical Code (NEC)* has been published by the National Fire Protection Association (NFPA), and will be enacted into law by many states and local jurisdictions after January 1, 2002. My column in *HP86* covered changes to the *NEC,* sections 690.2 through 690.14. This column will cover changes in the remainder of Article 690, and discuss the start of the 2005 *NEC* activities.

About 40 people in the PV industry worked on a set of 32 proposed changes to the 2002 *NEC.* Others inside and outside the industry had input, as can anyone who will take the time to properly fill out the required form.

Many of these proposals were not well substantiated, and were rejected on the first cycle of the three-year process. Several changes were made during the public comment phase. The Code Making Panel (CMP-3) had their say, and then the NFPA correlating committee made the final revisions and edits.

The exact contents of Article 690 for the 2002 *NEC* will not be repeated here due to space restrictions. Everyone designing and installing PV systems is encouraged to get a copy of the compete 2002 *NEC,* and better yet, the 2002 *NEC Handbook.*

690.45 Size of the Equipment Grounding Conductor
This section was added to reflect recent research that shows that the equipment-grounding conductors for module source and output circuits must essentially be as large as the circuit conductors (at least they must have an ampacity of 1.25 times the short-circuit current). Oversizing the equipment-grounding conductors when the circuit conductors are oversized for voltage drop is still required, but they don't have to be any larger than the circuit conductors.

If the system is protected by a Section 690.5 ground-fault detection device, the equipment-grounding conductors are to be sized according to Section 250.122. This sizes the equipment-grounding conductors based on the overcurrent device protecting that circuit.

690.47 Grounding Electrode System
CMP-3 revised this section into two parts. Section A addresses alternating current grounding and Section B addresses DC grounding. All the section really does is refer back to the appropriate AC or DC grounding sections in Article 250.

690.55 Photovoltaic Power Systems Employing Energy Storage
This new section requires a label that will show the maximum operating voltage (including any equalizing voltage) of the system, and the polarity of the grounded conductor. Although most PV systems use a negative ground, some telecommunications systems use positive grounds. The label should be placed near the main system disconnects.

690.56 Identification of Power Sources
Part A deals with the marking required on the outside of buildings with stand-alone PV systems. Part B covers the exterior markings on buildings that have utility service and PV systems. In both cases, the requirement is to indicate the locations of the main disconnects for all sources of electrical energy to a building—including renewable, utility, or backup generator sources.

690.71 (D) Battery Nonconductive Cases and Racks
This section requires that flooded, lead-acid battery systems operating at over 48 volts nominal (twenty-four, 2 volt cells) have nonconductive racks and cases to minimize the potential for leakage currents, carbon tracks, shocks, and explosions. These problems have been seen on batteries in high-voltage battery banks (100–500 volts). This requirement does not apply to valve-regulated, lead-acid batteries (VRLA) that are sealed, because they normally don't pose similar hazards.

690.71 (E) Disconnection of Series Battery Circuits
This section requires that battery banks operating at more than 48 volts nominal have provisions to disconnect the series-connected cells into sets of 24 cells or fewer for servicing. Bolted or plug-in disconnects are allowed, and the plug-in disconnects do not have to be load-break rated. (A switch that can carry the circuit current, but that is not rated to open the circuit while carrying current is known as a non-load-break rated switch.)

690.71 (F) Battery Maintenance Disconnecting Means
A disconnect (for use by qualified people only) is now required to open the grounded conductor of battery banks operating above 48 volts nominal. This

disconnect may be a non-load-break switch, and it may not unground the rest of the PV system.

690.71 (G) Battery Systems of More Than 48 Volts
Battery systems of more than 48 volts nominal may be (permissive language, not required) operated with ungrounded conductors if several conditions are met. The PV array must be grounded. Any AC and DC load circuits must be grounded. The first two conditions are probably going to be met by certain types of inverters that provide internal ground-circuit isolation between the PV array, the load circuits, and the battery system.

All ungrounded input/output battery circuit conductors will be required to have switched disconnects and overcurrent protection. A ground-fault detector will be required to monitor the battery bank for ground faults.

690.72 (B) Diversion Charge Control
Subparagraph (1) requires that any system using a diversion charge controller have a second independent method of charge control. With diversion controllers, if the diversion circuit fails, the batteries may be overcharged, and can pose hazards (explosions, smoke, and fire). This requirement would apply to both AC and DC diversion controllers.

The code is not specific in the type of independent charge control required. It might be a second diversion controller or a series-type controller set at a slightly higher voltage. One way, when using an inverter with an extra adjustable relay measuring battery voltage, is to have the inverter drive an external relay to open the PV circuit if the diversion controller fails. Xantrex Technologies recommends this method when selling excess energy from the PV array back to the grid as a means of protecting the batteries from overcharge if the grid should fail.

Subparagraph (2) says that the current rating of the DC diversion load, the ampacity of the diversion load circuits, and the rating of the overcurrent device protecting those circuits must be at least 150 percent of the current rating of the charge controller. Of course, the diversion charge controller should be sized to handle the total output of the renewable source.

Clearer Code?
Most of the changes in Article 690 of the 2002 *NEC* make it somewhat clearer. The revisions to the comments in the 2002 *NEC Handbook* should also make it easier to understand the rationale behind the code requirements. Now is the time to start deliberations on the 2005 *NEC,* to improve it as well.

The 2005 *National Electrical Code*
Now that the 2002 *NEC* has been published, work is starting on the 2005 *NEC.* Remember that anyone can submit well-substantiated proposals to the National Fire Protection Association for consideration by the code-making panels.

Since NFPA, Underwriters Laboratories (UL), the Institute of Electrical and Electronic Engineers (IEEE), the International Association of Electrical Inspectors (IAEI), and other organizations have members on the code-making panels, the substantiation for proposals should address any requirements and concerns that those organizations might have, such as compliance with other electrical industry requirements. For example, a proposal suggesting that cables not listed by a recognized testing lab be used in PV systems would not receive much support by the panel members unless it had very good substantiation.

If you are interested in participating in the e-mail discussions of the 2005 code, or attending the meetings, just e-mail me and I will put you on our list for future information. The proposals that we at the Sandia National Laboratories make are well substantiated, and are coordinated with UL and IEEE members before submission.

2005 *NEC* Proposals
Here are a few items that are being discussed and may be proposed for inclusion in the *NEC* or in the appropriate UL standard.

- Some stand-alone inverters may have DC input currents that have RMS (root mean square) AC ripple currents that exceed the average DC currents. Should this RMS value be marked on the inverter, and then used for cable ampacity and overcurrent device ratings?
- Should the grounding point for framed PV modules be placed inside the module junction box to facilitate the equipment-grounding conductor connection? This would minimize the copper-to-aluminum compatibility problem, and keep all the conductors together to minimize the circuit time constant by reducing the circuit inductance.
- Should all PV modules be marked for use with 90°C (194°F) conductors, since very few locations would allow the use of 75°C (167°F) conductors because junction box temperatures usually exceed 70°C (158°F)?
- Should the warning required by *NEC* Section 690.5 (C) be made part of the UL-required marking on the inverter? The warning states that a ground-fault indication may mean that the normally grounded circuit conductors are no longer grounded and may be energized.

- Should inverters that ground the PV array inside the inverter be required to have an external warning stating the grounding method? Should they be required to have terminals large enough to meet code-required, grounding-electrode conductors?
- Should the *NEC* adopt language similar to the European and Japanese standards for ungrounded PV systems up to 120 volts?
- What will the most advanced plug-n-play PV system look like, and what are the safety issues that need to be addressed in the *NEC*?

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

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Kathleen Jarschke-Schultze

In the winter, we heat our home with wood. I have been doing this for the last sixteen years, Bob-O for much longer.

As with all mountain-living necessities, there is a learning curve. You have to learn how to start a fire, keep it going, bank it for the night, and clean your woodstove. Then there is cutting the wood, as well as splitting, stacking, and drying it.

Light My Fire

Ever since Prometheus brought fire to man, many people around the world and throughout history have used wood fires for heating and cooking. While some areas of the world have been denuded of trees for cooking fires, many well-forested areas use this renewable resource. There are increasingly efficient ways to burn wood for heating. In some parts of the country, this is the preferred and accepted way to heat homes, as it is in our area.

When I first moved to the mountains, I knew how to light a campfire. My family did a lot of camping when I was a kid, and my father taught us all how to start and maintain campfires. When I was very young, we lived in a house with a potbellied stove. Because I was so young, I was not allowed to touch the stove when a fire was in it. Then I met Bob-O, and using a wood heating stove became a way of life.

Be Kind to Kindling

In order to start a fire in a woodstove, you need dry kindling. You need a goodly amount. Knowing just how much to use with your particular stove comes with experience. It does no good to skimp on kindling. We prefer Douglas-fir, because it splits so nicely. If the wood is pitchy, all the better.

The very best kindling wood is from the stump of a standing snag that has died naturally. When this happens, all the sap drains back down the tree. The rounds taken from the bottom two to three feet of the stump are prime fatwood, wood completely saturated in pitch. It only takes a few pieces of fatwood to get a fire going. Juniper and pine will make fine kindling. The caveat here is that the wood must be dry. Of course, this is just what's available in this part of the world.

By the way, the swell method of splitting kindling with a hatchet is also the safe way. You take a piece of wood, set the blade of the hatchet on the up-ended top. Hold the wood with one hand and the hatchet with the other. Lift the two together and drop sharply to the chopping block, just enough to plant the hatchet blade about an inch into the top of the wood.

Remove your hand from the wood, lift the hatchet with the wood attached, and drive it down onto the stump, splitting the wood. When you split the wood, you have *one* hand on the hatchet handle, and *none* on the piece of wood.

Making a Wood Stew

The art of burning wood for heat depends on having dry wood. Wood that is too wet yields little heat but lots of creosote. If it's too dry, it will burn too fast.

To start a fire, take four or five pieces of newspaper, wadded loosely. [Editor's Note: Newspaper printed with colored inks should not be used to start stoves equipped with catalytic converters. The metals present in the ink contaminate the catalyst and will result in premature failure.] Place the newspaper on the floor of the firebox. Take your kindling and lay a few pieces on top of the paper at an angle. Place a few more pieces on top of that at the opposite angle, forming an open cross hatch pattern. On top of this, gently lay a couple of slightly larger pieces of kindling parallel to the firebox walls.

Light the paper in several places across the front. Open the damper if you have one. If you don't, instead of completely shutting the stove door, leave it cracked open a little for a few minutes. Never walk away from your woodstove when the door is open.

You should be rewarded with the roar of the paper torching off. When that sound dies down, your kindling should be burning. When the kindling has truly caught fire, start adding larger pieces of wood to the fire. These must be graduated in size.

It would not do to add a big thick split of wood too early. The fire would go out, and you would have to remove all the wood in the stove and start again. This can be very messy, and if a few pieces are just smoldering but not burning, it can be quite smoky. This is experience talking here.

Sometimes your fire will burn down through lack of attention, and you have to revive it. Use the coals as your starter, and place small kindling on top. As that wood kindles, add the progressively larger wood. If you have pieces of dry bark, it is good to use them for this. They will burn hot and fast, and really kickstart an almost dead fire.

My dad taught me a trick for when you have a smoldering fire that won't flame. He went to a secondhand store and picked up a cheap blow dryer. He disconnected the heater element. The hair dryer was now an electric bellows. It directed a stream of air to right where he wanted it (the area of wood that was smoldering), and got it flaming fast. After I saw his, I got one, and it really works great. It can be kind of messy till you get the hang of not blowing the ashes out of your stove at the same time.

Woodsheds

At our last house, on the Salmon River, we had an ace woodshed. Bob-O and his friend Cedar built it. It was a pole woodshed, 12 feet tall, about 14 feet wide, and 8 feet deep. It had two bays. One bay was for stacked firewood, and the other for stacked kindling rounds, ready to split.

There was enough room on the kindling side for all the wood tools, axes, mauls, hatchets, etc. We always kept back a nice big flat round to be the chopping block. This is what you set the wood on to position it for a good swing of the axe. It also keeps your axe and maul edges sharper longer if you don't hit the ground with them.

Since we moved here to the creek, we have had no woodshed. Every year we set out wood pallets, drive metal fence posts into the ground along the sides, and stack the firewood in between. After curing (drying) the wood during the summer, we cover the stack with a heavy tarp held down with pieces of firewood as weights.

