
relax.

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Trojan® BATTERY COMPANY

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #83 June / July 2001

Features

Features

GoPower

Cover: Allen Patterson brings 1.9 kilowatts of grid intertied PV to his surburban Bellevue, Washington home.

GoPower

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Book Review

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We're not trying to rub anyone's nose in it. This is about celebration. Sure, we mean to flaunt it, but it's a good thing. And the people who've realized that deserve to celebrate. We know that we've got reliable power, and that it came from clean sources.

Join us. We want everyone to experience the benefits, the simplicity, and the excitement of making their own energy with the renewable power of nature. This isn't about energy evangelism, nor is it PV pyramid sales. We want everyone to join us 'cause it's what's best—for them, for all, and for the planet.

So if the lights go out at your house, you're welcome at ours. We'll blend cocktails, or make a pot of tea. We'll give you a tour of our RE system if you want, or we can just hang out. Just drop in. We'll be easy to find—it's the house with the lights on.

–Ben Root, for the *Home Power* crew,
and (we hope) renewable energy system users everywhere

People

"Think about it…"

Blackout?
What blackout?

–Anonymous RE user

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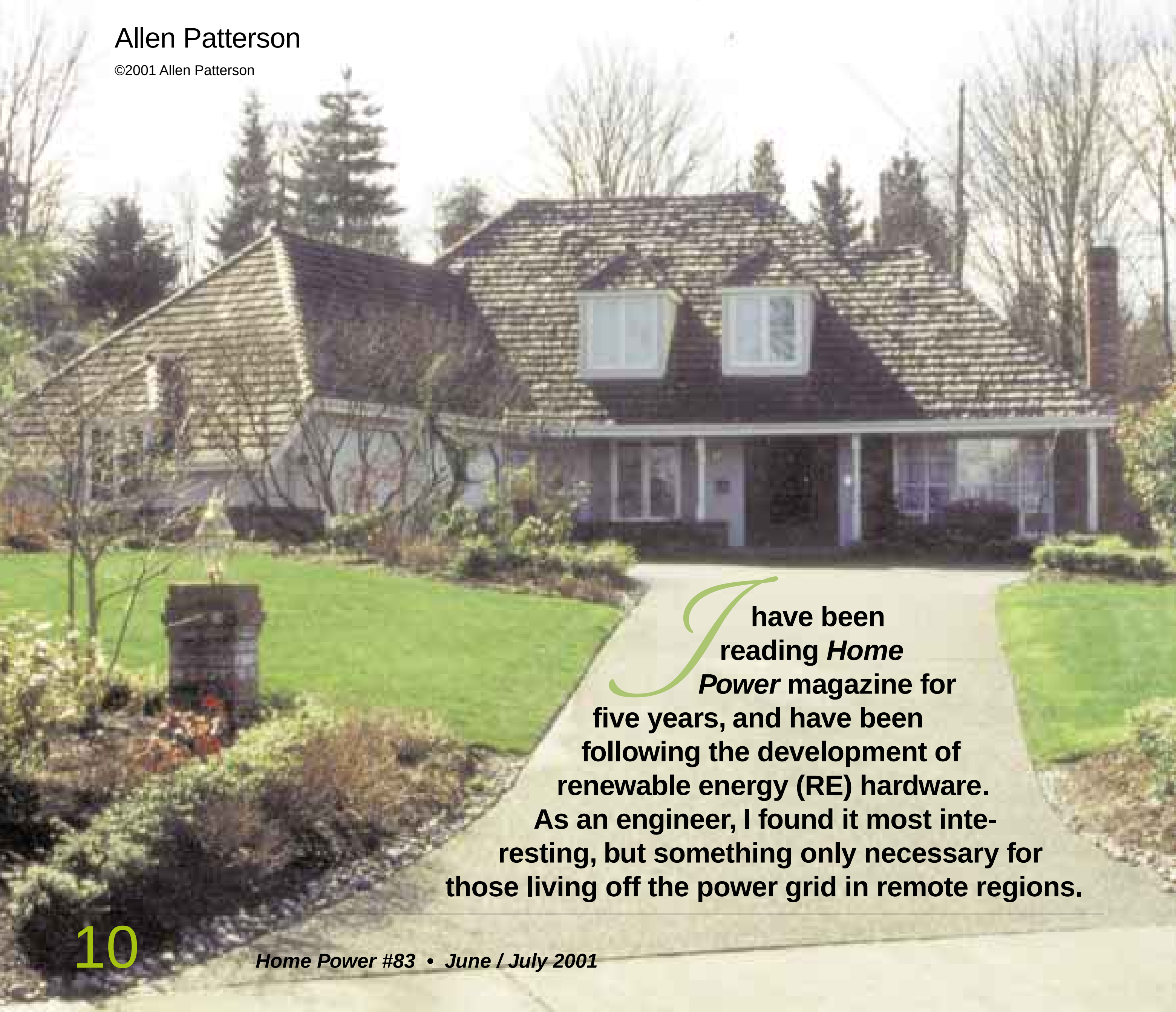
Allen Patterson



I have been reading *Home Power* magazine for five years, and have been following the development of renewable energy (RE) hardware. As an engineer, I found it most interesting, but something only necessary for those living off the power grid in remote regions.

In the last two years, I slowly became aware of an impending power crunch. Power deregulation was being touted as the new way to reduce consumers' energy bills. California deregulated one side of the equation and left the other side regulated, and energy conservation seemed to have a very low priority. To me, this looked like a formula for disaster.

Sixteen AstroPower PV modules, for a total of 1,920 rated watts, are mounted on the south-facing roof above the greenhouse.

Modern Home

In December of 1999, I bought a fourteen-year-old home that had all the modern features. I wanted to add an RE system, using the south-facing roof for the PV array, and the oversized garage to contain the batteries and associated electronics. In July of 2000, I began the search for a qualified, experienced, and knowledgeable contractor.

I wound up contracting with Planetary Systems from Ennis, Montana. I explained to owner Bill von Brethorst that I was looking for blackout and brownout protection, and that I was concerned about possible rate increases. Little did I know! My home had a new chef's kitchen with two ovens, standard incandescent lighting, and all the normal appliances. I also wanted to be able to operate my amateur radio station (KC7SYR) in the event of an emergency. This all added up to a lot of energy.

I sent Bill digital pictures of my house showing the roof, location of the gas meter (for connection to the generator), and garage. He designed the complete system, and sent back specifications and pricing. We signed a contract on October 31, 2000, and equipment began arriving over the next six weeks.

Power Package

Planetary Systems' "Power Package" (patent pending) is a state-of-the-art system. It encompasses all of the advantages of previous renewable energy systems, without the inherent downsides of learning about and adjusting to new and highly technical equipment.

Utility input capability is up to 40 amps at 120/240 VAC, or 9,600 watts. Generator input is up to 30 amps at 120/240 VAC, or 7,200 watts. And PV input is up to 120 amps at 24 VDC, or 2,880 watts. Power Package output on the AC side is up to 60 amps at 120/240 VAC, or 14,400 watts maximum. DC output is available at 24 VDC up to 30 amps, or 720 watts.

The system arrived in two modules—a battery module and a control module. The control module, which

Author Allen Patterson keeps tabs on his RE system with digital metering.

includes the Trace inverters, disconnects, charge controllers, grounding, and wiring, is completely assembled and tested when it arrives. This eliminates not only a good portion of the labor, but also a great deal of the frustration.

Planetary Systems personnel were on site mainly to help install the solar-electric panels on the back roof. With the Power Package, only a couple days of work were needed to install this relatively large system.

The rear (south) side of the house is focused on solar collection, with PV panels, a greenhouse, and garden beds.

The preliminary work was done by a local electrician. It included changing the house panel board configuration so that there would be a main utility panel and a house subpanel. This means that the selected utility-only house loads are isolated, and that the sell-back feature of the Power Package would feed a utility-only power panel, per Trace recommendations.

The Trace manual recommends setting up a subpanel for all circuits that you want to run with the RE system. In our system, we ended up with only the two electric ovens, hot tub, and yard lights remaining on the main grid panel. Everything else was shifted to the subpanel. This gave us a system that can sell back power, import power from the utility grid, and still maintain the house power reliably, whether or not the utility is available.

The AC system setup uses plug-in connectors and flexible UL-listed cords. The electrician wired an input circuit from the utility, an input circuit from the generator, and an output circuit to the house main panel. These went to a junction box on the wall, and connected to the cords in the Power Package that were labeled for each use.

Each cord is mechanically coded, so wrong cords cannot be plugged into each other. A bypass mechanism is also built in, so that the inverter output to the house panel may be plugged into the utility supply, thus bypassing the inverter system. Each cord is “dead front” meaning no live parts are exposed. (The end with voltage is the female end, and the end that has no voltage is the male end.)

The system’s modular containment design is extremely easy to maintain. It’s much better than traditional systems with components mounted all over the garage walls, allowing access by unauthorized people. Dust and particulate matter normal to any garage is also kept out of the equipment.

Initially, the system operated as an interactive system without sell-back,

The main grid panel and subpanel with the automatic transfer switches for the ovens, below.

Solar array 40 amp breakers and Trace PVGFI-2 ground fault interrupter.

providing power to the house and purchasing off-peak power from the grid to charge the batteries. Once the system was inspected, both by the local electrical inspector and by Puget Sound Energy, a contract for sell-back was initiated and signed.

A ten-minute phone call to Planetary Systems was all it took to walk through the Trace inverter programming and initiate the sell-back feature of the system, which has been operating in that mode ever since. The simplicity of the design makes it easy to operate this high-tech system.

Hungry Kitchen in a Smart Home

My kitchen has two electric ovens, one with gas burners and one with an attached microwave. I wanted to be able to get power to both when off the grid, but only enough to run the gas igniters on one oven and the

Planetary System's packaged electronics module provides drag and drop convenience.

The battery module provides vented containment for the twelve IBE lead-acid cells.

Patterson Loads*

Unit	Watts
Hi-Fi	300
Furnace	223
Freezer	218
Refrigerator	204
Projection TV	192
Small TV	48
Total	1,185

* Other than lighting

microwave on the second oven. The electric ovens would be much too power-hungry to operate off-grid.

Two Todd Engineering automatic transfer switches were added to the design to switch the ovens from the grid panel (30 amp breakers) to the subpanel, using ten amp breakers with a twenty-second delay. This provides enough power for the igniters and microwave, but the breakers trip if the main electric ovens are used.

My home utilizes Smarthome technology for lighting, HVAC, entertainment, and security alarms. It uses a JDS Technologies Stargate computer with X-10 technology to control loads when off the grid. X-10 is a standard technology used by many manufacturers to send control signals over a home's wiring. The control signal is sent when the sine wave is at the zero crossing. The communication between the two Trace SW4024 inverters in the solar-electric system did not interfere with the zero crossing technology.

Appliances & Lighting

After the solar-electric system was installed, I began to look at where my power was being used. I added "Power Planners" to our fairly new refrigerator and freezer, furnace, clothes washer, and attic fan. These

The 8,500 watt Kohler backup generator runs on natural gas.

Generator, utility power, and main output breakers.

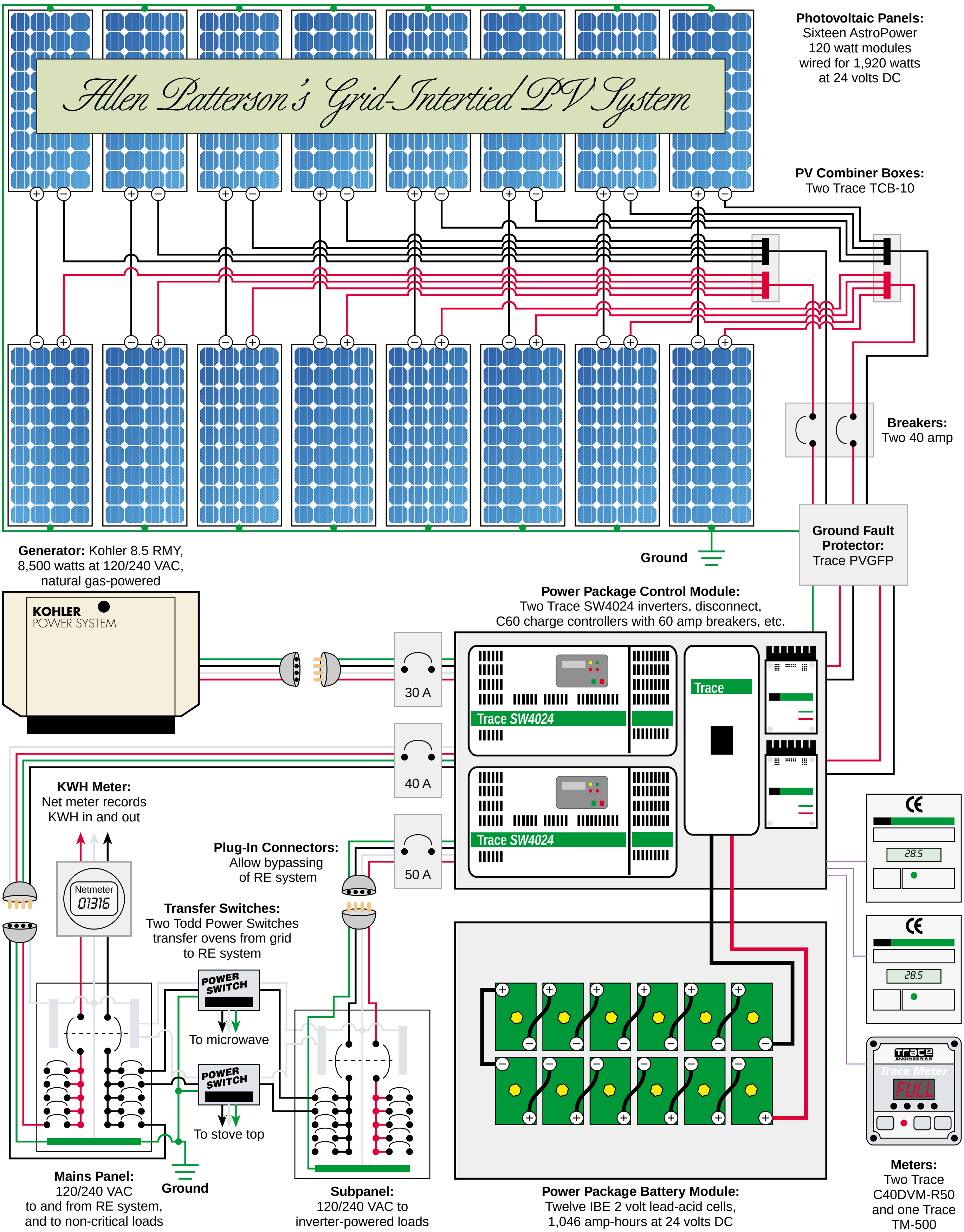
devices are made by EnergySmart, an Arizona company. There is some disagreement about the effectiveness of these units in some situations, but they did seem to result in a drop in energy use in my home.

Next I looked at lighting, which is a major load in most homes. I wanted to keep bright lighting available throughout the house, and still reduce the load as much as possible.

My in-house lighting total was 4,550 watts. Out of that, 790 watts would need to stay with incandescents. They were in bathrooms and the dining room, and the fixtures were not easily retrofitted with compact fluorescents. But 3,760 watts could be changed to dimmable compact fluorescent lights compatible with my X-10 Smarthome control system. These lights were used frequently, so significant savings was realized by replacing these with 713 watts of compact fluorescents—a 3,047 watt savings!

Power Savings:
Incandescent vs. Compact Fluorescent Lighting

Area	Incandescent (Watts)	Fluorescent (Watts)	Savings (Watts)	Percent Savings
Den	650	111	539	82.9%
Bedrooms	1,040	182	858	82.5%
Kitchen	600	115	485	80.8%
Hallways	600	115	485	80.8%
Garage	600	129	471	78.5%
Library	270	61	209	77.4%
Total	3,760	713	3,047	81.0%


Allen Patterson's Grid-Intertied PV System
Photovoltaic Panels: Sixteen AstroPower 120 watt modules wired for 1,920 watts at 24 volts DC
PV Combiner Boxes: Two Trace TCB-10
Breakers: Two 40 amp
Ground
Ground Fault Protector: Trace PVGFP
Generator: Kohler 8.5 RMY, 8,500 watts at 120/240 VAC, natural gas-powered
KOHLER
POWER SYSTEM
Power Package Control Module: Two Trace SW4024 inverters, disconnect, C60 charge controllers with 60 amp breakers, etc.
Trace SW4024
Trace SW4024
Trace
30 A
40 A
50 A
KWH Meter: Net meter records KWH in and out
Netmeter
01316
Plug-In Connectors: Allow bypassing of RE system
Transfer Switches: Two Todd Power Switches transfer ovens from grid to RE system
POWER SWITCH
To microwave
POWER SWITCH
To stove top
28.5
28.5
Trace
Trace Meter
FULL
Mains Panel: 120/240 VAC to and from RE system, and to non-critical loads
Ground
Subpanel: 120/240 VAC to inverter-powered loads
Power Package Battery Module: Twelve IBE 2 volt lead-acid cells, 1,046 amp-hours at 24 volts DC
Meters: Two Trace C40DVM-R50 and one Trace TM-500

Phantom Loads & Always-On Loads

Item	Watts	WH per Day
Home telephone system	24	576
Computer, router, and hub	57	1,368
Satellite receiver	31	744
Small TV sets (4 watts each)	12	288
Projection TV	16	384
Furnace	13	312
Microwave & electric oven	17	408
Gas-top & electric oven	27	648
Battery chargers in shop	18	432
Other home battery chargers	45	1,080
Total	260	6,240
Total KWH per day		6.24

Phantoms
After dealing with lighting efficiency, I estimated close to 500 watts of phantom loads that I had to hunt down. I figured that I could reduce this significantly. See the table for the present state of my phantom load battle. The phantom loads add up, and they are hard to find.

I plan to put X-10 appliance modules in selected outlets for the battery chargers and have them automatically switch on for eight hours each week. The oven phantom loads are for the display and control electronics. There is not much I can do about them without changing ovens, which I don't plan to do.

Additionally, my Stargate system will automatically turn off certain loads in the event of a power grid failure, such as the instant water heater. The one gallon (3.8 l) instant water heater in my kitchen is a very nice device. It is not on very often, but when it is, it draws 660 watts. In normal operation, the Stargate system turns it off every night, and back on at 6 AM.

We have a mixture of incandescent and fluorescent lighting on the same X-10 dimmer circuit. As I push the dimming switch, the incandescent lights dim faster than the fluorescent lights. So I can easily dump much of the high incandescent load, and still have a majority of the fluorescent lighting on. If I continue to push the dimming switch, the fluorescents will continue to dim until they are completely off.

Utility & State are Cooperative
I was very pleased with the cooperation, encouragement, and enlightened attitude of the state of Washington and Puget Sound Energy regarding my renewable energy system. I dealt with Shannon McCormick, Program Manager for Energy Efficiency Services for Puget Sound Energy, who helped me obtain a contract for net metering.

Net metering is the law in Washington state, and the state feels that it is a win-win situation. By reducing the need for costly new combustion turbines, they can better serve a growing customer base. It also reduces their need to seek rate increases.

Renewable Insurance
This has been an interesting and rewarding project for me. As I dove into all the details, I became keenly aware of all the energy I was needlessly wasting—just like the majority of the population. My biggest load was lighting, which I reduced by over 81 percent just by changing to fluorescent lighting wherever possible. The savings was over 3,000 watts! I should have done this a long time ago.

My friends and family are slowly becoming educated about renewable energy. At first they questioned the wisdom of this kind of expenditure. But now they hear of major concerns for our area of the country—shortages of hydro power and natural gas, and the very real potential of brownouts and blackouts. This new awareness already has them buying Power Planners and fluorescent lights, which helps in energy conservation.

My system is working flawlessly. It's a little early in the game to have much hard data, but here's what I know so far: I use between 10 and 20 KWH per day depending upon how much the furnace, washer, dryer, and hot tub are used. This is a lot, but I started out with a traditional suburban house. I see now that if I were starting from scratch, I could do much, much better. Bill at Planetary Systems says that he runs a comfortable home on 3.5 KWH per day.

If the sun is out for five hours, and the array is producing 1,000 watts of solar power, it will provide for my needs during the daytime, and sell about 1 KWH back to the utility (when I keep my usage down to the

Patterson System Costs

Item	Cost (US$)
Power Package model #2DS1, includes:	$12,824
2 Trace SW4024 inverters	
2 Trace C60 charge controllers	
12 IBE 85N-21, 2 V, 1,046 AH batteries	
2 #PV120-8 solar packages, includes:	10,670
16 AstroPower 120 watt modules	
Trace PVGFP ground fault protector	
2 Trace TCB-10 array combiners	
Kohler 8.5RMY propane generator	4,544
Installation	3,065
Total	$31,103

The utility meter records both incoming and outgoing kilowatt-hours.

Shannon McCormick of Puget Sound Energy gives the RE system the OK for intertie.

10 KWH level). During the summer, with longer days and more intense sun, I should be able to almost cover my needs around the clock. I don't have much data yet, but I plan to aggressively collect and analyze my data, and use it to improve my system.

I run a business out of my home, and I need to have the assurance that I will have electricity available at all times. Also, in the event of any disaster, I will have power for my ham shack for emergency communications. My renewable energy system is my insurance policy.

Access

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Planetary Systems, Bill von Brethorst, PO Box 340, Ennis, MT 59729 • 406-682-5646 • Fax: 406-682-5644 brethors@3rivers.net • www.planetarysystems.com

Puget Sound Energy, Shannon McCormick, PO Box 90868, Bellevue, WA 98009 • Energy Efficiency Hotline: 800-562-1482 or 425-454-2000 energyefficiency@puget.com • www.pse.com

R&I Electrical Contractors Inc., Ioane Aufai, 16202 89th Ave. NW, Stanwood, WA 98292 • 360-652-3623 Fax: 360-652-8228 • Electrician

Kelsun Distributors, 13000 Bel-Red Rd., Bellevue, WA 98005 • 800-223-3808 or 425-453-1199 Fax: 425-453-1043 • Dimmable fluorescent lights

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JDS Technologies, 12200 Thatcher Ct., Poway, CA 92064 • 858-486-8787 or 800-983-5537 Fax: 858-486-8789 • www.jdstechnologies.com Stargate computer

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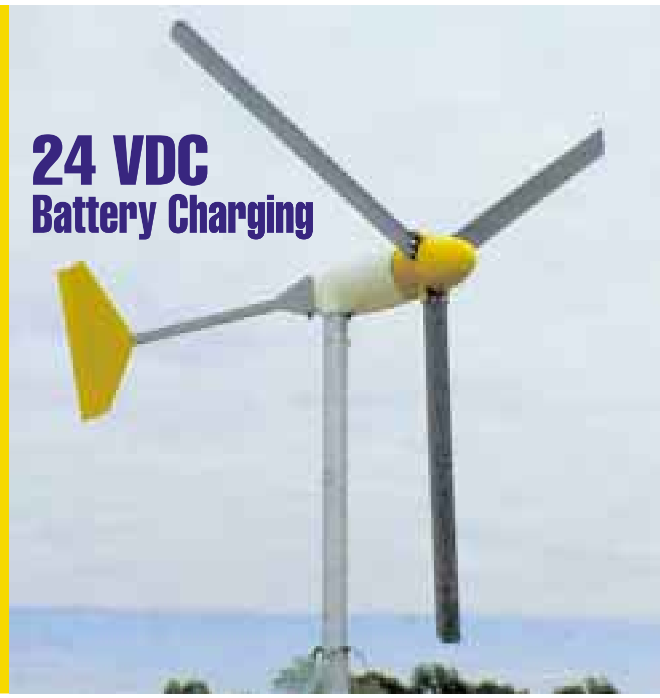
*Patent Pending



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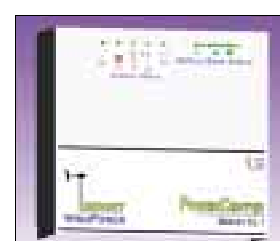

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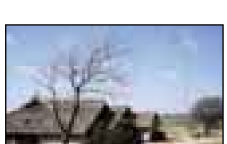

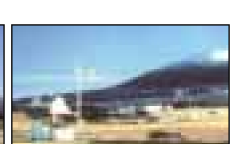

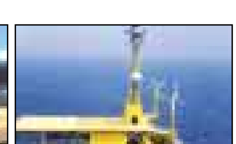

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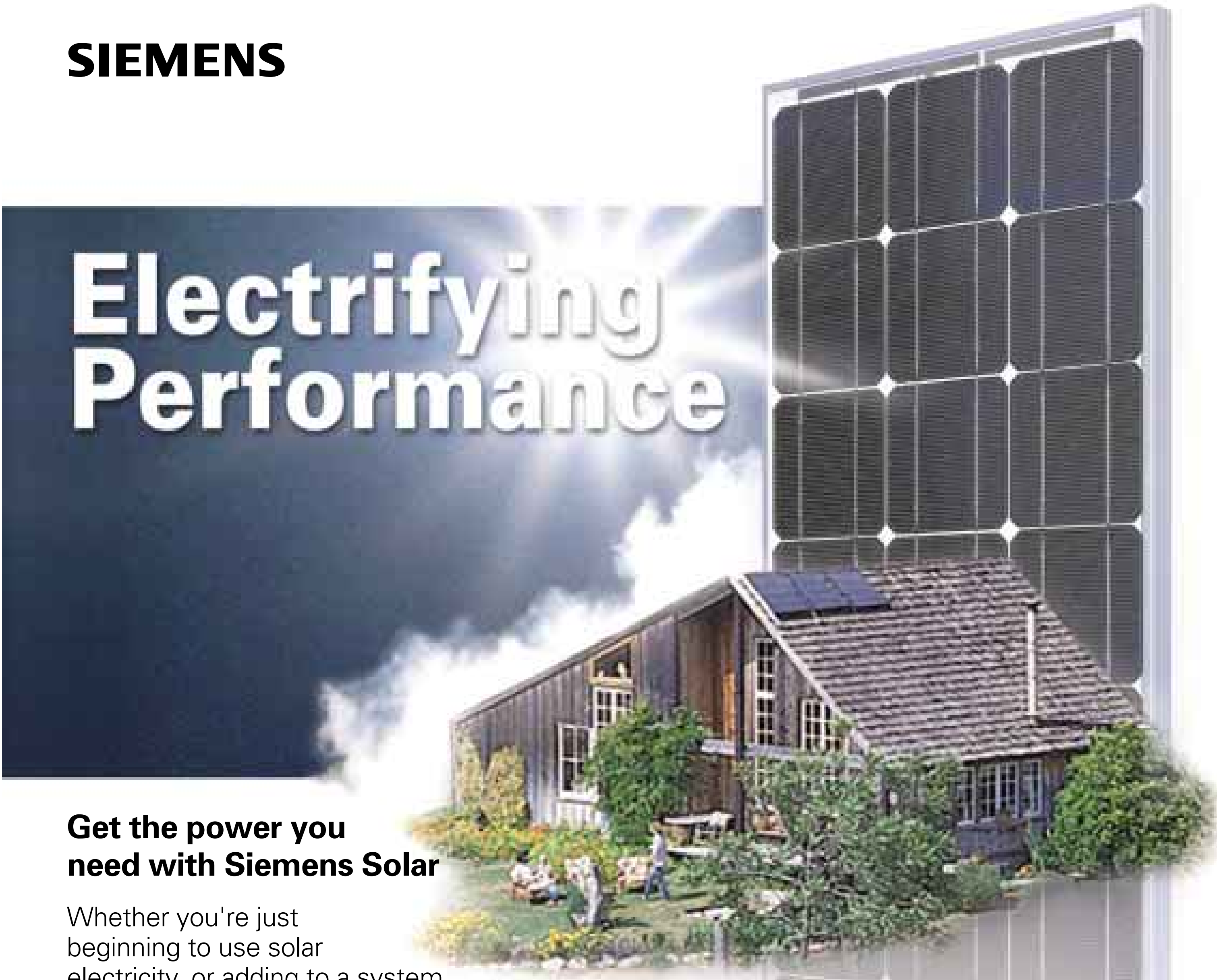

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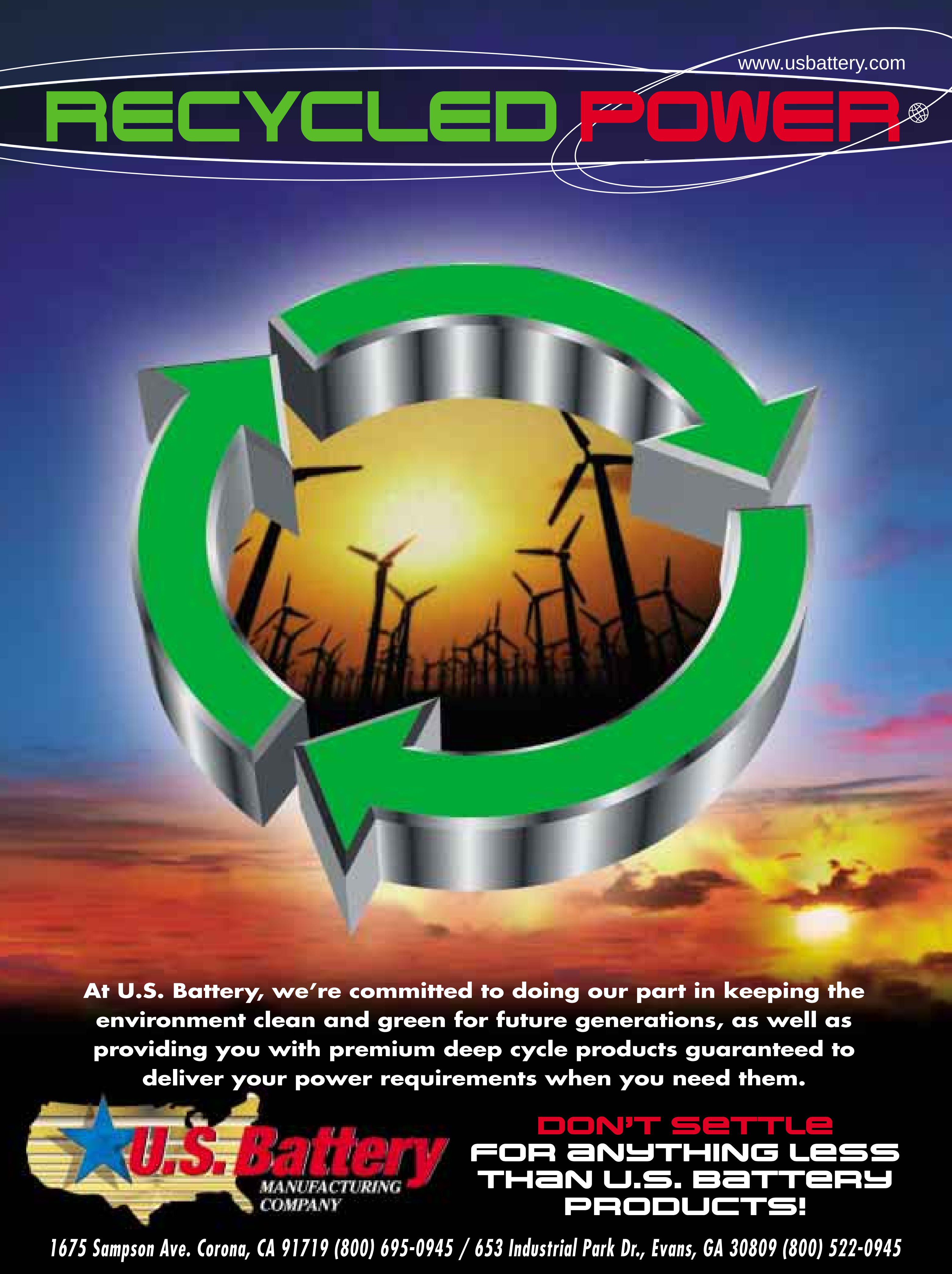
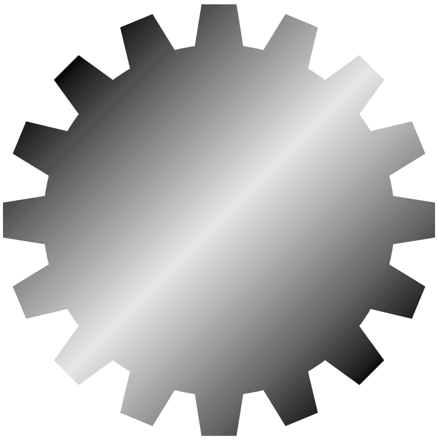
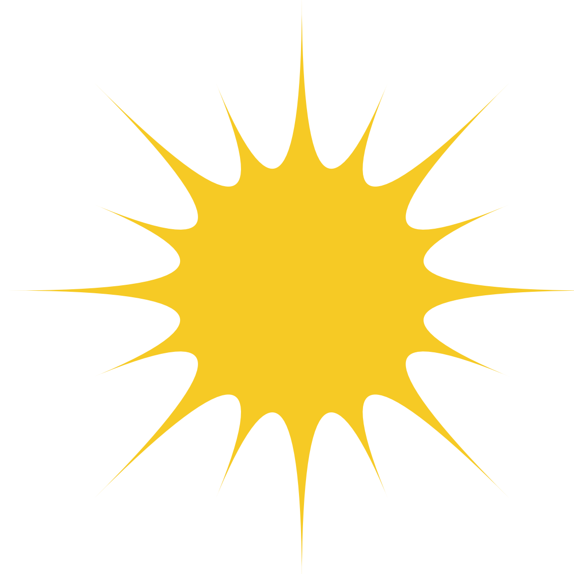






Practical Solar

A Californian Combines Net Metering with Time-of-Use Metering to Make PV Pay

Philippe Habib

Half of the Habib family's utility-intertied PV system was paid for through California's buydown rebate program.

I never wanted to be a power producer. I came to it when the advantages couldn't be ignored anymore. When grid power was reliable and cheap, there was no reason to spend a pile of money on a photovoltaic (PV) system. I thought that a PV system would not only never pay for itself, but that it would double my energy bill. Besides, the last thing I needed was another thing to take care of. You never see a magazine called *Utility Power User* on the magazine rack, and there's a good reason for that. Utility power just works; it doesn't require a support group to pass around hints and tips.

It wasn't that I didn't feel capable of designing or installing a system. I designed our house, and I was very involved in its construction. But with a busy life, I don't want to spend the little free time I have adjusting this or that, or troubleshooting on a regular basis.

Thermal Efficiency

My wife and I kept with the pragmatist theme as we were designing and building the house. Energy use and efficiency were an important but not overriding part of every decision. All windows are double glazed, and all south or west-facing glass is low-E. All of the insulation exceeds the typical R-19 ceilings, R-13 walls, and R-13 floors in our area—we have R-30, R-15, and R-19 respectively.

All hot water and house heat comes from a very high efficiency Polaris model water heater made by American Water Heater. The tank of this 94 percent efficient unit is made entirely of stainless steel. So in addition to fuel savings, I also avoid buying a new heater every few years. The heat system is hydronic, using cross-linked polyethylene pipes in the floor. In addition, two 4 by 8 foot (1.2 x 2.4 m) solar thermal panels pre-heat water, which is stored in a 100 gallon (380 l) tank for domestic use.

We also installed a masonry heater, made by Temp-Cast Enviroheat, for our main source of heat. It burns a very hot, low-polluting fire for a fairly short time, and stores the heat in masonry walls a foot thick. The heat is let out slowly over the next 24 to 36 hours. Three to four fires a week is all it takes in our mild climate to keep the house warm.

Payback was the Point

We are not so committed to conservation that we will make big changes in our lifestyle or spend lots of money just to save energy. We built a practical house that uses less energy than other houses of its size because we chose to spend more up front on features that have a long-term payback. But every feature is there because it has a payback, not because we would do *anything* to raise efficiency, no matter the cost.

With that attitude, I did a bit of research to confirm my negative biases about PV power. What I found really surprised me. With California's Emerging Renewables Buydown Program 50 percent rebate, I could give my money to the utility every month, or I could use it to pay off a PV system. The cost would be the same—until the utility raised its prices.

The utility-intertie Trace Sun Tie 2500 sine wave inverter (right) and the upstairs AC subpanel.