This method has worked, but I have never liked it. I am the person who keeps the home fire burning and fills the wood rack next to the stove from the outdoor ricks. Too many times, in the dead of winter, I have found myself having to balance on ice-covered pallet slats, ducking under the tarp, trying to avoid or escape dumps of icy water or snow sliding off the tarp while I grab an armload of firewood. I'd venture to say that you have not felt real pain until you have clapped your nipple between two pieces of split madrone wood, or dropped one on the instep of your cold foot. The chopping block was out in the elements, without any cover from the harsher weather.

Slow Shedding

This year I told Bob-O that I really wanted a woodshed. Time went by, and we did not have the time to build anything. I suggested one of those metal roofed carports. We looked into it, but the cost was prohibitive. Time grew short, and we needed to get our firewood in. We were at a local membership shopping warehouse when I saw that they had steel-framed canopies.

These canopies are 10 by 20 feet, with two long sides and one short side, covered by heavy duty, fitted tarps. The peaked roofs were also fitted, and hung over the sides by a foot. The cost was US$149. I convinced Bob-O that it would work. The tarp material is supposed to last three years. By that time, we will be able to put some metal roofing on it.

I assembled it, with Bob-O helping to lift it onto the side posts. We cut foot-long pieces of 6 by 6 inch, pressure treated wood. We then drilled two holes in each of the eight pieces. After anchoring the side posts to the pieces of 6 by 6 with large wood screws, Bob-O hammered lengths of rebar through both holes in each 6 by 6 to anchor the whole assembly to the ground.

I called the company who made the canopy and ordered another short end section of tarp for US$25. By enclosing both short ends, one full long side, and two-thirds of the long side facing the house, I have a completely viable woodshed.

The tarps are attached to the steel frame with tarp bungees. Those are funny looking bungee loops with a round knob on the end. I got extras, and double bungeed the corners and put extra bungees on the sides. We drove metal fence posts into the ground on the inside along the short ends of the shed, and threaded wooden pallets onto them to hold the rows of firewood in place.

With four cords of wood—cut, split, and stacked—there is still room for me to walk a wheelbarrow alongside the rick and pick and choose the pieces I want. I use a mixture of sizes for during the day, and some big solid honkers for banking in at night. It reminds me of shopping down the aisle of the market with my basket. When I am washing dishes and I look out my kitchen window, I can see my full woodshed. I think to myself, "That is a thing of beauty."

Of course there are the winds and snows of winter to be anticipated. I have high hopes for the durability of my woodshed. Come Spring, I'll let you know how it has fared the frozen north.

Truck & Stack

For the last few years, we have been buying our wood already cut and split. We take our flatbed trailer behind Bob-O's pickup, and drive about 50 miles to a small but professionally run woodlot. The owner has a self-loading log truck. He gets the otherwise discarded and unused hardwoods from logging operations. Most of it is madrone. Madrone is a hardwood native to the

Northwest. It is solid and heavy when first cut, and splits well when green. It dries fast and burns hot and long with little ash.

The wood is stacked one cord to a row at the woodlot. By stacking it carefully in the truck and trailer, we can get two cords in a single load. Back at home, we stack the wood as we take it out of the pickup. The trailer can't get close to the woodshed, so we unload the wood into the pickup, and drive up to the shed and stack it from there.

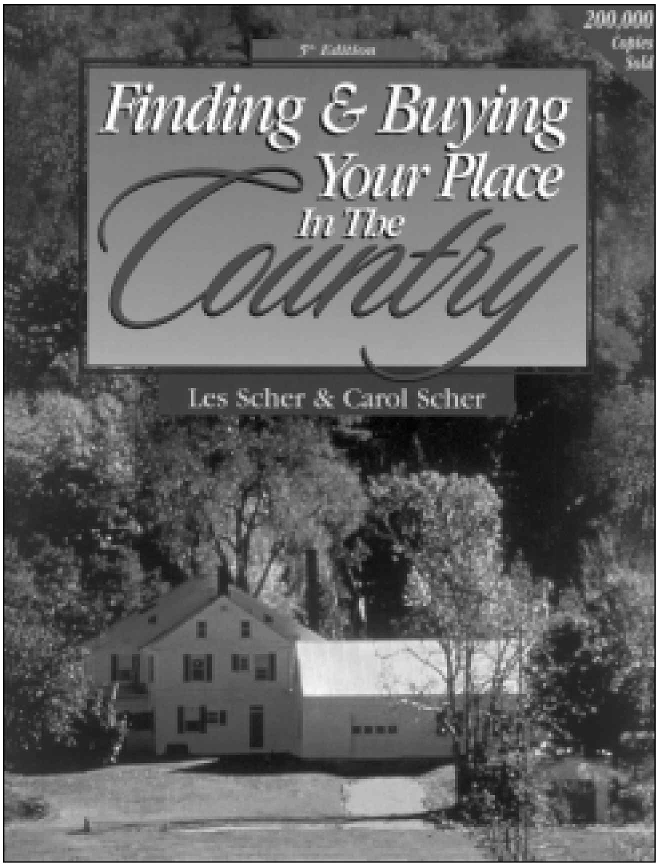
Fire & Ice

There is a saying that firewood warms you twice—once when you cut, split, and stack it, and once when you burn it. The problem is that the weather is not cold when you get the wood. This year it happened to be hot—in the 90s or 100s—when we did our wood work. Heaving and stacking the wood, we were downright sweaty more than twice.

But when winter rolls in, there is nothing so wonderful as a good warm woodstove when it is snowing outside. A really special treat is to eat ice cream while sitting in the heat emanating from a woodstove or fireplace. People who live in the Tropics will never know this joy. Marge George, the proprietress of the old Forks of Salmon general store, once told Bob-O that she sold more ice cream in the winter than she ever did in the summer. Oh, those wood burners, they are very wise.

Access

Kathleen Jarschke-Schultze is still working on that darn chicken palace at her home in Northernmost California, c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 • kathleen.jarschke-schultze@homepower.com



Finding and Buying Your Place in the Country (Fifth Edition)

Les Scher and Carol Scher
Reviewed by Eric Grisen ©2002 Eric Grisen

The fifth edition of *Finding and Buying Your Place in the Country* is still the best resource available for expert advice on purchasing rural land. It's like having an old-timer's and lawyer's advice at your fingertips. If you're buying a rural home or property for the first time, this book is a must. The third edition was also found to be indispensable in a review appearing way back in *HP29*.

I suppose an eager reader might attack this 417-page book straight through, reading it start to finish. My partner and I use it for reference on specific issues when needed. We've found that it addresses every subject we've needed information on—wells, water rights, and how much water our home and garden will need; what the zoning abbreviations stand for; building permits and dealing with county officials; and road easements—to list a few.

The book has thorough and detailed information, accompanied by plenty of graphics. The authors have provided sample documents, detailed drawings, and extensive contact information when applicable. Although the authors' expertise is on California laws and consumer issues, their state-by-state contact listings are complete. In addition to the general table of contents, the book has a detailed index. With 8-1/2 by 11 inch pages and a two-column layout, it's easy on the eyes.

My partner and I are making an offer on an older home and 20 acres in the Cascade mountains near Ashland, Oregon. The 22-page chapter titled "Evaluating Houses, Manufactured Homes, and Other Structures" has been particularly helpful to us.

The authors wrote this section in an organized, linear, foundation-to-attic style that prepares you to start inspecting any house. They have identified common problem areas with foundations, framing, plumbing, electrical, roofing, and other potential trouble spots. They've also made recommendations for finding a professional home and pest inspector. An eight-page section titled "The Property Buyer's Complete Checklist" helps you avoid missing any inspection or required piece of information.

Finding and Buying Your Place in the Country has extensive sections aimed at helping you negotiate to buy a home or land. The book can help you evaluate the price of the property, and bargain the seller's price down. Additional chapters give model contracts of sale and option agreements, as well as steering you through the escrow process.

In Chapter 12, "Zoning Laws," the authors introduce the topic of land use and the law. They emphasize the importance of researching the zoning where you want to live to make sure you can do what you want to do with your property. Their general instructions helped me research the zoning for specific parcels that we found for sale.

It was even more useful to be able to research how the surrounding land was zoned. From the book's list of common zoning symbols and brief descriptions, I was able to determine the difference between property listings that were zoned rural residential, woodland reserve (or woodland resource depending on your perspective), and forestry/recreation. Some zoning types allow homesites, while others do not.

I think *Finding and Buying Your Place in the Country* is a good book—I recommend it. It's a key resource about the nuts and bolts of property law, and it's packed full of details. My partner and I are thankful we found this book before we blindly bought country property. It's nice to have a guide through the many challenges of buying or building a home in the country.

Access

Finding and Buying Your Place in the Country, (Fifth edition) by Les Scher & Carol Scher, 2000, ISBN 0-7931-4109-5, US$27.95 plus shipping from Dearborn Financial Publishing, Inc., 155 North Wacker Dr., Chicago, IL 60606 • 800-245-2665 or 312-836-4400 Fax: 312-836-9958 • bermel@dearborn.com www.dearborntrade.com

Eric Grisen, c/o *Home Power,* PO Box 520, Ashland, OR 97520 • eric.grisen@homepower.com

HAPPENINGS

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

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

Solar On-Line (SõL) Internet courses. Year-round. PV Technology & Opportunities—A Qualitative Overview; PV Systems Design: Basic Course; PV Systems Design: Professional Course; PV System Installation: Hands-On! Solar Homes; Healthy Buildings; Solar Energy for International Development. SoL, PO Box 217, Carbondale, CO 81623
Fax: 559-751-2001 • sol@solenergy.org
www.solenergy.org

CANADA
Microhydro Courses: Assess site, determine feasibility, & design & install a system. Apr 26–28, '02, Selkirk College, Nelson, BC, 250-352-6601. May 3–5, '02, College of New Caledonia Prince George, BC, 250-561-5801. May 10–12, '02 Univ College of Cariboo Kamloops, BC, 250-828-5039. US$80 to US$160. Robert Mathews, 250-679-8589
www.energyalternatives.ca/mhcourse.htm

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

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

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

NEW ZEALAND
Feb. 2–3rd '02; Canterbury Sustainability Expo, Christchurch. Alternative energy, building & construction options, heating options, energy efficient housing & appliances, home products, Gov. info, new & emerging technologies, composting toilets & greywater, alternative transport, education, speakers, demonstrations, exhibits. John, 025-576527

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

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

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

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

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

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

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

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

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

Solar Curriculum for schools. 6 wk. science curriculum or individual sessions. Free! 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center
321-638-1017 • www.fsec.ucf.edu

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

ARIZONA
Apr. 19–21, '02; AZ RE Expo; Prescott Valley, AZ. For consumers, educators, contractors, youth, & public. Info: Prescott Valley Economic Development Found., 888-240-4256 • www.pvedf.com

Info on tax credits for solar in AZ. ARI SEIA, 602-258-3422

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

ARKANSAS
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loren@ipa.net • www.Sun4Life.com

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

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm., 800-555-7794 or 916-654-4058
callcntr@energy.state.ca.us
www.consumerenergycenter.org/buydown

Energy Efficiency Building Standards for CA. CA Energy Comm, 800-772-3300
www.energy.ca.gov/title24

Solar e-Clips, free weekly email newsletter. CA news & info solar energy. To subscribe email with "Subscribe" in subject to solareclips-request@
californiasolarcenter.org

Mar. 4–9, '02; SEI PV Design & Installation Workshop, Sacramento, CA, Municipal Utility District (SMUD) Energy & Technology Center. Hands-on basics of PV. US$550. For SEI contact info, see Colorado.