In June of 2000, when I was first designing this system, the tripling of prices in San Diego was in the news. So I expected something similar to happen when my utility, Pacific Gas & Electric (PG&E), was permitted to raise its prices. I was impressed both by the long warranties on the PV modules, and the fact that a lot of the systems installed thirty years ago are still running and still producing power. If done right, it looked like this could be an install-it-and-forget-about-it kind of deal.

Our monthly electrical use is about 900 KWH. About 600 of that goes to charge my electric Ford Ranger pickup, and occurs at the off-peak rate between midnight and 7 AM. I measured how much space was available on my roof, and priced components. It looked like a 2,000 to 2,500 watt system would be a good fit for both space and energy produced.

Sun Tie

At the time I was designing the system, Trace was about to introduce the Sun Tie (ST) series of inverters, which promised to lower the cost and ease the installation of a grid-tied system. Normally, I would be wary of buying a brand new product, but I figured that Trace had been in the inverter business long enough that a new product might not be a big risk.

As things turned out, the display on the unit I received was dead out of the box. It took about six weeks between my first contact with Trace and the replacement of the inverter. The second inverter's display only worked for the first few hours of each day. Eventually, I did some troubleshooting and found the problem. The display was in close proximity to the inverter's power components, and electrical noise was causing the display to fail. Wrapping it in a grounded copper envelope solved the problem.

This was more involvement than I wanted with a product, but I did know that I was buying an early release, and the process was kind of fun, anyway. Other than the problem with the display, the Sun Tie is a wonderful product. Getting it working consisted of nothing more than bolting it to the wall, and attaching the DC wires from the panels and the AC wires to the house electrical panel. All breakers and fuses are factory installed. There is nothing to set up or configure—it just works.

In order to get my cost per installed watt down as much as possible, I went with an ST2500 inverter and twenty-four Kyocera 120 watt panels. The cost per watt of the ST inverter goes down as the capacity goes up. An ST2500 does not cost 2.5 times the price of an ST1000. I figured that once I got the lowest dollars per watt inverter I could find, the best value would be to load it

Habib System Costs

Item	*Cost (US$)*
24 Kyocera 120 watt panels	$11,880
Trace ST-2500 inverter	1,725
Wiring and mounts	400
Service contract*	225
Total	$14,230

* To bring the warranty to five years, as required for the buydown program.

up as fully as possible with PVs. That meant I wasn't paying for any inverter capacity that I wasn't using.

For the California buydown rebate, the calculations look like this: twenty-four 120 watt PV modules have a PVUSA Test Conditions (PTC) value of 105.7 watts each, for a total of 2,537 watts. The 94 percent efficient inverter makes a system output of 2,385 watts total.

I was ready to order the equipment from out of state to save the sales tax. But when I heard that I'd have to pay it anyway to get the buydown, I figured that I'd keep my money in state. I wound up making my purchase from Solar on Sale, who beat the out-of-state price anyway. The people there have been very knowledgeable and helpful. In all, the system cost me about US$6 per watt. I'll get half of that back from the buydown program.

I did all of the installation with the help of my friends Greg Stefancik and Dave Kucharczyc. Since I have a pretty complete metal shop in the basement, I made my own mounts using aluminum angle and stainless steel hardware.

TOU with Net Metering?

I did some research, and learned that my utility, Pacific Gas & Electric, was obligated to offer net metering (E-NET, the PG&E tariff schedule that deals with net metering). Now, that was interesting. As the owner of an electric car, I'm on the E-9 tariff schedule. This is a three-tier time-of-use (TOU) rate. The two lower priced tiers are offered in the winter, and the third, highest priced tier is for the summer months during the afternoon.

The rate schedule is set up to discourage use during peak load time, and to encourage you to charge your EV between midnight and 7 AM. The peak cost coincides with a PV system's peak production. I concluded that a PV system could pay for itself just by saving me from buying that expensive summer peak power.

I read the tariffs on PG&E's Web site. It wasn't clear to me how net metering worked for TOU customers. Would surplus generation be credited to me in kilowatt-hours spread out over my bill? Or would it be in dollars applied to my purchase of power at a lower rate later?

Bureaucratic Goose Chase

In getting the special rate for my truck charging, I learned that most of the people who answer the phones at the utility don't have the training to be of help with unusual questions. You have to work to find the person who can really answer the more complicated questions. For instance, within an hour of getting in touch with Efrain Ornelas, alternative vehicle program manager for PG&E, my EV account was set up. Prior to that, I'd had at least half a dozen conversations in a three week period.

Figuring that the alternative vehicle program manager would know who I should talk to about E-NET, I called and asked him for help. He put me in touch with Harold Hirsh in the renewables department. According to him, the answer was that I'd be credited in neither power nor money. He said that PG&E did not offer net metering with TOU rates. I would have to switch to a non-TOU rate if I wanted net metering. Funny, I never saw anything that said I'd have to be on a particular tariff to get E-NET.

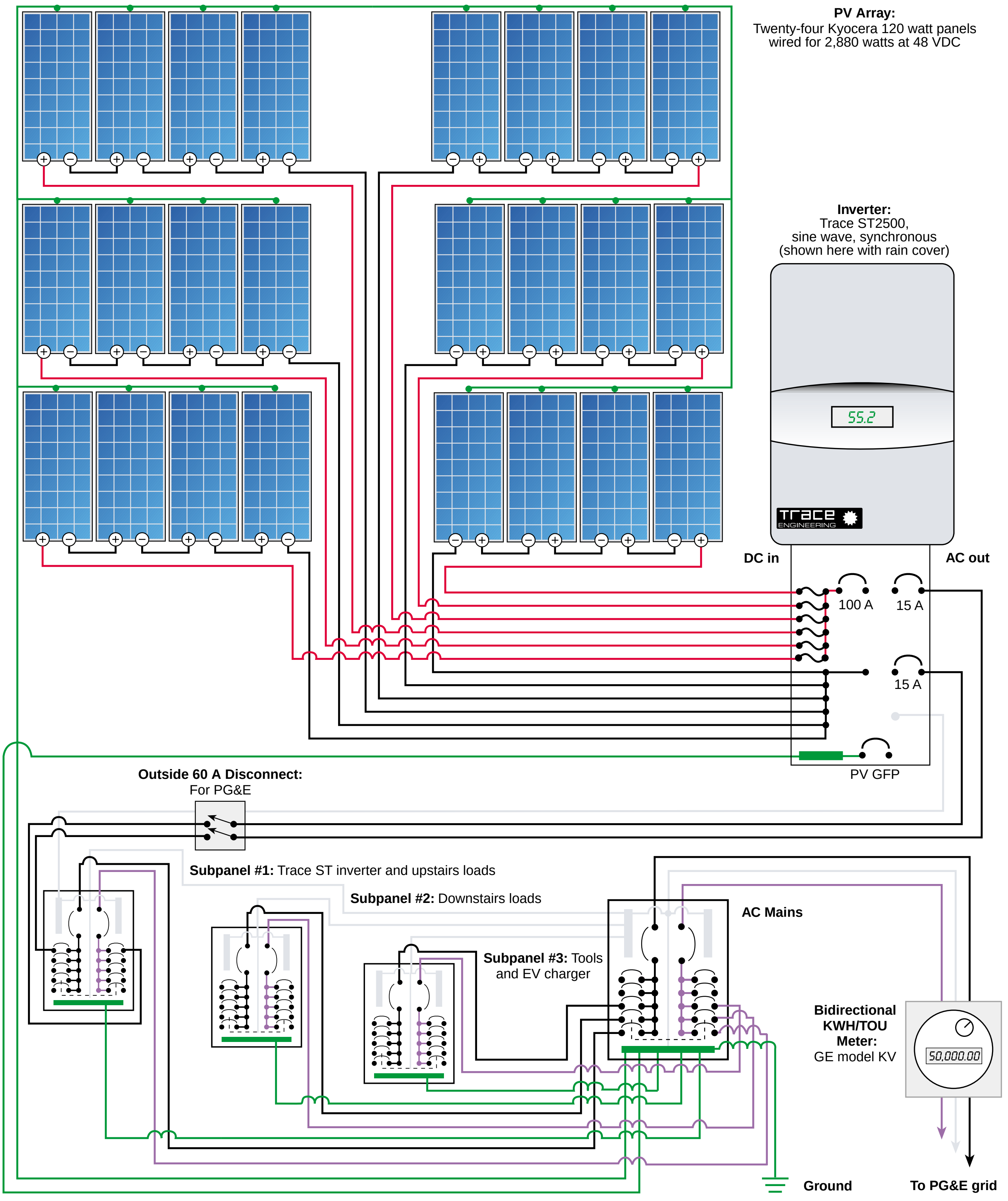
So I made a few phone calls to the California Energy Commission (CEC) to try to clear things up. No one there had the definitive answer, but one name kept being mentioned as the person who would know—Vince Schwent (now with Sacramento Municipal Utility District). I called him and he said my take on it was correct. Every tariff was eligible for E-NET, and I should be credited in dollars, not power. This meant I could sell my summer afternoon excess at US$0.30 per KWH, and buy that power back at night to charge my truck at only US$0.04 per KWH!

I went back to PG&E, and they said that it was not technically feasible to do E-NET with TOU because the TOU meter was not capable of going backwards. The meter apparently treats all energy going into the grid as theft, and never allows the count to decrease.

Another conversation with the CEC pointed me to the Sacramento Municipal Utility District (SMUD). They have a comprehensive renewable energy program, and their meter shop had done a lot of meter testing. They found that General Electric makes a TOU meter that can accurately register backwards. This is their model KV.

During my next conversation with PG&E, I mentioned the GE model KV meter. Apparently there were lots of reasons why it wouldn't work for me. PG&E didn't use that meter and could not use it because of PUC regulations. They couldn't take SMUD's word that it accurately read in both directions. And the computer billing software wasn't set up for TOU and E-NET, so it wouldn't work anyway.

Philippe Habib's Utility-Intertied PV System



The tariff is pretty clear on one point; PG&E had three options:

1. Provide me with an appropriate meter.
2. Allow me to purchase such a meter.
3. Pay to have my house rewired to use dual meters.

Since they claimed that they couldn't do number 1, I was prepared to do number 2. In fact that was my preference, since I wouldn't have to make a lot of US$12 monthly meter rental payments to pay for a US$300 meter. The threat of option 3 seemed to be the way to get them to do one of the other two.

Further conversations with PG&E yielded more information. It turned out that they *do* use the KV meter, but only on some industrial accounts. So much for it not being in their inventory and unavailable to their meter shop.

Net Metering Solution

Eventually, I got connected with Phil Quadrini from PG&E's headquarters in San Francisco. He is the guy who knows the arcana of tariffs inside and out. He agreed that TOU and E-NET did not need to be mutually exclusive, and he figured out a way to make it all work.

I would get a GE model KV meter, which the meter shop would pre-load with 50,000 KWH as the starting point reading. Since the meter can't show negative numbers, this was necessary so that the meter will not stop at zero if my surplus ever exceeds my use. At the end of the one year averaging period, PG&E would read the meter and I'd pay for any net use during the year.

Once that was settled, Phil put me in touch with Jerry Hutchinson, who sent me the application package to get me legally connected to the grid. I sent in my application to connect my PV equipment to the grid and waited. Six weeks later, I still hadn't received anything back. I called to check the status of my paperwork.

The person who processes the applications told me I'd have to switch to a non-TOU rate to do E-NET. Apparently, the word had not filtered down. A few more phone calls referring back to my earlier conversations with Phil straightened that out. I now had a commitment from PG&E to combine TOU with E-NET.

It took a lot of perseverance to get the utility to go along, but everyone wins with this arrangement. This makes a PV system more affordable and therefore more feasible for homeowners. And for the utility, buying my surplus, even at about US$0.30 per kilowatt-hour, is cheaper than the high peak prices (which recently went above US$1.40 per KWH) when demand gets high. And the overloaded transmission network does not have the additional burden of bringing me energy from far away.

Since getting this arrangement, I've learned that I'm not the only one who sees the benefit of it. California State Assembly member Fred Keeley authored AB-918 to clarify the issue of E-NET and TOU. This legislation (now California law) requires the utilities to offer them together, and to buy back power at the retail cost of that power at the time it is generated. So there is now a very clear mandate that it must be done this way.

Not Just for Tree Huggers

A system like mine shows that PV power is no longer just for tree huggers and those who live far from the grid. If this system did not promise to be reliable and cost effective, I would not have installed it. Getting the E-NET and TOU helps to make the payoff even more attractive, but the economics are there even without it. If you don't have an electric vehicle to qualify you for the E-9 rate, you can get E-7. Right now, the cheapest E-7 rate is US$0.085.

The E-7 TOU rate still allows you to sell your summer afternoon surplus at high rates and apply that money to your off-peak usage. You just don't get the ultra-low rate from midnight to 7 AM. Of course, this assumes that you have a summer afternoon surplus, and that you're not dipping into the grid to run an air conditioner.

Now that the system is installed and has been working for a few weeks, I can say that I'm very pleased with it. On a nice day in February, I can get about 10.5 KWH of energy from the PV array, and on a partially overcast day, I might get 6 to 8 KWH. A couple of weeks ago, I got a bit more than 15 KWH. Once summer starts, I would not be surprised to see more. The best part is knowing that no matter what happens, my cost for electricity is frozen. Not contributing to pollution is nice, but it was not my overriding reason.

RE Goes Mainstream

I'm reasonably handy, but had no prior knowledge about anything solar. And I put together a working and cost-effective PV system. This shows that the products have matured to the point where PV is not just for the isolated or the ideological anymore. Homeowners who live in suburbia can decide to install a PV system purely for financial reasons, and still make it work out.

I do realize that I owe a debt to the traditional readers of publications such as this one. You are the true believers who brought things along to this point. There may even come a day when *Home Power* magazine is as tough to find on the newsstand as *Utility Power User…*

Access

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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.tracegridtie.com/products/gridtie/suntie.html

Solatron Technologies Inc., aka Solar On Sale, 19059 Valley Blvd., Suite 219, Bloomington, CA 92316
877-744-3325 or 909-877-8981 • Fax: 909-877-8982
sales@solaronsale.com • www.solaronsale.com

Renewable Energy Program, California Energy Commission (CEC), 1516 Ninth St., MS-45, Sacramento, CA 95814 • 800-555-7794 or 916-654-4058
renewable@energy.state.ca.us
www.energy.ca.gov/greengrid

Pacific Gas & Electric (PG&E) • Efrain Ornelas: Program manager for clean air transportation, 415-972-5617
Harold Hirsh: Renewable energy department, 415-973-1305 • Jerry Hutchinson: Takes care of getting your system legally grid tied, 408-282-7345 • Dave Turner: PG&E E-NET Processing Department, 415-973-4525 • Phil Quadrini: Knows tariffs forwards and backwards, 415-973-4213 • www.pge.com

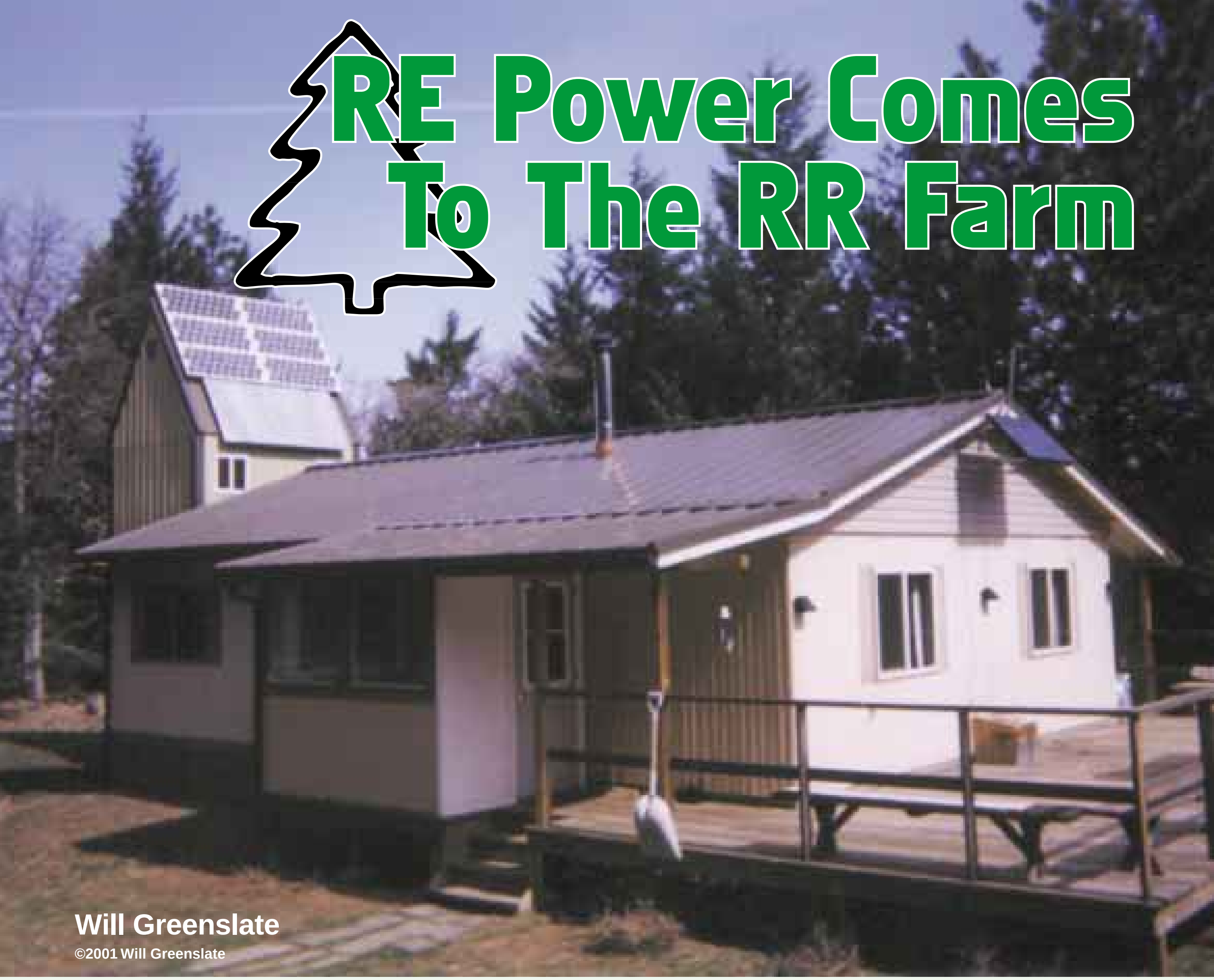
American Water Heater Group, PO Box 4056, Johnson City, TN 37602 • 800-999-9515
www.americanwaterheater.com • Polaris water heater

Temp-Cast Enviroheat, PO Box 94059, 3324 Younge St., Toronto, ON M4N 3R1 Canada • 800-561-8594 or 416-322-6084 • Fax: 416-486-3624
staywarm@tempcast.com • www.tempcast.com
Masonry heater

General Electric • 800-432-2572 or 770-999-7131
www.geindustrial.com/industrialsystems/meter/catalog/kvmeter • TOU meter, model KV

RE Power Comes To The RR Farm

Will Greenslate



Will and Norma Greenslate's off-grid home on their Renewable Resources Farm and restoration project.

In the summer of 1977, I returned to Oregon from an assignment as chief engineer at a pulp mill in Swaziland. My wife Norma and I had decided to seriously search for a place that would allow us to live our preferred lifestyle.

I spent twenty-five years in various career endeavors, starting with farm laborer through forest fire fighter, GI, door-to-door salesman, aerospace draftsman, plant engineering and maintenance supervisor, to consulting engineering project manager. But this did not darken my dream of living a subsistence lifestyle in rural isolation.

I was fortunate in that my high school sweetheart, who became my wife and partner, shared my dream. Both of us were raised in a rural environment. As young people, we could roam the countryside and forests at will without encountering the ugliness—both visual and social—that one is likely to meet with in the wilderness today.

Where We Are

About nine dirt and logging road miles (14 km) due south of Mosier, Oregon, we found what we thought could become our dreamland. It was some ruinously logged-over land that had been divided into 40 acre parcels by a developer. After the logging and subdivision, the land had been further desecrated by unrestricted public use of four-wheel drive vehicles and off-road motorcycles, trash dumping, slovenly hunters, campers, and woodcutters.

We made what we thought was a ridiculously low offer on three contiguous parcels. Surprise—the developer snapped it up! We started calling the place the "Renewable Resources Farm." All we had to do to build our Shangri-la was meet the payments, pay the taxes, restore the damage, and re-establish the property as private.

The first two duties would be easy. I would continue to sell my mind and body to get the wherewithal. The third duty was a labor of love requiring all of our free time and physical stamina. This effort is still ongoing, and will probably outlast us. Brush continues to grow even as you cut it.

The fourth task turned out to be the most frustrating and disheartening. It took almost twenty years of ousting trespassers, posting and replacing signs, building and repairing fences, and reporting and repairing theft and vandalism. In short, I had to become known as “that SOB out on Kellar Creek” in order to claim the land as ours. The situation has only improved in the last three years, after closing the road off with a locked pipe barricade.

Our intention was (and still is) to restore the property to viable forestland that can produce timber for sale. We first became certified as tree farmers. This really didn’t mean much except to allow a partial property tax deferral until harvest. We added two more parcels to our original purchase in the mid-eighties. This brought the total property under our management to about 210 acres.

Dwellings

When we first bought the property, we planned to build a house. For temporary accommodation, we bought a used sixteen foot (4.9 m) travel trailer and parked it near where we intended to build.

By 1982, we had wised up to the fact that we wouldn’t have the time or energy to build a house ourselves. And the location and access made contractor construction cost-prohibitive. So we started spending evenings during the week looking at mobile homes. We also applied for a building permit with Wasco County.

It was a buyer’s market for mobile homes at that time, and the dealer we worked with checked out okay as far as we could tell. When we inspected the finished home, we found one serious visible deviation from our specifications. They had installed all electric appliances, though we had specified propane. We didn’t find the other serious hidden item for two years, one year after the warranty expired. The water pipes were installed with doglegs that wouldn’t drain. I patched six pipe splits and abandoned two faucets because of freeze damage.

When we were living in the travel trailer and working in the city, we were basically on an extended camping trip. We would arrive late in the evening from Portland with food, drinking water, white gas, and propane. The stove and refrigerator used propane. The white gas was for the Coleman lantern, which furnished light and some heat. Our bathwater was roof runoff that we captured in a bucket and heated on an old wood-burning cookstove located on the porch.

The stove also tempered the cold in the trailer a little—at least the corner that was nearest to it. We also had a small catalytic propane heater that helped take the chill off in the mornings. We bought a military surplus generator, but we never used it because it was difficult to start and too noisy.

The Mobile Home Arrives

Living conditions improved drastically after we moved into the mobile home. We now had space, privacy, warmth, convenience, and creature comforts! Our home could have been advertised as a *2 bdrm, 1 bath remote cutie; 864sf; vaulted kit, lr, dr; mud rm; lots of strg; wdstv heat; propane appl; entry vest frt & rear; lg deck; gvty wtr supp; sept sys.*

We still used the Coleman lantern for light, and hauled our potable water and propane supply. The difference was that we now hauled a month’s supply at a time. We also continued collecting roof runoff for washwater and to flush the toilet. After the first year, we installed two 275 gallon (1,040 l) water tanks, with gravity-fed piping into the house. We filled the tanks about every two months, or whenever we could haul 100 gallons (380 l).

First Exposure to PV

Because of our trespasser and vandalism problems, as well as fire danger and personal injury potential, we felt

One Siemens M-77 panel powers the radiophone, and introduced Will and Norma to renewable energy.

Greenslate System Winter Loads

Item	*Watts*	*Avg. Hrs./Day*	*Avg. WH/Day*
Vacuum cleaner	1,020	0.10	102.00
Kitchen, compact fluorescents	15	5.00	75.00
Living room, compact fluorescents	15	4.00	60.00
Microwave	600	0.10	60.00
Dining room, compact fluorescents	15	3.00	45.00
Mixer	100	0.25	25.00
Charger for saw	240	0.10	24.00
Bedroom 1, incandescents	40	0.50	20.00
Bath, incandescents	40	0.50	20.00
Store room, incandescents	40	0.25	10.00
Utility room, incandescents	40	0.25	10.00
Laptop	50	0.20	10.00
Printer	90	0.10	9.00
Charger for radios	50	0.10	5.00
Bedroom 2, incandescents	40	0.10	4.00
Power Tower, incandescents	40	0.10	4.00
Charger for drill	30	0.10	3.00
Charger for razor	2	0.10	0.15
Total	2,467	14.85	486.15

that we needed an outside communication method. We started with an AT&T briefcase telephone, which was a real iffy proposition. It had to be charged in Portland during the week. A boating enthusiast at work suggested a solar-electric panel and battery he had seen at a marine supply store. It looked like a possibility, so we bought a Siemens M-77 panel with a small on-off charge controller.

We hooked this up to a pair of Trojan T-105 batteries. It worked well enough for battery charging during the summer. So we abandoned the briefcase telephone and bought a GE SMR vehicle radiotelephone and installed it in the house. Communications were much improved for a while until the carrier started changing hands. Prices went up and the service got terrible. We have now returned to AT&T with a digital cell phone. It allows the connection of a yagi antenna, giving us an almost land-line quality connection.

Through our phone adventures, we learned a lot about battery maintenance, charge life, and PV charging. Our first pair of batteries lasted about a year and a half, and the second pair about double that. Probably they could have been made to last longer with what we know now. The set we have now is about four years old, and seem to be as good as new.

We had introduced renewable energy (RE) power to our home, and started to become aware of the possibilities. The catalog and dealer information showed us the potential for an improved standard of living.

RE System Planning

We began playing around with the various system sizing and configuration approaches available in the RE catalogs we had received. This resulted in several different capacity requirements, depending on whose method we used, and what we estimated for our appliances and utilization. We also discovered a wide range of costs, starting high and going higher. Obviously this was not something we wanted to jump into without some thought.

Norma and I noticed a PV array at a house down the road from us. We were acquainted with the people who lived there, Dan and Celia Brogan, so we called to ask if we could take advantage of their knowledge and experience. They were very generous with their information and time, loaned us another catalog, and introduced us to *Home Power* magazine.

That experience lead us to order the *Solar Electric Independent Home* book by Jeffrey Fowler. The book helped us decide what equipment we would get. The array sizing calculations led us to believe that we needed between 600 and 1,000 watts of array capacity and between 800 and 1,400 amp-hours of battery storage capacity.

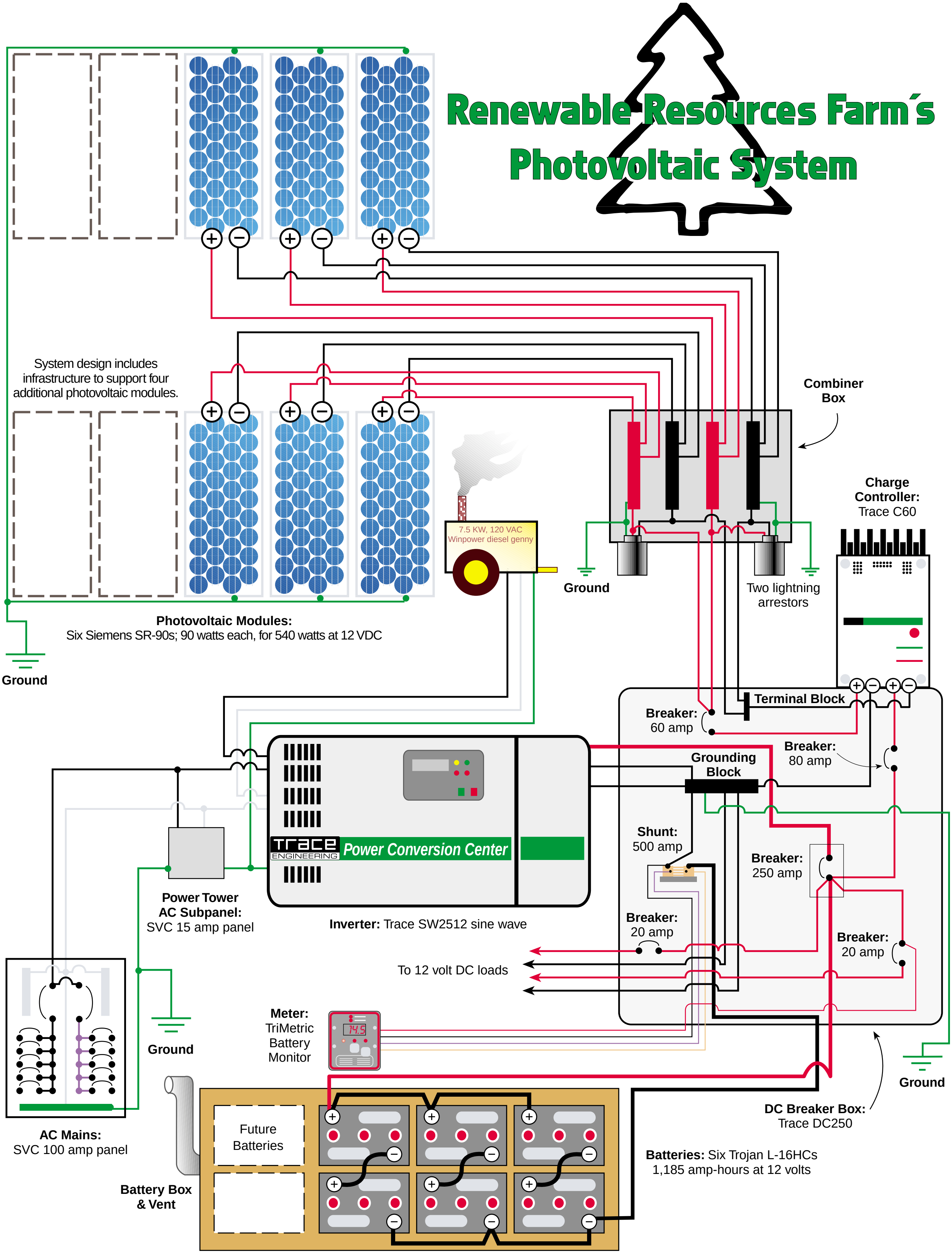
We had decided on a 12 volt system mainly because of component availability. We decided to buy:

- Trace SW2512 inverter
- Backwoods Solar DC250 power center kit, with Trace C60 controller and conduit box
- Six Siemens SR-90 PV panels
- One HUP SO-6-85-21 battery

The inverter and controller were sized to allow for expansion in the future to ten SR-90 panels if necessary. We planned to use our old 7.5 KW Winpower diesel generator as backup.

Waiting for Bargains

Our financial situation made it impossible to buy all the equipment at once. We decided that we would watch the catalog prices, and buy when money was available


Renewable Resources Farm´s
Photovoltaic System
System design includes infrastructure to support four additional photovoltaic modules.
Combiner Box
Charge Controller: Trace C60
7.5 KW, 120 VAC Winpower diesel genny
Ground
Two lightning arrestors
Photovoltaic Modules:
Six Siemens SR-90s; 90 watts each, for 540 watts at 12 VDC
Ground
Terminal Block
Breaker: 60 amp
Breaker: 80 amp
Grounding Block
Shunt: 500 amp
Breaker: 250 amp
Breaker: 20 amp
Breaker: 20 amp
Power Conversion Center
Power Tower AC Subpanel: SVC 15 amp panel
Inverter: Trace SW2512 sine wave
To 12 volt DC loads
AC Mains: SVC 100 amp panel
Ground
Meter: TriMetric Battery Monitor
Ground
DC Breaker Box: Trace DC250
Future Batteries
Battery Box & Vent
Batteries: Six Trojan L-16HCs 1,185 amp-hours at 12 volts

or a price reduction came up. We planned to buy the batteries last, since that would be the only component that would deteriorate if unused over time. The warranties on the Trace inverter and controller were the big risk. Another risk turned out to be technology changes and manufacturer ownership changes.

The first cost-saving opportunity that came up was the PV modules. Northwest Energy Storage advertised a price reduction on the Siemens SR-90 panels. We bought six, and after peeking into each case to check for breakage, we stored them in the barn.

The second opportunity was the Trace SW2512 inverter. Backwoods Solar Electric Systems had a special that excluded their normal supply of battery cables. It was still a good deal. The inverter joined the panels in the barn.

We called Backwoods to get the particulars on the DC250 power center kit and learned that the C60 controller was not yet available. According to my calculations, we needed at least a 50 amp controller if we didn't want to operate with parallel controllers. The alternative was to look at other power center systems, which we did.

After comparing the options available, we settled on a Pulse power center for about US$400 more than the DC250 kit. But it would be a package unit with a 60 amp controller. Now we were watching for a deal on the Pulse power center.

Norma finishes up the Power Tower's siding, which was recycled from a storm damaged barn.

The Power Tower was constructed with lumber from trees that needed to be removed for solar exposure. The noisy 7.5 KW diesel generator (left) was moved far away from the house.

Power Tower

Since we needed a panel support system and power shed anyway, we decided to build what we now call the "Power Tower." We planned a two-story 8 by 10 foot (2.4 x 3 m) post-and-beam structure, with the panels on the south slope of the gable roof. The roof slope would correspond to the winter sun angle. The ground floor would house the power center and batteries. The second floor would be my storage room.

We milled our own timbers and structural lumber from the tree farm timber, using trees that would have to be removed for solar exposure. The collapsed barn roof supplied the siding and roofing, after a lot of bending, straightening, priming, and painting. The reclaimed siding is obviously salvaged, but it doesn't look bad at all.

PV Panel Mounting Frame

The PV panel mounting and support frame is designed to accommodate ten Siemens SR-90 panels. Since we had the six panels in storage, we pulled the dimension sheet and installation instructions from one box. Using the dimensions from the sheet, I fabricated a frame using 1-1/2 by 2 by 3/16 inch (3.8 x 5 x 0.5 cm) angle iron with the 1-1/2 inch leg as the mounting surface for the panels. The 2 inch leg is the vertical support depth.

A crane made it easy to install the wired and racked PVs.
The rack space covered with sheetmetal is where four more modules will be installed later.

The panels are mounted with the long dimension horizontal rather than vertical. That configuration more closely fits the roof dimensions. It also took less steel and welding.

Again using the Siemens dimension sheet, I drilled forty 5/16 inch (8 mm) diameter holes for mounting bolts. A lift beam of the same size angle iron as the main frame is welded on the underside of the frame. The top of the frame is supported on three 1-1/2 inch (3.8 cm) square tubing stands, 13 inches (33 cm) tall. The stands are welded to square baseplates that were bolted to the top of the ridge beam. Each stand is grounded to a vertical ground wire that runs the full length to the roof peak, with one wire running the length of the peak beam. All wires are clamped together in the attic. All power center devices are grounded to this system, including the panel support frame and the power center baseplate.

The top of the support is attached to the top of the panel support frame by 5/8 inch (16 mm) diameter hitch pins inserted through 11/16 inch (17 mm) diameter holes. The pins serve as both an anchor and a hinge point for the array adjustment. After the supports were aligned, leveled, and bolted to the ridge beam, we finished off the ridge with an extra-wide metal roofing ridge cap.

We cut 1-5/16 inch (3 cm) square openings in the cap to match the stand locations. We left the tabs made by cutting the openings attached to the cap on each side of the ridge, bending them up to create the opening. After sliding the cap over the stands, the joints were sealed with clear silicone caulking compound.

The two adjusting screws spaced 5 feet (1.5 m) apart penetrate the roof using rubber roof jacks as seals. The rod ends connect to the lift beam under the frame with the 5/8 inch (16 mm) diameter hitch pins. The threaded rods pass through the roof and into a 4 inch (10 cm) long, 1-1/4 inch, schedule 80 IPS pipe sleeve that has 1/2 inch (13 mm) diameter pins welded at the midpoints to serve as pivot points.

A roll thread nut rides on the top of the sleeve to serve as a bottom support for the weight of the array assembly and as the lift mechanism for the frame. We had a zerk fitting installed on the nut so we can grease it. The 4 foot (1.2 m) rod length is enough to raise the bottom of the assembly up 30 degrees to match the summer sun angle. The system works fine mechanically, but failed architecturally. The roof jacks leak in the raised position.

After priming and painting the frame and stands, we fastened the rigid PVC conduit for the panel wiring, and pulled in a pair of stranded #10 (5 mm^2) THHN wires for each of the ten panels. There is a 12 inch (30 cm) long, 1/2 inch flexible conduit drop from the rigid conduit to the panel junction boxes. The east and west panel rows are wired in separate conduit runs from bottom to top.

The “future” panel positions are terminated in conduit caps for weather protection until additional panels are added. All the wires extend to the top of the frame. The top 1-1/4 inch conduit section is coupled to 3 feet (0.9 m) of flexible conduit to allow the frame to move. The looped flexible conduits penetrate the north roof slope through two rubber roof jacks, and are connected to the combiner box inside the attic.

After installing the conduit and wire, we hauled out the panels to assemble them to the frame. Then came our first big setback. The width of panel mounting hole spacing was not 21.65 inches (55 cm) as the spec sheet said, but 22 inches (56 cm)! We wore out two 1/4

The custom PV combiner box was made from an electrician's leftover bits and pieces.

inch (6 mm) rotary files slotting the forty holes we had drilled in the frame. It probably would have been easier to slot the aluminum frames on the PV panels, but we were afraid the warranty would be voided.

After the slotting operation, we mounted the first panel—no sweat. The second big setback came when we tried to fit the second panel. The frame dimensions actually turned out to be 1/8 inch (3 mm) longer than what was given on the dimension sheet. In addition, the frame corners were fastened with round-headed screws that protruded another 1/8 inch above the frame edge! Aargh!

Forget the warranty—we removed the screws one at a time and countersunk the holes to accept flathead screws on the abutting panel edges. So much for using manufacturer supplied dimensions as if they were certified. While installing the panels, we discovered that two of the panels had apparently been used. Two knockouts on opposite sides of the junction boxes had been opened, and the terminal screws showed screwdriver marks. The supplier promised a call-back after verifying warranty support.

After finishing the panel installation, we filled in the "future" positions with two 24 by 80 inch (60 x 200 cm) pieces of 26 gauge galvanized sheetmetal to prevent snow buildup on the lower part of the frame. We used the "future" mounting bolts and slots for attachment.

Array Installation & Wiring

With the array assembly complete, we now had to address the question of how to get it up to the attachment points on the roof. I calculated the array and frame weight to be about 320 pounds (145 kg). Knowing that there was no way we could raise it ourselves, I contacted all the equipment rental places in the area about truck cranes. They don't rent them! I started contacting crane operators, and the cheapest price for about twenty minutes of work was over US$500. The charge was from the time they left the shop until they got back.

I let my fingers do the walking through the local area yellow pages. I noticed a sign company ad that mentioned crane service, and had a Mosier address. I called, and Russ Cole, owner and operator of Allied Sign and Lighting Company, said that he could do the job for US$100. It turned out to be the best $100 we spent on the project. The array was on the stands not more than twenty minutes after Russ and his helper wife arrived.

Once the assembly was pinned in place, I modified a leftover piece of roofing ridge cap to attach to the top of the array frame. It slopes down at the angle of the north roof side to act as a weather shield for the supports. After feeding the flex conduits through the roof jacks and into the attic, we finished closing off the north roof, which was left open for access during the panel assembly installation. This completed the weather side of the job; everything else would be done indoors.

The next effort on the agenda was to install a combiner box for the panel output wires. We were helped tremendously with this by Wayne Lease of Leaco Electric Company in The Dalles, Oregon. Wayne had just completed his inventory for the year, and had a lot of electrical bits and pieces that were going to be scrapped. He came up with a 21 by 14 by 4 inch (53 x 36 x 10 cm) box, and two copper bus bars drilled and tapped for terminals. He cut the bars in half, drilled the cut ends for mounting the stand-off insulators, and found four insulators.

This gave us an enclosure, and a positive and negative bus for both the east and west arrays. Each panel is attached individually in the combiner box to their respective buses with solderless connectors. A Delta LA-302-DC lightning arrestor is attached to the buses for each array, and grounded to the ground system.

The Power Center

About the time we started fabricating the PV panel frame, we called Backwoods to order the Pulse power center. JD told us that the C60 controller was now available in Backwoods' power center kit. We could go back to the original plan! Unfortunately, the price of the kit was now US$100 more. Still it was less costly than the Pulse, so we went ahead with the order.

We had used the catalog dimensions for the inverter and the breaker box to design and have fabricated a 30 by 48 inch (76 x 122 cm) steel baseplate to mount them on. The perimeter frame is 1-1/2 by 1-1/2 by 1/8 inch

(3.8 x 3.8 x 0.3 cm) angle iron, with the toes out for mounting flanges. The flange is drilled with 3/8 inch (10 mm) diameter mounting holes for 5/16 inch (8 mm) lag bolts. The holes are spaced on 16 inch (41 cm) centers on both 48 inch (122 cm) flanges, with two additional holes equally spaced on each of the 30 inch (76 cm) end flanges. The completed baseplate is primed and painted white with Rustoleum.

None of the power center drawings gave any component assembly location dimensions. So we took a sheet of kraft paper and positioned the inverter, conduit box, offset connector, and breaker box on the paper as they would be installed on the baseplate. After tracing the component outlines and mounting holes onto the paper, we taped the paper to the baseplate.

We were careful to clear the diagonal stiffeners with the knockouts and mounting holes. We then used a 1/16 inch (1.5 mm) drill to put pilot holes through the paper and the mounting plate for each of the components and their knockouts. After comparing the pilot holes to the drawings and finding no discrepancies, we drilled and tapped the mounting holes. We used a hole saw for the knockout penetrations.

Next we mounted the breaker and conduit boxes (coupled with the offset connector) to the baseplate. We finished the back entry penetrations with two 2 inch (5 cm) cable clamps through both the box and the baseplate, with the locknut on the back side. After mounting the boxes, we installed the internal wiring according to the Backwoods and Trace instruction sheets.

Trace SW2512 inverter, DC250 disconnect box, and C60 controller in the Power Tower's first floor room.

This all went well, thanks to the completeness and clarity of the instructions. It helped considerably to use the optional grounding block. A few more inches space in the breaker box would have made installing the heavy cable to the 250 amp breaker and the shunt much easier, however.

Then the fun began! We muscled the baseplate with the wired-up breaker and conduit boxes into the Power Tower. We had pre-installed two temporary mounting screws in the wall where the baseplate would go, to locate and support the plate while placing it.

With me lifting the plate into position, and Norma feeding the wires through the appropriate penetrations, we got the plate onto the temporary screws. Believe me, this sounds simpler than it actually was. Fortunately our marriage suffered little long-term damage. I'm not so sure about my back.

With the plate in position, we drilled the other mounting holes and installed the lag bolts. We installed a ground wire from the ground system to the plate using one of the bolts. The next job was to lift the inverter into place. The keyhole-slotted holes in the inverter slipped over the screws in the baseplate with only minor difficulty, and the inverter slid along the screws into position. After installing and tightening the inverter mounting screws, we installed the C60 controller to the breaker box.

We added a 60 amp DC breaker to the breaker box for the PV array. There was space for it in the box, and it really simplified the wiring. We connected both positive #4 (21 mm^2) wires to the breaker with double solderless connectors. We then ran a single #6 (13 mm^2) wire to the controller. After making all the connections on the PV side of the system, we checked out everything for continuity and polarity. It all looked good so far!

Battery Enclosure

After deciding to use the Trojan L-16HC batteries, we made an enclosure with some 5/8 inch (16 mm) thick plywood from an old ping-pong table. The box was sized using the catalog dimensions, allowing 1 inch (2.5 cm) spacing between the batteries and the front and end walls of the box. We allowed 3 inches (7.6 cm) between the back wall and the batteries for a wire chase. The box is sized for eight batteries, though we decided to use six.

The removable top of the box slopes up 2 inches (5 cm) from front to rear where it meets a gas collection channel across the back of the box. The 3 inch (7.6 cm) wide gas collection channel slopes up another 2 inches (5 cm) from each end to the center.

A 1 inch PVC conduit is set into the middle of the channel, and extends vertically 5 feet (1.5 m). Then it makes a bend, and horizontally penetrates the north wall of the tower for venting. The conduit extends 6 inches (15 cm) beyond the outside wall, and is cut off at a 45 degree angle for weather protection.

All joints in the battery enclosure are caulked inside with clear silicone caulking, except for the removable top. There are two 2-1/2 inch (6 cm) round soffit vents installed as ventilation inlets in the front wall of the enclosure, 4 inches (10 cm) up from the floor.

The bottom of the box and 4 inches up the walls is covered with a sheet of 4 mil clear polyethylene plastic as a containment barrier. The 2-1/2 inch flexible PVC conduit between the box and the breaker enters the box 4 inches below the top of the batteries. This reduces the potential for gases rising into the breaker enclosure. The box end of the conduit is also sealed off with caulking compound.

120 VAC & Meter Wiring

With the DC side of the system in place except for the batteries, it was time to stop procrastinating and start digging and crawling. The first bit of dirty work was running the 1/2 inch PVC conduit for the TriMetric meter from the breaker box into the house. I had estimated the run to be about 65 feet (20 m). Backwoods included 75 feet (23 m) of #22 (0.33 mm^2), two twisted pair, four-wire cable in the kit. Bogart's instruction sheet recommended #18 (0.82 mm^2) wire if the run exceeded 55 feet (17 m).

The thermostat for the furnace that was shipped with the house was mounted at the dining room end of the kitchen counter bar. We removed the thermostat and pulled out the wire, pulling in the meter cable. We pulled the cable into the breaker box, cutting it off at the shunt termination. The excess cable measured 22 feet (6.7 m), getting us within the recommendation from Bogart. The Backwoods and Bogart instructions made the terminations a snap.

The next nasty job was running the 120 VAC service wiring to the house breaker panel. The three #6 (13 mm^2) cables were pulled through a 1 inch PVC conduit from the inverter to the original 1-1/4 inch service entrance conduit. The 1 inch conduit was installed underground from the north wall of the tower to underneath the house. We bracketed the conduit to the floor joists under the house, and to the original entrance conduit that protruded through the floor directly below the service breaker panel.

We terminated the wires to the 100 amp breaker in the old panel. The way things had been going with the house, we decided to ring out the original wiring. "Ringing out" is identifying which wire goes where in a wiring system. Everything checked out okay except for the kitchen and dining room light circuits.

The original fixtures were three 48 inch (1.2 m) two-tube fluorescents. We were going to change to two single Panasonic light modules. So we removed the old fixtures, replacing the dining room fixture and one kitchen fixture with two screw-base ceiling lamps. We reused the original switches and wiring, reconnecting them to the new fixtures and correcting the faults as well.

Batteries

With the system complete at both ends, it was time for the batteries. We had originally planned to get HUP batteries, but by the time we were ready to purchase them, the price had gone up. We had also heard there was some warranty satisfaction problems with the HUP batteries. For both of these reasons, we switched to six Trojan L-16HCs. This saved about US$1,000 compared to our original plan, but it meant a more complex and larger battery bank.

Backwoods had a dealer outlet in Richland, Washington where we could pick up the batteries without sales tax, since we live in Oregon. We stopped there during a trip to visit Norma's mother in Idaho.

The battery bank is well vented, and holds six Trojan L-16HC batteries.

Greenslate System Costs

	Item	Cost (US$)
Structure	Windows, doors, & trim	$679
	Fasteners & connectors	304
	Sheetrock & insulation	298
	Flooring	234
	Siding & vents	222
	Foundation	152
	Paint	139
	Subtotal	$2,028
Cable, Conduit, & Fittings	Fabricated items	$359
	Fasteners & hardware	352
	Conduit & fittings	255
	Wire & cable	202
	Subtotal	$1,168
Power System	6 Siemens SR-90 modules	$2,939
	Trace SW2512 inverter	2,085
	Winpower genny, 7.5 KW, used	1,800
	6 Trojan L-16HC batteries	1,264
	Breaker kit w/Trace controller	1,100
	Battery cables, #4/0, 10 feet	165
	4 Panasonic CF lights, 15 W	89
	2 Delta lightning arrestors	88
	Subtotal	$9,530
	Total	$12,726

When we got home, we placed the batteries into the enclosure and connected them together. First, we wired three sets of two 6 volt batteries in series. After paralleling the three sets, we connected the cables from the breakers to the completed 12 volt bank. I switched on the array breaker, the controller breaker, and then the 250 amp inverter breaker. Nothing tripped, and the inverter display lit up. I spent the rest of the day playing around with the inverter menu system, which really is confusing—to me, anyway.

Backup Generator

During the house and barn roof rebuild, we had bought a used Winpower generator for the power tools. Up until then, we had used hand, gas-powered, and cordless tools for our projects. The rebuild was way too much for that! The generator is a 7.5 KW, 120/240 VAC unit, driven by a Slanzi two-cylinder, air-cooled diesel engine. The alternator was built by Winpower.

After getting the PV system operating, it was time to rewire the generator and connect it to the system. We wanted to convert the generator to all 120 VAC operation so we could use it in our power system. The wiring diagram showed both 120 and 240 volt systems.

I called Winpower, and asked if there was anyone available who could talk me through rewiring it. I was put in touch with Jim Helgerson, the Winpower service manager, who was a godsend! He dug out the correct wiring diagram from their archives, and talked me through the conversion changes required.

After the conversion, the generator output under load was only 104 volts. During our previous conversation, Jim had mentioned that the choke air gap was what set the output voltage. I called him back to ask how to change the gap to get 120 volts. He told me to increase the gap to increase the voltage and decrease it to decrease the voltage—simple, huh? Even I could do that!

It did take four tries to get it right. Three increase tries, and the fourth a decrease try. This landed the output at 120 volts with no load, and at 118 volts running a 3 hp circular saw, cutting a 2 inch (5 cm) board as hard as I could push it. The generator works great, and the diesel starts easily even in 20°F (-7°C) weather. Now if we could only find a supplier for the engine's oil filter. A manual for the engine would be nice too!

Generator Connection

After getting the generator conversion complete, we installed it as far behind the Power Tower as the 30 feet (9 m) of #6 (13 mm^2) wire would allow. While the diesel engine works well, it is noisy! We buried the 1 inch PVC conduit between the Power Tower and the generator, and pulled in three #6 (13 mm^2) wires and four #16 (1.3 mm^2) control wires for a future remote control start system. We manually start the generator now.

After connecting the service wires and verifying with Elizabeth at Backwoods that we didn't have to make any inverter setting changes, we fired the generator up to see what would happen. What happened was that the inverter grabbed the generator output, switched the house to generator, and started charging the batteries just the way it was supposed to! Man, are we good or what?!? (With a little outside help, of course.)

Satisfaction

We are well pleased with the system. It more than meets our needs during the summer months. In fact, last summer the TriMetric indicated "full" every evening, even though the panels were in the winter position. This is partly because we don't need much lighting during the summer. It will probably not be necessary to move the array position unless we start using a lot more energy.

And the system has also performed well in the winter. We have to cut back our energy usage a little, but we rarely run the generator, and then only to equalize the batteries. We use one light where we might use two in the summer, and vacuum when it's sunny. No complaints!

We have stored the Coleman lanterns and kerosene lamps—no more fumes. We can use a light wherever we want it, at the flip of a switch. Norma uses her mixer and vacuum cleaner whenever she wants, and we are on the lookout for a microwave. Since we went from no electricity to where we are now, conservation is easy for us. It becomes more difficult when we have overnight city guests. On-grid folks are just not in the habit of turning lights off when not in use, and they will turn them on at the passing of a cloud!

Lessons Learned

- Help is available from most everywhere if you just keep asking!
- Get as much literature as possible from the manufacturers for the hardware you need. A lot of detailed information is available that can help in arranging things. You may find opportunities for improvement before you get in trouble, but you have to ask for them.
- Don't assume that what you get in hardware will match the literature or drawings—even if it comes out of the same box. Some things will not be stated, and some statements may be incorrect. Try to foresee problems and build flexibility into your arrangements.
- Be prepared to learn even in the areas where you are knowledgeable. Ask questions, even stupid ones. It might save money and keep you out of trouble. Having said that, listen to other folks' experience, but make sure that the experience applies to your situation.
- If you find good sources, stay with them and support them.

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Generator

The Solar Electric Independent Home Book, 1998, ISBN 1-879523-01-9, 180 pages, US$16.95 plus US$3 shipping from New England Solar Electric, PO Box 435, Worthington, MA 01098 • 800-914-4131 or 413-238-5974 • Fax: 413-238-0203
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New Zealand's First Sustainable Energy Fair!

John Veix

The response to New Zealand's first sustainable energy fair—The Canterbury Sustainable Energy Fair—shows that energy awareness is high. Renewable energy sources are starting to catch people's attention.

The idea began from a desire to promote our company, Solar Electric Specialists, and to promote the RE industry as a whole. Normal "business" or "home" shows were not entirely suitable to promote solar, wind, or RE. My vision started coming into focus after an email to Richard Perez, asking for advice and help. His reply was totally supportive and to the point—"Do it!" He also referred me to Tehri Parker of the Midwest Renewable Energy Association, who was more than helpful. I enlisted the aid of a fellow enthusiast, Arthur Williamson, and other volunteers.

Busy Weekend

The two-day exhibit was held on the grounds of Cashmere High School in Christchurch, in the Canterbury region of New Zealand's South Island. It brought together suppliers, educators, and environmental advocates to showcase the future of energy conservation and efficiency. Approximately 1,000 people attended the event on January 27 and 28, 2001. It was a busy weekend of promotions, displays, and talks.

Promoters of sustainable alternatives were on hand to explain both the technical capabilities and the applications of a range of systems. These included

Author and co-host, John Veix of Solar Electric Specialists, outside the main tent.

solar-electric (photovoltaic), wind generation, solar thermal (hot water), and microhydro systems.

Mostly clear skies and a gusty wind blowing through the grounds provided ideal conditions to demonstrate the solar and wind generation systems. Displays included several electric vehicles, Stirling engines, a solar cooker, energy efficient lighting, and an energy efficient freezer.

The Shell Renewables "Explorer," promoting awarness of renewable and sustainable technologies, was a hit with the public.

Positive Response

The response to the fair was encouraging. There is no doubt that people are becoming interested in sustainable energy. There is a very high awareness of the international decline of the oil market, the California electricity crisis, greenhouse gas emissions, the ratification of the Kyoto protocol, and the rising of earth's temperatures. People are actively seeking information and solutions. The fair enabled them to see a good cross section of emerging technologies.

The fair attracted people who were already quite informed, as well as many more who were just starting to become informed of the wider issues. The exhibitors benefited from being in a specialised show, and were impressed with the attendees. This demonstrated that the timing of the fair was extremely appropriate.

I was also impressed by the willingness of exhibitors who had reserved space but couldn't make it, and donated their site fees "because they wanted to give their support to the industry." Other institutions, companies, and individuals lent display items that helped to fill the fair and arouse interest.

Among the positive comments, one visitor noted that it was "nice to attend such an event where there are so many experts. Where else can you go to have your queries answered on renewable energy?" A large number of first-day attendees returned the second day. They came back to attend some of the one-hour talks on issues such as biomass generation, solar-electric systems, solar hot water, and energy efficient buildings. From the response of the public, it appears that this should become a regular event. Plans are underway for next year's fair, to be held at about the same time of year.

A cut-away model of an efficient home, on loan from Environment Canterbury, helped with design, efficiency, and technological education.

Renewable Future

The fair was not as big as the ones in the United States. But it was a start, and the important thing is that you have to start somewhere. A year ago, it was just an idea and a dream, and then it became a reality. The support of sponsors, volunteers, exhibitors, and attendees demonstrated a commitment to renewable energy for future generations in New Zealand.

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PV Household Storage Battery Test

Lance Barker

Test setup: The regular meter panel (visible from the easy chair). Clockwise from upper left: analog voltmeter tells battery voltage at a glance, E-Meter amp-hour meter, analog meter for 12 V circuits, ammeter for 12 V use (lights and little stereo), ammeter for DC input into Trace SW4024 inverter, ammeter for 24 VDC use (Sun Frost), and ammeter for the array output.

A recent issue of *Home Power* magazine restates a common opinion that "lead-acid batteries can last ten to twelve years if maintained properly" *(HP74,* page 149). I've frequently been told that my twenty-year-old bank of C&D 2-volt cells must be about to crash, or that they are somehow unfit to rely on.

I am trying to reuse a resource that is otherwise simply going to get wasted. There are quite few of these C&D batteries out there, surplused from backup service with the telephone companies. I recently called the manufacturer in Pennsylvania to try to determine the model and capacity of these batteries. They had me count the plates, and determined that we have KCT-720 cells. They are rated at 720 AH at the eight-hour rate, or 882 AH at the twenty-hour rate. New, they cost about US$600 per cell.

Turning Off the PVs?!?

After long considering the possibilities, I decided to run a drawdown and load test. In spring we often have more energy than we can use in our solar-electric home (which has never had a backup generator or propane appliances). At noon on Thursday, the first of April, 1999 (not an insignificant date), with the E-Meter reading 100 percent, I threw the switch…both figuratively and literally.

With only battery power (PV panels disconnected), we began the countdown. How far would I go? How far could I go? Which would crash first—my batteries or my courage? Or maybe…just maybe…we could draw down to the target 20 percent state of charge, run a load test, and then charge back up to 100 percent without mishap.

Energy Guzzlers

At our normal usage of approximately 1 kilowatt-hour (KWH) per day, it would take over two weeks with no input at all to drop to 20 percent state of charge. I did not want the batteries sitting in a discharged state for that long. The goal was to draw them down in less than a week. So we had to shift from our normal lifeway to being energy guzzlers. We began to use electricity like there was no tomorrow. This was somewhat difficult with our energy-conserving appliances.

We washed all of our clothes. We pumped water out under the yard trees. We left lights on. After twenty-four hours, we had used 118 AH, and the E-Meter read 86 percent. We upped our power usage. We drained, scrubbed, and refilled our wood-fired hot tub (500 gallons; 1,900 l). Jennifer vacuumed the house and washed the rugs and bedding. We used the hotplate to pop popcorn, and then to cook lunch.

By Monday morning, after four days, we had used 617 AH, and the E-Meter read 21 percent state of charge. The batteries had not crashed…yet. And we hadn't lost our nerve.

Load Test

We were ready for the load test at 20 percent state of charge. We turned on all the lights in the house, and then loaded the inverter with the freezer and the deep-well pump to test whether the voltage would hold up to keep the Trace SW4024 inverter on for all essential services.

When this proved successful, we added the 1 KW hotplate to the load. As the last kernel in our pan of popcorn popped, the voltage held at 21.3 under a 104 amp load on the severely discharged batteries. The Trace never missed a hertz-beat. A successful load test!

Recharge

We shut down all the loads, and ten minutes later at 8 AM, the voltage had recovered to 23.4. A beautiful sunny day had presented itself to begin recharging the batteries. We switched the array back on and started charging at 10 amps. It took four variably sunny days to reach a 100 percent state-of-charge reading again. In the two years since the test, the batteries have performed normally (including supporting our home during the dark days of two winters).

The results of this test seem to raise a number of questions. What is the difference in lifespan between a truly fully-charged battery and a chronically undercharged one? How do we define and achieve full charge? And how long can high-quality flooded lead-acid batteries last?

Still Life with Batteries

Our normal habits of charge and discharge may contribute to battery longevity. As we have a subsistence farm, the year-round pattern is seasonal and fairly predictable. From mid-January through spring, we have more electricity than we can ever use. The Trace C40 controllers allow the voltage to reach 29.4 V, and hold it there for two hours. Then the batteries are floated at 28 V for the rest of the charging day.

After a month of daily full charging, the battery will hold at 28 V with less than one amp. When our battery holds this high a voltage with this low an input, it is a well-charged battery. This conditioning treatment prepares it for harder work ahead.

As serious irrigation begins in (gasp) May or (usually) mid-June, the battery is cycled daily to at least 85 percent, and occasionally as low as 50 percent (if we expect to be away a day or more). Four or five thousand gallons (15,000–20,000 l) a day are metered out through an automated drip irrigation system for garden vegetables, fruits, seed crops, shelter belts, and the green lawn that is our firebreak.

We begin to have excess energy again as the weather cools in September, and the surplus continues until winter storms begin to roll in off the Pacific. From early November through early January, we have to make careful use of the available electricity. When the state of charge drops below 85 percent, we begin to limit discretionary use: the VCR, the *big* stereo, power tools, air compressor, vacuum cleaner, refilling the hot tub, and such.

Lance, in front of the PV array that energizes the Barker home. The Barkers have never had propane appliances or a generator!

Battery Load & Charge Test Data

Date	Time	Voltage	Amps	AH	SOC	Comments
Discharge Cycle						
4/1/99	12:00 PM	26.00	-0.5	0	100%	Array turned off. Immediately falls to 26.0 V.
4/1/99	3:00 PM	24.90	-0.3	-5.4	100%	Need to use more power than this!
4/2/99	12:00 PM	24.10	-8.7	-117.8	86%	
4/3/99	12:00 PM	23.80	-7.6	-272.0	65%	Just ran pump for half an hour.
4/4/99	1:15 PM	23.30	-9.0	-511.0	35%	Just pumped hot tub, freezer running. Recovered to 23.7 V one hour later.
4/5/99	4:30 AM	23.55	0	-617.0	21%	Voltage of battery at rest.
4/5/99	7:50 AM	21.30	-104.0	-623.0	20%	104 amp load—no problem! Drawing battery down to 21.3 V.
4/5/99	8:00 AM	23.40	0	-641.0	18%	
Charge Cycle						
4/5/99	8:00 AM	23.40	10.0	-641.0	18%	Plugged array back in, charging started at 10 A.
4/5/99	12:00 PM	24.80	18.2	-575.0	26%	
4/6/99	6:00 AM	23.85	0	-527.0	33%	Battery at rest.
4/6/99	12:00 PM	25.00	8.6	-426.0	46%	
4/7/99	6:00 AM	24.25	0	-367.0	53%	Battery at rest.
4/7/99	12:00 PM	26.50	33.0	-281.0	64%	
4/8/99	6:00 AM	24.60	0	-214.0	73%	Battery at rest.
4/8/99	12:00 PM	25.30	3.3	-182.6	77%	Cloudy, dark day, snowing.
4/9/99	6:00 AM	24.55	0	-185.1	77%	Battery not truly at rest, fridge had just run.
4/9/99	12:00 PM	29.60	40.7	-121.0	85%	Sunny with cumulus clouds, variable high rate of charge.
4/9/99	4:30 PM	—	—	0	100%	Jumped to 100% from around -40 AH.
4/10/99	6:00 AM	24.95	0	-17.0	98%	Battery at rest.

The Barkers challenged conventional battery assumptions—the twenty-year-old, reclaimed bank of flooded lead-acid cells proved worthy.

It isn't as though we suffer, since base loads continue. Domestic water pumping, lights, the Sun Frost RF16, Vestfrost freezer, little stereo, computer for SolWest Fair, and coffee grinder (of course) go on as usual, and laundry is done in the Staber on sunny days.

PVs, Not Dead Dinos

We have only added base loads over the years as the array grew to support them. When the battery was acquired (at five years old in 1983), the array was 200 watts. We have built it one step at a time as money was available. We bought more PVs with the cash that we *didn't* have to spend on generators, generator sheds, upkeep, and battery replacement. Our array has grown in twelve separate purchases to 1,900 watts rated, and will grow again before this article is printed.

How low the state of charge goes during the last two months of the year depends on the weather. The low points have ranged from years never below 80 percent to a year with forty-two days of continuous storms with only two positive days. Even with serious conservation, the resting voltage dropped to 22.8 V before the sun

Solar cooking and other conservation-minded practices keep the Barkers' electrical and petroleum demand low.

returned. The occasional deep discharge seems if anything to "wake up" the battery, and we return to the heavy-charging, clear days of midwinter when the array actually exceeds its rated output.

We will likely find out how long a high-quality flooded lead-acid battery bank can last. There is probably a technical measurement for this. But for us, our battery is like one of our family, a dependable, companionate pet. You don't need any expertise to know when your dog is getting old.

Access

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Power Services Group Inc., Rob Cary, PO Box 11338, Santa Rosa, CA 95406 • 707-525-8030 Fax: 707-525-8034 • rcary@batterytesting.com www.batterytesting.com • C&D technical consultant for PV systems

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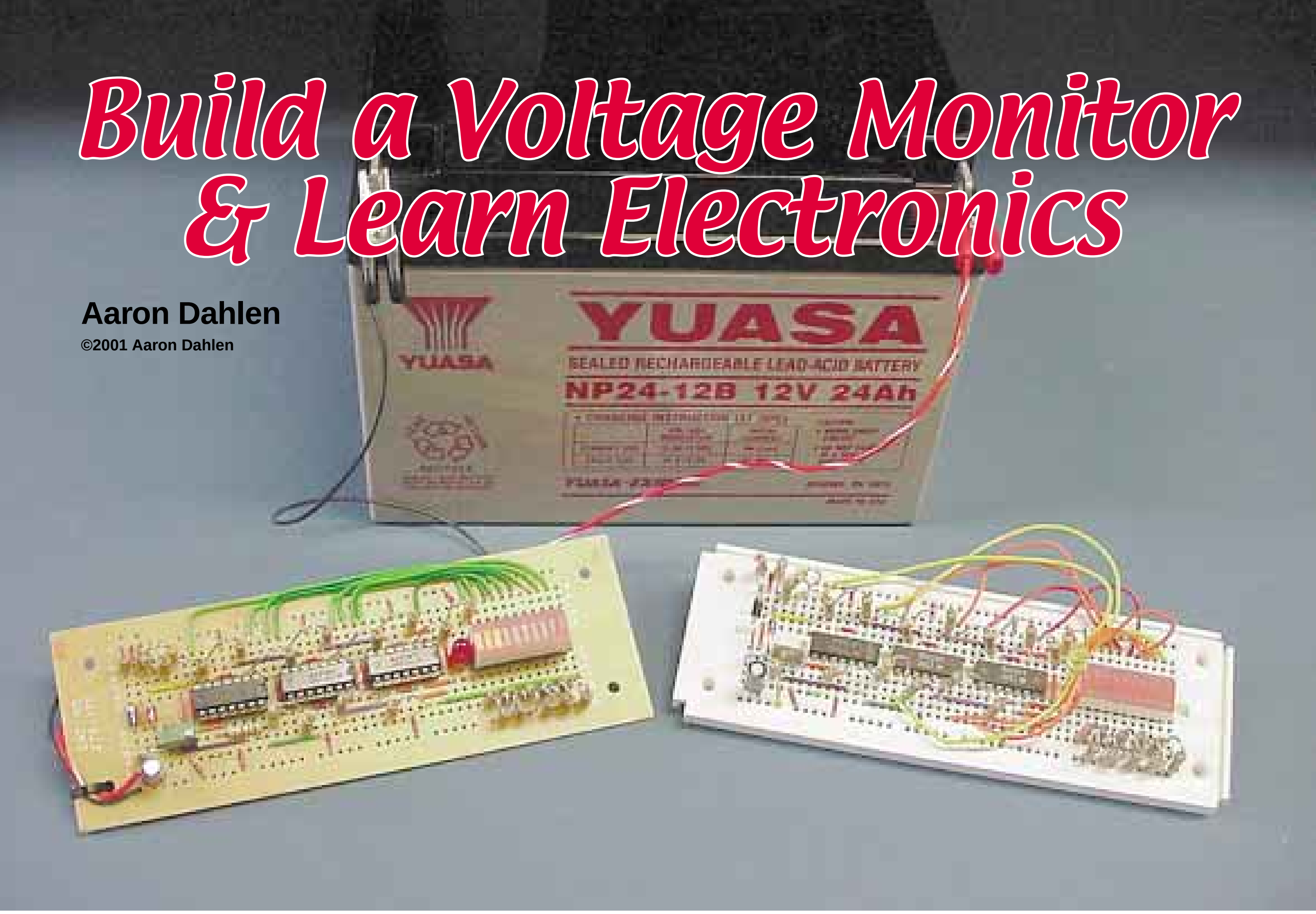
Build a Voltage Monitor & Learn Electronics

Aaron Dahlen



The completed voltage monitor on circuit card (left) shows 12.75 volts on the battery. The working prototype is assembled on breadboard (right).

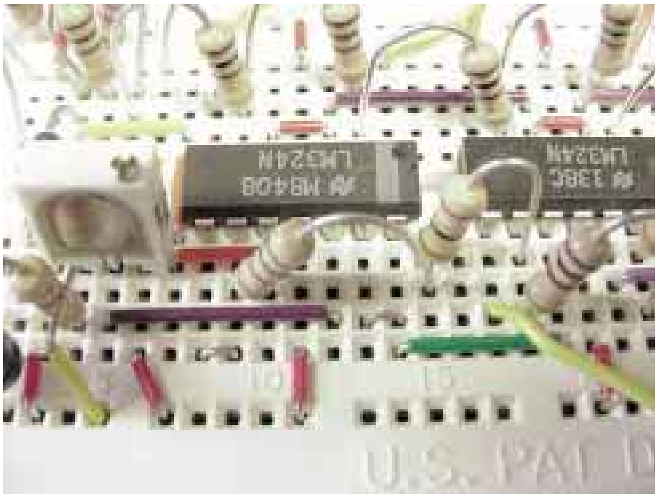
I was twelve years old when I built my first project—a crystal radio kit from Radio Shack. I'll never forget the joy and pride I felt when the local AM radio station, CFOB, came loud and clear through the earphone. Over the years, I have built many electronic circuits. I still get the same feeling I did when I built that first circuit. It's a wonderful experience having your ideas become reality. So, have you ever built an electronic circuit?

Building circuits is the best way to learn electronics. My intention is to introduce a simple electronics construction method that does not require complex circuit cards. The process is demonstrated by building a 12 VDC battery voltage monitor.

Basic Electronics

I am assuming that you have a working knowledge of electronic parts, have access to basic electronics tools, and can solder. There are numerous basic electronics books available to further your knowledge. Your local

A breadboard makes prototyping of a circuit fast—and makes the transfer to circuit card easy.



library should have several. While you're there, check out one of those "hundreds of circuits" books. The construction method outlined in this article is applicable to most of the circuits found in those books.

Why not use custom printed circuit cards? Printed circuit cards require time. Time to arrange the parts, time to perform the artwork (circuit trace layouts) and time to manufacture. Also, the chemicals required to etch and develop printed circuit cards pose a problem for the hobbyist. Please, please, please—research the disposal of the chemicals before you purchase them, if you decide to use custom printed circuit cards. And don't dump used chemicals down the drain! It's bad for the environment, and they can damage your pipes!

The process outlined in this article has the advantage of speed, and requires no chemicals. A circuit is built and tested using a breadboard. When complete, the circuit is simply copied onto a circuit card. This circuit card is identical to the breadboard. It has the same number of holes and the same pattern for connections.

Disadvantages? The breadboard to circuit card approach doesn't work well if you need many copies of a circuit. If you need more than ten copies, your time is better spent making a custom circuit card. Also, the breadboard doesn't function predictably with high frequency circuits. Simple analog and digital circuits seem to work best.

Tools

A breadboard is used to prototype and test electronic circuits. Electrical components are held in place by friction, allowing easy installation and removal. Once a circuit is completed and tested, the components and wires are duplicated on a circuit card.

Radio Shack sells breadboards and circuit cards with identical layouts. The photo on page 61 shows a back side view of a completed circuit card. Notice the vertical connections, with five holes each. Electronic components will be placed in these holes to complete the circuits. Also, there is a bus on the top and bottom of the card. These buses make convenient connections to the power supply—top to positive, negative to bottom. The breadboard has an identical layout, but it cannot be seen through the plastic.

Pre-cut wire greatly simplifies the construction and copying process. Electronic parts are built to a 0.1 inch scale. The wire is color-coded: red = 0.2 inch, yellow = 0.3 inch, green = 0.4 inch, etc. Color-coded wires along with the index numbers on the breadboard make it easy to copy a circuit. Simply line up the large parts based on the index numbers, and use the pre-cut wire to connect the circuit together. I have purchased a large number of these wires (the 3M line is available from Digi-Key), and I keep them arranged in a plastic box for quick use.

Voltage Monitor

Now let's discuss the project—more on breadboarding later. The voltage monitor is useful in determining the voltage level in 12 VDC circuits. It complements my pedal generator described in *HP81.* Voltage is read from ten LEDs. Readings start at 12.25 VDC, and go to 14.50 VDC in 0.25 volt increments, read left to right. For example, if seven LEDs are lit, the voltage is between 13.75 and 14.00 VDC.