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

COLORADO
Carbondale, CO. SEI: hands-on workshops. 1–2 week sessions. PV Design & Installation, Advanced PV, Wind Power, Microhydro, Solar Cooking, Environmental Building Technologies, Solar Home Design, & Straw Bale Construction. Solar Energy International (SEI), PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

IOWA
Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. All welcome. Call for schedule changes. IRENEW, PO Box 355, Muscatine, IA 52761 • 319-288-2552 irenew@irenew.org • www.irenew.org

KENTUCKY
Livingston, KY. Appalachia: Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, more. ASPI, Rt. 5, Box 423, Livingston, KY 40445 Phone/Fax: 606-453-2105 • aspi@kih.net www.kih.net/aspi

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

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

MONTANA
Whitehall, MT. Sage Mountain Center: one-day seminars & workshops, inexpensive sustainable home building, straw bale constr., log furniture, cordwood constr., PV, more. SMC, 79 Sage Mountain Trail, Whitehall, MT 59759 Phone/Fax: 406-494-9875 cborton@sagemountain.org

NEVADA
Jun. 15–19, '02; Solar 2002: Sunrise Sustainability Expo. Reno, NV. Annual American Solar Energy Society conference. ASES, 2400 Central Ave. #G-1, Boulder, CO 80301 • 303-443-3130 Fax: 303-443-3212 • ases@ases.org www.ases.org

NEW HAMPSHIRE
Spinning a Web of Solar Spirits; workshops on living with the sun. 1st Wed. every month. Sunweaver, 1049 1st, NH Turnpike, NH 03261 • 603-942-5863 Fax: 603-942-7730 • fonature@tiac.net

NEW YORK
Apr. 27, '02; North Country Sustainable Energy Fair, Canton Middle School, Canton, NY. Workshops, activities, vendors, exhibitors, & presenters. Home tour Apr. 28. Scott Shipley, 315-386-4928 cobbship@northnet.org • www.ncenergy.org

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

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

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

Feb. 8–10, '02; Introduction to Permaculture: A Design Workshop for Women on Self-Reliant Living. Lost Valley Educational Center, Dexter, Oregon. Comfortable, supportive environment for women to learn philosophy, principles, strategies, & techniques. US$180–$225, incl. materials, food, & lodging. Contact: Jude, 1161 Lincoln St., Eugene, OR 97401 541-342-1160 • hobbsj@efn.org

Mar. 29–31, '02; The Stoppiello Whole-House Workshop, John Day, OR. (See EORenew below for access info.)

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

Sept. 21, '02; All-day Solar Cookery Equinox Extravaganza, Seneca, OR. (See EORenew access info above)

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

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

Apr. 22–27, '02; SEI PV Design & Installation Workshop, Summertown, TN, Ecovillage Training Center on The Farm. Hands-on basics of PV. US$550. (Lodging, camping & meals available). For SEI info, see listing in Colorado.

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

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

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

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

WISCONSIN
MREA Workshops: Solar Space Heating, Wind Systems Installation, PV Installation, Straw Bale Construction, Masonry Heaters, Sustainable Living Workshops, RE for the Developing World. Significant others half price. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • Fax: 715-592-6596 mreainfo@wi-net.com • www.the-mrea.org

To have your event included in the *Home Power Happenings* listing, send e-mail to happs@homepower.com or snail mail to: Happenings, c/o *Home Power*, PO Box 520, Ashland, OR 97520

the Wizard speaks...

The Water Barrier

After the hydrocarbon economy comes the hydrogen economy. This new energy economy may have a serious potential limitation. It might be limited by how much water is available for use in the process of storing hydrogen. This limitation is the "water barrier." There may not be a problem here, but if we had thought about carbon dioxide emissions earlier, we might not have a problem with global warming today.

This water limit is affected by how much water is used for drinking, food growing, washing, and other necessary activities. It is also greatly affected by how much total water can be removed from the biosphere for all human uses. Sooner or later, a point may be reached where removing more water from the biosphere will quickly degrade the environment. Before this point is reached, we must find new ways to store energy.

Batteries and new types of capacitors may take up some of the need. Also, there are potential superconductor, magnetic, and flywheel storage technologies. However, it will take new breakthroughs in physics, engineering, and materials science before the water barrier can finally be breached.

In the long term, it may be better to seek our energy from new technologies that do not require storage. Two possibilities are energy from the subtle fields of space, and energy from quantum fluctuations of space. We can hope that a combination of technologies will eventually emerge that are clean, efficient, and ecologically sound.

Errata
In the schematic on page 15 of HP86, *the battery terminal polarities are reversed. In the schematic on page 87 of* HP86, *the neutral and ground labels are reversed on the AC side of the inverter. The green/ground wire should be bonded to the inverter case and the neutral/white wire should be connected to the inverter's neutral output wire.*

No Free Lunch
Dear Sirs, This is a recap of a letter I already sent to *Windpower Monthly* magazine. In the Techwatch section of the June 2000 issue of *Popular Mechanics,* they have an article entitled "Wind Recharger for EVs," which is about the Automotive Rotor Blade System developed by the Genesis Engineering Group of Hemet, California (maybe that company folded, I cannot find it anywhere). This is a horizontal windmill that is installed atop electric cars and vans, and automatically adjusts its blades to accommodate wind from diverse directions to power a generator that recharges the vehicle's batteries.

Why stop there? Rehire the entire population of Flint, Michigan to mass-produce much larger versions of these units. Then use the power line repair crews to install them atop all the electric power line towers in the world, to derive power from the wind up there, and feed it into the local grid. Their collective output of clean energy would be enormous. But why stop there? Make smaller versions of this horizontal windmill and install them atop all telephone poles and lamp posts, and house rooftops as well. Solar panels could be added to the unit's top, so let's call it "Suntops." The Suntops would be so valuable that we could use them as a form of barter to pay off our debts to other countries, since all nations need clean energy now. Best Regards, Bob Schreib, Jr.

Hello Bob, The Genesis Engineering Group didn't understand basic physics, which probably had something to do with the company folding!

There are always losses in any energy conversion process. Mounting a wind generator on a vehicle has a negative impact on the vehicle's aerodynamics. In this case, just like putting a bike rack on your car or a lumber rack on your truck decreases your gas mileage, it would take more energy out of the EV's battery bank to propel the vehicle equipped with the wind generator. The wind generator would never come close to offsetting the energy lost to the increased air friction it was causing.

Transmission line towers aren't engineered for the forces associated with wind turbines. But the installation of utility scale wind projects is gaining momentum here in the U.S. The energy produced by these wind farms is cost effective when compared to coal-fired generation. And the wind farms can be up and running in about a third of the construction time. Here in the Pacific Northwest, one of the world's largest wind farms is under construction. Its output will be 265 MW, enough electricity to power over 50,000 homes.

As you suggest, solar-electric (PV) panels are the perfect technology for distributed power generation. Telephone poles and lamp posts aren't the best place to mount them. But approximately one third of the homes in America have unobstructed, south facing roofs that could be retrofitted with PVs. Now all we have to do is start buying PVs! Take it easy, Joe Schwartz • joe.schwartz@homepower.com

Refrigerator Experimentation
Dear *Home Power,* Your readers might be interested in my experience with a wrinkle in refrigerator technology. Last month, the propane refrigerator that I use at my remote cabin in Sonoma County, California gave up the ghost. I had just read the "Things That Work!" review in *HP84* of the big Maytag refrigerator, but could not justify anything so large and expensive for occasional weekend use.

Since I have a small surplus of PV generated power, I decided to take a chance on a 4 cubic foot electric refrigerator, Magic Chef brand, made in Korea by Daewoo, which I bought at a yard sale for US$20. My hope was that even though it wasn't in the Sun Frost category of efficiency, it might be good enough. Using a surplus 110 V KWH meter, I measured power consumption of 0.5 KWH per day with the control set for 32°F inside at 65°F room temperature. This was good enough for me.

Next I decided to see if adding insulation to the outside of the refrigerator would make things even better. Since I had tried this before with disappointing results, I did an experiment with a one square foot piece of two inch thick rigid foam insulation taped to the side of the refrigerator. I used a Fluke model 52 digital thermometer to measure the temperature on both sides of the insulation. With the refrigerator running, I expected to see a reading at the side of the insulation that was next to the refrigerator several degrees cooler than room temperature. I was amazed to find the opposite. The insulated surface of the refrigerator was 5°F warmer than the outside air.

Investigation revealed that the condensing coils of the refrigerator, which dissipate the heat from the compressed refrigerant, were not in their usual place behind or underneath the unit. Instead, they are built into the top and sides, underneath the sheet metal. While this probably improves efficiency and means you don't have to worry about dust accumulation on the coils, it does mean that adding insulation to these areas would be a disaster in terms of efficiency.

Footnote: I can't say enough good things about the Fluke digital thermometers. They use one or two thermocouple probes to measure from below -300°F to over 2,500°F with a resolution of one tenth of a degree. They are rugged, simple to use, and accurate. I see them on eBay selling for US$60 to $80. No one who is interested in homebrew energy should be without one. John Kelly

Energy Bumper Sticker
Hello, I enjoyed your article in the December *Home Power* magazine about "Energy and Security." Just before I read it, I had a bumper sticker made, which I am sending to you as an attachment. I hope it gets people to think of conservation as not just another "Tree Hugger" wimpy idea. Gene Cass

Modern & Efficient Is OK
I generally very much enjoy your magazine. However, I want to rebut a letter (*HP86,* page 144) by Eric Kahmann regarding the Davisons' "New Tara" system in *HP84.* I couldn't disagree more with the writer of this letter (no offense intended to author). I am all for conservation and renewable energy. However, I quite like my modern lifestyle. I even like my phantom loads. More specifically, I like the things they do for me. I do not intend to count them, nor do I intend to put them on a switch. I'm quite happy to let them draw a few watts continuously so I can have the convenience they provide.

When I build my next house, I intend to build it to be as efficient as practically possible, and use alternative energy sources where practical. However, I do *not* intend to lower my standard of living; I intend to raise it. There is nothing wrong with that.

When the renewable energy people stop expecting everyone else to downgrade their living standard and live in houses that have few creature comforts and require the owner to babysit the energy system, and when such adequately sized systems are financially practical, then renewable energy systems will explode in popularity. I say more power to the owner of New Tara. Good show! If I had the money, I'd do something similar. (I'd be driving an electric SUV too, but that's another story.) Bring that functionality to the average Joe, and you'll have more customers than you can count.

Let's take an example. Suppose hypothetically that we had an energy technology that had a capital cost of around US$1 per watt, not including installation and accessories. If I were trying to figure out how to bring it to the average Joe, it would be hard. I have an all-electric house in Georgia. Energy usage varies from 50 to 70 KWH per day. Putting this hypothetical 40 KW energy system on it to handle peak loads would cost about US$40,000. Payback would be about 20 years—not too attractive.

However, I have enough sense to know that, if I start telling potential customers to turn off their heat pumps during our *hot, humid* summers, and unplug TVs, VCRs, and clock radios, I'll be beaten before I can start. The scenario is even worse with existing technology at US$3 to $6 per watt. Until such time as I can get a more efficient house (may be a while), I'm trying to figure out how to get a bigger energy system or use a smaller one more effectively. Any suggestions you have would be appreciated. Sincerely, Ron Frazier

The Future of RE
I read with some amazement and concern the response by Eric Kahmann to the "New Tara in Georgia." I believe Mr. Davison should be commended for putting his money where his mouth is. He has done more to help the environment than a hundred families running around replacing lightbulbs with compact fluorescents. To imply that his system "darkens the earth" is not only arrogant, but it smacks of class envy. Just who is the pompous soul that can sit in judgement of another's needs, energy or otherwise.

Since the 1960s, I have been called an earth nerd, tree hugger, or just plain out of touch. I can assure you that if you try to sell RE on the basis of its "greenness" or social equality, you will be babbling the same old mantra, while gumming your Granola bar, from your wheelchair in the nursing home.

RE has to be sold on its own merit. Surely, in a country that can sell the notions that an SUV is better than a van that is larger and costs less, that football is not football unless watched on a big screen TV, or life is not complete until you have seen the Harry Potter movie, we can sell the concept of individual energy independence. This means all the energy people want and need.

Imagine the RE sales potential if prime time TV ran ads showing how you can "scoff at utility bills," or a scene showing a family fretting over the budget while their neighbor installs a yard light over the pool. "It's modular," he smiles. "If you need more, just add another panel...and it helps save the planet," chirps the wife. Celebrities like Oprah and Rosie gushing over the benefits of their RE system would sell more than all the *Home Power* ads combined.

The right ideas for all the wrong reasons? Who cares? When one billion Chinese or 700 million Indians decide to modernize, there will be no cheap energy, no matter how much is yet to be discovered. The developed countries of the world will not cut back on their energy needs. They will be forced to use renewable vegetable alcohols and oils for hybrid or fuel cell transportation, and nukes for grid power. The more RE sales generated by the "I've got mine" attitude, the smaller those nukes have to be.

Systems like the Davisons' are the wave of the future. Conservation and improved efficiency will help, but no country in modern times has reduced its standard of living for any significant length of time. Ron Prusinski, Plymouth, Indiana • rbpru@att.net

Hi Ron and Ron, Thanks for your good letters. I'm really glad you took the time to write them, even though they don't reflect my personal philosophy. We all come to renewable energy for different reasons. Thousands of us did start using RE largely for environmental reasons. Many, if not most, systems today are installed not for economic payback or energy independence, but because of a commitment to clean energy. This mindset has in large measure driven the RE industry to its present popularity.

But it is short sighted to think that everyone will view RE the same way any one of us does. While my sympathies are closer to Eric Kahmann's than yours, we ran the Davison system article for many of the reasons you outline. The HP *crew still generally feels that it's vital to be efficient and to use energy carefully. Americans use an enormous amount of energy and create a huge amount of pollution for their numbers. We are dealing with unreal energy pricing that does not reflect the true costs of our actions. But you're right that it's rather pompous of folks to look down their noses and sneer at others' choices.*

I'd like to see everyone using RE. I think that's a great focus. We can get sidetracked by arguing about exactly how *they use RE, but that's a real distraction. We want* Home Power *to be a resource for how-to information about RE, whether your motivation is environmental, energy independence, reliability, or just the fascination of making your own. Let's respect each other's motivations, and have fun with this stuff. Your letters are full of good points, and I appreciate them and what you're doing to increase the use of RE. Ian Woofenden ian.woofenden@homepower.com*

LED Error

Well, I see that in *HP85,* page 142, you did indeed find the error in the resistor value from the article on converting a flashlight to white LEDs (*HP84,* page 74). However, the corrected resistor value (33 ohms) is still not correct. It will, in most cases, work just fine, since it will provide a bit over 27 mA (most LEDs are rated for 30 mA max), but it will shorten battery life by about 35 percent, and will shorten the life of the LED (though probably not appreciably).

As stated in the article, LEDs are most efficient at 20 mA. They do get brighter as more current is applied, but the increase in light output is small relative to the extra power dissipated as heat. This wasted power mostly shortens battery and LED life.

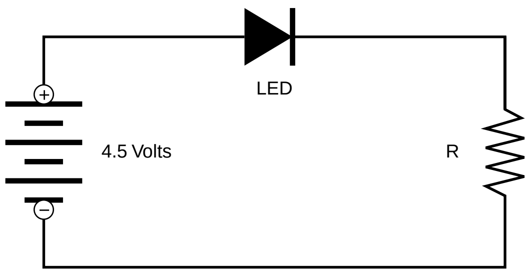
Figuring the resistance value is actually quite easy if you know Ohm's law:

V = I X R

Where V is voltage, I is current in amps, and R is resistance in ohms. If we rearrange this to solve for R, we get:

R = V ÷ I

So, now to the LED circuit. We know we want "I" to be 20 mA (0.02 A), but what do we use for "V"? Well, another law of electronics, Kirchhoff's voltage law, states that the sum of all voltages around a circuit must equal zero. So, for the LED circuit:



Starting at the lower left with zero, going clockwise, we add 4.5 for the battery, subtract the voltage used by the LED, then, by subtracting the voltage used by the resistor, we'll be back to where we started, with zero:

$$4.5 - V_{LED} - V_R = 0$$

$$\text{or } V_R = 4.5 - V_{LED}$$

Now, from the article, we know that the LED needs 3.6 volts to run at 20 mA so:

$$V_R = 4.5 - 3.6 = 0.9\text{ V}$$

We see we need to drop 0.9 V at 20 mA through the resistor, so using V ÷ I = R, we get:

0.9 V ÷ 0.02 A = 45 ohms

Thanks, C.J. Johansson, Boise, Idaho • cj@boi.hp.com

Hi C.J., Sorry for the error on the value of the resistor in the flashlight article. I let it slip through the proofing process. The flashlight was in fact constructed with 33 ohm resistors. I take the point about the math of Ohm's law, for a drop of 0.9 volts, a 45 ohm resistance would certainly be needed, however, the 0.9 volts is only a nominal figure, taking the drop across the LED as being exactly 3.6 volts. Carrying out tests using LEDs from different manufacturers, I've found that this figure can vary, so I always do a "trial and error" check with the actual components to be used.

The value of 33 ohms was chosen after trials with the actual LEDs used, and the approximate current drawn by each LED was, in fact 22 mA using fresh alkaline cells, close enough to the nominal preferred 20 mA. Like many things in life, the theory and practice don't always work out as planned!

Incidentally, the original set of cells are still in the flashlight, and are still going strong. But as soon as I can get hold of a "Linear Technology" LT1932 constant current DC/DC LED driver chip, there will be a rebuild under way, and with only two cells needed for eight LEDs! Peter Jones g4gri@hotmail.com

CF Color Temperature

Hi *HomePowerites,* One aspect of compact fluorescent lights that I rarely see mentioned is the "color temperature or chromacity," which describes the overall warmth or coolness produced by the bulb. In the Grainger catalog, the specification charts for fluorescent lamps list these ratings in the "color temp." column. The numbers range from 2,700 to 5,000, with the lower number the warmest, the higher number the coolest. This info is also found in the column "description," which indicates the "phosphor" (the substance used to produce the light in the bulb), and often on the lamp base.

For instance, a Sylvania lamp will have something like "CF13DD/E/841" on the base, with the "841" indicating a color temperature of 4,100 (midrange between warmest and coolest). The lamps advertised as "daylight" or "full spectrum" are in the 5,000 range or "850". Look for an "800" number and the last two digits will tell you what the color temperature is (dropping the two zeros).

So what? My family likes a lot of light to offset the dark and dank of winter. We had been using the commonly available compact fluorescents that are generally at the lower end of the warm range (an 827 phosphor with a color temperature of 2,700). These were OK, but have a warm, yellowish color similar to incandescent lights. We needed something brighter. Higher wattage with the 827 phosphor didn't help. I obtained some "cool white" lamps from Backwoods Solar Electric, which turned out to have the 841 phosphor and brightened up the house a great deal.

It is interesting that all fluorescent lamps of a given wattage have the same lumen rating (amount of light), but the 841 *seems* much brighter since the light is whiter. But it's not as aggravating as the typical cool white found in regular fluorescent lamps. So if you're looking for a way to brighten up the house (not to mention the psyche of your family) during the long winter nights, consider trying some of the cooler fluorescent lamps. Al Latham • thinkedge@olypen.com

Solar Hot Water Gauges
Hi Ken, I just read the articles in *Home Power* magazine and then installed a system on my house. I was wondering where you get the temperature gauges, and about what they cost? I love instrumentation. I enjoyed the articles. Lots of info. Regards, Steve Bunville • slbun@udel.edu

Hi Steve, It is so rewarding to hear that you have installed a solar hot water system after reading the HP *articles. That is exactly the intended result!*

The temperature gauges are available at any standard plumbing supply house that sells hydronic heating equipment. I like the temperature gauges that come with a separate brass well fitting. The fitting is soldered into place and the temperature gauge pops into the well. It is removable. This also means you can easily align it the way you want. Good alignment is difficult with threaded gauges because you need to install the gauge after all soldering is complete to avoid damaging the gauge with excessive heat from nearby soldering. AAA Solar sells such a gauge manufactured by Pasco. It sells for a little over US$15.

I would install a gauge on the collector return line and another on the collector supply line. This will tell you what your temperature rise is across the collectors (same as temperature drop across the heat exchanger). You are usually looking for a range of 15 to 20°F. Consider another gauge in the water line as it exits the heat exchanger on the way to the solar storage tank. Ken Olson • sol@solenergy.org

Old SDHW Panels
Dear *Home Power,* I just purchased eight old 4 x 6 water heating panels for US$75. They were installed on a hospital years ago and were removed when the building was re-roofed. The labels on the panels say "Daystar 21, Daystar, Burlington, Mass." I plan to refurbish a few of them and put them back in use. I have not been able to find any info on Daystar, or any specs or how old these units are. The boxes, copper, and glass are in pretty good shape, so I am confident that I can recycle them. I would like to know more about their original configuration, manufacturer, etc. Can you help me? Thanks! Gray Hungerford, Peckerwood, North Carolina

Hello Gray, Daystar was a division of American Solar King out of Waco, Texas, and they made a collector called the Daystar 1600, which is what I think you have. The 21 refers to 21 square feet, nominal. Standard procedure on panel construction—low iron glass, copper absorber with selective surface, 1/4 inch risers on 2 inch centers, 1 inch headers. The big thing to watch for in this collector is the absorber delaminating from the riser tubes. I don't know what you are going to do with these panels, but do not *use water in these panels in the winter, because the risers are too small. Smitty, AAA Solar, Albuquerque, NM*
smitty@aaasolar.com

Battery Float Oil
Dear *Home Power,* I am a solar home owner. Our house is powered by four PV panels and twenty nickel-iron batteries. When the system was installed, the installer did not put any float oil in the batteries. Since then, we have seen a performance decline in our system. We had another consultant look at the batteries, and he said we have a carbonate build-up. We tried flushing the sludge out, but did not have much success. I asked the consultant if there was some chemical that can be added. He said he heard about barium hydroxide. Do you know about this? Or do you know someone who might know a solution to this problem? Thanks, pattih@ci.glenwood-springs.co.us

Hello Patti, The barium treatment is strictly experimental. I've heard good things and I've heard bad things about it. What I do know is that electrolyte replacement (it sometimes takes two or three replacements), followed by several severe overcharge cycles, will bring these cells back to life. The "float oil" is USP mineral oil, and is available at any drug store. An eighth inch layer does the job. Richard Perez
richard.perez@homepower.com

Battery Tapping Not Allowed
Hi Richard, I've enjoyed and learned from your hard work for around ten years now, and I wonder if you could point me in the right direction. I have accumulated a number of low voltage charging/powering devices over the years, and I'd like to put together something to get rid of all those wall cubes. I want to take the 24 VDC from our system and tap it out at different voltages (3.7 VDC for cell phones, 8 VDC for kid's walkabout radios, 12 VDC for my 2 meter radios, 6.5 VDC for

fire call pager...you get the idea) to either run or charge these devices. What do you think? Thanks! Eli Spooner

Hello Eli, Bad idea. Tapping a battery in the middle of its series strings will unbalance the series connected cells. I tried center tapping 24 VDC batteries to get small amounts of 12 VDC to run radios. The 24 VDC battery began to suffer very quickly from having series connected cells with differing states of charge.

We've found no good solution for this problem. If you want various voltages of low voltage DC, build a regulator (powered by 24 VDC) to make the various voltages you need.

What we do here is just use the wall cubes powered by the inverter. We always have them on a plug strip, and switch them off when they are not actively being used. Richard Perez • richard.perez@homepower.com

Prius Review, Reviewed

Hi *Home Power,* Andy Kerr's review of the Toyota Prius in *HP85* was spot on. No need to make comparisons between the Prius and an EV because the Prius is not an EV. It is a hybrid. I have a couple of thoughts I want to share with you. I acquired my Prius in late October, just over a year ago. I have put nearly 12,000 miles on it. My drive to work is 11 miles. One-third of it is city streets, and the rest of it is county roads, which here in central New Jersey typically have speed limits of 45 mph. All summer long, I have been getting 55 to 57 miles per gallon on the computer, which translates to about 53 to 55 mpg measured.

This car is absolutely ideal for this kind of driving. About three miles of my trip to work are travelled on battery power alone. At speeds above 41 mph, the gas engine always runs, regardless of load. Once the car is going less than 40 mph, the gas engine will shut down if there is no load on it. One exception to that is as follows: If you are going 45 (or faster) and get on the brakes, the engine will stay running no matter how slow you go, unless you get off the brakes briefly once moving less than 40 mph. If you plan for this ever so brief letting off the brakes, the engine will shut down well before you get stopped and save a bit more gas. If you don't do this, the engine will shut down about 4 seconds after you stop moving. This still saves gas and contributes to the car's SULEV status, but not as effectively as it can when you get the engine shut down sooner. In case you were worried about steering or braking with the engine shut down, don't worry. Both systems are electric, and don't need the engine running to work properly.