LEDs and Corresponding Voltage Range

LED	*Voltage Range*
1	12.25 to 12.50
2	12.50 to 12.75
3	12.75 to 13.00
4	13.00 to 13.25
5	13.25 to 13.50
6	13.50 to 13.75
7	13.75 to 14.00
8	14.00 to 14.25
9	14.25 to 14.50
10	14.50+

In addition, a separate LED will blink if the voltage is less than 12.25 VDC. Circuit operation becomes erratic if the monitored voltage is less than 5 VDC. The voltage monitor is connected via two wires: red to positive, black to negative. If polarity is reversed, the circuit will not function, but will not be damaged.

Block Diagram

Every electronic device is composed of multiple simple circuits or function blocks. There are six function blocks in this circuit. Please refer to the block diagram.

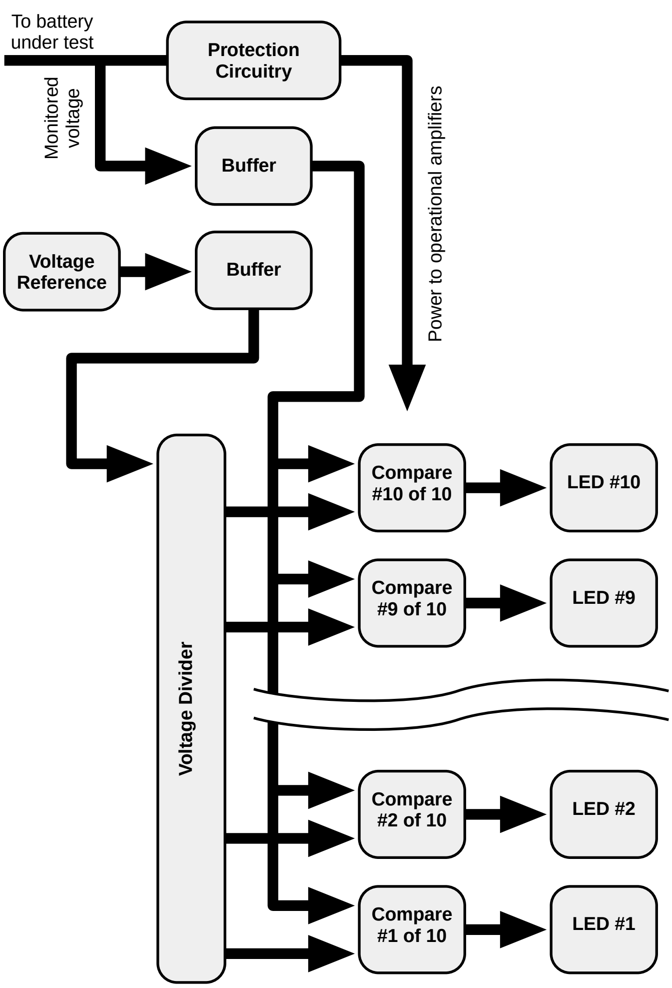
1. Polarity/overcurrent protection—This prevents circuit destruction if the operator accidentally connects the circuit backwards. Also, if the circuit should seriously malfunction, current is held to a safe level.
2. Voltage reference—The accuracy of the monitor depends on this stage. A voltage reference is a steady unchanging voltage level, 6.20 VDC in this project. This "known" steady voltage is later compared with the "variable" voltage (monitored circuit).
3. Voltage reference buffer—This isolates the voltage reference section from the voltage divider.
4. Monitored voltage buffer—This isolates the monitored voltage from the "comparing" operational amplifiers (op-amps).

5. Voltage divider—The resistor values were selected so that full charge (13.80 VDC) would be in the middle of the display, and to give good resolution (0.25 VDC steps). LED turn-on voltages may be changed by selecting different resistors. Resistor selection is an exercise in Ohm's law. See if you can determine how the resistor values were chosen. (Hint: I started by selecting a 100 ohm value for R8 through R16. I chose a 3 to 1 ratio; 18.6 VDC ÷ 3 = 6.2 VDC.)
6. Op-amp comparators—Each op-amp compares the monitored voltage (variable) to its sample of the voltage reference (known). If the monitored voltage is higher than the reference voltage, the op-amp will light the corresponding LED.

Theory of Operation

D1 prevents circuit flow if the input polarity is incorrect. R1 limits current during a circuit malfunction. C1 filters noise into and out of the circuit. R2 and variable resistor R3 provide an adjustable sample, buffered by op-amp U1D, of the monitored battery voltage.

Voltage Monitor Path of Operation



R4 and zener diode D2 form a 6.20 VDC voltage reference. U1C buffers the voltage reference, and sends it to the voltage divider. Resistors R5 through R18 form the voltage divider. The buffered voltage reference is "divided" or stepped down. Each op-amp receives a slightly different voltage.

Diode D3 forms the display. D3 is a ten-segment LED array. Each LED is driven by an op-amp. Each op-amp has two inputs:

1. Voltage reference—This is a steady unchanging voltage. Each op-amp receives a slightly different voltage from the voltage divider (R5 through R18).
2. Monitored voltage—This voltage is common to all op-amps. It is a sample of the monitored battery voltage. If the monitored voltage goes up, so does the input to each op-amp.

Each op-amp compares these two voltages. If the monitored voltage is higher than the voltage reference, the op-amp's output goes high. A high output turns on the LED. Each op-amp receives a different voltage reference. This turns on the LEDs at different voltage levels. The voltage divider is set up so that the LEDs turn on in 0.25 VDC steps, covering a range of 12.25 to 14.50 VDC.

Diode D4 is connected opposite of D3(1). If the voltage is less than 12.25 VDC (D3(1) off), D4 will be activated. A blinking LED was chosen for this application.

Breadboarding

Breadboarding can be a rewarding undertaking or a frustrating mess. Take your time. Focus on a single circuit block at one time when building a new circuit. Build the block. Test the block. When the block functions correctly, add the next. This project consists of six functional blocks, as described above.

The following steps were performed when I built the prototype. Due to space limitations, the steps are rather general. See the photo on page 60 to get an idea of parts placement.

1. Install D1 and R1.
2. Connect your power supply to the breadboard. Connect ground to the bus at the bottom of the breadboard. Connect B+ (old radio word for positive supply) to the anode of D1.
3. Apply power, and test with a volt meter. Voltage on the upper bus should be approximately 0.6 VDC less than your power supply voltage.
4. Install D2 and R4 to complete the voltage reference section. This block of the circuit is found on the left-

hand side in my example. When complete, you should read about 6.20 VDC on the cathode of D2.

5. Install R2 and R3 to complete the "monitored voltage" block of the circuit.

6. Add the first op-amp (U1). Watch the orientation. In my example, pin 1 is up and to the right. Complete the power connections (pin 11 neg, pin 4 pos). Complete the voltage reference buffer circuit. When complete, you should read 6.20 VDC on pin 8 of the op-amp.

7. Complete the "monitored voltage buffer circuit." The output (pin 14) should be identical to the input (pin 12). The voltage should change when R3 is adjusted.

8. Install U2 and U3. Complete the power connections.

9. Connect the "monitored circuit bus" to all op-amps.

10. Complete the voltage divider. It wraps around all of the op-amps, starting at U2C and ending at U1B. When complete, the voltages should be within a few tenths of those indicated on the schematic.

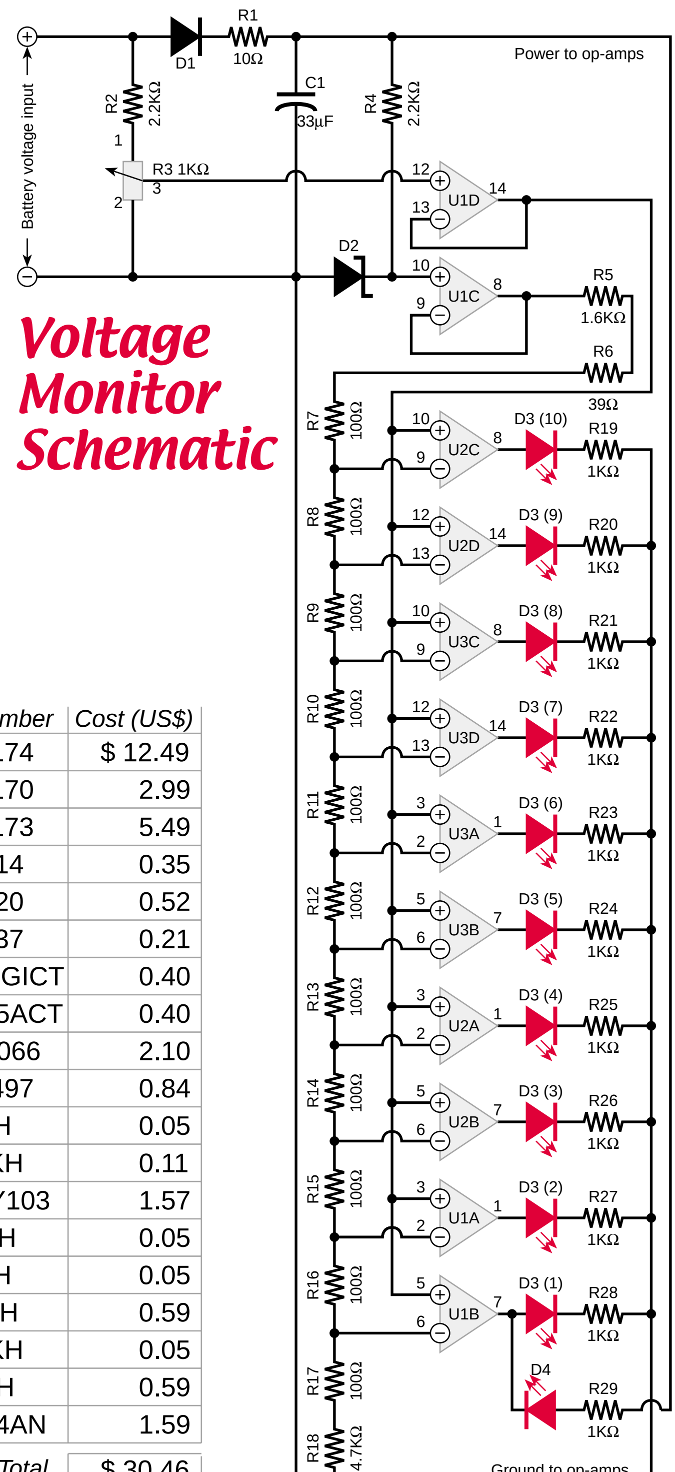
11. Set the bench power supply to 13.50 VDC. Monitor the output of U1 at pin 14. Adjust R3 until the voltage is 4.50 VDC.

12. Monitor the output of the "comparing" op-amps. U2 pin 8 should read approximately 0 volts. U1 pin 7 should read approximately 13 volts.

13. Complete the circuit by connecting the LEDs.

14. Adjust the bench power supply up and down. The LEDs should follow the voltage.

Voltage Monitor Schematic



Battery Monitor Parts List

Item	*Supplier*	*Part Number*	*Cost (US$)*
Breadboard	Radio Shack	276-174	$ 12.49
Matching printed circuit card	Radio Shack	276-170	2.99
Jumper wire kit	Radio Shack	276-173	5.49
14-pin soldered IC socket	Digi-Key	A9414	0.35
20-pin soldered IC socket	Digi-Key	A9420	0.52
C1: 22 µF 35 VDC radial capacitor	Digi-Key	P6237	0.21
D1: Rectifier diode 1N4001	Digi-Key	IN4001GICT	0.40
D2: Zener diode 1N4735A	Digi-Key	ZM4735ACT	0.40
D3: Red 10 segment LED bar graph	Digi-Key	160-1066	2.10
D4: Red blinking diode	Digi-Key	67-1497	0.84
R1: 10 Ω, 1/2 W resistor	Digi-Key	10H	0.05
R2 & R4: 2.2 KΩ, 1/2 W resistor	Digi-Key	2.2KH	0.11
R3: 1 KΩ cermet trimmer resistor	Digi-Key	CT94Y103	1.57
R5: 1.6 KΩ, 1/2 W resistor	Digi-Key	1.6H	0.05
R6: 39 Ω, 1/2 W resistor	Digi-Key	39H	0.05
R7–R17: 100 Ω, 1/2 W resistor	Digi-Key	100H	0.59
R18: 4.7 KΩ, 1/2 W resistor	Digi-Key	4.7KH	0.05
R19–R29: 1 KΩ, 1/2 W resistor	Digi-Key	1KH	0.59
U1–U3: Op-amp LM324N	Digi-Key	LM324AN	1.59
		Total	$ 30.46

Voltage Divider Resistor Values*

	Volts	*Scaled*	*Total E*	*R Value*
R5**	18.60	6.20	1.3667	1,600.00
R6**				40.00
R7	14.50	4.83	0.0833	100.04
R8	14.25	4.75	0.0833	100.04
R9	14.00	4.67	0.0833	100.04
R10	13.75	4.58	0.0833	100.04
R11	13.50	4.50	0.0833	100.04
R12	13.25	4.42	0.0833	100.04
R13	13.00	4.33	0.0833	100.04
R14	12.75	4.25	0.0833	100.04
R15	12.50	4.17	0.0833	100.04
R16	12.25	4.08	0.0833	100.04
R17***				100.00
R18***	12.00	4.00	4.0000	4,700.00
	I Total =	0.00083	*R Total =*	7,440.00

* 18.6 scales to 6.2, then each 0.25 volts = 0.0833.

** R5 and R6 are added together for required resistance of 1,640 Ω, which equals 18.60 VDC.

*** R17 and R18 are added together for required resistance of 4,800 Ω, which equals 12.00 VDC.

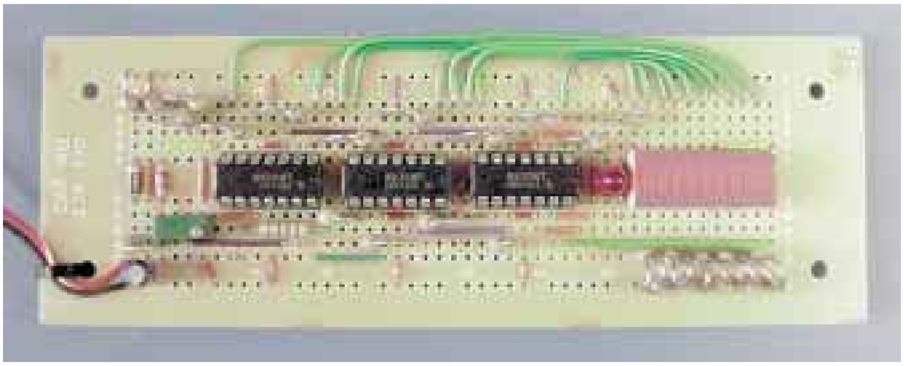
Copying to a Circuit Card

The next step is easy. To copy the circuit onto a circuit card, install and solder the components in the following order:

1. Pre-cut wires, using the breadboarded circuit as a template.
2. The DIP sockets for the op-amps and LED array (observe orientation).
3. Resistors.
4. Diodes.
5. LEDs.
6. Wire connections to the outside.

Take your time, watch the index marks, and use the correct color (length) of wire. A simple mistake takes a long time to correct once the part is soldered into place.

The completed voltage monitor on circuit card.



Calibration

An accurate voltmeter is required to calibrate the LED display. Adjust the bench power supply to 13.5 VDC. Resistor R3 is adjusted until LED #6 just turns on. Adjust the bench power supply in 0.25 VDC steps, and verify that the LEDs follow.

A variable power supply is required to build and test this project. If you plan to build many circuits, you may want to invest in one. Be forewarned that these power supplies can be expensive—over US$150. A cheap alternative is to build your own. A circuit based on the LM317AT is a good starting point. You can download the LM317AT data sheet from National Semiconductor's Web site. Three 6 VDC lantern batteries connected in series make a good "raw" power source for the LM317AT. Avoid flooded lead-acid batteries on your test bench. A spark could cause the battery to explode.

A 10 ohm, 1/2 watt resistor should always be placed in series with the output of the variable power supply. The resistor will limit current if a mistake is made in circuit layout (short or incorrect polarity). This will limit the damage to the circuit, the breadboard, and you! Parts can get hot—hot enough to melt the breadboard and give you a nasty blister if you mistakenly touch one of them.

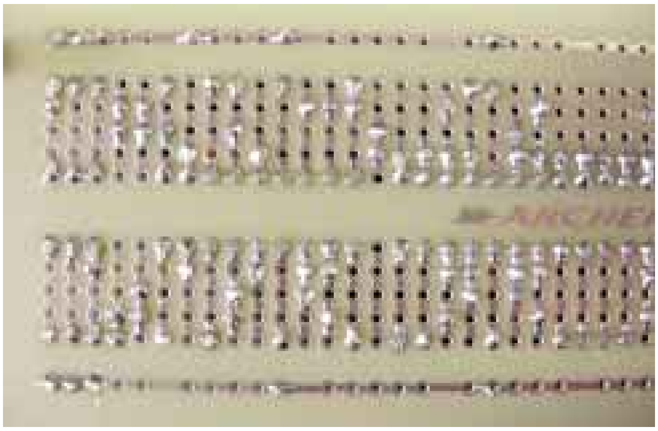
Don't be surprised if your 10 ohm resistor bursts into flame while you are prototyping. This is actually a good thing—the resistor saved your circuit. A fuse could be used to limit the current, but fuses get to be expensive after a few mistakes.

Final Tips

Take your time! Breadboarding, like any other skill, takes time to master. Purchase more parts than you will need. This is especially true of the op-amps. Shop around; surplus electronics dealers can save you lots of money.

This project reinforces learning to build by using functional blocks. Circuit complexity forces you to build and then test each block. You will be glad to know that there are simpler ways to design this project. But I encourage you to build it as described here. Build a small simple block, and test it. Build another and test it. It's the best way to learn electronics—building, testing, and finally understanding.

Build other projects and apply these ideas. With practice, understanding will come before building. Then you



Clean soldering on the back side of the circuit card.

will see your ideas become reality. Construction electronics can be a rewarding experience. I hope this article inspires you to try!

Access

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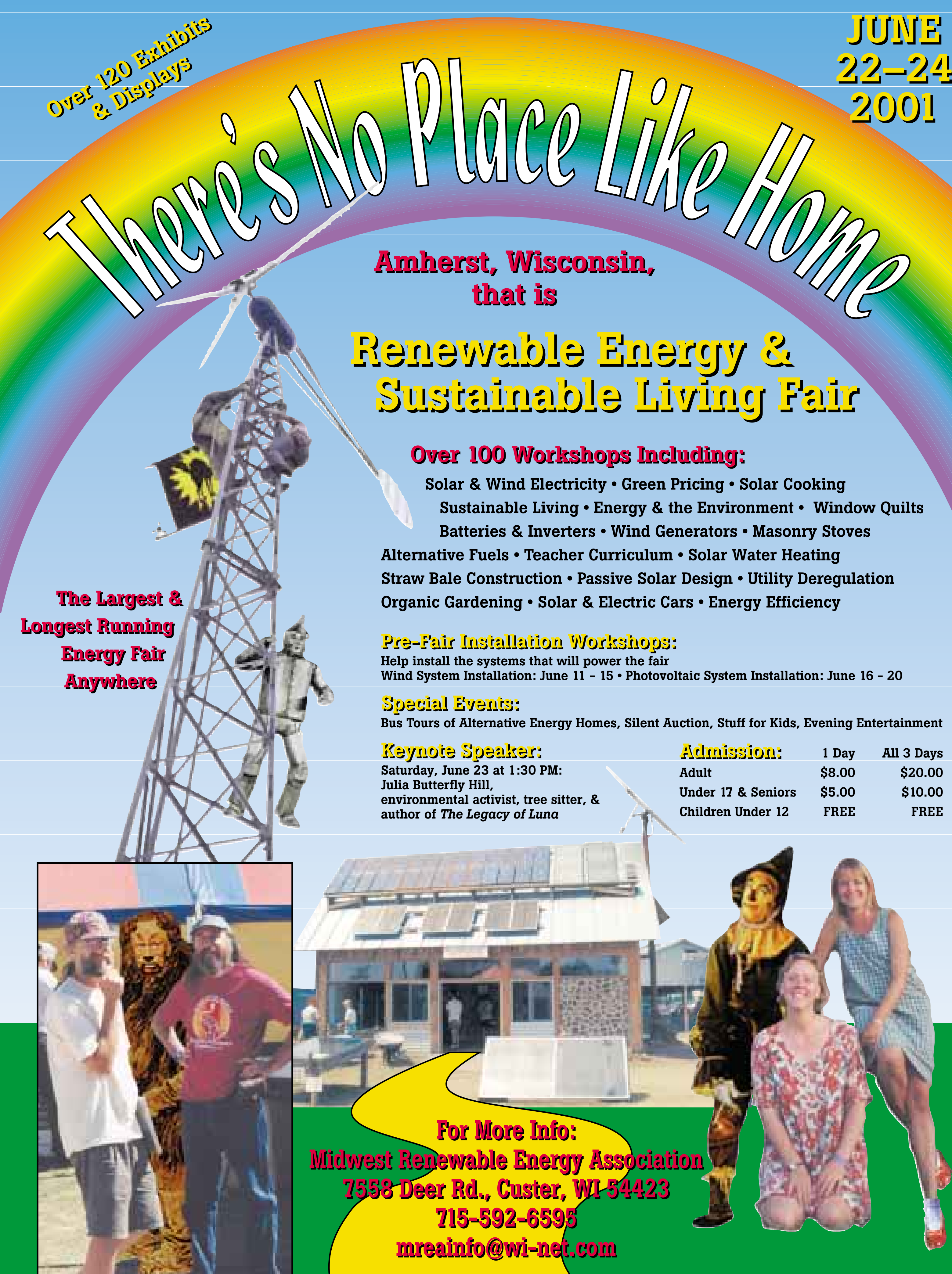
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Passive Cooling

Part II — Applied Construction

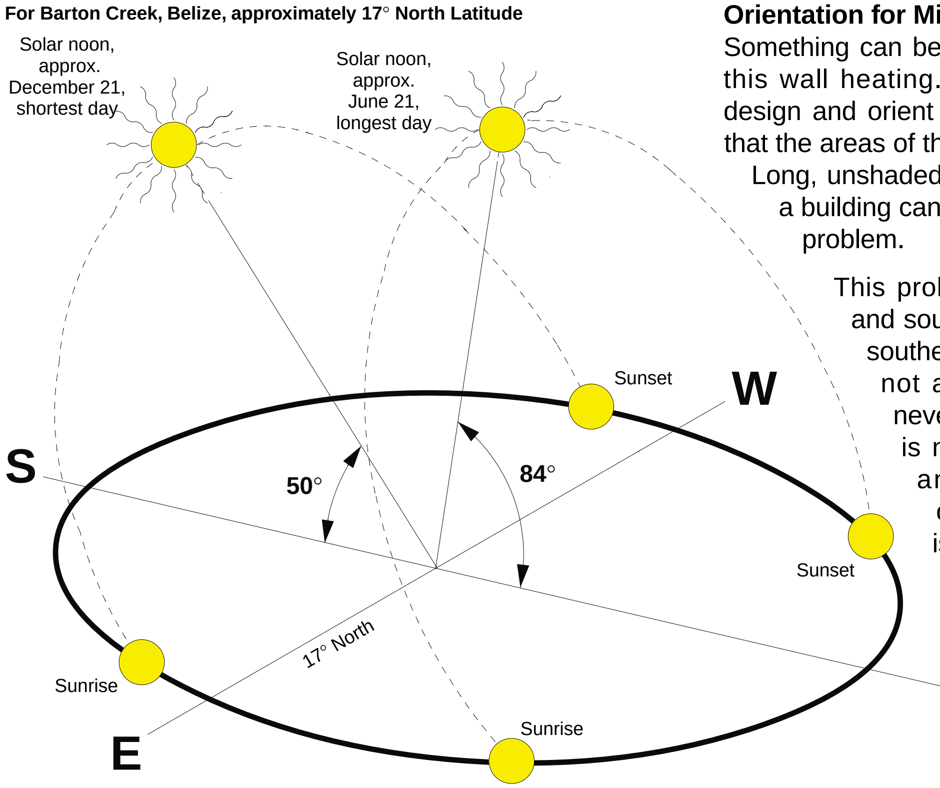
Cliff Mossberg

In Part 1 of this series (see *HP82,* page 84), I outlined the three modes of heat transfer, and tried to integrate this knowledge with the factors of human comfort. This information is basic to any design or construction geared towards minimizing the discomfort of living in the tropics.

In Part 2, I would like to show some of the design techniques for dealing with the effects of heat and humidity in a dwelling located in what we know as “the humid tropics.” This label differentiates this climate from that of a hot, arid, desert type of environment. The desert might ultimately be hotter than the conditions found in the humid tropics. But the low humidity found in the desert makes it practical to use some techniques of dealing with the heat that we cannot use in more humid locations.

Figure 1: Seasonal Variation of the Solar Path

For Barton Creek, Belize, approximately 17° North Latitude



Solar Incidence as a Design Element

The sun is the primary engine of heat gain in a tropical dwelling. It is not usually ambient air temperature that causes heat discomfort, but the radiant energy of sunlight, either directly or re-radiated in long wave infrared. The first line of defense against heat buildup in a building is to minimize the surfaces that sunlight can fall on.

It is obvious that the building’s roof is going to be the main absorber of solar energy. If the roof is designed to block heat flow down into the dwelling, and made large enough to cover and shade the walls, the builder should be successful at reducing unwanted heat. This simple concept is more difficult to accomplish that it seems at first.

If the sun was always in the high-noon position, the job would be simple, but it’s not. In the morning, it starts out shining low in the eastern sky. It can heat up a building’s walls for many hours before it rises high enough for the roof’s shadow to shield the east wall from radiant energy. In the afternoon, the sinking sun has the same effect on the western wall.

Orientation for Minimum Incidence

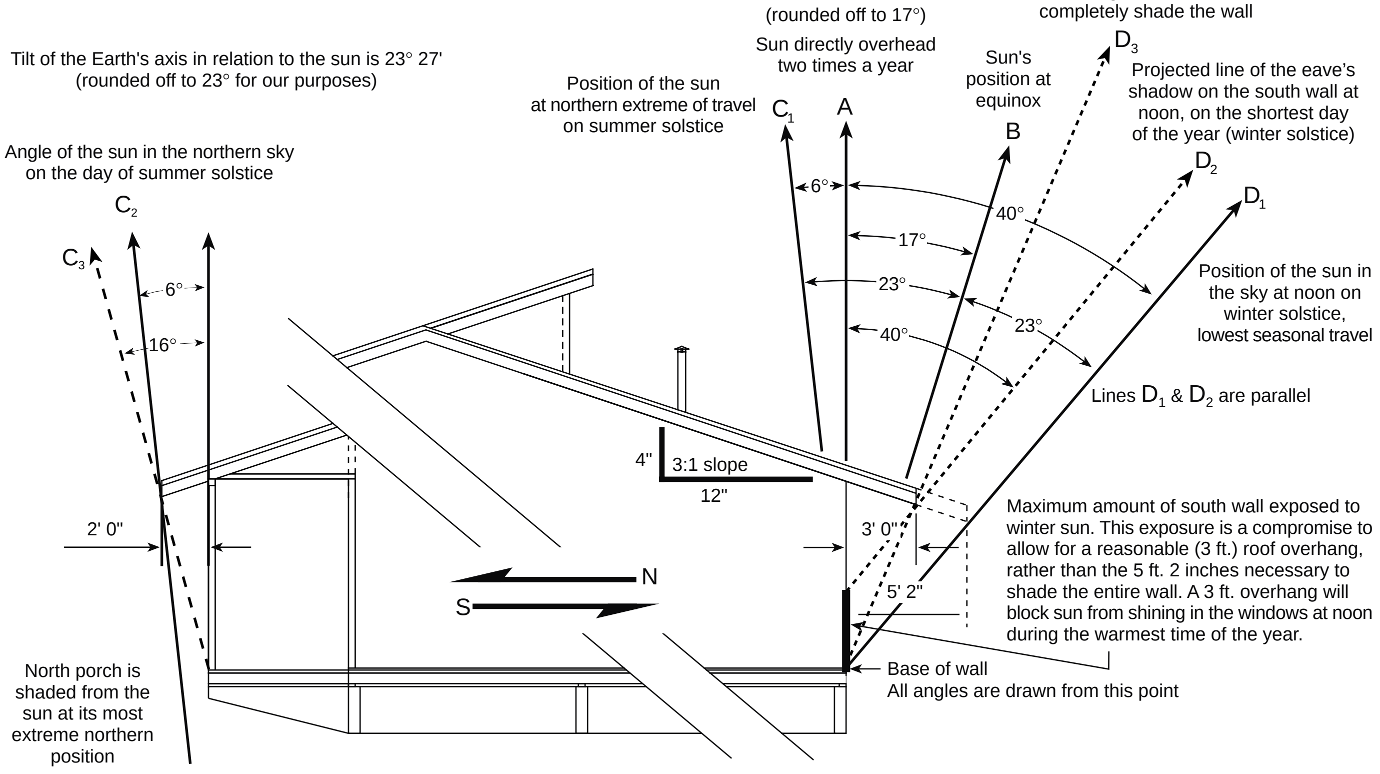
Something can be done at the design stage to reduce this wall heating. The very first effective step is to design and orient the structure on the building site so that the areas of the east and west walls are minimized. Long, unshaded walls on the east and west sides of a building can significantly contribute to the heating problem.

This problem is not as severe on the north and south walls. The sun will be lower in the southern sky in winter when wall heating is not as big a problem. But the sun will never be as low in the southern sky as it is near sunrise and sunset in the east and west, so engineering roof overhangs to block the southern sun is much easier.

Roof Overhangs

In Figure 2, angle **A** represents directly overhead. Angle **B** has its pivot point at the base of the south wall. It is plotted at the local angle of north latitude. At that angle, the sun would appear

Figure 2: Angles of the Sun and Cast Shadows



directly overhead at the equator on the days of the solar equinox. **A** is easy to find—it is straight up. **B** is easy to compute graphically once local latitude is known. Once you have **B,** you have a baseline.

If we swing an angle north 23° from **B**, we will have the northernmost angle of the sun's travel in the sky in Belize. In this case, it is an angle of 6° north of vertical, or 84° vertical declination from level ground, pointing north (Figure 1). I have labeled this line $\mathbf{C_1}$. If $\mathbf{C_2}$ is drawn at the exact same angle as $\mathbf{C_1}$, but touching the edge of the roof overhang on the north wall, the lower extension of $\mathbf{C_2}$ will indicate the path of the sun's rays on the north side of this building.

In this case, the sun will not ever touch the base of the north wall. $\mathbf{C_3}$ is the position the sun would have to travel to for it to begin to heat the base of the wall. $\mathbf{C_3}$ is an imaginary angle, since the sun is never that far down in the northern sky at this time of day and this location in Belize. This shows us that a standard 2 foot (0.6 m) overhang on the north edge of the roof is sufficient to shade this north wall at all times of the year at this location.

Returning to our baseline **B**, we need to turn another 23° angle, south from **B** this time, just as we turned north before. This will produce line $\mathbf{D_1}$, the angle of the sun's rays at its extreme southern sky position. It is immediately obvious that $\mathbf{D_1}$ does not touch both the base of the south wall and the edge of the roof overhang. We know from this that the roof overhang is insufficient, even at 3 feet (0.9 m), to completely shade the south wall.

The south roof overhang would have to be extended all the way out to 5 feet 2 inches (1.6 m) to completely shade the wall. This large overhang would be structurally weak in high winds, and would also hang down far enough to block the view out of windows on the south wall. A compromise between 100 percent shade, vision, and structural rigidity will be necessary.

There are at least two possible solutions to this need for compromise. In Figure 2, I have chosen to construct $\mathbf{D_2}$ as a line parallel to $\mathbf{D_1}$ but moved over enough so that it touches the south roof overhang. If it is extended down to intersect the wall, the lower projection of $\mathbf{D_2}$ represents the limit of the south wall shading. Above the intersection with the wall will be shaded; below will see direct sun at this time of the year. The line of shade appears here to be sufficient to keep the sun's rays out of the window openings.

Vegetation

Trees and shrubs that shade the structure are one approach to blocking sunlight. From a practical standpoint, it is difficult and extremely expensive to add mature trees of any size to a building design. The usual procedure is to plant smaller ones and tolerate the sun

A wall of decorative concrete block allows ventilation and provides shade, transmitting only muted light.

until the smaller trees are big enough to produce shade. Unfortunately this can take ten years or longer. Where possible, keep what you have.

Vining plants are a good alternative to trees, with one serious caveat. One of the goals of a tropical house design is the exclusion of termites from the wooden parts of the structure. This can be done by building elevated columns with termite collars on top. Any vegetation planted on the ground and close enough to the structure to touch it will provide a path for termites to circumvent the exclusion features of the design. Without the termite problem, it would be effective to use a trellis on the east and west walls. Vining plants such as passion fruit can intercept the sunshine and put it to good use growing flowers or edibles.

Wall Shading with Architectural Elements

It is possible to use architectural elements to moderate direct sun on the walls. Properly designed architectural screens can be made to block and modulate sunlight to good advantage. The photo above illustrates the use of such a screen, here composed of simple decorative concrete blocks placed together into a pleasing texture. This very effectively opens up a whole wall to air and muted sunlight.

This screen can conceal wooden or metal louvers fitted with insect screens. These can be opened for the warm dry weather, but closed for storms. In this design, the concrete screen is integrated as part of an upscale-style Belizian house. It will take a substantial foundation to support such a screen. Such massive architecture is not necessary.

Hassan Fathy describes a traditional screen used throughout the Middle East that is made up of round turned spindles arranged into a rectangular grid. It is known as a mashrabiya. The same term is used to describe vertical louvered blinds that can be adjusted to shade an entire wall.

Both of these devices allow conditioned light to enter the building for illumination, while blocking the strong exterior sunlight. The harsh contrast of the sun beating on the outside of the screen blocks outsiders from seeing through the screen to the inside. But it allows someone on the inside to easily see out into the bright exterior.

Window Shading Devices

There are two problems to deal with if you wind up with sunshine on your outer walls. There is the re-radiation of the solar energy into the interior from the walls. I'll deal with that next. But first I want to deal more thoroughly with the problem of solar energy directly heating the interior space through the window openings. Where this is a problem, the windows themselves can be constructed to block the sun's rays through reflective glass coatings and through the use of solar screens.

Jalousie windows are commonly used in the tropics. They use single panes of glass to form the louvers. These single panes have virtually no insulation value. In contrast, double and triple pane argon-filled glass used in the colder regions are designed primarily to block conductive and radiant heat flow outward, not to facilitate natural ventilation inward. They would be valuable in an air conditioned house.

While air conditioning has a role in tropical cooling, it is not going to be a factor in our passive design focus. We want to foster good air circulation and a design that excludes solar radiation. Jalousie windows glazed with glass that uses reflective films can do this.

Glass can be made with a permanent reflective coating deposited on one face. This is conventionally either bronze or aluminum in color. This coated glass can block up to 80 percent of the heat energy in incoming sunshine. Films that can be applied to uncoated glass are also available for this purpose, and provide approximately the same excellent result. The downside to reflective coatings is a reduction in the amount of visible light entering a house for general illumination.

Louvered "jalousie" windows are coated with a reflective surface to block sun. They also readily facilitate ventilation.

Solar screens that go on the outside of the windows in place of conventional insect screens are also very effective, reducing the incoming heat energy by up to 60 percent. Using both of these strategies produces a tropical window that is extremely effective at blocking invading radiant energy, while still providing excellent ventilation. The cost is higher than uncoated glass and normal screening, but it is worth the money.

There are many traditional methods available for blocking solar heat from infiltrating the inside of a house through the window openings. As a general rule, external devices such as awnings, louvers, and roll shades are more effective than inside devices such as venetian blinds and roll shades. The efficiency of each device is a function of its material, color, and texture.

Radiant Barriers

The material of choice for blocking both visible light and infrared is a shiny sheet of polished metal. Aluminum foil is one of the best materials, reflecting up to 95 percent of both wavelengths. This foil is a very good conductor of heat energy, but it is a very poor radiator of radiant heat energy. It has a maximum emission inversely proportional to its reflectance.

In English, that means that a highly polished aluminum foil might only re-radiate 5 percent of the radiant heat energy falling on it. It is an ideal blocker of radiant energy. Used in this way, these foils are known as radiant barriers. Under peak sunshine conditions, a radiant barrier can reduce heat inflow by as much as 40 percent or more.

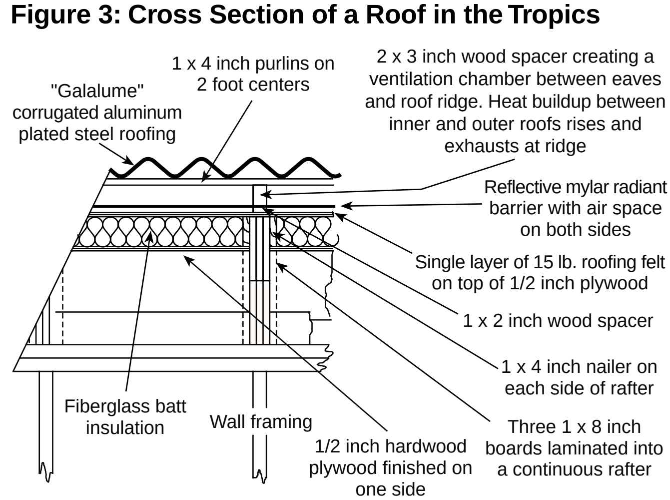
For a radiant barrier to be effective, it must have an air space on one or both sides. Aluminum is a very good conductor of heat. Without this air space, the foil would simply move heat from whatever substance is on one side of it to whatever is on the other. It would do this very efficiently. When it is installed with an adjacent air space, the air (which is a good insulator for heat transfer in the conduction mode) blocks conduction of heat from the foil, while the poor emissivity of the foil blocks heat transfer through the process of radiation.

Roof Design & Radiant Barriers

The roof is the most critical heat blocking device in your arsenal. It can operate passively, blocking radiant energy from moving downward into the house using a radiant barrier. It restricts conductive flow of heat through the roofing materials. And it can be designed to use thermal convective flow to carry off air heated by the roofing.

The roof design I prefer is actually two roofs sandwiched together. The upper roof blocks wind and rain. It also contains convective air channels (see Figure 3) between spacers over the structural joists. These cavities form ducts so that air heated by the hot roofing can rise and exhaust at the high point through thermal convection. Below these vent channels is a layer of radiant barrier material. This barrier blocks the heat that is radiated by the metal roofing, keeping it out of the dwelling.

Figure 3: Cross Section of a Roof in the Tropics



The lower sandwich contains the structure as well as fiberglass batt insulation to block conductive heat flowing downward into the living area. As mentioned in Part I, radiant heating is the principal mode of heat flow downward. Conductive heat does not move as readily downward through materials.

Where the roof is built of standard sheet roofing over rafters, installing the radiant barrier is quite simple. It can be tacked to the underside of the rafters, above the ceiling joists. For this use, radiant barrier is available in several different designs.

Radiant Barrier in the Walls

Walls can also easily incorporate a radiant barrier. Where double-wall construction is used, the barrier material can be installed on the inside with the foil material facing the outer wall. In areas where insulation is to be used in the wall, more care must be taken so that there is an air space between the insulation and the barrier material.

One method of utilizing the radiant barrier material requires that it be installed on the outside of the sheathing. Spacers are then nailed over the barrier material, and a second, vented skin is installed on the outside. Vents at the top and bottom of this second building skin form a solar chimney, allowing heated air to exhaust from the wall by convection. This tactic works with either open single-wall construction or insulated double-wall construction.

Building Insulation

Many materials have been developed to do the job of holding air as an insulator. From sawdust, thatch, and straw, to high tech materials such as aero-gells and ceramic foams, all materials have pros and cons. The first materials I've mentioned are organic, and subject to biological degradation. The second two are ridiculously expensive for home use. Good home insulating materials should be cheap, effective, and stable.

The ideal building insulation is nothing. The nothingness of the vacuum in space is a case in point. Heat flow due to conduction or convection simply cannot occur in a vacuum because it depends on the interaction between molecules of a substance to move the heat. No substance equals no heat movement. But a vacuum is not easily maintained.

Among commonly available materials, air is a very good insulator. It is cheap and efficient, but air has a tendency not to stay in one place when it is heated. We need to stop convective air movements by trapping it.

Stability in Insulation Materials

Many insulating materials are available that do this successfully. Sawdust is one of the earliest and cheapest insulators. One of the great drawbacks of using sawdust is that it can absorb water from rain or moisture in the air, or even from the building interior. Water absorption will degrade the insulation value, and may lead to bacterial, fungal, or insect damage.

Sawdust is also subject to settling. Even the mechanical vibrations a building may be subject to can cause settling of the sawdust, opening up large cavities above the insulating material where convective heat flow can occur. A good insulator must be more than efficient; it must be stable too, maintaining its original volume and material properties.

Insulation Toxicity

To be a stable building insulator, a material must contain as much air as possible, trapped in a matrix of inert material. Rock wool is one of the oldest commercial insulators available in batt form. It is still used around heating systems where resistance to flame or high heat is desirable.

Rock wool is manufactured from inert materials that have been heated and spun out into fine fibers. It is then fabricated into batts containing innumerable small air spaces. It is a brittle material with friable fibers that can break down easily during handling. These fibers can be a severe irritant to the human body, both to the lungs and to the skin.

So besides being stable, a good building insulator should be benign to the people who must install it and live around it. Asbestos is the classic example of the perfect insulation material that is also supremely toxic.

Materials such as glass wool—fiberglass—and several types of closed-cell foams are non-toxic and non-irritating to a greater or lesser degree. Fiberglass is less benign than other materials, but not nearly as irritating as rock wool.

Fire Retardant Qualities

Another material that is common in the residential building trades is cellulose insulation. This is manufactured out of ground-up paper, frequently newspaper. It has fire retardant added, and sometimes materials to make it resistant to insect damage. Cellulose is a very efficient, non-toxic insulator, but it has a tendency to settle in vertical cavities, just as sawdust does. Because of this, it is primarily used as loose fill above ceilings. If it is kept dry, it works very well.

Foam boards and foamed-in-place urethanes are excellent insulators, but they do not like heat. Under high heat conditions, they can produce toxic gases that are lethal. Under sustained heat conditions such as those found under a tropical roof, they can break down and outgas, losing their closed-cell foam structure, and seriously degrading their insulation ability.

The material I prefer for insulation in the tropics is glass wool, most commonly known as fiberglass. It is available in the U.S. in either batts or loose fill that can be blown into place. Fiberglass is similar to rock wool in its physical construction. Since it is “spun” out of fine strands of real glass, it is inert to heat, resistant to airborne moisture in the form of high humidity, and is a very effective insulation. It is slightly more physically irritating to handle than some other insulations, but new materials are better than aged materials in this respect.

Shipping Cost

Since all of the commonly accepted thermal insulations are light and bulky, they are expensive to ship long distances. The cost of shipping this type of product is based on its volume rather than its weight. That can be substantial.

Fiberglass suffers from the same drawback that other insulating materials do. It is difficult to obtain in Belize and other tropical areas because it frequently must be shipped in from more developed nations. Many nations place a high customs duty on imported goods such as these.

Where it is available, two-component urethane foam insulation is very convenient because the resin to manufacture it can be shipped by the barrel, in concentrated form. With modest equipment, the two-part resin can be combined and applied directly. It will then expand in place. Keep in mind that this foam does not like high heat.

How Much Insulation?

Some people define “R” values as “resistance” to the flow of heat. This is a good way to think of R-values. R-values can be added together, and they are a directly proportional measure of heat resistance. The chart at right lists common building materials, including insulation materials, and their associated R-values.

Where there is little difference between inside and ambient temperatures, and where air movement through natural ventilation is the goal, uninsulated walls and floors are acceptable. In a temperate climate, where winter heat and summer air conditioning expense is an important factor, a well-insulated house envelope is required. R-values in the floors, walls, and ceilings are specified by the location of the house in specific climate zones.

The type of energy used to heat or cool a building affects recommendations too, with higher R-values specified for electric heat than for fossil fuels, for

R-Values of Common Building Materials

Material	*R-Value*
Insulation	
Polyurethane, per inch	7.00
Polystyrene, extruded (blue board), per inch	5.00
Polystyrene (bead board), per inch	3.85
Rock wool, per inch	3.45
Fiberglass batt, per inch	3.35
Masonry	
Concrete blocks, 8 inches	1.11
Brick, common, 4 inch	0.80
Concrete blocks, 4 inches	0.71
Stucco, 1 inch	0.20
Concrete, per inch	0.08
Siding	
Wood bevel siding, 3/4 inch	1.05
Wood shingles	0.87
Wood bevel siding, 1/2 inch	0.81
Aluminum siding	0.61
Roofing	
Wood shingles	0.94
Asphalt shingles	0.44
Felt paper, 12 lb.	0.06
Wall Covering	
Insulation board sheathing	1.32
Cement board, 1/4 inch	0.94
Gypsum board (drywall), 5/8 inch	0.56
Gypsum board (drywall), 1/2 inch	0.45
Windows	
Sealed double glazing	1.92
Single thickness glazing	0.91
Wood	
Common construction softwoods, 3-1/2 inches	4.35
Common construction softwoods, 1-1/2 inches	1.89
Common construction softwoods, 3/4 inch	0.94
Plywood, construction grade, 3/4 inch	0.93
Maple, oak, or tropical hardwoods, 1 inch	0.91
Particleboard, 5/8 inch	0.82
Plywood, construction grade, 5/8 inch	0.78
Hardwood finished floor, 3/4 inch	0.68
Plywood, construction grade, 1/2 inch	0.62
Plywood, construction grade, 1/4 inch	0.31
Tempered hardboard, 1/4 inch	0.31
Regular hardboard, 1/4 inch	0.25

example. Additionally, fiberglass batts are only available in certain thicknesses, so recommendations usually adhere to what is available. 3-1/2 inch (9 cm) thick batts are rated R-11, 5-1/2 inches (14 cm) at R-19, etc.

Dead Air Spaces Used as Thermal Blocks
There are other ways of designing to resist heat flow from solar-heated walls besides radiant barriers and insulated surfaces. In new construction, during the design phase, it's necessary to be aware of potential heating problems. It is cost effective to design cabinets, closets, garages, or other unoccupied or infrequently occupied spaces along those walls that are sources of interior heating due to exterior solar radiation. This practice creates a double wall with an interior dead air space to resist heat moving across that space into the living environment.

Mass Used as a Thermal Flywheel
From the adobe pueblos of the southwest Indians to the rock walls in the ancient stone city of Great Zimbabwe, many indigenous forms of architecture have taken advantage of the thermal storage inherent in large mass. This mass can store heat, and can also even out the temperature fluctuations in a hostile living environment. The modern equivalent of these classic examples is the Trombe wall.

Using mass to mitigate temperature swings in a dwelling only works well where the temperature differential between the mass and the tempering heat source is fairly large. If you try to adapt the Trombe wall or other less passive applications of thermal mass storage to cooling in the humid tropics, you are limited by environmental factors.

Solar-driven temperatures inside a poorly designed building can go up to 125°F (52°C) in the heat of the day. This gives you a nice temperature differential to drive heat exchange, but such a gain is never desirable! But you do need a significant temperature difference to move much heat from the hot interior mass to the cooler outside nighttime air. In a passively cooled house in the humid tropics, there is no concentrated source of "cold" that can drive such a cooling heat flow the way there is with solar heating.

Convection
In Passive Cooling—Part 1, I covered the theory of convection, the movement of heat carried by the flow of a fluid such as air or water. Here I will try to explain how the designer or builder can use the building envelope to force convective flow to occur passively—without any input of energy other than what is applied to the fluid through natural influences.

I should say here that I do not personally subscribe to the need for *entirely* passive designs. Where the energy is available or where you can create it efficiently, there are good arguments for the use of active designs. Low voltage DC ceiling fans are a good example.

The key to good design is the word "efficiently." Both passive and active cooling systems can be designed that are so expensive to install that it could well be more efficient, all things considered, to run a generator and an air conditioner. So when I talk about efficiency of design, I am factoring in the overall cost of the design, not just operating costs.

Chimney Effect Ventilation
Hot air is less dense and therefore lighter than cool air. It rises or floats on the heavier, cooler air. As with all forms of heat flow, "hot" and "cold" are qualities that are relative to the temperature of a human body—98.6°F (37°C). There is no absolute quantity known as "hot" or "cold."

The important consideration is the difference in temperature between one heat source and another, not whether it is hot or cold. This concept is known technically as Δt (delta t), shorthand for the change in, or the difference in temperature.

Δt governs all things thermal, including radiation of energy from one hot body to another, conduction through a substance, or how easily hot air will float on cooler air. If Δt is high, hot air is more buoyant and will rise faster. If Δt is small, there is less tendency for a heated mass of air to move upwards. I am using air here as a familiar example, but technically, any fluid from air to water to molten metals will support convective heat flow.

Solar chimneys are structures designed to heat air with solar energy. This heated air then rises in a duct, just as furnace-heated air in a stovepipe rises. Under most conditions, stand-alone solar chimneys cannot justify their cost with their performance. Solar-enhanced ventilators (roof panels that are designed into new construction) may have a slightly better cost/benefit ratio, but as a general rule, their performance is disappointing. They are especially ill-suited to the humid tropics.

Roof Venting
In Part 1, I described heat buildup in the attic air space under a hot roof, and I showed how this buildup transfers heat to the ceiling and then down into the living space. If we return to that example, we can now discuss the role convection will play.

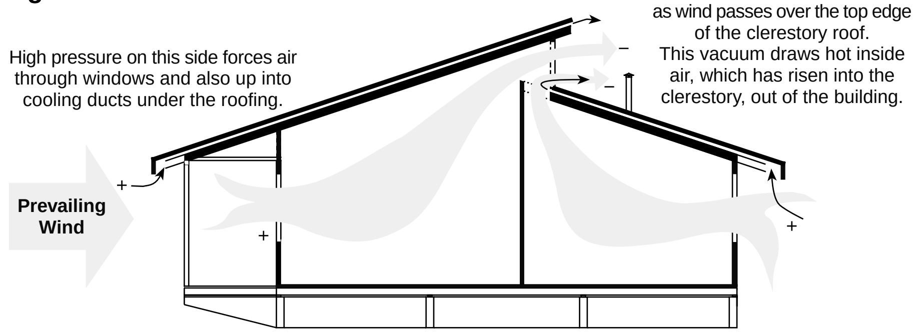
In the example above, the hot roof will attain temperatures of around 140°F (60°C) maximum. In the living space, the desirable temperature is around 72°F (22°C). There is a Δt between the roof heat source and the ceiling of 68°F (20°C). That is sizeable.

Suppose now that we open the roof up and allow the hot air, which has risen to the highest point of the roof, to keep rising and escape? This air removal technique is known as roof venting, and it is highly recommended for any enclosed roof or attic space.

Of course, for air to flow out of a cavity, there must be provision for replacement air to flow in. The hot air flows out, creating a very slight vacuum, which draws cooler air in from some other place, usually around the roof eaves or gables.

As this replaces the hot air with much cooler air, the Δt between the attic air space and the ceiling membrane is considerably reduced. The Δt between the roof and the attic air is increased, allowing more heat to transfer from the roof surface to the attic air, which is vented outside to the ambient air. This reduces the roof temperature. Clearly, convection can be useful.

Figure 4: Ventilation Paths



Whole House Venting
The type of convective heat removal described above is not just useful in attics and roofs. It is also useful for whole house ventilating under certain conditions. The point of whole house ventilation is to completely change the air inside the living envelope periodically.

Large fans are typically used for whole house ventilation in hot climates. These are installed in the ceiling, and thermostatically controlled to respond to overheating of the living space. This is typical for houses without refrigeration-type air conditioning that encounter seasonal high temperatures. For our purposes, we must try to accomplish the same end goal, but without the fan. (When practical, a whole house system is an excellent application for a solar-powered fan.)

Whether you employ a fan or rely only on convection for whole house ventilation, it is desirable to achieve about twenty air changes per hour, or 0.33 air changes each minute. The volume of the structure can be found by multiplying the floor area by the wall height. For the house in Figure 4, it works out to about 6,850 cubic feet (194 m^3). So the resulting airflow desired is around 2,260 cubic feet (64 m^3) per minute (0.33 x 6,850 = 2,260.5).

Disadvantages of Convection Alone
In Figure 4, the outer wall of the house is around 8 feet (2.4 m) tall, while the roof over the clerestory windows in the center is over 14 feet (4.3 m) tall. The interior of this house has a cathedral ceiling that rises to a high point above the clerestory. Hot air can flow out at this high point to drive whole house venting. Calculating the ventilating airflow under the best of conditions gives about 300 cfm—not very good! Here we are assuming no wind augmentation, just the induced circulation due to hot air rising and exhausting.

The reality is that we are not going to be able to ventilate this dwelling without the help of solar energy. Either we will need it to run an active fan system, or at a minimum to heat up the building so there is differential temperature gain that can be put to work moving air. But the last thing you want to do is introduce hot air just to get rid of the hot air! Convective cooling alone is not possible in this house under these rainy-season conditions. During the dry season, some air exchange is possible using convection.

Buried Cooling Tubes
Another idea that frequently creeps into conversations about passive cooling is the use of earth tubes as air intakes for solar chimney driven ventilation. The principle here is that pipes are buried in the cooler earth to draw air into the structure. The intake air cools down to earth temperature as it is drawn in, cooling the building.

Where a source of forced ventilation is available, such as an electrically driven blower, this can be made to work. Even then, there are potential problems with moisture build-up in the tubes, which can lead to introducing mold and mildew into the structure. Without using a powered blower to force air through the cooling tubes, non-circulation or even reverse circulation (pulling heated air into the structure from a hot source) is a possibility.

It is important to remember that stack-effect ventilation requires that the *average* temperature in the air column be higher than the cooler surrounding air. If the air column is 85°F (29°C) in the dwelling, 100°F (38°C) in the stack 10 feet (3 m) above, and 70°F (21°C) 10 feet below, down inside the cooling tubes, we have an average column temperature of 85°F. Ambient air temperatures outside would have to be lower than 85°F for upward movement of the air column to occur.

Wind Used for Ventilation

Wind is a form of convective air movement driven by the sun. It is a concentrated form of energy. Every time you double wind velocity, you increase wind energy eight times, because wind energy is a cubic function of velocity.

Wind will act on a building, whether we intend it to or not. Contrary winds can and do drive heated air backwards in solar ventilating ducts. They can allow cold air infiltration into a heated building envelope, and they generally do unexpected things in a structure not well thought out to resist wind dynamics.

Where a reliable breeze is available, you can use it to good advantage to drive air exchange through the envelope of a building. A considerable amount of information is available about how wind interacts with the planes and curves of a building structure.

The U.S. Federal Emergency Management Administration (FEMA) has thoroughly explored the dynamics of wind/structure interaction, seeking a better understanding of hurricane damage to buildings. Figure 5 and 6 are taken from FEMA course material, and illustrate the envelope dynamics of a building very well. This information is basic to understanding how the forces developed by wind can be used to foster local area and whole house ventilation.

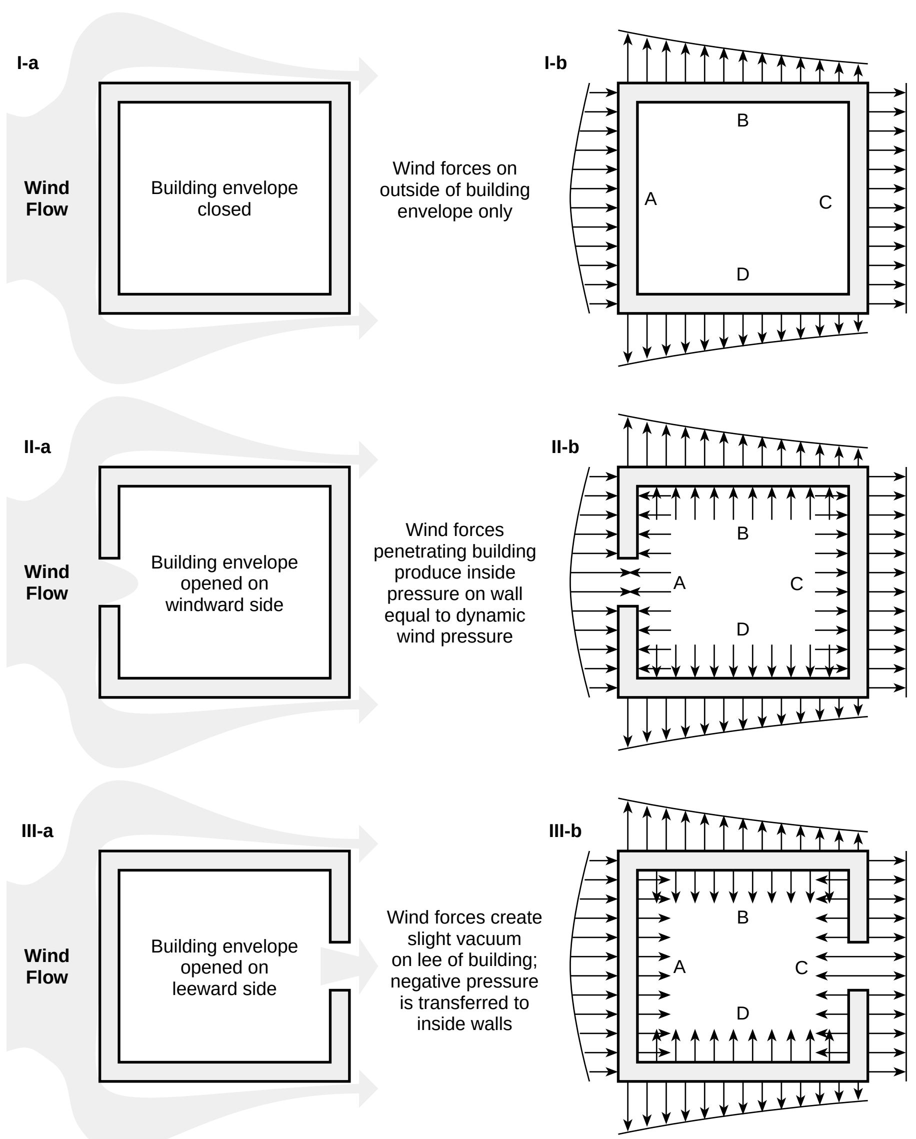
Wind blowing against the walls and roof of a building is forced along the planes of the surfaces. When it reaches the limit of a surface—the corner of the wall or the edge or peak of the roof—it continues to blow in the direction in which it has been flowing. This is a property of the inertia of the mass of the air in the wind current.

As it passes the edge of a building panel, wind does not turn the corner and follow the building planes. Instead, it lifts away from those flat sides, creating an area of lower pressure just past the edge. Technically, it makes a transition from smooth laminar flow along the panel to turbulent flow away from the second panel.

Air Flow Around Walls

Figure 5 illustrates wind flow as if we were looking down from above on the floor plan of a rectangular building. On the left is a pictorial schematic of the path of the wind flow. On the right is a schematic diagram of the vector forces of pressure and vacuum induced by the wind pattern on the left. Arrows pointing inward at the wall represent pressure. Arrows pointing outward,

Figure 5: Wind-Induced Pressure Vectors Under Different Conditions of Building Ventillation



away from the wall, represent vacuum. The curved lines are a rough representation of a graph of the pressure/vacuum forces, showing how they vary in different locations.

Illustrations I-a and I-b in Figure 5 show a building with sealed walls and roof. In this theoretical illustration, there are no paths for pressure to be transmitted into the envelope. Every time a building design creates an impediment to smooth airflow, it will induce a high pressure area. And every time airflow is forced over a hard edge with nothing behind it, a modest vacuum will be created.

Figure 5, illustrations II-a and II-b show a building with a breach in its windward wall. This can be a door, window, or just siding torn off under high wind forces. There are no other openings in the walls, so pressure builds up inside the building until it exactly equals the dynamic force of the wind entering the windward wall. The air is actually compressed somewhat, causing a rise in the static pressure against all of the inside walls.

Once the inside static pressure and the dynamic wind pressure equalize, it is just like a balloon that's been blown up. No more air can blow into the building because it is balanced by the force pushing out by pressure of compression. As II-b illustrates, the pressure inside this building is exactly equal to the highest pressure developed on the windward wall. This is because the wall opening is located in the area of highest pressure.

If the wall opening were moved over to an area with less pressure (near the corner), that lesser pressure would be what is transmitted to the inside of the building. Wall C is subject not only to the force developed by the mild vacuum pulling on the outside, but also to the force of the static pressure inside. These forces add up. In hurricane winds, a building can explode under these forces.

The designer should be sensitive to the areas of wind-induced high and low pressure in a structure. Maximum interior air flow value can be achieved by allowing pressure into a building envelope at points of highest dynamic wind pressure. Conversely, air can be drawn from inside a building most efficiently by strategic placement of exit venting at points where the wind has developed negative pressure. Combining both strategies gives a very effective push/pull effect. It is desirable to have the outflow openings larger than the inflow. A six to one ratio of outflow to inflow area is optimum.

Air Flow Over Roofs

Figure 6 shows buildings in cross section to illustrate the dynamics of airflow over different roofs. The flat roof and the low-pitched gable roof are subject to negative forces trying to lift up on them. Roofs with pitches over 40° do not have sufficiently sharp eaves to cause the flowing air to pull away from the roof as it moves along. Consequently, the windward side of the roof receives a substantial impact from the direct wind. So there are positive pressures on one side of this building, including the roof, and negative pressures on the downwind side.

These are the notes of the tune we want to play. Now we must put the notes together into a melody. If you open a building up to ventilation on the windward side only, you will have no ventilation. The inside and outside pressures cancel each other out, and that's that. This illustrates that you must have both an inlet and an exit for air to flow. Air must flow out of the envelope as fast as it can flow in or there will be pressure build-up that will restrict inflow.

Figure 6: Wind-Induced Pressure Vectors Over Different Roof Configuartions

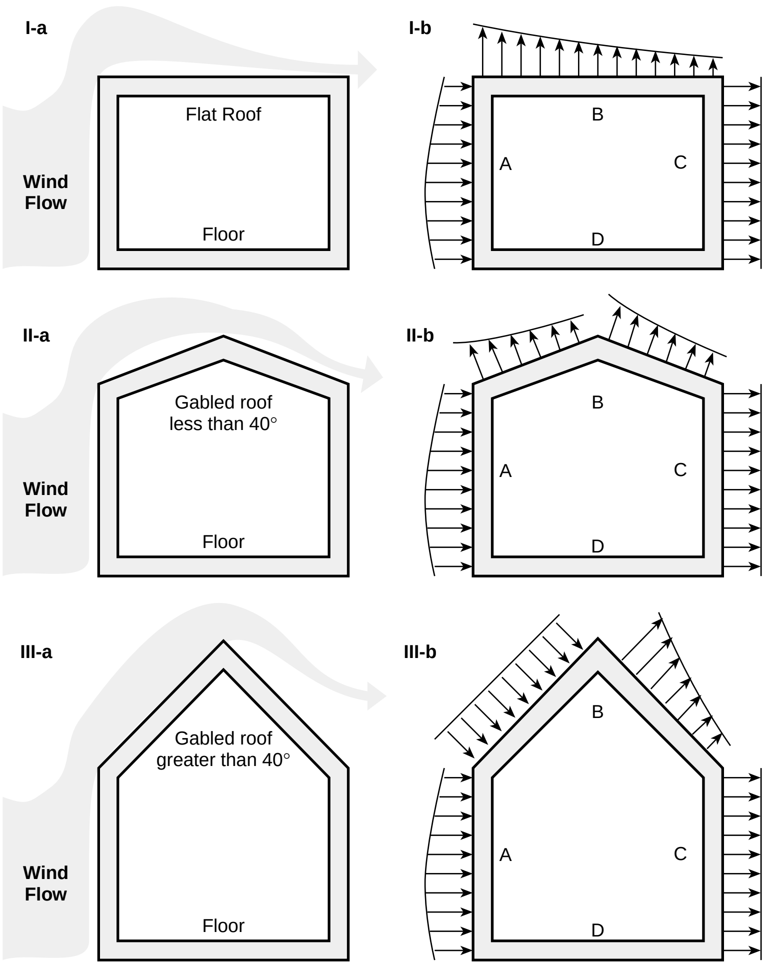
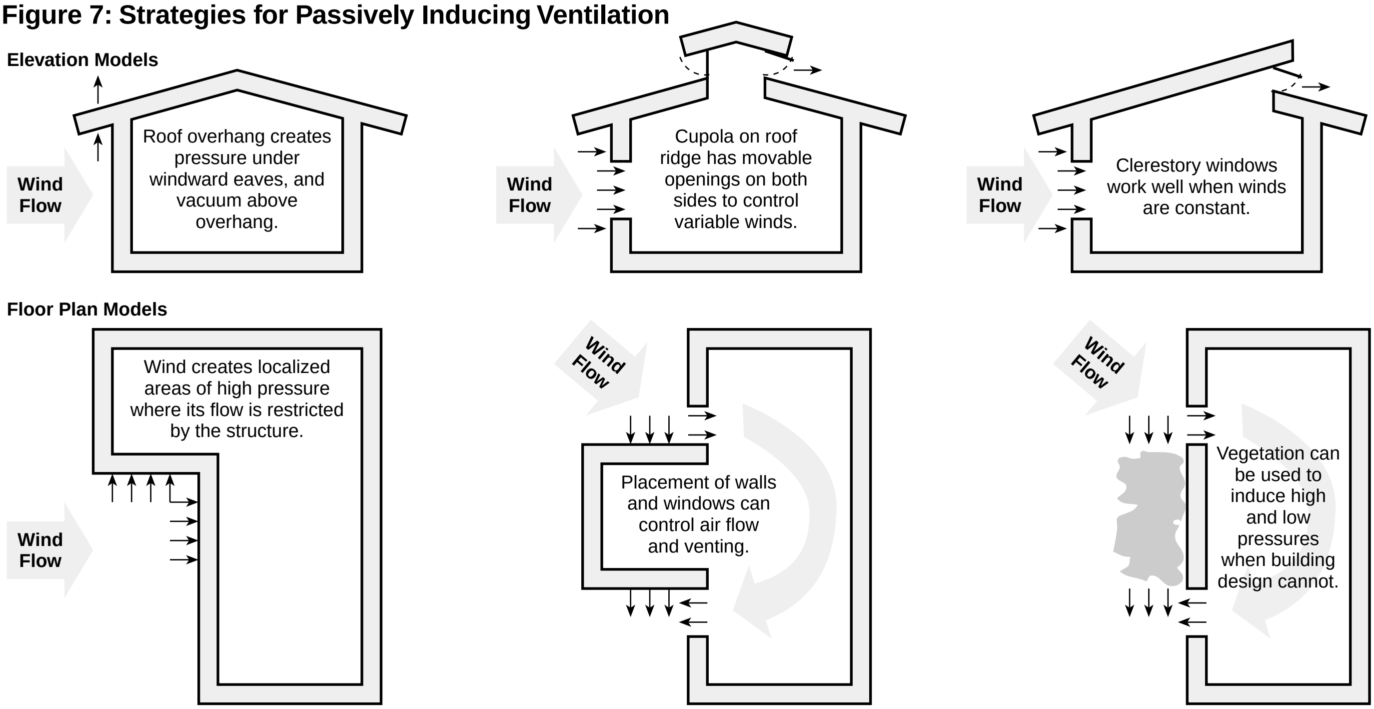


Figure 7: Strategies for Passively Inducing Ventilation



Direct Action on Building

Figure 7 illustrates some specific building treatments that are effective in fostering passive building ventilation. The important concept here is that even under moderate wind loads, there are pressure differentials on the outside walls and roof of the structure. If the designer takes advantage of these, it is possible to induce significant forced ventilation circulation through a structure. Under the right conditions, this ventilation will equal or exceed what you could obtain with an electric fan.

Vent windows placed high on the downwind wall allow negative pressure to extract hot air from inside.

Conclusion

In Passive Cooling Part 1—Basic Principles, I described the three basic mechanisms of heat transfer. I also related the transfer of heat to the sensation of comfort that people seek.

In Passive Cooling Part 2—Applied Construction, I have tried to relate the basic information in Part I to the world of wood, concrete, and glass. Here, to a limited degree, I have shown specific building techniques for thwarting the penetration of heat into a living environment. I've covered the principles and pitfalls of using natural forces to create that comfort envelope we seek in order to keep the effects of excessive heat at bay.

I have also tried to list other, more extensive sources of information on the subject of passive cooling, for the enthusiastic reader. I hope this has been of some help to people trying to live comfortably in the humid tropics. It can be done.

Access

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attara@gci.net

Resources for further study:

Architecture For the Poor, 1973, and *Natural Energy and Vernacular Architecture, Principles and Examples with Reference to Hot Arid Climates,* 1986, by Hassan

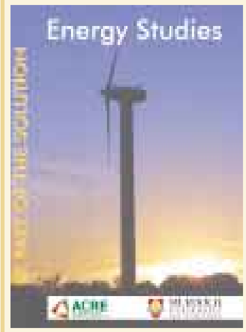
Fathy, both published by The University of Chicago Press, Chicago. These books can be hard to find. I was able to locate them through my regional inter-library loan program.

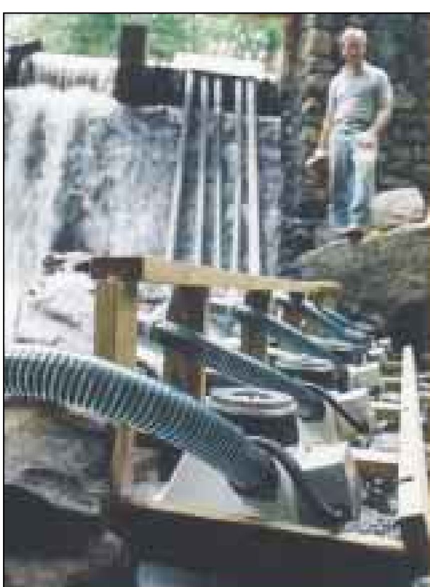
Building for the Caribbean Basin and Latin America; Energy-Efficient Building Strategies for Hot, Humid Climates, Kenneth Sheinkopf, 1989, Solar Energy Research and Education Foundation, 4733 Bethesda Ave., #608, Bethesda, MD 20814 • 301-951-3231 Fax: 301-654-7832 • plowenth@seia.org www.seia.org

Radiant Barriers: A Question and Answer Primer, by Ingrid Melody • Florida Solar Energy Center www.fsec.ucf.edu/Pubs/EnergyNotes/En-15.htm

Low Energy Cooling; A Guide to the Practical Application of Passive Cooling and Cooling Energy Conservation Measures, Donald W. Abrams, Van Nostrand Reinhold Company, New York, 1986 Apparently no longer in print, but check with used bookstores and inter-library loan.