It helps a lot to have a vacuum gauge so you know for sure when the engine is running. The LCD is lousy for indicating engine operation. I drive the car differently with engine on vs. off. My mileage went up a bunch once I learned a few secrets about driving this car. If you don't mind jumping through a few hoops, you can get fabulous mileage. If you drive it like an ordinary car, you still get fine mileage for a car of this weight and equipment—mid-40s or better.

Very Important: Toyota says you may not jump start the Prius, but you may trickle charge the 12 V battery at rates not exceeding three amps. I had a problem with a short circuit in a wiring harness and this ran the battery down. They fixed what turned out to be a tricky problem, and the car has been trouble free since then.

For what it is worth, I think that thing on the back of the trunk lid is aero-trash and took it off about a week after acquiring the car. The trim under the front bumper also comes off quite easily. The motivation for doing this was that when we were in Japan during July of '00, we saw lots of Priuses there with no aero-trash and they looked a lot cleaner. As an engineer who previously worked in computational fluid dynamics, I am of the opinion that the so-called wing does nothing but add weight and drag to the car. Don't need it. Pete Gruendeman gruendeman@worldnet.att.net

No Nukes—Speaking Out

In *HP86,* the *Power Politics* column hit home. I live within a 10 mile radius of the Indian Point Nuclear Power Plant. I was wondering if I could get reprints of this article in order to wake up New York state to the dangers imposed by not closing this plant. I'd like to get reprints of the article and perhaps subscription forms for *HP* and place them in the mail boxes of the community. I think a lot of people just don't get the real problem, or they're just not informed. Perhaps this article might help people start looking at renewable energy. I'm also interested in getting my public library a subscription to *HP*. Let me know how this can all come about. Thanks for your time, and for creating a magazine with a great deal of information. Steve Jensen

Hi Steve. Glad you find the article useful. We don't do article reprints, but I would be happy to send you an Acrobat PDF file of the article if you'd like. Just give the word. I give you permission to copy the article and distribute it for noncommercial purposes (which means don't make money off them).

We have a program that helps get Home Power *into the libraries. See page 119 for information about our Adopt a Library program. Michael Welch michael.welch@homepower.com*

Nuclear Waste

I just sent this letter to the editor of the *Patriot News* in Harrisburg, Pennsylvania. So why not send it to *Home Power* too? I'm not talking about spent fuel rods and items that were close enough to the radioactive reaction to become radioactive themselves. No, I'm talking about the money and effort that was wasted in building, licensing, operating, regulating, and protecting nuclear plants like Three Mile Island.

If we could have just spent that money on solar panels, storage, and electronics to connect the power to the grid, we would be far ahead by having a completely clean power source. And it would be so spread out that it would be impossible to attack.

New buildings could have had their roofs subsidized to become solar collectors, as well as old buildings that needed their roofs replaced. Large areas of marginal land could have been developed as "solar farms" to provide an abundance of energy. This technology is not new. It has been around for twenty years or more. It is being used right now on off-grid homes and businesses as well as by energy conscious people who prefer to produce their own electricity and sell back their excess to the grid.

Hundreds of millions of dollars have been wasted by our government on these nuclear plants in the form of grants, subsidies for research, and construction. A whole branch of our federal government bureaucracy would not be needed—the Nuclear Regulatory Commission. Of course, this is not reflected in the cost of electricity, but in our taxes. And now protection. The National Guard being used to protect nuclear plants is just another subsidy that we pay, with our taxes, in order to have these dangerous nuclear plants in our midst.

I've heard it said that the containment buildings in these nuclear plants are strong enough to withstand an airplane collision. But what if a terrorist plane hits the control room or the spent fuel containers? Either could cause a release of radiation over a widespread area. And if the Price Anderson Act is renewed, our insurance coverage could be only 10 cents on the dollar of a widespread contaminated area (our homes) that no one could safely go into for years.

Let's close these nuclear plants as soon as possible and save billions of tax dollars. But of course, now billions of dollars must be "wasted" to clean up the mess that's already there. Ted Keck at Blackstone Mill • ted@blackstonemill.com

Intelligent Response
Dear Mr. Woofenden, Your comments regarding the terrorist attacks on September 11 are right on target. (*HP86,* page 8) The overwhelming support for the responses taken to eliminate the consequences of unchecked terrorism is mind boggling. Purchasing more solar-electric panels is indeed "a more practical and intelligent response to the murderous attacks." And if in the future, for some curious reason these attacks persist, well then...we'll just go out and buy more panels. Hamilton Easter, Butler, Maryland

Hi Hamilton, Thanks for your comments. It is mind boggling. Out of one side of their mouths, our "leaders" warn us that our attacks on Afghanistan and other places will certainly bring retaliatory strikes. But at the same time, they vehemently deny that our past actions have led to the September 11 attack. Why we think we can teach nonviolence with violence is beyond me. Ian Woofenden ian.woofenden@homepower.com

Powered by Solar, Advil, & Old Crow
To *Home Power* magazine editor and staff, It is with great pleasure that I again renew my subscription to your great magazine! Yours is indeed one of the best magazines covering "green power" technology, as well as some of the economic and political aspects.

I have been a contributor a couple of times regarding solar installation and performance (*HP55* and *HP70*). I would like to say that after several years, our installation continues to function just as planned. For those of us who have made our own installations and for those who are contemplating an installation, the detail as to just where to get parts and their names and numbers is most helpful.

We are hooked up to the grid, so we have uninterruptible power—a great convenience to modern hi-tech equipment. We enjoy an informal relationship with Lee County Electric Cooperative, which has inspected our installation, put it on a TV spot, and written it up in their newsletter as well as a note in their billing to all customers. Our meter runs backward now and then, and I consider our relationship one rabbit to one horse in size. We buy 60 to 70 percent of our KWHs from the co-op.

One might well say, "Solar will never pay for itself." Does your car, or second car, your TV, sauna—I could go on, but you get the drift. Also, where do you think your KWHs are going to come from 50 years from now? Do you think global warming is for real?

Yes, we do a bit of gardening down here in the Everglades National Park, our country's third largest. We even grow bananas, papayas, sweet potatoes, eggplant, green peppers, green onions, and grapefruit. We grow about all of these that we can eat. Does it pay? We don't use chemicals, but it takes a lot of sweat. That even may be healthy—I'll soon be 90 years old. The doctors say I'm a remarkable man and ask what I'm taking. I reply, "Advil in the morning and Old Crow in the afternoon!" With best regards, Lincoln J. Frost, Everglades City, FL • Linckd4qc@aol.com

Missouri Self-Reliant Homestead
Hello *Home Power,* From 1991 until 2000, my wife and I lived on our sailboat in the Pacific. When we bought Natural High, the first thing we did was throw out the generator. Then we installed solar, wind, and water generators for our battery bank. We operated on both 12 VDC and 110 VAC.

We are now developing a homestead in northern Missouri. It will include our home and a guest house. Power will come from solar and wind. Water will come from a small lake and a small pond, as well as water collection into cisterns from our roofs. Our animals and farming will be serviced by our water and power systems. We live in a county that has no permit or inspection system for RE development. Therefore, we may invest as we are able to do so. The county is Grundy on Missouri State Highway 6.

Oh yes, we will have wireless internet service as soon as our tower is installed. And we are only one and a half hours from Kansas City and the airport. The property is rolling hills, meadows, timber, and creeks. It's heaven compared to the cities. Join us!

Alternative power is not difficult. In fact, using nature is much simpler than the way most of us have lived. But once you start, you and your family will be hooked—whether on a boat, in an RV, or on a family farm. Self-reliance through natural power is one of life's mysterious freedoms—that is until you and your family experience it. Steve and Peggy Horton hortonsw@aol.com

Where Are You, NY RE Industry?
Dear *Home Power,* We are building a timber framed home off-grid on 150 acres, and plan to install a 6 to 8 KW RE system with a budget of US$50K, and could go higher. What's amazing to us is that we have received no responses

to our e-mails for bids, catalogs, and help. We plan to expand the PV system to handle greenhouse hydroponics and some animal barns. Is the PV industry dead in New York? Pete Reynolds • mcrey@taconic.net

R-Value of Concrete
Great article in *HP86* by Douglas Stockman, "Renewable Energy in the Cloudy Northeast." Nice to see someone fight City Hall and win! I question the insulating value of the concrete block basement wall, foam filled, estimated at R-20. I live in an older subdivision of single story concrete block houses on block foundations. These buildings are very cold in this climate, and various schemes have been tried to make them more liveable, none very successful. Most tables I have seen rate block wall at R-3 to R-4, the same as solid concrete or brick. Filling the voids does little to change the thermal properties because heat is conducted very well through the web, in effect bypassing the insulation.

Think of the structure in terms of its heat conduction properties. This is especially true where the outside surface of the wall is in contact with the soil. We insulated the outside of the wall with 2 inches (5 cm) of extruded styrofoam, all we could afford, and cedar siding. We took care to excavate and insulate right to the bottom of the foundation. The experiment was very successful, and we gained a lot of thermal mass as a bonus. Great in the summer heat. One room is noticeably colder, the one where an existing sidewalk prevented excavating and insulating below grade, although the exposed outside wall of the room received the same treatment as the rest of the house, and the whole room is above grade. That proves the "conduction model theory" for me. If it's a problem, insulate the outside as a first choice, the inside as a second choice, but the middle won't help much. Jim Palmer, Courtenay BC, Canada

Calling All Canadians
Dear *Home Power,* Today I received an invitation in the mail to become a member of the Midwest Renewable Energy Association. It brought forward some thoughts I have had lately.

I have been attempting to prod and prompt governments in Canada to support incentives for homeowners who wish to pursue alternative energy. I have e-mailed members of government locally in the City of Barrie, provincially in Ontario, and federally. All I get is lip service that: "Yes, it is a good idea, but..." Most monies are going into research into how municipalities and institutions can use renewable energy, but the biggest user, the individual home owner and vehicle driver, is getting no help whatsoever.

This brings me to my reason for writing this letter. I would like to connect with *HP* readers if there are any who live in the southern Ontario area, especially within a 100 km (60 mile) radius of Toronto. Are you interested in renewable energy, and in getting in contact with me or each other with the idea of forming some sort of association to promote renewable energy in this area, in Ontario and Canada as a whole? I have listed my contact info below.

Thanks for hearing me and keep up the good work. I download your magazines religiously every two months and read them from cover to cover. Paul R. Thompson, 73 Briar Road, Barrie, Ontario Canada L4N 3M5 • 705-721-6847 paulthom@rogers.com

I-Renew Guest Editorial
Richard, It was so great to have you all here for the Iowa Renewable Energy Association's (I-Renew) tenth annual Energy Expo, and to have you do a great keynote. I wish I could express how much your support has meant to the members, and especially the board folks who have worked so hard on the expos over the years. I think if this one hadn't flown, it may have been the end of the road for our expo, but I think we really found our place in the universe this year.

I just finished laying out the I-Renew newsletter, and I thought you might enjoy my "From the Prez" editorial. I hope that you don't mind the quote—your speech at the fair was so timely, and I have watched the tape of it with friends several times since. Thanks again, and we'll see you next year! Rich

> "By the way, if you want to have a war over oil, leave me out of it... because I don't think we need it. All I have to say is go solar! Go wind! Let a little freedom into your life, and help your neighbors stay free, too." —Richard Perez' keynote address, final remarks at I-Renew's 10th Anniversary Expo, Sept. 8, 2001
>
> I was disassembling the geodesic dome we had erected at Prairiewoods for Expo on September 11th, 2001. It was a warm and windy late summer day, and the trampled grass in the meadow still held the positive energy of the 2,000+ curious and excited visitors who had walked there in the previous days. In dark contrast, the radio in my truck flooded the air around me with news of unspeakable acts of desperate and hateful men.
>
> The attacks held personal significance to me. Though a native Iowan, I lived and worked in and around lower Manhattan for over a decade. As I began to unscrew the bolts that held the dome together, my mind was back in New York City, tracing in vivid detail the sights and sounds of my daily bicycle ride across the Brooklyn Bridge, under the shadow of the twin towers—dodging taxis or catching a tow on the back door of a delivery van—to my woodshop a few blocks north of the World Trade Center.
>
> I sat down and looked up through the triangular sections of the dome, which made the sky and prairie around me look like the colored segments of a stained glass window. I feared for my friends and family back in the city, and for the world, and listened with dull, numb disbelief.
>
> In the months that followed, I kept thinking about the words of Richard Perez during his keynote address, just three days before the attack. He talked about the freedoms that renewable energy can bring. Among them were economic freedom and freedom from wars over oil. Since September 11th, I have read extensively about the roots of the hatred for America in Central Asia and the Middle East, and realized the extent to which motivations for action on both sides of the conflict are determined by the lust for oil.
>
> It is with this knowledge that I invite you all, as members of the renewable energy community, to join me in working

with new and greater resolve, to prove to the world that we in Iowa can become exporters of homegrown energy, that we can significantly reduce our nation's dangerous reliance on vulnerable sources of energy—foreign and domestic crude, natural gas, and nuclear power. We know that we can do this by using the great renewable resources we are blessed with in our state, not the least of which are our minds, hearts, and spirits.

Let us in Iowa and across the nation take this on as our personal responsibility, to make this America's last battle caused by foreign entanglements rooted in oil, and to honor the lives of those forever entombed under the rubble of corporate greed.

Rich Dana, President, I-Renew Board of Directors
irenewsletter@yahoo.com

Analysis of Nuclear Power
It is clear that the constraints on the U.S. economy are different now than they were in the 1960s and 1970s, when most commercial nuclear plants were built. At the time, labor was relatively plentiful (including skilled labor, engineers, researchers, etc.). Construction materials and technology were expensive.

The inverse is true today. Labor is critically short across the board, and this is most acute in the professions. Construction material prices are dependent on productivity, which has been rising steadily over the last 30 years.

Looking at talent as a constraint, the table below is my view of how a nuclear project fits into the scheme of things. "Qualified Constructors," as itemized above, is the number of people who could competently carry out the project. Clearly there is some wiggle room. There are probably more than 10,000 people building commercial strip centers and more than 1,000 people building high schools. Above that scale, however, talent runs out in a hurry.

The South Texas Nuclear Project (STNP) cost about US$6 billion (in the early 1980s) and took 7 years to build. The combined plant generates about 3,200 megawatts (4 x 800 megawatt units).

If a power plant lasts 30 years, 25 percent of our generating capacity has to be replaced every 7.5 years. If the total capacity of the U.S. power generation infrastructure is 1 million megawatts, we will need to replace 250,000 megawatts over the time required to build a nuclear plant. This has nothing to do with additional capacity; this is purely drop-in replacement.

Using the "too cheap to meter" assumption, we would have to build nuclear power plants at a cost below US$1 per watt. This means that we need to spend US$250 billion over the next 7.5 years on power generation infrastructure of one kind or another. This would be 25 very large nukes, using this analysis.

Another way of looking at US$250 billion: divide by the current average annual wage of US$30,000, or US$15 per hour. This is US$33 billion per year, 2 billion labor hours per year, and 1.1 million people in continuous employment during that time. This is just for the construction of the plants, and has nothing to do with long distance transmission facilities or substations.

A 1.5 megawatt wind turbine is equivalent to a 2,000 horsepower locomotive (divided by 750 to get horsepower). Could we build 700,000 locomotives over the next ten years? If that answer is yes, we could do the same with wind turbines. Meredith Poor, San Antonio, Texas • mnpoor@txdirect.net

Solar Hot Water in the UK
Dear *Home Power,* First, thanks for a great magazine—keep up the good work! Second, I have been following with interest your articles on solar hot water systems and whether two tanks are better than one. Here in the UK, a company called

A Business-Like Analysis of Nuclear Power

Project	*Cost Scale (US$)*	*Qualified Constructors*	*Incremental Responsibility*
Dog house	100	100,000,000	Protect animal from wind, rain, sun
Storage shed	1,000	10,000,000	Structural integrity, security
Major kitchen remodel	10,000	1,000,000	Electrical, plumbing, appliance installation
House construction	100,000	100,000	Financing, city inspections, historical review, etc.
Commercial strip center	1,000,000	10,000	Financing consortium, environmental impact, public hearings
High school	10,000,000	1,000	Bond issue, competitive bid, infrastructure improvements (streets, utilities, telephone, power)
Major bridge	100,000,000	100	Significant geologic analysis, usage analysis, engineer for corrosion, wind, collision, maintainability, etc.
Major coal burning power plant	1,000,000,000	10	Environmental compliance, transmission integration, process controls, waste heat disposal
Nuclear plant	10,000,000,000	1	Radiation shielding, nuclear materials security, containment structure, community evacuation plan, spent fuels disposition

SolarTwin (www.solartwin.com) has come up with an ingenious system whereby only one tank is required. The system consists of a flat plate panel on the roof with a small PV panel attached to it. This is connected to a small pump in your loft by rubber tubing, which is then fed directly into the top of your hot water tank (so there are no heat exchangers, no toxic antifreeze, and no need for a second tank). The sunnier the day, the quicker the hot water is pumped through the system, and the cloudier the day, the longer the water remains in the panel heating up!

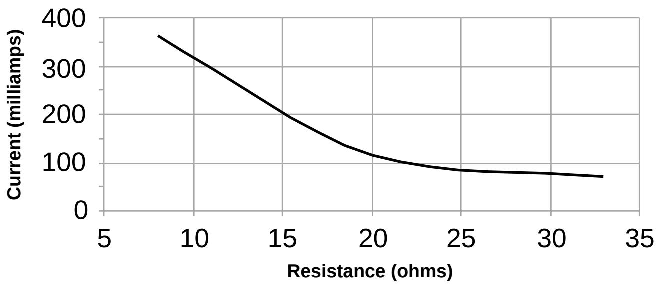
The reason this system is ingenious is the way the flat plate collector on the roof is freeze tolerant (something you need here in the UK!). When the panel is frozen over first thing in the morning, it normally takes about an hour or so to defrost and start working. We have had our system a year and a half, and it is proving very reliable, even pumping plenty of hot water on Christmas Day 2000. Whether this system would work in the U.S., I'm not sure, since I do not know how your hot water systems operate. I hope you find this of interest—keep spreading the word on RE! Yours sincerely, Roger Osborn • rogerosborn67@hotmail.com

Light Emitting Diode (LED) Lighting
I was fascinated with the information on LED lights that has been published in *Home Power.* Industrial applications for traffic lights and electrically lit advertising banners take advantage of the long life and low maintenance in replacement/running costs.

For me, the technology was heaven sent, since I am now in Taiwan where lots of this stuff is made and quite inexpensive. I have been tinkering with LEDs, and have found out a few things about them.

Part of the problem of using the LEDs purchased here is that they lack documentation, and it's hard to determine the current limiting resistor to go with the power source that is going to power the LED. Having purchased a digital voltage meter (DVM) and several resistors, the current measured indirectly across the resistor (in series with the LEDs) would allow one to compute the current in the circuit. Several articles suggested a maximum limiting current is 25 milliamps. The spreadsheet chart is enclosed for reference.

Light Emitting Diode —
Current Flow & Resistance Relationship



In this case, three resistor values were used against three LEDs and the voltages measured across the resistor, and the conclusion is that once the current exceeds 30 milliamps per LED, a large proportion of the electrical energy would dissipate as heat energy, and the LED would get fried when the current gets excessive. This is indicated by the steep vertical curve once the current exceeded 100 milliamps or 33 milliamps per LED. A nominal 6 volt battery was used to drive the LEDs.

Based on this experience, my observation is that LEDs are going to make an impact on our lives. They are extremely low consumption in electrical energy for automobiles and public lighting, etc. For aesthetics, colour rendering, and temperature, LED lighting has not reached a mature age for upmarket applications. YC Lim • limyenchung@yahoo.com

GS Catches More Flak
Dear Richard, With respect to the the "Step-By-Step Guerrilla Solar" article in *HP86,* I offer the following suggestion. The inverter should not be plugged into any AC outlet for two reasons. First, with another load on the same circuit, an island might be set up where the inverter continues to operate after the utility shuts down. Second, if an outlet protected by a GFCI is used, the backfed GFCI may either create an island itself or be destroyed in the process. A dedicated circuit is required by the *NEC* for these reasons. Guerrilla solar advocates should not assume that they are always safe when taking shortcuts using listed equipment.

Joe Schwartz was partially correct in his answer to a letter about GFCIs in the same issue. There are circuit breaker GFCIs that operate at 5 milliamps just like the receptacle GFCIs, and they provide the necessary antishock protection for all connected circuits within the number of outlets per breaker allowed by the *NEC.* There are also equipment-protection GFP circuit breakers that operate at 20 to 30 milliamps, but do not provide the necessary antishock protection. John Wiles • jwiles@nmsu.edu

Hello John, Thanks for these tech comments on the "Step-By-Step Guerrilla Solar" article in HP86. *We want GS to be safe. It is essential that these GS systems harm no one. This is a nonviolent, nondestructive protest, and we need to give folks the info to keep it this way.*

Since all the home's 120 VAC wiring is essentially in parallel, I fail to see the electrical difference between plugging the inverter into a wall receptacle or directly into the mains panel. In either location, the inverter is in parallel with all the loads on that particular 120 VAC leg.

In terms of GFCI circuit breakers or receptacles, you may be correct—they may be damaged by backfeeding. But household circuits not GFCI protected should have no problems handling the small output of the 100 watt inverter. Considering the load presented by on-grid homes, it is virtually impossible to island an inverter—there simply isn't enough power available unless the entire home is using less than 100 watts. Richard Perez richard.perez@homepower.com

Send us your letters by e-mail to:
letters@homepower.com

Writing for *Home Power* Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small-scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your renewable energy (RE) experiences printed in *Home Power.*

Informational Content
Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough that our readers can actually use the information. Name names, and give us actual numbers, product names, and sources.

If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article.

Article Style and Length
Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible.

We prefer simple declarative sentences that are short (fewer than twenty words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power.* After you've studied a few, you will get a feeling for our style.

We edit all articles for accuracy, length, content, organization, and basic English. You can help by keeping your sentences short, simple, and to the point. Our editing crew will make your text shine.

Photographs
We can work from good photographic prints, slides, or negatives. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs, since the ink can transfer to the front of the next photo. Please provide a caption and photo credit for each photo. Include some vertical format photos—you might even find your system on *HP's* cover. People are nice in photos; a fuse box is only so interesting, even to solar nerds.

Digital photos should be at least 280 pixels per inch (ppi) at the final printed size. This means that a column width photo should be 1,000 pixels wide or more. A full page width photo should be at least 2,300 pixels wide. Basically, set your digital camera at its highest resolution, and crop thoughtfully. We prefer Photoshop files, but we can handle the following formats in descending order of preference—EPS, TIFF, and JPEG.

Art, Schematics, & Tables
System articles must contain a schematic drawing showing all wiring. Our art department can make gorgeous diagrams, charts, and schematics from your rough sketches. If you want to submit a computer file of a schematic or other line art, please call or e-mail us first.

For system articles, we require a load table listing all loads, with wattage and run time. We also require an itemized cost table listing each system component and its cost. We prefer to have the tables come to us in Excel format. But we can use them from any word processor or spreadsheet format if they are saved as "text only," with tabs as the delimiter between data.

Computer Talk
We can take text from most word processors. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use the "Save As Text" option in your word processor.

If you want to send files larger than 5 MB (such as digital photos), use removable media and snail mail it to us. We can read ZIP disks (either Mac or IBM) and CD-ROMs. You can also FTP your large files to us at ftp.homepower.com, to the "incoming" folder. Please let ben.root@homepower.com know after you have sent us files via FTP.

Putting It All Together
We get many more articles submitted than we can print. The most useful, specific, organized, and complete get published first. Here are the basic components of a great *Home Power* article:

- Clearly written, well organized, and complete text, with a strong introductory paragraph, subheads for each major section, and a strong closing paragraph.
- Photos (plenty) with clear captions.
- Cost table.
- Load table.
- Other tables, charts, and diagrams as appropriate.
- System schematic.
- Complete access information for author, installers, consultants, suppliers, and manufacturers.

Have any questions? Give us a call Monday through Friday from 9 to 5 Pacific and ask. Or send e-mail. This saves everyone's time. We hope to see your RE project in *Home Power* soon!