Passive Cooling, 1989, edited by Jeffrey Cook, US$55 from The MIT Press, 5 Cambridge Center, Cambridge, MA 02142 • 800-356-0343 or 617-625-8569 Fax: 6l7-625-6660 • mitpress-orders@mit.edu http://mitpress.mit.edu



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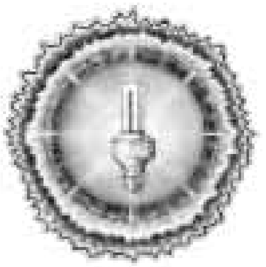

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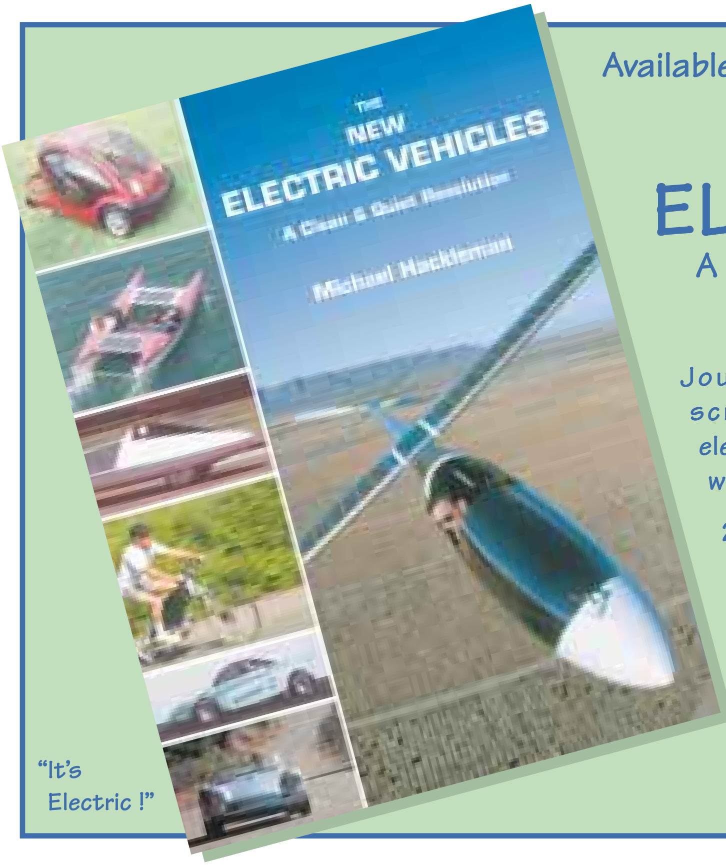


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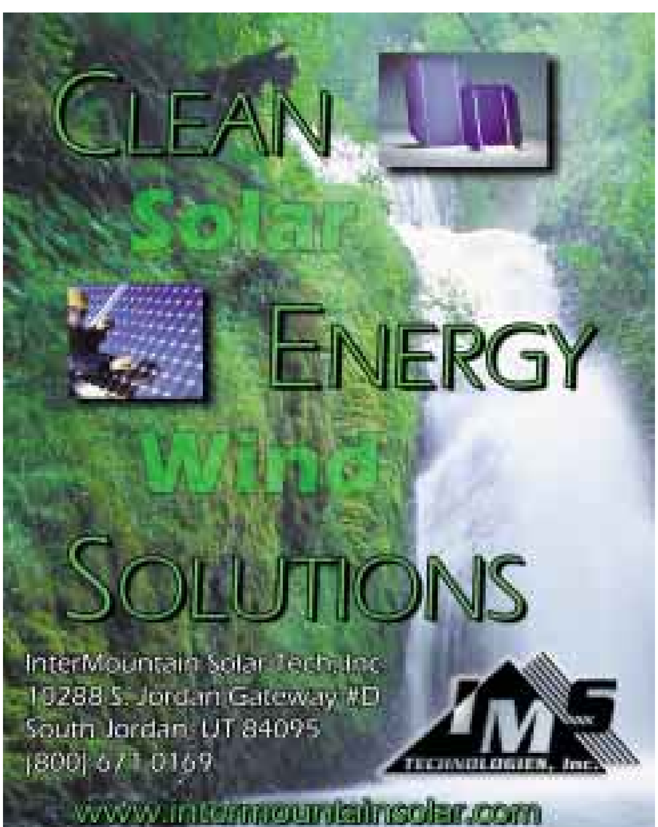
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Electric Tricycle

M. Tariq Iqbal

One variation of Tariq Iqbal's home-built, drill-powered electric trike.

Before I moved to Canada late last year, I lived in Pakistan. When my father developed knee arthritis, I started thinking about building an electric tricycle for him. I had some experience building electric vehicles for fun, but none of my earlier prototypes was suitable for use by an old man on the road.

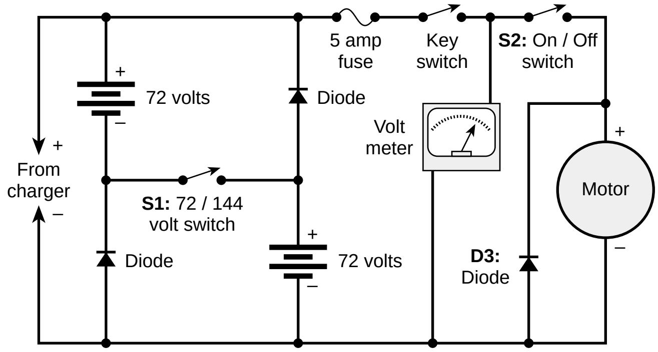
In a survey of the local Pakistani market, I found no locally developed products. A few imported electric wheelchairs were available, but these were very costly and there were many maintenance problems. I decided to make a cheap tricycle for outdoor use, using locally available materials. This tricycle can go up to 20 kilometers per hour (12 mph) for about 20 km (12 miles) per charge.

Building a Body

The first task was to build a frame. I decided to design the frame based on commonly available L-iron. After a few days of careful thinking, I developed a sketch based on 3/4 and 1-1/2 inch (19 and 38 mm) L-iron. My plan was to use 20 inch (51 cm) bicycle wheels, handles, and brakes. Cheap 20 inch diameter bicycle wheels are available everywhere.

A mechanic in a nearby workshop agreed to build the frame for me. He delivered it after two days, in finished painted form, for Rs.1,500 (Rs. 54.5 = US$1 in June, 2000). Plywood was the most available material for bodywork. It is cheap and resistant to battery acid. I got a 4 by 8 foot (1.2 x 2.4 m) by 1/2 inch (13 mm) sheet. The 20 inch bicycle parts were purchased from a local bicycle shop.

Trike Wiring



In my home workshop, I fitted the bicycle parts to the metal frame and screwed plywood pieces into shape. I also bought foam and curtain cloth for the seat and backrest. I enjoyed constructing and painting the trike in my spare weekend time. The tricycle is 140 cm long, 72 cm wide, and about 1 m high (55 x 28 x 39 inches).

Power Unit

Locally made DC motors are not available in this part of the world. But cheap Chinese electric drills are very common. I decided to use a drill to drive my tricycle. My father's neighborhood is flat, and acceleration was not a major consideration. I decided to use a 420 watt, 1/2 inch (13 mm), fixed-speed, aluminum body Chinese drill. It is a geared hand drill, but can be used in continuous duty. It is based on a universal motor that can run on AC or DC.

The drill is fitted to the left rear wheel of the tricycle. I attached a 48 tooth bicycle gear to the tricycle wheel and an 18 tooth bicycle gear to the drill shaft. A 5 mm

The completed frame.

(3/16 inch) thick metal strip acts as a support. This metal strip has two holes. Through one of the holes, I press-fitted the drill. The axle of the wheel goes through the second hole. Common bicycle chain is used to couple these two sprockets.

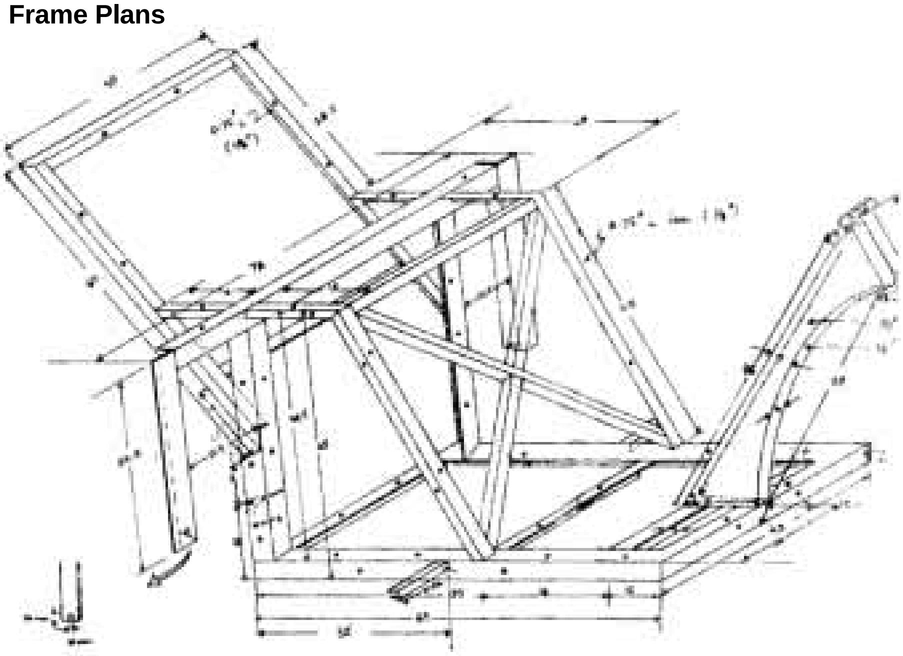
The local workshop did some machining and welding for me. The 48 tooth gear is attached through a standard bicycle freewheel (one way clutch). This allows free forward movement of the tricycle. In other words, if the tricycle is going down a hill, there is no need to run the motor.

At first I designed and built a 700 W, 12 VDC to 220 VAC pulse width modulated inverter to drive the drill in variable-speed mode. I installed it and tested it on the road for few days. It was costly and there were many blown fuses. Once I burnt my expensive set of power MOS transistors on the road and learned a lesson.

Later I decided to switch to a simple DC system. The universal drill motors can run on DC or AC. Torque output with DC supply is higher than AC because of much reduced inductance. I reduced the input voltage to have a reasonable torque. After some testing, I settled on 144 V as my battery voltage.

In a local battery shop, the cheapest option was twelve AGS 12 V, 2.5 AH motorcycle batteries. I decided to test my tricycle with these before buying costly 12 V, 6 AH maintenance-free batteries. To keep my system as simple as possible, I

Frame Plans



An early prototype in progress.

Aizaz Iqbal likes the smaller model.

decided to stick to a two-speed on/off control arrangement. The batteries are installed in a battery box under the seat.

Controls & Metering

A circuit consisting of diodes and switches is shown on page 85. One switch is a key switch, and the other two are on/off switches. These switches are normally used in automobiles and meant for DC operation. When switch S1 is on, the motor is supplied with 144 VDC and the tricycle goes faster (about 20 kph). When switch S1 is off, the two battery banks are connected in parallel to run the motor at 72 VDC, resulting in a slower speed. Diode D3 is a freewheeling diode. All diodes are rated at 600 V, 6 A.

A voltmeter is attached across the motor to indicate battery state-of-charge. I marked the existing scale with red and green areas to clearly indicate battery limits. I marked the lower limit as 11.5 V per battery when the motor is running.

Electric Tricycle Costs

Item	*Cost (Rs.)*
12 AGS batteries, 12 V, 2.5 AH	3,800
Bicycle parts, 20 inch	2,500
Metal frame	1,500
Chinese electric drill, 1/2 inch, 420 W	1,500
Foam and curtain cloth, 15 inches by 4 feet	500
Switches, voltmeter, & wires	500
Plywood, 1/2 inch, 4 by 8 feet	350
Battery charger, homemade	300
Paint and fillings	250
Machining costs	200
Diodes, bulbs, fuses, & neon indicator	100
Total	11,500*

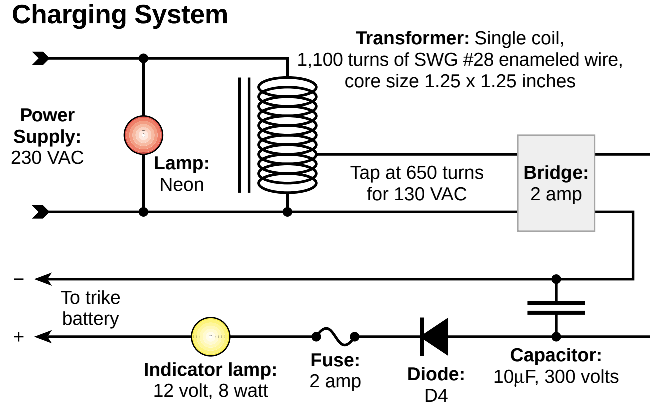
* US$220

Charger

I was not able to find a charger suitable for my use in the local market, so I decided to build one. I purchased iron core winding wire, wound the coil, fitted the core, and tested it. It worked fine. My design is based on a 65 W output. It can easily charge fully discharged 2.5 AH batteries in about six hours. The transformer output voltage is 130 VAC at 500 mA. To limit the charging current, a 12 V, 8 W automobile bulb is used in series.

Circuit diagram and transformer specifications are given in the schematic below. Note that it is a single-coil type transformer. Diode D4, connected in series, is meant to avoid discharge of the batteries through the capacitor. The wiring insulation has to be good.

Charging System



I have been using this design for more than a year without any problems. The charger is installed in the battery box, under the seat of the tricycle. To charge the batteries, switch S1 is switched on along with the charger. This is a manual battery charger, so I have to switch it off after reading a final voltage of 186 V (15.5 x 12) from the meter. This charger does not dry up my batteries, since peak AC input to the rectifier is 187 V.

Performance

I have tested this tricycle on various roads, and it has performed well. It is able to climb 10 degree slopes for a while. Motor temperature remains below 40°C (104°F) after continuous running for more than half an hour. It can go more than 10 km (6 miles) during that time. The motor draws about 1.1 A in slow-speed mode, and about 1.6 A in high-speed mode.

I keep depth of discharge to a minimum, and charge the battery bank as soon as possible. After about a year of use, the batteries are still going strong. I gave this trike to my father. He used it for few months before dying of a heart attack. Now I drive it for fun.

I made two copies of this electric tricycle for handicapped people. I also made a fourth copy using 16 inch (40 cm) diameter wheels. It is bit smaller, but the power pack is similar. My son is very fond of the smaller version shown in the photo on page 86. Total cost of this electric tricycle was about US$220 in 1999. This very cheap electric tricycle is good for fun, and is very useful for handicapped or older people.

Access

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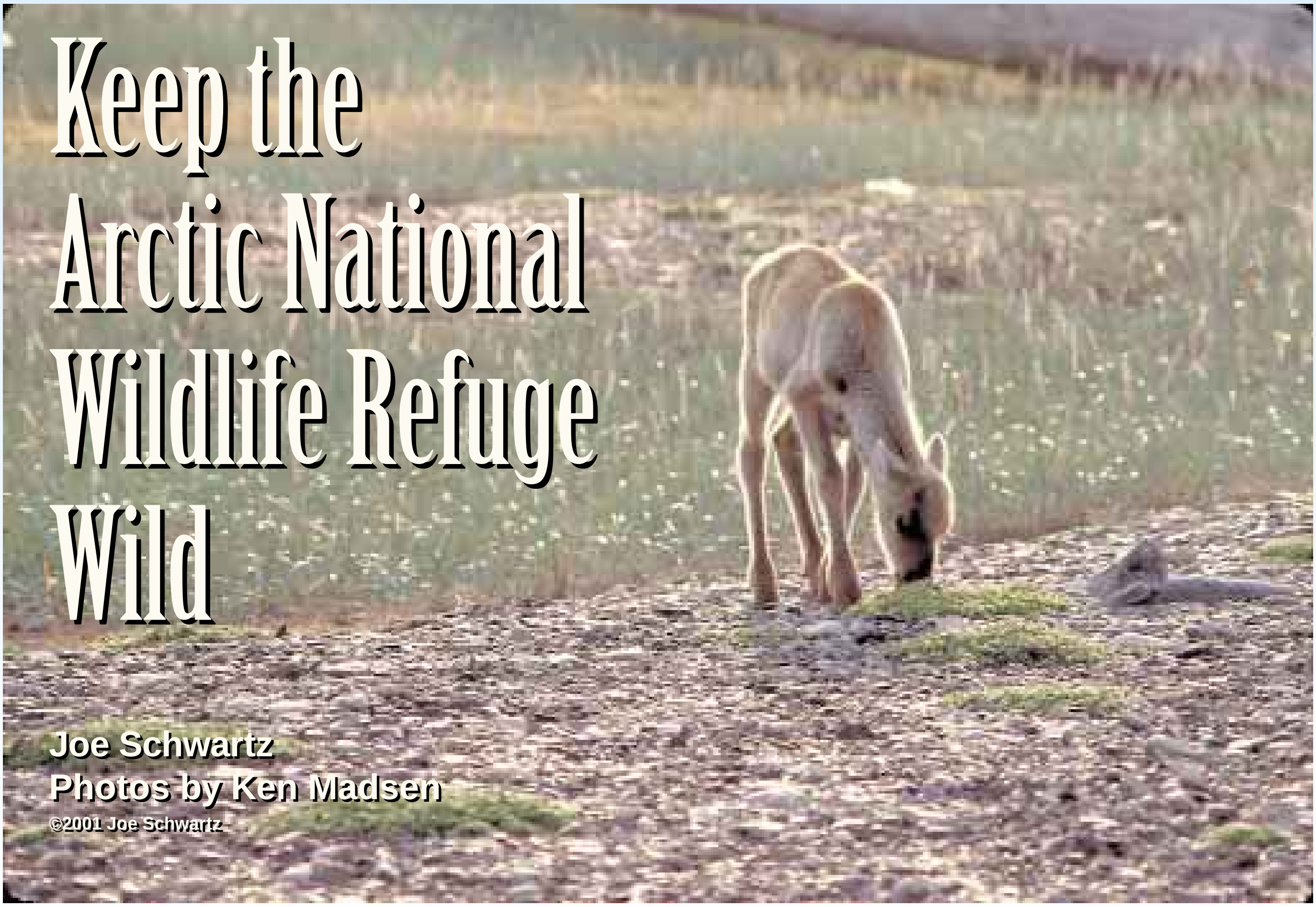
Keep the Arctic National Wildlife Refuge Wild

Joe Schwartz
Photos by Ken Madsen



A baby caribou sniffs out a meal in Area 1002, the final 4 percent of undeveloped coastline of Alaska's North Slope. This area is threatened by the U.S. government, its corporate backers, and the citizenry's lust for oil.

The current U.S. administration and its corporate sponsors put their heads together and have come up with a way to ensure the security of our nation's domestic oil supply—drilling for oil in the Arctic National Wildlife Refuge (ANWR). According to U.S. Geological Survey (USGS) estimates, there's a 50 percent chance of finding a nine-month (domestic) supply of oil inside the refuge boundaries. The two big questions are: How much "security" do they think we'll get from a nine-month supply of oil? And is the American public willing to destroy the last four percent of Alaska's undeveloped northern coastline for this "security"?

For generations, Americans have demonstrated their insatiable demand for natural resources. As a result, the ecology of the North American continent has been radically altered. People in the renewable energy community are taking steps to ease human impact on the planet. But as a whole, Americans' voracious appetite for resources has devastated the ecological systems that ultimately support us.

The American people and our tax dollars, corporations, and politicians are totally responsible for these changes. The indigenous people of the North American continent were victims of genocide as European settlers repopulated their lands. Native animal populations including bison, wolves, grizzly bears, and other species have been all but eradicated from the lower 48 U.S. states. Only the smallest fragments of old growth forest ecosystems remain. Virtually all of the continent's major rivers have been dammed, destroying salmon runs that once seemed inexhaustible.

Americans' irresponsible use of domestic and international oil reserves has now brought us face to face with the destruction of the last great expanse of undeveloped North American wilderness—The Arctic National Wildlife Refuge.

The Arctic National Wildlife Refuge

The 19 million acre Arctic National Wildlife Refuge is located above the Arctic Circle and to the east of Alaska's Prudhoe Bay. The refuge encompasses the eastern end of the Brooks Range, and stretches northward to the Arctic Ocean's Beaufort Sea. It is one of the wildest places left on earth. The U.S. Fish and Wildlife Service describes the refuge as "America's finest example of an intact, naturally functioning community of arctic/subarctic ecosystems."

The Arctic National Wildlife Range was established in 1960 by the Eisenhower administration to preserve this undeveloped arctic ecosystem in perpetuity. Under the Alaska National Interest Lands Conservation Act of 1980 (ANILCA-1980), the Carter administration more than doubled the size of the refuge. The majority of it was designated as wilderness, and it was renamed the Arctic National Wildlife Refuge.

This wilderness designation allows for no development within the majority of the refuge. The area of the refuge that remains unprotected by the 1980 legislation is the refuge's 1.5 million acre coastal plain, known as Area 1002. Why was Area 1002 exempted? Because that's where the oil is.

The coastal plain has been in a precarious state ever since the Arctic National Wildlife Refuge was created. It represents the last 4 percent of undeveloped coastline on Alaska's North Slope. For decades, it has been considered an ecological jewel by scientists and wilderness advocates. And it has been lustily eyed as a cash cow by both international and domestic oil interests. The Bush administration is definitely interested in this piece of real estate, but not in its inherent value as the largest remaining U.S. arctic ecosystem.

The Coastal Plain—
To Drill or Not to Drill

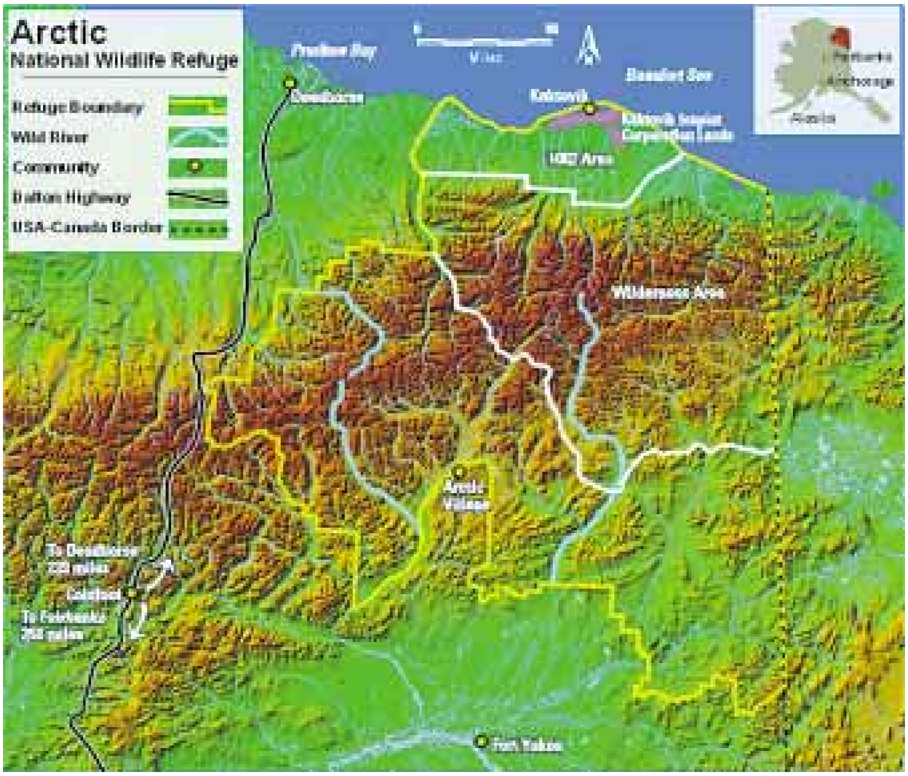
The coastal plain is considered to be the ecological heart of the entire Arctic National Wildlife Refuge. The species that inhabit this region include caribou, polar and grizzly bears, wolves, wolverines, musk oxen, and more than 130 species of migratory birds.

The coastal plain is the post-calving ground for the Porcupine caribou herd, which numbers 130,000. Each year, up to 40,000 caribou cows feed on the brief bloom of summer grasses, and nurse their calves on the coastal plain. It is also the onshore denning area for 42 percent of the Beaufort Sea polar bear population.

The width of coastal plain varies from 20 to 40 miles (32–64 km), backing up against the snow-capped peaks of the Brooks Range. As a result, an amazing array of wildlife is concentrated into this very small and fragile area. Because of this biological concentration, development on the coastal plain would be nothing short of an ecological disaster.

The U.S. Geological Survey (USGS) concluded that the oil reserves located within the Coastal Plain are "small, scattered, and in a complex geological formation." The U.S. Fish and Wildlife Service (USFWS) believes that "development in the 1002 area could likely require a large number of small production sites spread across the refuge landscape, connected by an infrastructure of roads, pipelines, power plants, processing facilities, loading docks, dormitories, airstrips, gravel pits, utility lines, and landfills." And pro-drilling interests still assert that oil development on the coastal plain will have no impact on wildlife. This assertion is ridiculous.

A 1987 legislative environmental impact statement (LEIS) concluded that oil development on the refuge's coastal plain would "have a major effect on caribou and musk oxen populations." On November 1, 2000, two hundred and forty North American scientists and natural resource managers sent a letter to President Clinton.



Map courtesy of U.S. fish and Wildlife Service

The Gwich'in, the region's indigenous inhabitants, unanimously oppose drilling.

This group included prominent U.S. and Canadian ecologists and wildlife biologists. The letter stated, "Based on our collective experience and understanding of the cumulative effects of oil and gas development on Alaska's North Slope, we do not believe these impacts have been adequately considered for the Arctic Refuge…"

The Vintut Gwich'in First Nations— Cultural Genocide

For thousands of years, the Gwich'in Indians have inhabited the region just outside of what is now the Arctic National Wildlife Refuge, in Canada's Yukon and Northwest Territories. The Gwich'in are Athabascan Indians, and one of the most traditional indigenous cultures still in existence.

Their villages were originally established along the migratory routes of the Porcupine Caribou herd, which they still rely on for a major portion of their food supply. The Gwich'in currently number 7,000. They live in fifteen villages that even today are located along the caribou's migratory route.

In a recent U.S. public speaking tour, Sandra Newman, a spokesperson for the Gwich'in Indians, stated that the Gwich'in people unanimously oppose plans to drill on the coastal plain. They fear the inevitable impact that such large-scale development will have on the caribou population, and in turn, their culture. Across the border, the Canadian government has moved to protect the Porcupine caribou herd's calving and post-calving grounds within Ivvavik and Vuntut National Parks, which are adjacent to the Arctic National Wildlife Refuge.

Unfortunately, the current U.S. administration has no such good intentions. The predicament that the Gwich'in are facing is frightfully similar to the plight of the American Plains Indians as the bison herds were destroyed by European settlers. It's unfathomable to think that it may happen again, two hundred years later, for the same ignorant, short-sighted, resource-based reasons.

British Petroleum (BP) is the dominant international oil interest pushing to drill within the boundaries of the Arctic National Wildlife Refuge. BP claims to be sensitive to traditional cultures affected by their development of oil reserves. But for the last month, the page on their Web site titled "Some Human Rights Issues Facing BP" has been curiously blank…

The Facts That Matter

Should the Arctic National Wildlife Refuge be exploited for international oil company corporate profits, or left to its own peaceful evolutionary devices? Take a look at the facts.

- Assuming there is no increase in consumption, the U.S. Geological Survey (USGS) estimates that there is a 50 percent chance of finding a nine month (domestic) supply of oil on the coastal plain of the Arctic National Wildlife Refuge.
- If the U.S. government votes in favor of oil production in the Arctic National Wildlife Refuge, it will take seven to ten years to develop the infrastructure that will make this oil available to consumers in the U.S.

Prudoe Bay, just west of ANWR, displays the classic signs of humans with oil as their priority.

Think—Act

You're reading *Home Power.* So chances are that you value the environment, the sensible use of the planet's dwindling resources, and an end to our fossil fuel based energy economy. But how often do we take an active role in the determination of how these resources are used, and when they shouldn't be used at all?

Well, here's our chance. And without our efforts, we are taking a big chance. The survival of the Arctic National Wildlife Refuge ecosystem will be determined by our combined efforts. So here's what we can do.

First, work within the political system. Write and mail letters voicing your opposition to oil development in the Arctic National Wildlife Refuge. Ask your senators and representatives to support The Arctic National Wildlife Refuge Wilderness Act (S411/HR770). Ask them to oppose The National Energy Security Act of 2001 (S388). Hand signed letters carry the most weight. Email is generally discarded without review.

Motivate your friends and neighbors to write letters as well. My partner and I recently invited some friends over for a letter-writing party that produced thirty letters condemning drilling for oil in the Arctic National Wildlife Refuge. We all took turns at the computer, and had a great dinner to boot.

Unfortunately, the current oil-soaked U.S. administration will ultimately decide if the Arctic National Wildlife Refuge ecosystem is destroyed for corporate profits. How many letters will it take to counteract the oil industry's monetary contributions to our elected officials' political campaigns? That's anybody's guess. So let's play it safe, and bury them in letters. Address your letters to:

President George W. Bush
The White House, 1600 Pennsylvania Ave. NW
Washington, DC 20500

U.S. Environmental Protection Agency
Ariel Rios Building, 1200 Pennsylvania Ave. NW
Washington, DC 20460

U.S. Department of the Interior
1849 C St. NW, Washington, DC 20240

U.S. Department of Energy
1000 Independence Ave. SW, Washington, DC 20585

Your Senators and Representatives: If you don't know their postal addresses, you can find them by using at: http://office.capwiz.com/congressorg2/dbq/officials

British Petroleum, Britannic House, 1 Finsbury Circus, London EC2M7BA England • www.bp.com

Disgusted with the politicians and their politricks? "They're all bought out by the corporations anyway. Write a letter? What's the point." Many people share your views.

But don't feel powerless about the future of the ANWR. Get active and work outside the political system. Organize local educational gatherings. Perform guerrilla street theatre that entertains and educates. Plaster your local utility poles and message boards with fact sheets. Express your desire to keep the Arctic National Wildlife Refuge wild.

- Americans currently consume 7 billion barrels of oil a year. Two-thirds of this is used in transportation. A 6 percent increase in auto and light truck fuel efficiency standards would, in just three years, equal the amount of estimated oil available in the Arctic National Wildlife Refuge.
- 96 percent of Alaska's North Slope is already open to oil and gas exploration and development. The coastal plain within the Arctic National Wildlife Refuge represents the last 4 percent of Alaska's undeveloped northern coastline.
- Various public opinion polls show that 60 to 70 percent of Americans want the coastal plain of the Arctic National Wildlife Refuge to be designated as wilderness, making it off-limits to oil development.
- Oil-fired turbines produce 1 percent of California's electricity. Drilling for oil in the Arctic National Wildlife Refuge will not ease the state's self-inflicted energy crisis.
- Alaskans are closely divided on whether to develop oil production in the Arctic National Wildlife Refuge. A statewide public opinion poll conducted in July, 2000 showed 49 percent of Alaskans for oil development within the Arctic National Wildlife Refuge's boundaries, 45 percent against development within the refuge, and 6 percent undecided.
- The state of Alaska has a "permanent fund" created by oil company royalties and oil development taxes. Every Alaskan man, woman, and child receives annual dividends from this fund. The year 2000

The Porcupine caribou herd numbers 130,000 and relies on this narrow strip of tundra between the mountain range and sea to feed while calves are nursing.

dividend checks amounted to US$1,963.86 for each state citizen.

- Oil and gas development in the Arctic National Wildlife Refuge will not necessarily lower U.S. gas and home heating oil prices. In 1978, when oil from Prudhoe Bay was added to the domestic supply, U.S. oil prices rose by 15 percent. The presence or absence of an individual oil field does not determine domestic oil prices. Oil and gas prices are determined by global supply and demand factors.
- There is no guarantee that oil produced within the Arctic National Wildlife Refuge will be used domestically, and not be exported for corporate profit.

Guilty Parties

The oil slick of an administration that has settled over Washington, DC made their intentions to drill in the Arctic National Wildlife Refuge clear early on. Then presidential candidate George W. Bush strongly supported opening the refuge to international oil developers. And while Bush was making jokes about (and mispronouncing) "photovoltaics" during his campaign stump speeches, individuals and political action committees (PACs) from the oil and gas industries were pouring just shy of US$2 million into his presidential campaign fund.

Republican Senator Frank Murkowski and nine co-sponsors recently authored The National Energy Security Act of 2001 (S388). The passage of this legislation would open the Arctic National Wildlife Refuge and other public lands to oil development. Want to take a guess at how much the oil and gas industries contributed to Murkowski's and the bill's co-sponsors' campaigns during the 1995–2000 election cycle? US$1.3 million. But the big question is, how much "security" will less than a year's worth of petroleum provide?

BP—Beyond Petroleum or Big Profits?

British Petroleum, ExxonMobil, Chevron, and Phillips Petroleum are all engaged in Arctic oil development. BP is by far the most influential player, and is responsible for 51 percent of the petroleum coming out of Arctic oil fields. Via campaign funding, they are working hard to influence the U.S. government to open the Arctic National Wildlife Refuge to oil production. On their Web site, British Petroleum states, "The track record of our North Slope operations demonstrates our ability to operate in sensitive environments in a responsible and sustainable manner, protecting this [the refuge's coastal plain] important habitat and the wildlife that it supports."

This is the same British Petroleum that in February of 2000 was fined US$22 million for illegally dumping hazardous wastes, including benzene and other toxic chemicals, down well shafts at their Alaskan Endicott oil fields. This, incidentally, is one of the "technologically improved" petroleum facilities we've all been hearing about. BP Exploration (Alaska) is currently serving a five-year probation for this violation of the Oil Pollution Act of 1990.

More and more American consumers are opting to spend their hard-earned dollars with "green" companies—companies with strong environmental records. Regardless of their environmental history, many companies are attempting to alter their corporate image to profit from this growing group of consumers. This tactic is often referred to as "greenwashing."

British Petroleum is currently executing a massive public relations campaign in an attempt to create a more environmentally friendly image. They've even gone so far as to state that BP is now an acronym for "beyond petroleum."

BP Solar, a division of British Petroleum, has been making great strides, and is well respected within the renewable energy community. And there's no doubt that British Petroleum has determined that photovoltaics will be an important energy source in the decades ahead. But for British Petroleum to attempt to change their entire corporate image based on their solar division, which generates less than 1 percent of their total annual profits, is ludicrous. It is a textbook case of greenwashing.

In a 1998 presentation to the Royal Institute of International Affairs in London, BP's group chief executive John Brown stated, "Our environmental commitment is not, in short, a gleam in my eye. It is not a matter of public relations. It is our day-to-day business reality." If this is the case, why is BP even contemplating oil development within the boundaries of the Arctic National Wildlife Refuge?

If BP is truly looking "beyond petroleum," voluntarily terminating their plans to drill in the Arctic National Wildlife Refuge would be the obvious place to start. In the words of Edward Abbey, "Sentiment without action is the ruin of the soul."

Access

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www.opensecrets.org

Caribou Commons Project, Coordinator: Ken Madsen, 21 Klondike Rd., Whitehorse, Yukon, Y1A 3l8 Canada
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The Wilderness Society, 1615 M St. NW, Washington, DC 30036 • 800-843-9453 • www.wilderness.org

U.S. Fish and Wildlife Service • Contact@fws.gov
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A Horse of a Different Color

Shari Prange

The Toyota Prius hybrid automobile integrates electric vehicle efficiency with gasoline engine convenience.

“Prius” comes from Latin, and means “to go before.” Indeed, the Toyota Prius is leading the new wave of gas-electric hybrid vehicles. The auto manufacturers have convinced themselves and much of the media that pure electric vehicles simply aren’t practical and affordable. (This is despite the fact that a high school student can build one in the garage—and many have! But don’t get me started on that…)

So, with mass-produced electric passenger cars almost a dead issue for the moment, manufacturers are turning their attention to the more attractive hybrids. These have the cachet of an electric motor, while still being refueled by “good” old gasoline. Last time, we talked about exactly what a hybrid is, and we looked at the Honda Insight. This time we’ll examine the Toyota Prius. Both are hybrids, but they are clearly different breeds.

Basic Numbers

The Prius was the first hybrid passenger car in commercial production. Although the Honda Insight hybrid was released in the U.S. just slightly before the Prius in the summer of 2000, the Prius already had an established sales record. In Japan alone, more than 40,000 have been sold since its introduction there in 1997.

The Prius is a five-seat four-door sedan, with cargo space in the trunk. Unlike the two-seat Insight, this makes it a practical vehicle for couples and small families. This is the first evidence of the diverging philosophies behind the two cars—they are designed for different market segments.

The curb weight of the Prius is 2,765 pounds (1,254 kg), which is close to the weight of a typical compact conversion. This is almost 1,000 pounds (454 kg) more than the Insight. However, the Prius uses a conventional frame rather than the more expensive but lighter aluminum frame of the Insight.

The manufacturer’s suggested retail price (MSRP) for the Prius starts at US$20,450. This is about US$1,500 more than the MSRP for the Insight. But both manufacturers have kept the prices artificially low, and they do not reflect the actual cost of manufacturing plus a conventional markup. These cars are considered market and technology experiments, with any real profits to come at some point in the future.

The point of the entire exercise is fuel economy. So how does the Prius stack up? Its EPA estimated mileage is 52 mpg (22 km/l) for city driving and 45 mpg (19 km/l) for highway driving. No, that's not a typo—both the Prius and the Insight get better mileage in city driving because they rely more heavily on their battery systems in that situation. This mileage is lower than the 68 and 61 mpg (29 and 26 km/l) respectively for the Insight. However, this does not mean that the Prius is less efficient. It's not really fair to compare a five-seat car straight across with a two-seat car that weighs two-thirds as much.