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Ozonal Notes

Wrenches vs. Dot Commers

Richard Perez

Over the last few weeks of October 2001, I followed with great interest an e-mail discussion between some wrenches (installing RE dealers) and some dot commers (noninstalling RE dealers who specialize in Web and catalog sales).

The Wrench List

The wrench e-mail list began in October of 1999. *Home Power* decided that the folks who were professionally installing or selling RE gear needed a place to share technical and business information. While only RE pros can participate in the list, its archives are open to the public.

The wrench list is a huge success, with more than 150 members and an average of eight postings per day over the last two years. It has been a big help to everyone in the small-scale RE community. Much technical knowledge and many business tips have been shared.

Recently, as happens about three times a year, the folks on the wrench list became polarized into two camps—the wrenches and the dot commers. These two groups share the common goal of getting you to use RE. But they have very different business approaches, and these differences have led to heated discussions. Who has the best approach for spreading the small-scale use of RE—wrenches or dot commers? Well, that's a decision you have to make.

The Wrenches

Wrenches are full service RE dealers. They will visit your site and do a site survey for RE potentials. They will help you measure and estimate your electrical energy load. They will design a working, effective, RE system that will fit your needs and your budget. They will sell you all the equipment you need. They will properly install all this equipment to *NEC,* electrical inspector approved, standards.

Good RE wrenches will show you how to operate the RE system. They will come to your site and fix the system should there be any problems after the installation. Most wrenches are state-licensed electricians or electrical contractors. Wrenches offer turnkey service. All you have to do is turn the key, because the wrench has done all the work.

The Dot Commers

The dot commers tend to be sales-only organizations. They market RE equipment from Web sites and from mail-order catalogs. They primarily service the do-it-yourself market. Their services typically do not include site surveys, load consumption estimates, system design, or equipment installation. This is left up to you, the customer. Many dot commers may have previously been wrenches, and some of them do offer technical support via telephone and e-mail.

Costs—Wrenches vs. Dot Commers

We all know that an RE system can be expensive—from US$7,000 up. And none of us would rather spend more than less. Fact is, dot commers can sell you RE hardware for less than wrenches can. Why? Compared to wrenches, dot commers have far, far less business overhead.

A working wrench will wear out heavy-duty pickup trucks like you wear out shoes. A wrench has years of time invested in learning how to survey sites, estimate loads, do the actual installations, and pass electrical inspections. A wrench has thousands of dollars invested in specialized tools. And here's the killer—the wrench sells less actual RE hardware than the dot commer.

Since dot commers are high volume dealers, they get bigger discounts from distributors and manufacturers. This enables the dot commer to sell RE equipment for less than a wrench can. Both groups need a profit to survive in business. The dot commer makes this profit on volume sales, and the wrench makes this profit on a much smaller volume of sales and personal service.

The Recent Conflict

The latest discussion between the wrenches and dot commers began when a wrench wrote to the list that he had been called by a person who bought an entire RE system from a dot commer and wanted to hire this wrench to install it. The wrench informed the caller that he did not install equipment that he hadn't sold. The potential customer was offended, and went away (with his pile of equipment).

The wrench gave some very valid reasons for refusing to install the dot com-bought gear. There had been no site survey, load estimate, nor system design. Without these elements, the wrench knew that the system probably would not satisfy the client. The wrench didn't want the headache of a system that would probably not satisfy its user. And at the bottom line, the wrench could not afford to install equipment that he didn't sell (and make a profit on).

This posting brought protests from the dot commers. While accusing the wrenches of a guild mentality, they stated that site analysis, load estimation, and system design are not rocket science—that anyone can learn to do them. The dot commers also stated that the actual installation would be within the capabilities of any homeowner who could use tools and who had done the homework of learning how to properly install RE equipment.

After hearing both sides of this argument, I realized that both sides were right, and that both sides had a place in the small-scale RE marketplace. The root problem in this case didn't lie with either of these business factions, but with the consumer.

The wrench was right not to try to assemble a possibly inappropriate pile of hardware into a system that would most probably displease the customer. The wrench was right not to take on a job that was profitless for his business.

The dot commers were right on both counts—RE systems can be effectively designed and installed by homeowners who have the knowledge and wrenching skills. Only the customer was wrong—he overestimated his knowledge and abilities, and expected the wrench to bail him out.

The Ironies of This Argument
The wrenches seem to have forgotten that, almost without exception, they began their careers as do-it-yourselfers. Almost all the wrenches' first systems were done for themselves and installed for their own homes. You have to begin somewhere...

We need more wrenches nationwide. It's silly for these professionals to be driving hundreds of miles to do a site survey or installation. Their time is far better spent working than driving a truck. The best of the new wrenches are beginning their careers just as the old-timers did, by doing it themselves, for themselves. So please, wrenches, realize that the do-it-yourself step is an essential entry portal into your profession. Give them a break.

The dot commers seem to have forgotten that it was the wrenches who pioneered this industry. Without all the work the wrenches have done in the field, there would be no "cookie cutter" designs for the dot commers to market. The dot commers should show the wrenches some respect—it's their work that has lead to the spread and success of small-scale RE.

Turnkey or Do-It-Yourself?
Should you purchase a turnkey system, or build one yourself? This is the decision that you, the consumer, must make. If you want to forget about all the details and still have a working system at a reasonable price, a turnkey system installed by a wrench is for you. If you want to learn all about the intricacies of site survey, load estimation, and system design, and you have the experience with tools, the dot commer can save you money on your equipment. The problem is that you have to choose between these two—turnkey or do-it-yourself.

At *Home Power,* we do all we can to educate and inform our readers. If you have been reading *HP* for long, you have the information you need to do a site survey, estimate your load, and design a system. The mechanical and physical skills needed to do an effective installation must be learned, and you may have these skills already. The *NEC* guidelines for installing a code compliant system have been published here, and are also available in the *NEC.*

If you are considering the do-it-yourself approach, please be realistic when you appraise your capabilities. Before you order your equipment, do a site survey, a thorough load analysis, and learn to do an effective design. Realistically evaluate your mechanical and electrical skills. Can you install the system properly and have it pass electrical inspection?

In short, do your homework. We are more than happy to assist you with information and answer technical questions. Our confidence in your abilities and skills is reflected in all the information we publish—we don't just publish those full line schematics because they look pretty.

Room for Both
Home Power accepts advertising from both wrenches and dot commers. We see that both groups are essential to the success of this industry. We know that our readers come in two distinct groups—turnkey folks and do-it-yourselfers. All we ask is that you decide which you are before you plonk down your hard-earned bucks for an RE system.

The decision to hire a wrench or save money by doing it yourself is a tough one. If you opt to hire a wrench, no worries, mate. The wrench takes care of everything. If you decide to go do-it-yourself, there are only problems if you chicken out or botch the job. Then you must seek the help of a wrench to bail you out. This is going to cost money, and your system will probably cost you more than if you hired the wrench in the beginning.

Far be it from me to discourage anyone from designing and installing their own system. This is how I began and how most wrenches began. This is how we learn and grow. I try to keep *Home Power's* RE system cutting edge, so even today, with pro wrench Joe Schwartz on staff, our system is still do-it-yourself.

If you are planning to do it yourself, at least hire a wrench to review your design. He or she is going to want to see your load analysis and site survey. If you haven't done them up right, you'll be embarrassed, and wasting your money and the wrench's time. The wrench will suggest changes. Make them.

Please don't insult the wrench by asking him or her to meet or beat a dot commer's price. And ask the wrench what it's going to cost to get bailed out if you are unable to install the system properly. Novice flyers should always have a parachute...

Access

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Wrench list archives: www.topica.com/lists/RE-wrenches

Q&A

Advice for Whole Solar Thermal House
Hi! I am designing a house with maximum solar energy usage where feasible. The design is a south-facing house, where the south wall is virtually all windows going into large, open rooms.

The first question that I have is about the use of solar collectors for domestic hot water (DHW). I'm in an area where freezing is a concern, so an antifreeze based system is desired. What I've been reading in *Home Power* is that I should use two tanks. The first tank would be heated from the solar collectors, and the hot water from this tank feeds into a second tank for use.

My local solar company is recommending a single, 80 to 120 gallon electric water heater with just the top element in use. This method is usually mentioned as an alternative method in *HP*.

Before I talked with this company, I had been thinking about using one large tank, with an on-demand gas water heater as the backup, or with a standard water heater as the backup. Which way do you think I should proceed? If two tanks are recommended, what sizes? Is there a preference for gas or electric for the second tank?

I am also planning to put in slab heating. The local solar company is recommending five solar collectors in series that go to an on-demand gas heater. The entire system would be filled with antifreeze. Does this sound reasonable to you? Thanks, Wayne Sheffield

Wayne, I don't have all the information about your project to give you specific quantitative advice, but I have some conceptual suggestions I think you will find useful.

If you plan to use gas in your house, you ought to use gas for your backup water heating. In general it is wise to use thermal sources of energy for thermal end uses, and use electric sources of energy for applications that must have electricity. I think you are on the right track with the on-demand water heater as backup. Unless you have a really large family with high peak hot water usage (greater than 6 gallons per minute with water saving devices), the on-demand gas water heater will be your most economical, energy efficient, and space efficient solution.

About the south-facing windows—the most frequent mistake made in passive solar design is too much glass. The result is high indoor temperature swings, overheating on sunny autumn and winter days, and cold indoor temperatures at night and early morning.

The rule of thumb is to use south-facing glass equal to no more than 7 percent of the floor area of your house. That applies to low mass, stick-frame buildings. If you incorporate thermal mass in directly illuminated floors and walls of your house, you can increase that percentage to 12 percent of the floor area of the house. If you really want to go for the gusto (sounds like you do), use indirect passive solar heating, such as trombe walls or attached sunspaces, which deliver their solar heat later in the day and early evening rather than contributing to daytime overheating. If you use this approach, you can bump that passive solar collector area up to 20 percent of the floor area.

Slab heating is often incompatible with passive solar spaces that have a lot of glass. The slab has lots of thermal mass and maintains an even temperature. As soon as direct passive solar heating enters the same space, you have overheating because the slab cannot respond quickly enough to cool down. I would suggest that you use the slab heating in spaces that have little direct solar gain from windows. Use a quick response, backup heating system for the passive, direct gain heated spaces. You can combine a hydronic slab (low temperature) with hydronic baseboard heating (high temperature) in the same system by putting them on different zones.

I would advise against solar thermal panels in series. Heating a slab is a low temperature application. Five solar panels in series will produce unnecessarily high temperatures, and cause the panels to operate at a low efficiency. The high temperatures will also cause problems with overheating the glycol if you use an antifreeze system. Ken Olson • sol@solenergy.org

E-Meters and Batteries
Dear *Home Power*, I read your magazine regularly, and glean much information from the technical questions and answers when they are stated in everyday terms. My question is about amp-hour meters. I am using the Trace TM500 meter with 32 Trojan L-16 batteries. I have had some unfortunate mishaps where I have had to shut my system down for several days at a time. I need to get a benchmark of 0.00 on the meter, this being the point where the batteries are full.

What is the easiest way to get an E-meter or TM500 meter to match the state of charge in the battery bank? In the past, I have equalized for 4 to 6 hours, let the batteries sit for 24 hours, and then reset the meter to zero. Is this acceptable? Sincerely, Ken Steelman

Hello Ken, E-Meter is the product name of one of the two amp-hour meters manufactured by Xantrex. Xantrex also *manufactures the TM500 amp-hour meter you're using. The third amp-hour meter commonly used in residential RE systems is Bogart Engineering's TriMetric, which the design of the Xantrex TM500 meter is based on.*

While periodic equalization of your flooded lead-acid batteries is important, equalization isn't necessary to synchronize your amp-hour meter with the battery bank's state of charge. Neither is waiting 24 hours (without charging or discharging) for the batteries to come to a chemical equilibrium.

All three amp-hour meters reset the amp-hour figure to zero each time the meter's fully charged parameters are met. These parameters are user programmable. In off-grid RE systems, the TM500 charged parameters are most commonly based on battery voltage and charge current. As the battery voltage rises, battery charge current decreases. But the TM500 also allows you to choose voltage and time, or voltage alone as the fully charged parameters. The TM500 manual explains this meter programming well.