Anatomy

The Prius is both a series hybrid and a parallel hybrid, in a pretty complex and sophisticated combination. We talked about these two terms in some detail last time. Briefly, it means that the Prius has both a gasoline engine and an electric motor, and that the engine functions to charge the batteries and provide power to the motor, as well as driving the wheels directly. Let's identify the main components first, and then look at how they all fit together.

The internal combustion engine (ICE) portion of the system uses a four-cylinder 70 hp gas engine. This is similar in power to the Insight engine, which has only three cylinders. The Prius is rated for emissions as an SULEV, or super ultra low emissions vehicle, the same rating given to the Insight with the CVT option. This means that it runs 75 percent cleaner than the standard for ultra low emissions vehicles (ULEV). The Insight with a standard transmission is rated as a ULEV.

The electric portion of the system features a 33 KW permanent magnet motor. This is three times as powerful as the Insight motor. It takes its power from a pack of 228 nickel metal hydride (NiMH) battery cells of 1.2 V each, for a system total of 273.6 V. This is almost twice the size of the battery pack in the Insight.

The pack weighs only 110 pounds (50 kg). It is completely sealed, and located behind the rear seat. It can be this small because it is not expected to carry the car very long on its own. The car runs only intermittently on pure electric power, and then the batteries are quickly charged up again by the gas engine. For this reason, a very small, low-capacity battery pack can be used.

The larger motor and battery pack in the Prius demonstrate the biggest difference in its design philosophy versus that of the Insight. The Insight is a gas car with an electric assist. The electric motor and battery pack are not powerful enough to drive the car on their own. They are only there to provide a boost to the gas motor at appropriate times and increase the gas mileage. The gas engine shuts off when the car is coasting or stopped, but the Insight never moves under pure electric power.

In the Prius, the electric drive system is more nearly an equal partner. It can drive the car with no assistance from the gas engine, and it does so at the times that prove most beneficial for overall efficiency.

Another way to look at it is this: the Insight defaults to the gas engine, and brings the electric motor online as needed; the Prius defaults to the electric motor, and brings the gas engine online as needed.

A similar new gas car would be a low emissions vehicle (LEV). A SULEV is 90 percent cleaner than an LEV. Pre-1970 cars are considered high emissions vehicles, but they're not called HEVs because that stands for hybrid electric vehicle. (You *are* keeping track of all these alphabetic acronyms, aren't you? There'll be a quiz later.)

The Prius achieves its level of clean emissions in part through Toyota's "Variable Valve Timing with Intelligence" (VVT-i). This system keeps the gas engine operating in its most efficient mode, which improves fuel economy and emissions.

The Prius draws on battery power first, then on the gasoline engine as needed.

Either the gas engine or the electric motor—or both—can drive the wheels of the Prius. The engine or motor drives through an electronically controlled continuously variable transmission (ECVT). From the driver's perspective, this is like driving an automatic transmission car, except that the transition between gears is seamless. Another curious feature of this system is that the car has no reverse "gear." Instead, when you want to back up, the electric motor spins in the opposite direction.

The hybrid portion of the system includes the generator and the "Advanced Control System" (ACS). The generator is powered by the gas engine, and produces electricity, which can be used to drive the electric motor or to charge the batteries. The generator also serves as the starter for the gas engine.

The batteries are recharged by regenerative braking as well, which converts the car's energy of momentum during coasting or braking into electrical energy.

ACS Holds the Reins

The real genius of the Prius is the way all of these components work together. Toyota's overriding design philosophy in the Prius was to continually monitor and adjust systems automatically to keep them performing at their optimum efficiency. This is evident in the VVT-i of the gas engine and in the ECVT. The philosophy achieves its pinnacle in the ACS.

Let's back up a moment and look at the overall picture. The Prius has a gas engine, which can drive the wheels, drive the generator, or both. The generator can provide electricity to the motor, to the batteries, or both. The electric motor can also drive the wheels of the car, and regenerative braking can be used to recharge the batteries. How does the Prius get all these functions in step and pulling together as a team?

Each component has strong and weak areas. For example, gas engines are very dirty and inefficient at low speed stop-and-go driving, which is what most cars do most of the time. Electric motors have an rpm band where they are most efficient. Batteries have an optimum charge/discharge profile for the longest life.

The ACS knows the optimum conditions for each part of the overall system. It constantly monitors engine speed, throttle position, brake pedal position, battery state of charge, and extra loads such as air conditioning, or a steep grade.

It then chooses the optimum combination for the situation. This could be running on the batteries and electric motor only, with the gas engine shut off, or it could be both the motor and the engine running. If the engine is running, it might be driving the wheels, or charging the batteries, or some combination of both activities at once. The ACS also knows when to turn on the regenerative braking system to charge the batteries. And when the car is standing still, the gas engine is turned off, unless it is needed to charge the batteries.

In a pure electric car, the batteries must be able to withstand deep discharges. In the "Toyota Hybrid System" (THS), the batteries are never very deeply discharged, which means that their lifespan is greatly extended. In fact, the battery pack is guaranteed for eight years or 100,000 miles (160,000 km), and is not intended to need changing during the life of the car.

It's a good thing, too, as NiMH batteries are not cheap. Due to the lengthy warranty, there is no established retail price for the battery pack. If there were, according to Toyota, it would be "under US$5,000." For comparison, this is four times the cost of the typical lead-acid pack in a pure electric conversion. Although the lead-acid pack would only last half as long as the NiMH pack, it would see much more demanding use during that time.

And by the way, the batteries in the Prius never ever get plugged in to the wall for recharging. There is no plug. They get all of their charge from the engine and regenerative braking.

In the Saddle

How does it feel to drive a Prius? Pretty much like a "normal" car. It has plenty of power and pep, and nice handling. All the mode changes talked about above happen continuously and seamlessly while you drive. The gas engine turns on and off by itself. You don't have to make any choices. The car starts from a stop silently on pure electric power. At somewhere between 13 and 25 mph (20–40 kph), the gas engine turns on.

Perhaps the most disorienting part is the electronically controlled continuously variable transmission (ECVT). It has a shift lever on the dash with an almost normal "PRNDB" display. The first four letters are familiar, but what's the "B" instead of "L"? This is a setting for increasing the amount of regenerative braking on long or steep downhills.

As you drive, you may subconsciously expect to feel the car shift gears—but you won't. It just accelerates smoothly from standstill to freeway, with no loss of power.

The dash is very different from a conventional car. The digital speedometer and bar graph gas gauge are centered where the windshield meets the dash, which feels strange at first. Further back, also in the center of the dash, is a small color LCD touch display screen. This shows the battery state of charge (which is always full unless you are climbing a mountain). It also displays a real time graphic of your power use, showing whether the motor or engine is driving the wheels, or charging the batteries, or if regenerative braking is in effect.

This is very informative. In low speed stop-and-go driving, the car will stay in pure electric mode. Once you get out of the school zone speed limit, the gas engine turns on. If you let off the throttle to coast, the engine shuts down after a few seconds, but as soon as you touch the throttle again, it kicks back on. If you are cruising, the engine is running. Even though the Prius gives the electric system much more responsibility than the Insight does, it still uses the gas engine to some extent most of the time.

Pros…

The advantages of the Prius over a conventional gas car are pretty obvious. It's cleaner, with better gas mileage, and is just as easy and convenient to use. But how does it compare to a pure electric from the manufacturers, such as the late, lamented EV Plus or EV1? In that comparison, it has the advantage of quick refueling as opposed to several hours of recharging, and fuel availability anywhere, while the special EV charging stations needed are much less common. And, of course, you can actually go down to your dealer and buy one.

What about pure electric conversions? The Prius will of course have the advantages of any new mass-market car, which include full passenger amenities, dealer support, and a manufacturer's warranty. The conversion has the same lengthy recharge time as a manufactured electric, but most conversions charge from common household outlets and don't need the special charging stations.

Vicki and John Pearse, of Santa Cruz, California, have had a pure electric Rabbit conversion in the family for about five years. Last fall, they bought a Prius. They have taken the Prius on a trip to southern California, and are contemplating a trip to Colorado, both of which would be impossible with the Rabbit.

However, the Rabbit still has an honored and busy place in their lives. Vicki says, "The Prius is not as quiet as the Rabbit, and not as conspicuously an electric car. Also, you still have to put gas in it, which isn't as convenient as plugging in the Rabbit every night at home."

…And Cons

A minor issue is service. The Prius requires service at 7,500 mile (12,000 km) intervals. This was once quite common, but is less usual for new cars, and not needed for a pure electric. This service is included in the purchase price for the first three years, so the only real hassle is remembering to do it.

Another issue is the flip side of not having to make any choices, which was mentioned above. This also means you don't *get* to make any choices. Some people would like to have a pure electric car most of the time, and only turn on the ICE system when they need to make a longer trip. That is not an option with the Prius. You *will* be using gas, even for short trips in town.

Also, although the electric motor is strong enough to drive the car by itself, it is not really an independent drive system, since its batteries get their energy from the gas engine. If you run out of gas, do not attempt to drive home on the electric system alone. Toyota warns that this could damage the batteries.

This leads to the larger philosophical issue of whether this is truly an electric car. It has an electric motor powered by batteries. However, the batteries receive all of their charging (except the small amount from regenerative braking) from burning gasoline. From the perspective of infrastructure, this is a good thing. We already have a well-developed system of gasoline distribution, so there is no need for expensive new fueling or charging facilities.

From an environmental perspective, it's not so good. Gasoline is not the cleanest source of energy. You do not have the choice of charging from electricity derived from solar, wind, hydro, or other clean sources. In the end, it is still a gas-powered car, albeit a very efficient and clean one. It does little to wean us from petroleum dependency.

The Finish Line

As with the Insight, whether the car is a "winner" depends on what you are comparing it to. First, you must determine what you need from a car in terms of passenger and cargo capacity, range, performance, refueling time, costs, convenience, and whatever other issues are important to you. Then you need to find out which vehicles can meet your needs satisfactorily.

If a pure electric conversion would do what you need to do and fit your budget and habits, then it would certainly be the more environmentally friendly choice. But for some people, this isn't an option, due to high mileage driving, demanding terrain or climate, or other reasons. This is often the case for people living off-grid and far from the madding crowd. If the choice is between a hybrid and a conventional gas car, then the hybrid is the cleaner greener machine.

But you may not need to choose at all. Many households have more than one car, like the Pearses. John and Vicki plan to sell their remaining gas car, leaving them with the pure electric conversion for local driving, and the Prius for more demanding trips.

The Prius is a stunning example of the complex but beautifully integrated technology that is possible when a manufacturer concentrates its resources and will on a goal. Imagine what we could have if one of them actually *wanted* to build a pure electric car for the people.

Access

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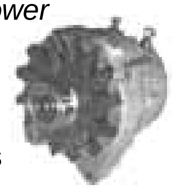
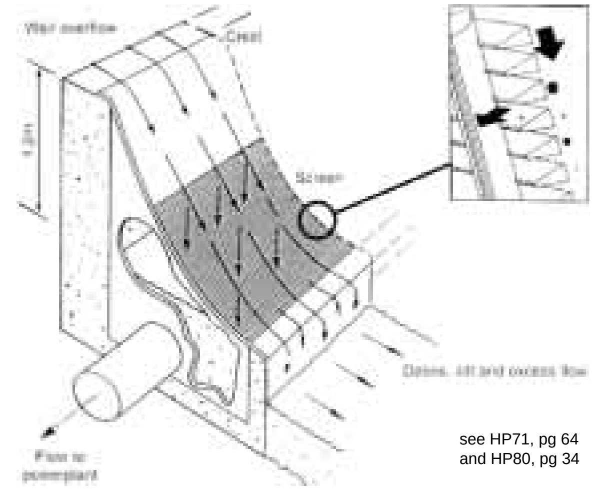
For more information on the Prius, see http://prius.toyota.com or your local Toyota dealer.





When You Need a Helping Hand

Mike Brown

"I am starting an electric vehicle (EV) conversion, and I know I am going to need help with some parts of the project. Where do I find the people and shops that I need?"

This question comes to me often. I think it is because I am always writing things like, "Take your drawings to the welder," "Go to the sheetmetal shop," or "Go to the parts house and look at their motor mount catalog." It's easy for me to say things like this. After living and being in business in the same area for twenty-six years, I've built up a support network of people and shops that can do jobs for me that I can't do myself.

During this time, I have also learned to communicate properly with these folks, for several reasons. First, so that I am not wasting their time (which costs money). Second, to be sure that the part I need built or ordered is right the first time. Re-dos or re-orders cost money and time. Finally, and most important, to take advantage of their experience. The parts often come out better than they would have if my original plans had not been modified by these experienced specialists. In this article, I hope to show you how to build up your own support network.

Fabricators

Unless you have unlimited time, ability, and money, it is not possible to learn all the skills necessary and acquire all the equipment required to do all the work on an electric vehicle conversion yourself. Let's look at some of the help you might need to fill in the gaps in your experience.

The need for a welder comes almost immediately in the conversion. One of the first things needed is a motor mount to hold the electric motor in the place where the internal combustion (IC) engine was. The next parts you will need are battery racks, and a way to attach them to the chassis. These are important load-bearing parts, and their fabrication is best left to a professional. Learning to weld while doing the battery racks for your conversion is neither a good nor safe idea.

Another skilled person whose services you might need is a sheetmetal fabricator. This is the person to see about metal battery boxes, if you are going that route. This is also the place to get small mounting brackets and component enclosures. The skill necessary and the specialized equipment needed to do the work put most of these jobs out of the average person's reach.

A plastic fabricator is someone else you might want to get to know. My local plastic fabricator makes the polypropylene battery boxes I use. This kind of shop is also the place for any kind of covers, mounts, or ductwork that require bending plastic, or precision cuts.

If your project calls for any large parts made of fiberglass-reinforced plastic (commonly known as fiberglass), a custom fiberglass shop is a good place to go. You can get help and advice there, as well as the parts themselves.

A machine shop with a skilled machinist is necessary for any part that must be turned, milled, or drilled to precise specifications. Again, the specialized skills and expensive machinery limits the amount of machine work the average do-it-yourselfer can do.

Not everyone who is converting a car will need all of the above skilled people and their shops. There are many people who have acquired the skills and equipment to do some or all of their own welding, sheetmetal work, fiberglass, plastic fabrication, or machine work. As long as you are comfortable with the quality, appearance, and safety of the finished pieces, there is no reason not to do your own work.

With the exception of welding metal or plastic, I have accumulated the skills and machinery to do most of my own fabrication work. However, when I reach the point where it is not safe and cost effective, or the resulting product does not have the appearance I want, I turn the job over to a specialist.

Parts Suppliers

There are some other people who are equally important to an EV converter's network. These people are in the automotive parts business.

The counter person at the dealership that handles the make of car you are converting is a source of information and parts that might not be available anywhere else. Some parts are only available through dealerships, because they are only made by the car's manufacturer.

The people who work at independent parts houses can open up the world of aftermarket parts to you. These are parts built by independent companies. Some are straight (but cheaper) replacements for the original manufacturers' parts, but others are modifications or upgrades. This gives you access to the more common "fast moving" parts at lower prices than at the dealership. These companies can also show you what is available in heavy-duty and special application parts that might be helpful during the conversion.

The staff of an auto wrecker, dismantler, or recycler (pick a name that suits your image of the place we used to call the junkyard) will be able to advise you on parts interchangeability. They all have books (or computer CDs) that list which parts will fit other cars from model to model in the same make. This can be helpful when trying to beef up a suspension to support the weight of the batteries.

All modern wrecking yards are part of a network with many other yards. If they don't have the part that you need, it can be located and sent to them. If your donor car is an older model, the dismantler might be your last hope for a part that was a dealer-only part that the dealer can no longer get. Even with all this "added value" service from the wrecking yard staff, the perfectly good used part will cost much less than a new part from the dealership.

Service & Repair Shops

Another useful member of your EV conversion network is an independent auto repair shop that specializes in service and repair of the make of car you have chosen as your donor car. If you already own the donor, this is probably the shop you've been taking the car to all along.

If you are shopping for a donor car, the specialty shop is a good place to start your search, since they often have or know of the type of car you are looking for with a tired or blown engine. An added bonus is that if the potential donor was one of their regulars, they will have its service history. In addition to helping you find a car to convert, they can alert you to any weak spots this car has and what the failure items are that should be checked and replaced if necessary during the conversion.

Depending on your cash vs. time ratio, skill level, or desire to do the job with your own hands, you might hire them to do some parts of the conversion. Jobs like pulling the IC engine, cleaning the engine bay and transmission, or installing the heavy-duty suspension parts might be something best left to somebody who does it for a living and has the necessary tools.

Body Shops

At first glance, about all an autobody repair and paint shop might be used for is a new paint job after the conversion is completed. But there is a place for the body shop in the early planning part of the conversion process, as well as doing some later construction.

Most of the body shops that deal with the late model unibody cars, in which the body and frame are all one piece, have information you can use. These shops have either books or CDs with charts and pictures showing which parts of the body/chassis are stressed load-carrying members, and which are unstressed panels.

If you were planning to sink your battery rack into a hole you cut in the floor, but that piece of floor is a stressed part of the chassis, you might have to re-think your plans. Later on during the construction phase, the body shop can advise you on how to cut that hole in the floor.

If you are using metal battery boxes, they can also tell you how to design them so they can be welded into place easily. A body shop might be a better place to have battery boxes welded in place than a conventional welding shop. Body shops are used to welding thin pieces of metal. They know what kind of metal they are welding, and which welding process to use. A body shop can also tell you what kind of compound or paint to use to cover cut surfaces to prevent rust. As you can see, there is more to a body shop than shiny paint.

Finding These Shops & People

I have given you a list of people and skills that I feel are necessary to any EV conversion project. Now let's talk about how to find them and what to look for during the search.

The way I have found most of my helpers is through referrals. I met Paul McCain of Orb Engineering, the welder that I have worked with for years, through one of my mechanics when I had a VW repair shop. My mechanic and the welder were partners in an off-road race car, and Paul did welding and fabrication to try to support the race car. When I needed the VW chassis modified for the Aztec EV, there was Paul, a welder with automotive experience.

The body shop that painted the Aztec put me in touch with a powder coating shop when I needed the Voltsrabbit battery racks painted with something that resisted battery acid. The search for these people might have been easier for me because I was in the auto repair business, but you can do a similar kind of networking.

Start with the auto repair shop you take your gas car to for service. Explain to the mechanic or owner what you are going to do and what you need, and ask for recommendations. They can tell you about the local body shops, parts houses, and wrecking yards.

The neighbor who has a race car, hot rod, or modified 4WD truck may know an automotive welder/fabricator and a machinist who work on automotive related parts. In fact, the neighbor himself might be a good source of advice, help, tools, and equipment. Anybody who has modified or customized a car or truck has had experiences that might prove helpful to you.

If there is a chapter of the Electric Auto Association (EAA) in your area, or another electric car club, join it. Many of the EAA's members have already converted cars, and are a wealth of information and resources.

The local telephone book's *Yellow Pages* is the next best source of the goods and services needed to do a conversion. In it, you can find a shop that services and repairs the make of car you have chosen as your donor. The ads for the auto parts houses and wrecking yards that have parts for your future EV will be there. This is also true for welders, sheetmetal and plastic fabricators, and machinists.

Finding the Right Shops

The process of finding out which of the shops in the ads is the right one to help you with your project can be time consuming and involved. First, read the ads. A welding shop that advertises itself as a structural welder does buildings, and may not be interested in fabricating a set of battery racks. Likewise, a shop that calls attention to its various certifications and exotic types of welding may also be uninterested.

What you are looking for is a small general fabrication shop that mentions some form of automotive work. A shop that offers portable welding in addition to shop-based work is a plus. They can fabricate the battery racks in their shop, and then bring them out to your place and weld them to the chassis of your car.

With the exception of the portable service, the same criteria apply to the sheetmetal shop, the plastic fabricator, and the machine shop. You want a small shop that is used to doing one-off jobs and custom work. A shop that is geared to doing production runs of hundreds of parts will not be interested in fabricating one set of battery boxes.

Once you have picked out some shops that might be potential suppliers, it's time to go and talk to them. You need to find out if they are interested in doing your work. Be prepared to get reactions ranging from "Gee, that sounds interesting. Let's see some drawings," to "Electric cars don't work, and I don't want to build parts for one." Try to find at least two shops of each type you need, if possible.

Talking to Fabricators

After you have found a shop that is willing to look at your job, learn how to communicate with them. See what they need for drawings. Will rough paper and pencil sketches with dimensions work? If more formal drawings are required, do they need to be drawn to scale in the traditional top, front, and side view format? If this kind of drawing is beyond you, see if your local high school has a drafting class that can turn your rough sketches into formal drawings.

Find out what the smallest unit of measurement is that they work to. This could be as high as 1/16 inch (1.5 mm) for the welder, and down to 0.001 inch (0.02 mm) for the machinist. Asking someone to work to smaller tolerances than they are used to will cause them frustration and cost you money.

Now take your finished drawings back to the shop. This is the time for the final design conference. Go over the drawings with the welder, for instance, and ask for input on any changes that could be made to make a part stronger or easier (and cheaper) to fabricate without affecting the basic design. Make the suggested changes at this time if possible, or go back to the drawing board if necessary.

When you are both in agreement on what is to be done, ask for a bid. When you get the bid, look it over. The total amount will probably be broken down into the amount of time required to build the part times the shop's hourly rate, plus the cost of the materials used to make it. There might be some time charged for consulting. If the people at the shop spent a lot of time helping you, pay it and consider it an educational expense.

If the price seems reasonable and the shop has been friendly and helpful through the process, accept the bid and let them get started on your parts. On the other hand, if the price seems high and the shop's attitude has been indifferent, go to another shop and get another bid. If both bids are close to each other, go with the shop that you feel most comfortable with.

Talking to Parts People

Communication with the counter people at the parts house or the wrecking yard is also very important. Again, observe their reaction while you give a brief description of what you are doing. This will let you know if you want to be there, and if you will get any help.

Step up to the counter prepared to make your request. Know or have written down the year, make, model, production date, engine size (in cubic centimeters or cubic inches), and vehicle identification number (VIN). Yes, it is important to identify the engine, even though you will be removing it, because many other parts are keyed to the engine. This information will make it much easier to find the parts you need or the information you are looking for.

A few words are in order about the type of parts house you should be looking for. The big nationwide chain parts house is *not* where you belong with an EV project. They specialize in selling the most-used parts for late model cars to do-it-yourselfers, and don't have the time or experience to help you research interchanges or upgraded parts for your project.

The parts house you are looking for is the one that supplies the local independent repair shops. This place will have more experienced counter people, and a broader base of suppliers to draw from. They are also tied into the local automotive community, and might be able to help locate other resources for your project.

Courtesy Counts

Now, a few tips on getting along with all these very important people. First, don't waste their time. Their time and skills are what they sell to make a living. Be as prepared as you can be when you go into their shop. Know enough to know what you don't know. Try to learn to speak their technical language.

If you are in a parts house and a mechanic (who is probably a regular customer of the shop) comes in looking for the parts order he phoned in earlier, tell the counter person to go ahead and help this customer first. They will both appreciate it, and you will get better help from a more relaxed counter person.

Depending on the size of their contribution to the EV project, a bag of chocolate chip cookies or a dozen donuts make a good end-of-project thank you. A big job like a set of battery racks and a motor mount that included a lot of design help, rates cookies during the project and a pizza lunch when they are finished.

You want the shops that are working with you to say to themselves, "Here comes our EV enthusiast," not "Oh, no, here comes that idiot again." Most important, when the EV is running, drive it around and show it to all of the people who helped make it happen. That might be the biggest thank you of all.

I realize that this article wasn't very technical, but I feel that the subject is one that needs attention. If you are building an EV and get stumped trying to find something, call, write, or email me. I'll try to help.

Access

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Human-Powered Machines

A. Jagadeesh

In developing countries like India and China, and in other parts of Asia, Latin America, and Africa, human power is a great asset. To bring rural employment, our approach should be as Mahatma Gandhi put it, "Not mass production, but production by the masses."

Treadle Washing Machine

A human-powered washing machine is much cheaper than an electrically operated machine. My design uses a box that is 38 by 38 by 61 cm (15 x 15 x 24 in.), made from thick galvanized iron sheet. On the ouside of the box, there is a 15 cm (6 in.) diameter aluminum pulley that is belted to the pulley on the sewing machine base. On the inside of the box, there is a 15 cm (6 in.) diameter fiberglass wheel. The inside wheel is made with a curvature that facilitates centrifugal motion.

The whole setup is mounted on the pedaling table of a treadle sewing machine. There is an opening with a cover on the top of the box to put in soap powder, water, and clothes. At the bottom of the box, there is a pipe that allows users to drain the used water. The upper portion and the sides of the machine are painted black. When the unit is placed in sunlight, it absorbs heat that can be used to warm the water for cleaning clothes.

Operation

The box is filled halfway with water, soap powder, and about 2 to 3 kg (4–7 lbs.) of clothes. It is covered for half an hour, so that all the clothes can soak in the soapy water. Then the treadle is operated for 15 minutes for synthetic fabrics and 25 minutes for cotton fabrics. The used soapy water is then drained out.

The clothes are removed, rinsed, and dried in sunlight. After washing, the box can be removed to make the pedalling stand available for the sewing machine. The whole washing machine, except for the sewing machine, costs around Rs 500 (about US$11), and can be fabricated locally.

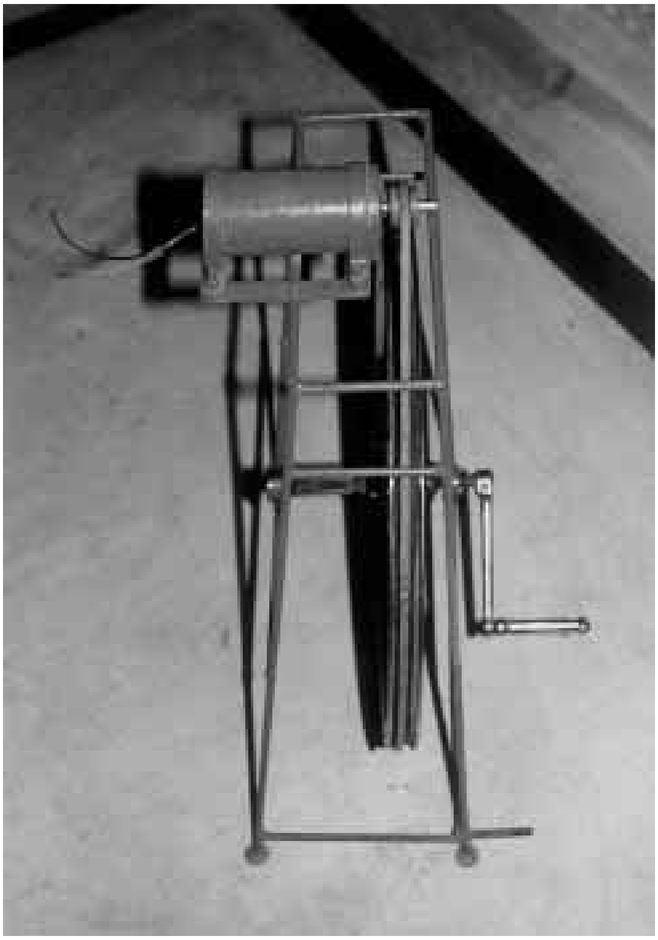
Advantages

- The unit is cost-effective.
- The unit is mobile.
- The fabrication of the unit will generate employment, especially in rural areas.
- It helps to conserve energy.
- Men and women are already accustomed to operating sewing machines, and the operation of this pedal-powered washing machine is not strenuous.
- The life of the clothing is extended compared to hammering it on rocks.
- Operating the machine provides excercise.

Hand-Operated Battery Charger

In developing countries, solar-electric modules to charge batteries for a television and one light are

Loads of wash take between 15 and 25 minutes in Dr. Jagadeesh's treadle-powered model.



The hand-operated battery charger utilizes a low-rpm generator, a bicycle wheel, and human power.

becoming more common. In Mongolia, wind chargers are widely used (over 150,000) to charge batteries for a television and one light. On average, a solar/wind battery charger costs Rs 30,000 (about US$638) in India. And wind chargers can't be operated in all places, since wind is site specific and intermittent.

I designed a hand-operated battery charger. It consists of a bicycle wheel and a low-rpm generator that is mounted on a frame and driven by a V-belt. There is a handle attached to the system. The system also has a blocking diode to prevent reverse flow of current.

Operation
Three 12 volt lead-acid batteries are connected in parallel, and then to the battery charger. By rotating the wheel for six hours, the batteries can be charged. Since many of the sewing machines are hand operated (especially in Northern India), people are familiar with this sort of system.

Advantages
- The whole unit weighs about 5 kg (11 lbs.) and is mobile—it can be carried on the back.
- It provides employment to rural people.
- The unit is easy to fabricate, even in rural workshops.
- In most countries, generators are available, and if not, they can be imported. Many countries exempt renewable energy equipment and generators from customs duty. Alternatively, automobile generators can be used by changing the windings.
- The unit is inexpensive—it costs about Rs 7,000 (US$150).
- It can be operated with either hand.
- It occupies little space.
- Women, as well as children, can operate the system.

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Pedal-Powered Washing Machines in the U.S.

Urban Homebrew Machine

Laura Allen

This pedal-powered washer was built in a day by two motivated people (Reuben and Laura). We used what we had: an old 55 gallon drum, an old bike, scrap wood, nuts, bolts, and one bale of hay (to lie down on). Anyone—especially you!—could build a washer like this.

The author using her homebrew washing machine.

Inside the homebrew barrel-style washing machine.

The barrel is cut into two pieces. A wooden paddle is attached to the front fork of the bike and inserted into the barrel. A chain attached from the pedals to the handlebars creates a back and forth motion of the paddle when you pedal. So simple and so effective!

The washer is filled using a garden hose, and drains out of hoses attached to the bottom. The water goes directly into the garden, so we must use biodegradable soap that doesn't harm the plants. This greywater enables us to have wetland plants in our yard. We water a beautiful bog, full of water irises, sedges, nettles, water parsnip, and other wetland plants. The water also goes to a fruit tree and a bed of garden plants.

Converted Wringer Washer

Amy Preuit and CCAT staff

Human power motorizes the washing machine at the Campus Center for Appropriate Technology (CCAT) at Humboldt State University (HSU). The CCAT washing machine is hooked up to a pulley system and connected to an exercise bicycle, so all the energy that runs the machine is from pedaling a bicycle.

The project itself is not that difficult to set up; it just takes a little elbow grease and patience. We used an old Maytag wringer washer that needed no special conversion. The biggest job was taking out the washing machine motor and setting up the connecting parts.

The bike uses a chain-driven flywheel, with a belt attaching the flywheel to a pulley, and another belt attaching the pulley to the driveshaft. The driveshaft was originally powered by the washer motor, but it is now spun by pedal power.

With this machine, you can wash your clothes, and with a flick of a switch, hook up the wringer to squeeze most of the water out—all from the seated position of the exercise bike. For more detailed information on the machine, see the CCAT Web site.

Forget that membership to "the club"—pedal your way to health and clean clothes.

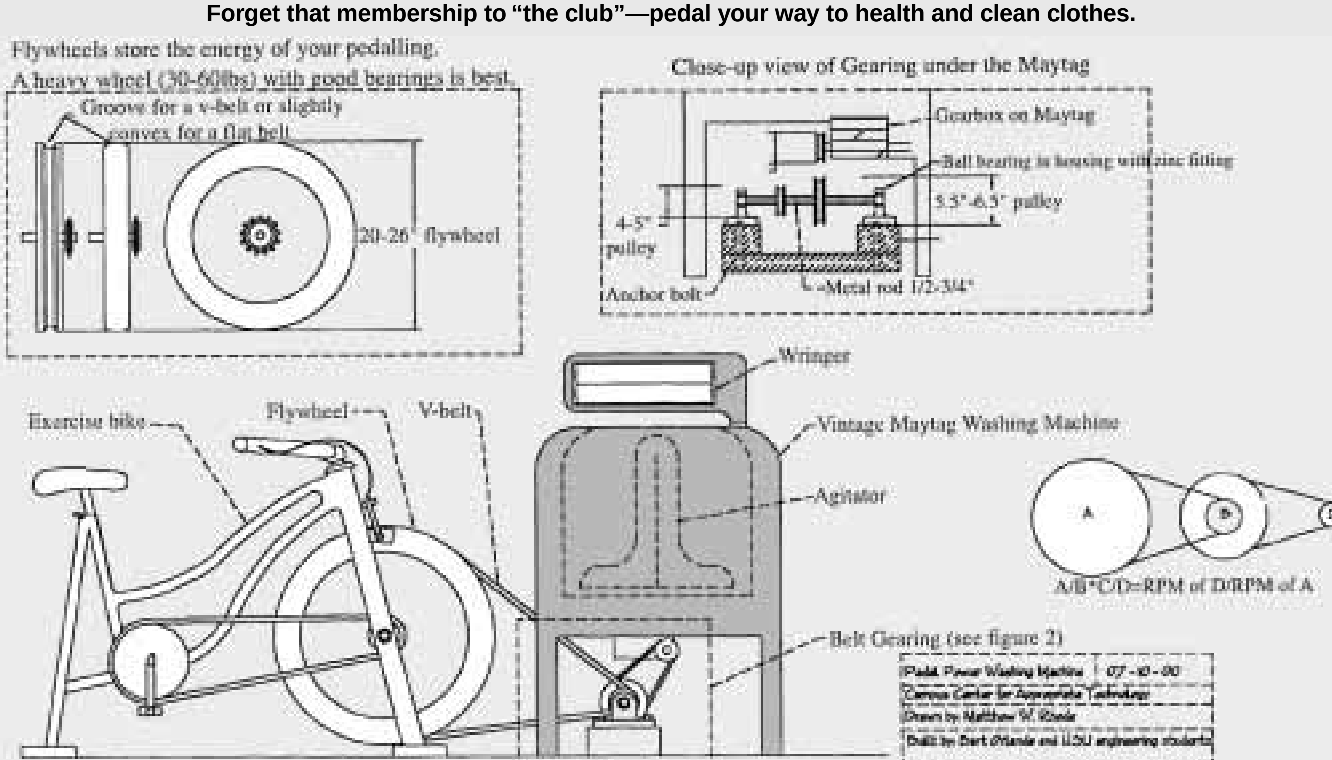

Diagram from the CCAT Web site.

Renewable Energy Terms

Series—Linked Together in One Electrical Path

Ian Woofenden

Derivation: From Latin serere, *to join, link together.*

Did you have one of those wooden train sets when you were a kid? Remember how all the cars lined up and linked to each other? Either they had a hook on one car and an eye on the next, magnets, or some sort of interlock. The train cars were lined up in *series,* one after the other. The front end of one car was connected to the back end of the next. When you pulled on the engine, all the cars came along with it.

Series circuits in electricity are similar. All the elements in the circuit are in one line, and anything that happens to one element happens to them all.

A flashlight is a common example of a series circuit. When you load the batteries in, you put them all in the same way on top of each other. So the positive end of one battery connects to the negative end of the next one. The flow of electrons goes through all the batteries, through the switch, and through the bulb. It's a single loop.

When you're adding energy sources or loads in series, the individual voltages add up. If your super-duper flashlight holds six 1.5 volt D-cells, you're packing a 9 volt flashlight.

In renewable energy (RE) systems, we see series circuits in several places. Photovoltaic (PV) panels generally come in a 12 volt nominal configuration. So if your system voltage is 24 or 48 volts, you'll have to wire the PVs in series strings. Two 12 volt panels will give you a nominal voltage of 24 volts. Four will give you 48 volts. (Remember that you're just changing the electrical "pressure" (voltage), and that the total energy (watt-hours) is not affected.)

In order to create a battery bank of a given voltage, sets of batteries are wired in series strings. Common batteries that are frequently used in RE systems (such as the L-16 and T-105) come in a 6 volt configuration. So you will need two of them in series for a 12 volt system, four for a 24 volt system, and eight for a 48 volt system.

In your house wiring, a switch and its loads are always wired in series. In order for the switch to be effective, all the electrons have to flow through one path that includes the switch and the loads.

You'll rarely find two loads wired in series. We used to see Christmas tree lights that were wired this way. When one bulb went out, it acted like a switch, shutting down the whole string of lights. Some inexpensive burglar alarms use circuits with many switches connected in series. When the bad guy or your brother-in-law breaks the window to get in, it opens one of the switches and sets off the alarm.