So with the meter installed and functioning, the battery needs to be fully charged (the meter's charged parameters met) before the meter will display accurate amp-hour and state of charge percentage information. Batteries like to be fully charged. In an ideal world, your batteries would be getting fully charged (and the meter would be automatically resetting itself) on a daily basis. But in off-grid systems, achieving fully charged batteries several times a week is more realistic.

On the TM500, the sun indicator will flash when the fully charged parameters are met. Again, it's important to note that on all three amp-hour meters, the state of charge percentage and amp-hour figures will not be accurate until the fully charged parameters are met at least once. And achieving a fully charged battery at least once a week is necessary to keep the meter in sync with battery state of charge. Joe Schwartz joe.schwartz@homepower.com

LED Night-Light

Dear *Home Power*, I enjoyed reading the article about converting a flashlight to LEDs in *HP84.* The article has given me an idea to build a much needed LED night-light for our mountain cabin. The cabin has existing 12 VDC circuits. We wanted to use one or two LEDs per night-light, and be able to power them directly from the 12 VDC circuit. The question I have is what size resistor would we need for each 5,600 mcd, 20 degree LED? Sincerely, Harry Deemyad, Fairfield, California

Hi Harry. LEDs are great for this application. I use several two-LED fixtures, both inside and out, to give me a "navigation" level of light at an energy cost of about a quarter of a watt per fixture.

There are a few things you need to know before you can calculate values for your resistors. I'll use figures for my favorite LED, the Nichia NSPW500BS (5,600 mcd, white). How many milliamperes (mA) will flow through the LEDs? The harder they're driven, the faster their luminous intensity will drop. I suggest 20 mA as a reasonable compromise between longevity and light output.

Next, it helps to know the junction voltage required at the current you want. I took ten of these LEDs, noted the voltage required to get 20, 30 and 40 mA rates. I then averaged the voltages, getting respective values of 3.41, 3.55, and 3.66 volts. If you add up the junction voltages (at the current you want) for the number of series LEDs in your circuit, subtract that from the supplied voltage, and divide the remainder by the ampere value you want (0.02 for 20 mA, 0.03 for 30 mA), you'll have the resistor value needed in ohms. *(also, see* Letters, *page 128.)*

Note that whether you have one, two, or three LEDs in series with a resistor, for a given voltage and current, each circuit uses exactly the same power—in this case, at 20 mA, about a quarter watt. It might be appropriate to get 50 percent more light from some of your fixtures by including a third LED in lieu of a bigger resistor (try a 123 ohm resistance with three LEDs, for about 20 mA in a 12 volt system).

Lately I've gone to using tiny LM317LZ adjustable regulators in my two-LED 12 V lights to precisely regulate the current, protect the LEDs, and give me full light output from 11 volts up. You can download a PDF of the application notes for this simple regulator, including sample circuits at: www.national.com/pf/LM/LM317L.html. Have fun. Don Kulha don.kulha@homepower.com

Care and Feeding of Hydrocaps

Richard & gang, How about writing a little piece on the care and feeding of Hydrocaps? There were absolutely no instructions provided with the ones I bought! Some basic guidelines would be very useful. It seems like I once heard that it was necessary to bake them in the oven from time to time. Chuck P.S. We are coming up on our first megawatt-hour of homemade energy!

Hello Chuck, I've never heard of baking Hydrocaps. I have had the vents plug up sometimes. All that's required is to remove the cap and rap it sharply, and the stored water drains back into the cell. I can see no harm in baking the caps in a very low oven (less than 150°F). The only big no-no with Hydrocaps is equalizing with them in place. Richard Perez richard.perez@homepower.com

Hi Chuck, We just did an installation with an SEI workshop using a single-point watering system. For about US$15 a cap, you will never have to lift a battery *cap again. And the watering system can even be set up with a reservoir to automatically water the batteries. You can equalize with these caps in place, and you don't have to take them off to use a hydrometer (they have a flip top and a hydrometer hole). I think we'll see more and more battery banks using systems like these in the future. I know I want one on my battery bank... Congrats on the MWH! Where's the party? Ian Woofenden ian.woofenden@homepower.com*

PV Panel Placement Problems
Dear *HP* crew, Thanks for a very informative and helpful magazine. I have learned a lot from the various articles. Of course, they deal with the most ideal solar sites. Some of us are not so fortunate. When we built our cabin in northern New Hampshire about thirty years ago, we had no idea that we might have electricity at our remote site. Today, we are surrounded by very tall pines.

In the summer, our one Solarex panel performs quite well, but as the sun gets low on the horizon in the fall and winter, we have to use the genny more than I would like. I have purchased a second panel, and I am questioning where to place it. I have a morning site of several hours and an afternoon site of several hours. I have thought that I might place one panel at each of the two sites. However, it seems to me that somewhere I read that this is not a good idea.

On the other hand, a TV report on PV said that on a cloudy day, a solar panel would generate 80 percent of its full sun output. I would appreciate your comments on these two points. Also, it would be interesting if you could publish an article on a site or sites that are less than ideal, giving information on how they cope with the problem and the performance of the systems. Thanks. Looking forward to another great year with *HP*. Richard A. Kenyon, Foster, Rhode Island exmoorri@aol.com

Hi Richard, Good article idea! We welcome articles on OK, good, excellent, and amazing solar sites, and look forward to seeing one from you one of these days too. I know what you're talking about as far as the challenges of siting in the woods. There are 120+ foot Douglas-firs at the back of our clearing, and in the depth of winter, they block the sun all but a few hours of the day. I'm scheming to move our main PV array off our roof and onto a tall pole, which will gain us several hours of sun each day. I also recently installed two PV panels on one of our homebrew wind generator towers. At 115 feet, the solar window is pretty good... I expect to get at least half again as much energy as I would if I'd put these two panels on my roof.

In a situation with good all day sun, facing some panels southeast and some southwest does not make sense. The most intense sun is in the middle of the day, and facing an array due south is ideal. In your situation, with one site having only good morning sun, and the other only good afternoon sun, splitting your array could work well. This assumes that the panels are in parallel, of course. But if I were you, I'd be looking for a tall pole, or even a spot in a sturdy tree to mount your PVs close to your battery bank, but up where the sun shines.

The TV report you heard was optimistic about 80 percent PV output in cloudy weather. On a "cloudy bright" day, but not so bright as to cast shadows, Richard Perez gets about 50 percent power from his arrays. And on a heavily overcast day here in the Pacific Northwest, I just pray for wind. Ian Woofenden, ian.woofenden@homepower.com

Batteries and EDTA
Hello Richard, I just received the Solar 3, 4, 5, and 6 CDs, and love them. They are many times better than I had expected. I do have a question—in your lecture on batteries, you talk about a chemical called EDTA. I have a neighbor that did not maintain or add water to his batteries for eight months. I went over and added almost three gallons of water to the eight Trojan L-16s.

Of course, the batteries are having some problems, and are not keeping a charge. The neighbors only use this house one or two weekends a month, and the batteries are about two years old. Do you feel that adding EDTA to their batteries will be of any benefit? Or is it a hopeless cause, and they should just replace the batteries? By the way, I am maintaining their system now, so this problem won't occur again. Thank you very much for any info on this matter. Rich Mumm

Hello Rich, EDTA is for stripping large sulfate crystals from the cells' plates. If these batteries were run low on water, they have been radically overcharged. Sulfation of the plates is not the problem, but oxidization (from being exposed to air) is the most probable problem. EDTA will not help.

Here are some things that you can do:

1. Adjust the charge controller so that the battery is not being radically overcharged while the system is unused. In a 12 VDC system, back the charge controller down to about 14 VDC, and lower it even further if the cells still consume large amounts of water. Double this for a 24 VDC system.

2. Equip the cells with Hydrocaps. This will prevent the cells from losing water, and increase the periods between watering.

3. If the cells have been damaged by running them dry, there is little you can do but pray. Keep them wet, recharge them, and hope for the best. Richard Perez richard.perez@homepower.com

Send your questions for Q&A to letters@homepower.com

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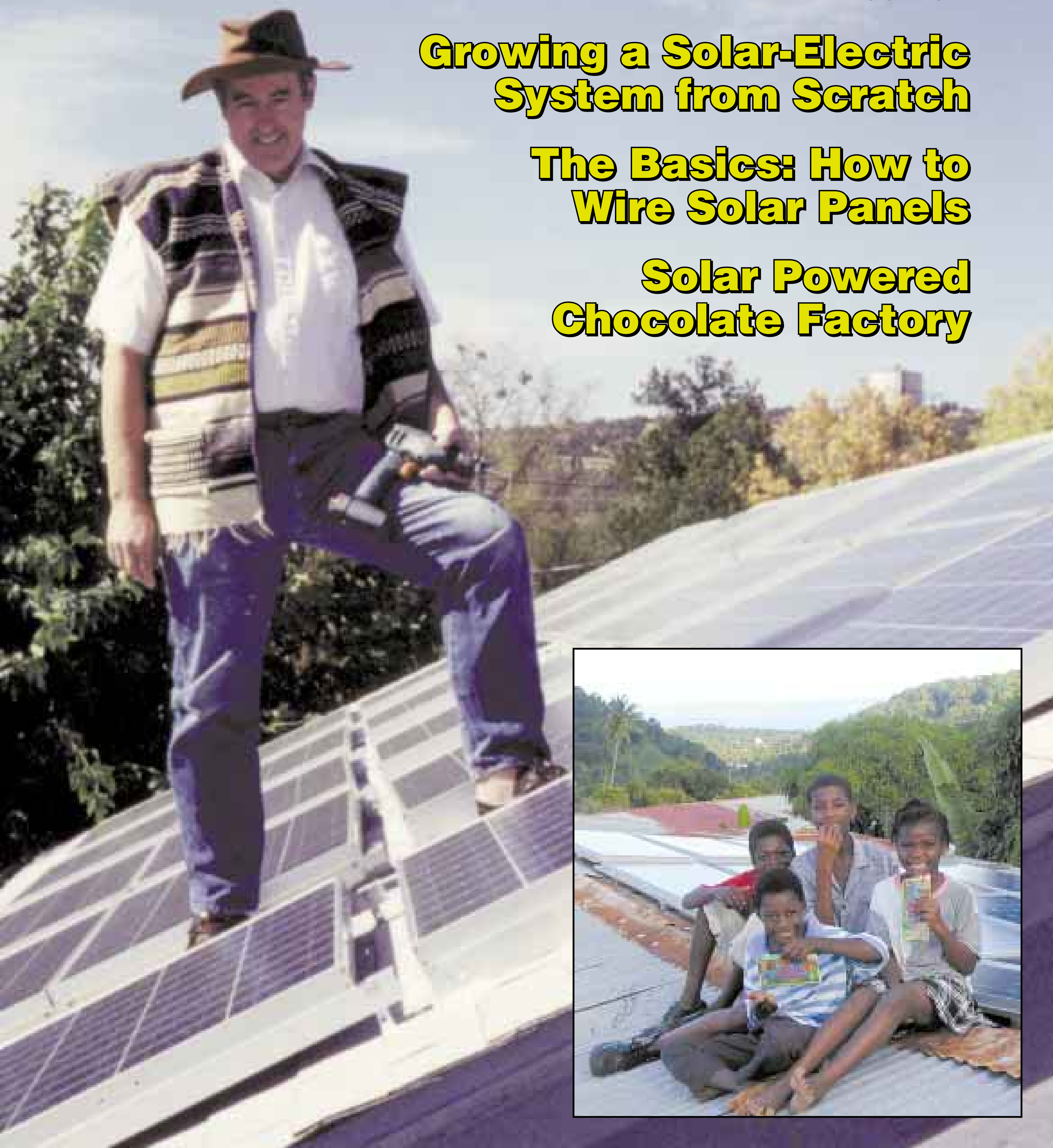

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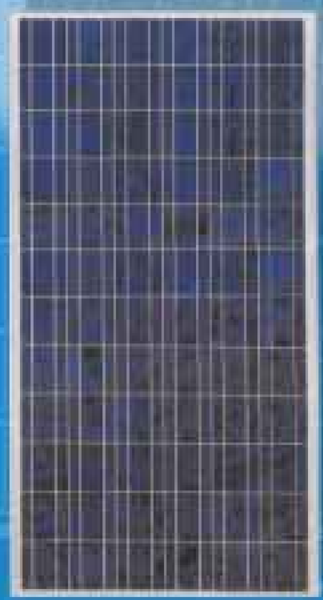

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