Wiring PVs and batteries in series is similar to the circuit in your flashlight. The positive terminal of one panel or battery is wired to the negative terminal of the next one in line. You tap your main negative for the system off one end of the string, and your main positive off the other end.

Other RE system components are also wired in series. Switches, fuses, breakers, ammeters, blocking diodes, and other things that control or monitor electron flow are all wired inline with the circuit, not outside it. For the circuit to work, each component has to allow electrons to flow. And if you use your multimeter to check current in a circuit (make sure it's well within the meter's range), you'll have to open the circuit and put the meter in series with it.

Since the electrons have to flow through all the components and the wiring in a series circuit, you can see how important it is to have adequately sized wiring and strong connections. A poor connection or undersized wire between two components can set up a resistance that will rob you of energy. And a failed connection can shut down your system altogether.

Next time I'll talk about parallel circuits, but here's a little preview. Most of the circuits in your home are wired in parallel with each other. If they were all in one series loop, you could only have everything on or everything off. This would make energy conservation—and life—rather difficult.

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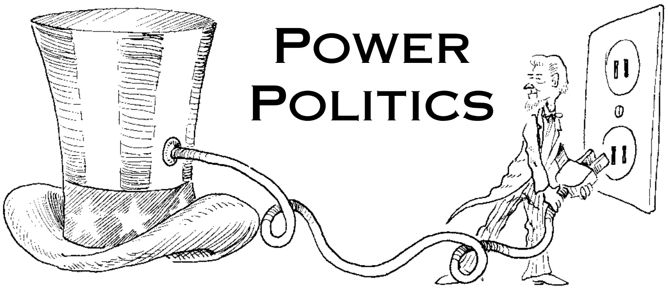

Nuclear Age Coming Back?

Michael Welch

What is the future of nuclear power? Five to ten years ago, most folks would have said that it was dying, and nearly extinct. But the powerful corporations that make up that industry think things are starting to look up.

Energy activists have been fairly pleased with the way things have been going for a nuclear-free future. Several older nuke plants were decommissioned. Partially built plants were abandoned in place after billions of dollars had been spent. The industry's troubled answer to nuclear waste, Yucca Mountain, Nevada, seemed like it would never be allowed to open. The public fear of accidents was heightened, and some utilities put their nuke plants up for auction.

It appeared that the nuke industry had all but given up on the U.S. No new domestic plants had been ordered in over twenty-five years. Utilities and local regulators were actually starting to have dialogues with energy and other environmental activists in their communities, rather than resorting to stonewalling—the industry-wide practice for so, so long. The nuclear industry cut back on its public relations campaigns, fearing backlash from the resoundingly anti-nuclear public.

But really, the nuclear industry has never given up hope. The industry has been quietly working behind the scenes the whole time. They have increased the number and size of interim high-level nuclear waste storage systems. They have received approvals for generic reactor designs, and continue to push hard for Yucca Mountain as the long-term waste solution. And they have managed to lessen the amount of input the public will have in future regulatory processes for nuclear power plants.

Some nuclear companies have been quietly buying up nuclear power plants from utilities that no longer want to own or manage them. Nuke plants are being purchased at a fraction of what they cost to build. AmerGen, Entergy, and Exelon are all companies that are operating nuclear power plants originally built and managed by local utilities.

One scary thing about these new owners is that, unlike utilities, some of these companies have very few assets. If something goes wrong, who's left to pay to fix the problems? And problems at nuke plants can be extensive and costly. Also, some are not in a public utility commission regulated power supplying business. They are in the business strictly to make a profit. Many people fear that they will operate the plants even when maintenance or safety factors would advise differently.

There have been proposals to restart construction on the ill-fated “Whoops” (WPPS) economic disasters in Washington state. Rumor has it that someone is looking into once more running the failed Trojan nuke plant in northern Oregon (currently moving toward decommissioning). And the Nuclear Energy Institute (NEI), which is the nuclear industry's pep team, recently told the Nuclear Regulatory Commission (NRC) that four utilities would be seeking pre-approval for new reactor sites.

One company, Exelon, met with the NRC, and announced that they want to build seven new reactors in the U.S. and one in South Africa. Exelon has high hopes. They believe that their reactors don't need containment buildings, and that they should have special dispensations that will make construction cheaper and more timely. Let's hope that the NRC will not agree to Exelon's request to streamline the process.

Third World Nuke Plants

Until recently, the industry has been pinning its hopes on selling plants to other countries. Nuclear power is a perfect political-economic match for the leaders of these countries. Third world nations' citizens see what is going on in opulent North America and Western Europe. The people want what we have—the riches, the freedoms, the cars, the TVs, the rampant consumerism—and their leaders know it. The leaders also understand that in order to industrialize their nations, they need as much electric power as they can get.

Nuclear reactors look good for this purpose. A country can work out a single energy deal, and end up with 500 to 2,000 megawatts (million watts) of power. Of course, they still have to deal with stringing distribution lines all over the countryside, but most of those additional project costs can be taken care of with the same financing that buys the nuke plant. They also need to figure out how to deal with their nuclear waste. The U.S. Department of Energy and its nuke industry puppeteers have the answer to this: "Just send it to us, and we will take care of it."

Funding is the key to greasing the path to third-world nukes. The amounts of money involved are so huge that things just kind of move forward as each participant gets a share of the pot. The leaders get wealthier. Local industrialists both contribute funds to start the process, and will eventually be the beneficiaries of the process. And the nuclear industry stands to make enough money that they can buy the political clout necessary to get countries development loans and grants, and even finance the projects privately.

But even with all that money flying around, many third world countries are hesitant. They look at the United States and think, "Hey, how come *your* country is not building these plants?" It makes them step back and wonder. That is the number one reason that the nuclear industry wants to build at least one domestic nuclear power plant of U.S. design.

Then they will have an example to hold up to foreign countries, and maybe more countries will go for it. Ironically, many folks watching the industry feel that just the opposite should happen: that companies will be able to re-enter the U.S. market *only* by building and proving their reactor designs elsewhere. Sounds like a bit of a Catch-22.

Energy Crisis

But in June of 2000, everything changed. That was the month that California's "energy crisis" hit. We've heard a lot about how energy providers want to get their fossil fuel powered plant construction "fast-tracked." We've heard a lot about the utilities being bailed out by the state. We've heard a lot about the obscene excess profits of some power suppliers. And we've heard a lot about the rolling blackouts that occur when consumption outstrips supply.

It's now a well-recognized fact that this is a crisis of overconsumption, not under-supply. In spite of this, there has been a huge outcry by powerful entities that more power plants must be built. The nuclear industry is taking full advantage of this, and so is the fossil fuel industry. They have stepped up their public relations campaigns, and are hoping that the public memory of past transgressions has faded. And now that they have a new guy in the White House who is the champion of corporate energy, things are likely to get even easier.

Is Nuclear Energy the Answer?

Many folks think that until we can get renewables online at a level necessary to make a difference, we will need to rely on building more coal and nuclear plants. But yuck, coal is so nasty dirty. And will more quickly-built nukes really help?

Probably not. Nukes could become even more prone to safety problems if construction is rushed. And even if construction is not rushed, they are still too unreliable to help in a crunch. They have to be taken offline for routine maintenance and refueling on a regular basis, and refueling can take several weeks.

Well, refueling can be planned for. But unplanned events contributed significantly to the California "energy crisis." During the peak of a storm that increased demand for electricity last January, high winds choked the Diablo Canyon nuke plant's water intakes with kelp. The plant was forced to run at 20 percent of its 2,000 megawatt capacity to avoid a meltdown.

And just last week, Redwood Alliance and its neighbors were hit by a rolling blackout for nearly two hours. I felt like I was just doing my share for the good of the state until I found out that the outage was caused by a fire at the San Onofre nuclear power plant. It was estimated that the state was short by around 800 megawatts, and the plant provides 1,120 megawatts at full power.

The utility claims that there was no release of radioactive materials. Thank goodness, but that does not help the energy problem in California. Now the plant will be out of commission for about three months for repairs. This is more proof that nukes are not a reliable option for helping our nation's energy crises.

Not as Bad as All That

I don't want to give the impression that this is all doom and gloom, and that we are certain to end up with more U.S. nuke plants. It is a serious situation. Nuclear power corporations have always hoped for a comeback, and this may be their best chance.

But there are some powerful and active folks out there who have been on top of what is going on in the nuclear industry. If we all remain vigilant and keep up the publicity about the realities of nuclear power, we may not have to put up with more nuke plants. Please support your local and national anti-nuke organizations. They are making the difference.

Solar Cheaper?

So what is the answer? If our so-called "leaders" had the political guts, it would be solar and wind. Nuclear power costs about US$2.50 per watt to construct plants. If we were to install a centralized 2,000 megawatt array of single-crystalline photovoltaic modules and intertie equipment, we could do it for about the same cost as a nuclear power plant of the same output.

Of course, solar works only during the day and best at peak sun, but fortunately, that is also when the grid needs it the most. And there would be no fuel costs and fewer maintenance costs.

For another 50 cents to a dollar per watt, we could spread these 2,000 megawatts of photovoltaics across a million rooftops of southern and central California. This would make it easier on the long distance transmission lines that eat up so much of our energy. Finally, we would have a million solar roofs.

Access

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Don Loweburg

Solar—The White Knight?

Are we learning anything yet? Remember the oil embargo of the 1970s? How could we forget Y2K? Now, it's the re-structuring mess in California (coming soon to your state)! In each of these instances, a huge surge of interest in solar energy occurred, only to be followed by a letdown, as the immediate "supply" problem was corrected.

In the '70s, we saw solar energy go south as oil prices came down. Y2K was a quick blip followed by sagging interest. We don't know yet about restructuring in California, but my guess is that if rates settle at US$0.15 per kilowatt-hour, a lot of the interest in photovoltaics (PV) and solar thermal will go away. As long as the public (and their representatives) remains reactive when it comes to energy issues, renewables will be held captive by the swings of the hydrocarbon supply pendulum.

In each of these moments of crisis, the public's interest in solar energy surges, yet solar energy is not the white knight. Solar energy, in the short term, can't fix supply problems. For example, if solar-electric systems were given away for nothing in California (some might consider this a bit extreme), it is very clear that the entire current global manufacturing capacity of PV could not correct the supply problem right now.

Responses that are jerky, reactive, and fade quickly will not build a renewable energy industry. Sustained support directed at the end user in the form of buydown programs and other incentives is what is needed to build a real market for PV.

California's ten-year funding commitment to renewables is a good start. It is, however, far short of what is really necessary. A strategic commitment to renewables is a fifty-year project with funding requirements in the hundreds of billions. Though these figures seem extreme, they are completely doable. Recall that this nation has dumped far in excess of that figure down the nuclear rat hole. What this country really needs is a PV death ray machine. Then we could have a "Peaceful Photon" program, and market solar energy as too cheap to meter…

The Other Side of the Coin

Renewables on the supply side constitute only part of the solution. On the demand side, energy efficiency is the other half of the solution. Howard Geller, past executive director of the American Council for an Energy Efficient Economy (ACEEE), makes the following observations. First, if frictional losses of replacement tires matched the existing standard for tires on new vehicles, the United States would save 70 percent more oil over the next 50 years than could be pumped from the Arctic National Wildlife Refuge (ANWR). Or, if the overall mileage standard were raised to 39 mpg, the United States would save fifteen times the total oil contained in the ANWR.

To these examples I would add that the generation of electricity using carbon fuels is the largest source of CO_2 emissions. Electrical efficiency can result in significant reduction of CO_2. See the ACEEE Web site for the full essay. While on the site, bookmark the list of energy-efficient appliances. This is a valuable tool for educating customers.

A Long Time Coming—Trace Version 4.10

Back in *HP74, IPP (Bugs in IEEE929),* we discussed some early problems with the new industry standard for grid-connected inverter performance. Early software implementations of the standard as used in a Trace upgrade chipset resulted in repeated nuisance grid disconnects. The problem was twofold.

The standard itself restricted the allowance for grid voltage fluctuation to an unrealistically narrow window. Additionally, it was determined that Trace's internal voltage calibration (specific to SW series inverters) was not accurate. Together, these two factors resulted in nuisance grid disconnects. The problem with IEEE929 was corrected just before the standard was finalized last year, but Trace continued to ship SW inverters with non IEEE929 compliant software until just a few months ago. Welcome SW version 4.10.

The easiest way to tell if you have updated (version 4.10) software is to check out the inverter's "certificate of compliance." The certificate is taped to the top of the inverter. The old certificate stated a frequency tolerance of plus or minus 2 Hz, while the new tolerance is less than 1 Hz. Keep in mind that these limits are only applicable to the "sell" mode. If you are using the inverter off-grid, none of this matters. However, if you are connecting to a utility that requires IEEE929 compliance, make sure that you have the updated software. If needed, the upgrade is available from Trace at no charge—contact their customer service.

As part of the IEEE929 standard, a specification was developed for "non-islanding inverters." This specification has been incorporated as part of UL 1741, and the new Trace SW version 4.10 now complies with this newer UL testing. The "non-islanding inverter" test specification was developed to satisfy the stringent safety concerns of the utility representatives on the IEEE929 board. With this standard in place, some utility personnel stated that they might consider dropping the requirement for the redundant lockable-visible disconnect. Some utilities do not require it, but others do. How about it? The industry lived up to its side of the bargain. It's time the utilities make good too.

The End of UPVG?

Begun in 1992, The Utility Photovoltaic Group (UPVG) was a consortium of interests with the goal of commercializing photovoltaic generation as part of the utility grid. The group included module manufacturers, utility representatives, federal and state energy commissions, and environmentalists. The model originally envisioned by this group was of large, centrally-located array generation. Later, they expanded the vision to include smaller residential and commercial rooftop-mounted systems.

In both models, it was assumed that the utility would own the PV systems. The idea was that the purchasing power of the utilities would be able to bring down the price of PV through a process called "sustained orderly development" (SOD). In order to promote this model, the group (UPVG) sponsored working groups in a number of states. In California, the group was PV4U (Photovoltaics for Utilities). The California PV4U group later dropped the utility reference from its name, becoming the California PV Alliance (CALPVA).

Now, years later, utilities are in the process of being de-structured, federal support for renewables is shrinking, attendance at the last UPVG conference was down, and UPVG is changing its name. The new name—Solar Energy Power Association—reflects a move away from the traditional utility ownership model towards renewable energy as distributed generation.

With a new name and a corrected vision that PV represents an independent energy technology, I hope that this new group can forward the role of renewable energy. But without significant funding, the organization's role may be reduced to that of the Million Solar Roofs program—disseminating hot air.

The Final CEC details

Last issue *(HP82, IPP),* I detailed some extremely questionable changes that the California Energy Commission (CEC) had proposed for the California buydown program. The most alarming was the inclusion of natural gas devices in the "renewable" category, and the allowance for utility participation in the buydown program.

Action on these and other proposals has been sidelined due to the crisis in California's energy supply and pricing. As an interim policy, the CEC has extended the current US$3/watt buydown, and will make sure funding is available for the remainder of this year. The buydown program has seen a quantum shift in the number of reservations being made per month. I'm sure that the suddenly increased participation in the program has caused the CEC to re-evaluate some of their proposed changes.

PVUSA Update

The uncertain status of PVUSA was discussed in *HP80, IPP*. At that time, the city of Davis had received a six month option to take over the site. According to a *Sacramento Bee* article dated March 22, 2001, a Dutch company has signed a twenty-year lease with the city to operate the existing PV arrays and systems. Nuon Renewable Ventures plans to expand the plant, with a percentage of the plant's electrical production going to the city of Davis.

There is also interest in having the site host a small systems test facility. In addition to testing residential and commercial-scale systems, the site would serve a "consumer reports" function. The PV industry needs an independent third party that is equipped to make impartial evaluations of inverter and module performance in the real world. There is a lack of publicly available information on total system performance. This, coupled with reliance on module manufacturers for module output values, is often the source for debatable system performance claims.

More California Energy Legislation

Though utility deregulation has been a disaster for the citizens of California, it has been great for renewables. In the past, I've mentioned legislation that extended the buydown program for ten years (SB1194), extended the net metering bill to include time-of-use (TOU) billing (AB918), and provided rebates for solar thermal and battery systems (SB1345).

Several new emergency bills being considered that affect renewables are: Elimination of sales tax on solar energy equipment (SBx1), a California income tax credit (SBx17), and a net metering revision to allow up to one megawatt of capacity (ABx83).

Other Thoughts on Deregulation

What are others saying about deregulation? For a perspective from the left, check out Public Citizen's "Debunking the Ten Myths of Utility Deregulation." Authors Wenonah Hauter and Tyson Slocum provide an introductory overview of California's electricity deregulation, and then systematically take on the "Ten Myths."

For a less politically identified perspective, read the article that appeared in the March 13, 2001 issue of the *San Francisco Chronicle.* It is titled, "Gov. Davis' Plan Puts Taxpayers on the Wrong Side of Future Technologies." Author Hal Plotkin makes a strong case against the state of California buying the transmission system as proposed by Governor Davis.

Plotkin concludes that the state is once again being duped into holding the bag—in this case, an outdated transmission system controlled by the federal government. The state (taxpayers) will now foot the bill to upgrade the transmission system for the benefit of large central generators. These are the same guys who ripped Californians on electricity pricing. The author considers this to be "the wrong side of future technology," given the widespread understanding that distributed generation is the new game in town.

Beware of Internet Experts

The IPP position regarding discount equipment sales on the Internet or mail order has been criticized by some readers as self-serving. Guilty as charged! But there is another side to this story.

What these critical readers do not experience are the frequent calls that installing dealers get from lost souls needing help with equipment purchased elsewhere. The worst part of the situation is that the callers did not save much money, and the system design is almost always flawed. It's very easy to make exaggerated performance claims over the phone to a customer who is thousands of miles away.

Here is an example. A caller from Fresno, California asked if I could beat a price of US$8,000 to "put solar-wind" on his home. A mail order competitor had determined that a PV-wind hybrid would do the job. I asked the caller what sizing discussion had taken place, and found that there had been none. The customer had no clue about what the system would produce, or what his loads were. The mail order salesperson had told the customer that the system as designed would run the house.

The truth is that there is not much wind in Fresno, and this system was seriously undersized for a grid-connected home. There was not even a tiny chance that the system would be large enough to cover the load. In a case like this, the installing dealer is serving the mail order customer, though no one likes getting bad news. Talk to a wrench before you buy.

Safe from Earthsafe

Siemens, like BP and Solarex, offers solar-electric system kits. These kits typically pretend to offer all the necessary components for installing a PV system. Universally, the instructions state that any electrician or electrical contractor can handle the installation. This is not always a safe assumption. See Bob-O Schultze's article in *HP81* on how a licensed professional can mess up a system.

The fact that the manufacturers are marketing kit systems indicates that they believe they can do better by going around the dealer-installer and marketing directly. I recently sat through a presentation by Siemens on the Earthsafe kit. Though the workshop was promoted as "heavy on content" (and the other presentations actually were), this section was a marketing dog and pony show.

The presenter from Siemens seemed to be unaware that the audience consisted of advanced installers. He repeatedly ducked or sidestepped questions from the audience, and emphasized the point of view that Siemens had taken care of all the details and we simply needed to sell the product. The tone of the presentation was that Siemens was doing all of this for "us."

But it was not lost on this audience that Siemens had just made a marketing agreement with the Ace Hardware chain. Now we can buy a solar-electric system at the hardware store! I suggest that Siemens and other manufacturers support the infrastructure of installing dealers, rather than attempting to make marketing end runs that go around dealers.

ICE-T is Approved
Several times during the last year, we have mentioned the Independent Clean Energy Tariff (ICE-T). The ICE-T proposal is supported by the PV industry. It is part of the California Public Utilities Commission (CPUC) Order Instituting Rulemaking regarding Distributed Generation (99-10-025). ICE-T was adopted by the CPUC in March, and eliminates all standby charges (traditionally imposed on self-generators by utilities) on solar energy generation up to one megawatt.

By eliminating the utility standby charges, larger PV systems become more cost effective. Projects covered by ICE-T are typically designed to offset local load, and are not net metered. However, the proposed changes for the California net metering law will include systems up to one megawatt.

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More Module Wiring

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

In *HP81,* I presented an example of module wiring as a sizing exercise. Here is a second example of the calculations required to select and size the proper array conductors for a PV system.

This 2,000 watt, 48 volt PV array will be mounted on the roof of a residence. This system will be one of the utility-interactive designs that are so popular in California and elsewhere these days. But the PV array wiring would be similar in a stand-alone system.

Specifications

The system will have twenty 12 volt, 100 watt modules that will be connected in series strings of four modules each. There will be five strings of modules. The modules have ratings marked on the back as follows: open-circuit voltage (Voc) is 20 volts; short-circuit current (Isc) is 6.4 amps; the peak-power current is 5.8 amps; maximum system voltage is 1,000 volts; and the maximum series fuse is 15 amps.

The lowest temperature measured over the last thirty years at this location is -15°C (5°F). So from Table 690-7 in the *National Electrical Code (NEC),* we must use a multiplier of 1.17 on the open-circuit voltage to determine our DC system voltage. The DC system voltage is 93.6 volts (4 x 20 x 1.17 = 93.6). All wiring disconnects and overcurrent devices in the DC PV circuits must be rated for at least this voltage.

The inverter for this system has eight fused inputs. The short-circuit current will be 6.4 amps in each string of four modules. Using the factors required by *NEC* section 690-8, we must multiply this current by 1.56. The result is a design current of about 10 amps. This value must be applied to the ampacity of the module and source-circuit wiring, and to any overcurrent devices in the PV source circuits.

Overcurrent Protection

The module protective fuse can be as high as 15 amps. So we can use the inverter input fuses (sized at 10 amps) to protect not only the conductors in the system (when properly sized), but also to provide the necessary module reverse-current protection. This technique will require that we run five separate source circuits from the PV array to the inverter (one for each of the five strings of modules).

As an option, the five source circuits might be combined on the roof with a fused PV source circuit combiner box like the Trace Engineering (Xantrex) TCB-10. Then a single circuit can be run to the inverter. While this may be possible, depending on the inverter input circuits (or an input to a stand-alone charge controller), it would require additional calculations.

The highest measured temperature in this location over the last thirty years is 45°C (113°F). The PV array is mounted close to the roof. So we will assume that the module junction boxes and the back of the modules may operate at as high as 75°C (167°F) on hot summer days when there is little wind.

PV modules generally operate at temperatures from 30 to 45°C (86–113°F) above the ambient temperature. For temperature derating purposes, it is suggested that an operating temperature of 75°C (167°F) be used if the modules are mounted less than 6 inches (15 cm) from any structure that prevents cooling air from reaching the back of the modules. If the modules are mounted on open racks or at least 6 inches (15 cm) from a surface, an operating temperature of at least 65°C (149°F) is suggested.

Conductor Routing & Selection

We will use exposed single-conductor cables for the module interconnections. We want to continue with the same conductors in conduit through a roof penetration and through the attic and inner walls of the house to the inverter.

With 75°C (167°F) module operating temperatures, we need a type USE-2/RHW-2 cable. This cable is sunlight resistant for use as the exposed module interconnections, and has a wet-rated, 90°C (186°F) insulation. The additional designation of RHW-2 indicates that it has a flame-retardant insulation, can be used in conduit, and is also wet-rated at 90°C.

Short lengths of this cable are connected between each of the four modules in a series string to make each of the five source circuits. Continuous lengths of conductors (five pairs) are run from each set of four modules into a weatherhead on the end of the conduit. They then go through the conduit to the inverter—about 100 feet (30 m) away.

The 30°C (86°F) ampacities for USE-2 conductors are presented in *NEC* Tables 310-16 (conduit runs) and 310-17 (free air). The basic ampacity requirement for each circuit is 10 amps. This number must be increased for both the exposed sections of the conductors (75°C module operation) and the conduit sections (45°C ambient temperature). For this type of conductor, the derating factors are 0.87 in conduit at 45°C, and 0.41 in free air at 75°C.

Since there will be ten current-carrying conductors in the conduit, an additional derating factor of 0.5 must be applied to the conductors in the conduit run. *NEC* Table 310-15(b)(2)(a) provides conduit fill derating factors for situations with more than three conductors in conduit. If we apply these numbers to the basic 10 amp requirement, we get 23 amps (10 ÷ 0.87 ÷ 0.5 = 23) for the conductors in conduit, and 24 amps (10 ÷ 0.41 = 24) for the conductors attached to the module and then in free air.

Since we are using only one size and type of conductor throughout, we must use the highest ampacity requirement, which is 24 amps. However, we must also check the ampacity in both areas. For this example, a #16 (1.3 mm^2) conductor seems to meet our ampacity requirements. *NEC* Table 310-17 indicates that it has a 30°C (86°F) ampacity of 24 amps. However, Table 310-16 indicates that a #16 conductor has an ampacity of 18 amps in conduit, which does not meet the 23 amp requirement. A #14 (2 mm^2) conductor has ampacities of 25 amps in conduit and 35 amps in free air, meeting our requirements.

Since USE-2 conductors are hard to get in sizes #18 to #12 (0.8–3 mm^2), let's see what a #10 (5 mm^2) conductor gives us. The ampacity in free air (Table 310-17) is 55 amps, but is limited to the use of a 30 amp fuse. The conduit ampacity (Table 310-16) is 40 amps, also limited by the requirement to use a 30 amp fuse. Calculations show that #14, #12, and #10 (2, 3, & 5 mm^2) conductors all meet our ampacity requirements. When using these ten #10 conductors, a 1-1/4 inch (trade size) rigid PVC schedule 40 conduit will be required. Other types of conduit might also be used.

Voltage Drop

Our conductor length totals 200 feet (61 m). Stranded #14 (2 mm^2) conductors have a resistance of 3.14 ohms per thousand feet (305 m). For a 200 foot length, the resistance will be 0.628 ohms (200 ÷ 1,000 x 3.14 = 0.628).

Using the peak-power current of 5.8 amps, the voltage drop is 3.64 volts. This represents a 7.6 percent voltage drop on a 48 volt system (3.64 ÷ 48 x 100 = 7.6), which is too high. The *NEC* suggestion is 3 to 5 percent voltage drop, but it is generally referring to 120/240 volt AC circuits.

#12 (3 mm^2) conductors, with a resistance of 1.98 ohms per 100 feet, have a voltage drop of 4.8 percent (200 ÷ 1,000 x 1.98 x 5.8 ÷ 48 x 100 = 4.8). With stranded #10 (5 mm^2) conductors (resistance of 1.24 ohms per 1,000 feet), the resistance for the 200 foot run is 0.248 ohms (1.24 x 200 ÷ 1,000 = 0.248). At 5.8 amps, the voltage drop is 1.44 volts (5.8 x 0.248 = 1.44), which is 3 percent of the nominal system voltage of 48 volts—an acceptable number.

Terminal Temperature Limitations

The fuse holders and most other overcurrent devices are limited to connections to wires with 75°C (167° F) maximum temperatures. We establish this condition by ensuring that the actual expected maximum circuit current of 8 amps (1.25 x 6.4 = 8) is less than the ampacity of a 75°C cable of the same size.

We assume that the inverter is operating at a temperature of 30°C (86°F), and that the ampacity of a #10 (5 mm^2), 75°C conductor is 55 amps (based on Table 310-17; the inside of enclosures are considered to be free air). This is much higher than our expected circuit current of 8 amps, so the cables and the terminals will be below 75°C where connected to the fuses.

If you think that this is a very conservative design when looking at that 8 amp to 75 amp ratio, consider the following. The bundle of ten conductors operating at full current of 8 amps each in the conduit at 45°C ambient temperatures will be pretty hot. And then remember that some of the conduit may also be heated by the sun to even higher temperatures.

Grounding

Based on the 10 amp fuse that we will be using, the modules can be grounded by using #14 (2 mm^2) bare or insulated conductors. These should be connected from each of the marked module grounding points on the module frames to the nearest module in the array in a daisy-chain fashion. Then, a single equipment-grounding conductor is routed in the conduit to the inverter. However, since we oversized the circuit conductors for voltage drop from a #14 to #10 (2 to 5 mm^2) conductors, this equipment-grounding conductor should also be increased to a #10 (5 mm^2) conductor.

Color Codes

This system will have the negative conductor grounded. It is difficult to get USE-2 conductors with the required white insulation. *NEC* section 200-6(a)(2) allows us to mark each end of the negative conductors from the modules to the inverters with white tape or other permanent white marking.

The equipment-grounding conductor, if insulated, should have green or green with yellow striped marking. No code provisions have been made for marking these smaller conductors with tape, so bare conductors would be the standard practice.

Metric Equivalents

The metric equivalent wire sizes that the editors have added to the standard American (AWG) wire sizes above should be used with caution. They are based on geometric calculations and may not represent actual, available metric wire sizes. The quality and type of insulation has an influence on the ampacity of any cable. So the locally available ampacity guides for each country should be used for selecting wire sizes, both AWG and metric. Some countries have more stringent standards for insulation quality than the U.S., but many countries have lower or no standards.

Summary

This 2 KW, 48 volt PV array can be connected with five source circuits, each using #10 (5 mm^2) USE-2/RHW conductors. The conductors are in free air at the modules, and are routed in 1-1/4 inch conduit to the inverter location. The negative conductor of each source circuit is marked white at each end. A bare #10 conductor is used for the equipment-grounding conductor. A 10 amp fuse is installed in the inverter input circuit for each source circuit. This provides overcurrent protection for the conductors, and reverse current protection for the modules.

Sandia National Laboratories PV Systems Symposium And PV/*NEC* Workshop

Sandia National Labs will be hosting a PV Systems Symposium July 18–20, 2001, in Albuquerque, New Mexico. System people from all over the country will be making presentations on what does and does not work with PV systems. All types of systems will be covered, including utility-interactive, stand-alone, and hybrid systems. Cost, performance, infrastructure, and other issues will be addressed. Advance registration is required.

In conjunction with this symposium, I will be making an eight-hour presentation on PV and the *NEC* on Tuesday, July 17, 2001 at the workshop location—the Sheraton Uptown Hotel. The cost will be US$35 for this eight-hour workshop. Advance registration for the workshop is required.

Registration information for both the symposium and the PV/*NEC* workshop may be obtained from Connie Brooks at Sandia Labs (see *Access*).

Revised Manual

Photovoltaic Power Systems and the National Electrical Code is a 117 page manual, written by the *Code Corner* column author. It is published by Sandia National Laboratories, and has been revised to the 1999 *NEC.* It is available in PDF form on our Web site: www.NMSU.Edu/~tdi/pvandnec.htm

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, email, or write me. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work was supported by the United States Department of Energy under Contract DE-FC04-00AL66794. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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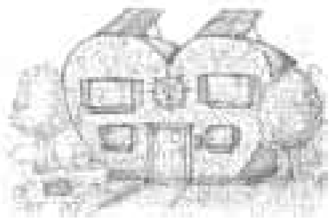
Home & Heart



Kathleen Jarschke-Schultze

With the "energy crisis" in California, the stage three electrical alerts, and the rolling blackouts, I have to admit that Bob-O and I have been hit by electrical blackouts ourselves. This certainly is not the norm for us. In fact, we had to go to some effort to actually experience grid blackouts.

Bob-O was skiing the slopes of our county's own Mt. Shasta. We call it "doing a frozen hydro survey." When the power unexpectedly quit, all the ski lifts stopped. The resort used emergency generators to get the lifts going long enough to get everyone off. Then they closed down the ski area. The power outage was caused by a snow-laden tree taking out a power line.

Over the Hills

I had been planning a trip to see my dad, who lives near Paradise, California. The night before I left home, I found out that there had been a snowstorm there, with two feet of snow in some places. The power and phones were down at his house. Of course, I went anyway.

As I turned up highway 70, just ten miles from Dad's, I was stopped by a California Highway Patrol blockade. When the officer found out that I was only going ten miles farther, and noted that my car was four-wheel drive and that I had chains, he let me through. As I slowly drove the winding country road, I passed many vehicles stuck by the sides of the narrow road. By then, the snowplow had boxed each of them in with a high ridge of frozen snow.

Dad had left the gate open for me, so I turned into his driveway, up a slight incline, and got stuck. I tried to back out. No luck. Dad and my sister Mary had been watching for me. They came out to help. We got the car loose and backed onto the main road.

The problem was that the driveway has a slight sideways lean to it. As I would take a run at the driveway, I would start slipping towards the ditch on the downhill side.

I didn't want to put chains on for the last 20 feet. And if I stayed outside the gate, the back of my car would be dangerously close to the icy road. Mary's friend Jer got in my car, and was assertive enough to get it up the driveway and through the gate. He managed to miss all the parked cars before sliding to a stop.

No Power in Paradise

Now this wasn't a blackout caused by the power crisis. This was an old fashioned snowstorm, lines-down kind of thing. Each evening we would turn on Dad's generator for a couple of hours. This would allow us to watch the local news, cook dinner, shower, run the well pump, and cool down the refrigerator. (We've offered to set up a battery/inverter system, but Dad has refused any help. He is fiercely independent.)

The rumor circulating was that the utility was in no hurry to fix the powerlines because then they wouldn't have to have a forced blackout somewhere else. That was good gossip, but I don't think it was true. But people did wonder...

After three days, the power and phones came back on. I was glad, since my itinerary was to continue on down to the Bay Area to visit my two brothers and sister and their families in the old hometown.

REaching the Kids

Whenever I visit my family in Napa, I call ahead and offer to give some sort of renewable energy presentation to my nieces' classes. If the time of year is right, I do some solar cooking.

This time my topic was living on renewable energy. Friends asked me what my classroom spiel was. I don't have one. I'm afraid my preparation included bringing a compact fluorescent light bulb, some *Home Power* mags, and a list of the components of our RE system.

My niece, Tesla, is in the eighth grade. Her teacher decided to bring in two classes, science and social studies, to my presentation. There were about sixty kids. It was daunting. Tesla wore her *Home Power* t-shirt in a show of support.

I started by drawing a crude diagram of our system and how we used the different renewable energies—wind, water, and sun. I invited any and all questions. I was glad to be interrupted at any time to answer the kids' questions.

When the questions slowed, I used a technique Richard Perez turned me on to—tell a story. Any little story related to what you are talking about will do. I told about our dual-axis solar tracker that was tracking lightning on a dark and stormy night. I did an impression of a tracker turning towards the light.

I explained about using energy as it comes into your system. I told the kids that when the wind blows, water flows, or the sky is blue, I know I can do several loads of laundry and vacuum besides. If you are producing energy and not storing or using it, you are wasting it.

When the sun goes down and the wind stops, we go into a conservative mode. Hence, the compact fluorescent light bulbs. I explained the one person/one light theory to the kids. After dark, when you need light, you turn on the light in the room you are in. When you leave that room, you turn out the light there and turn on the light in the room you are going to. Your one light follows you around, and you don't waste energy by having lights on in empty rooms.

Phantom Loads

"Phantom loads" were good for a couple of minutes of discussion and questions. These are things that consume energy twenty-four hours a day without any real benefit. For these kids, it was a totally new concept. By putting all your appliances that have built-in clocks or instant-on features on plugstrips (available at any hardware store), you can cut down on phantom loads.

For example, a television set with a remote control can draw as much as 10 watts just sitting there waiting for you to turn it on. Microwave ovens and VCRs are using energy all the time, just to keep the little clocks going. Computers and stereo components are often phantoms as well. To use these appliances, turn on the plugstrip, and then the appliance. It becomes a habit you don't even notice after a while.

Class Act

From Tesla's class, I went to my niece Anna's fifth grade class. As I arrived, the teacher was just finishing an assignment on energy in the kids' science book. They were taking turns reading aloud. The book explained some very basic terms, and had some good pictures. It even had a picture of a utility bill.

This was the best preparation I could have hoped for. I introduced myself as Aunt Kathy (I wasn't going to make those poor kids try to pronounce my last name). Then I started talking. This led to questions, which led to referencing some pictures in their science book. I passed out copies of *Home Power.* When the kids saw my picture in *HP41,* I suddenly gained celebrity status.

I suggested that the kids go home and make a deal with their parents. See if they could get a reward of a nickel for finding a light or TV left on in an empty room. This would save energy and money, and train both children and parents to be aware of wasteful electrical use. (Anna earned twenty cents before I left Napa…)

That presentation lasted for 45 minutes. The teacher said that they felt good if they could hold the kids' attention for 20 minutes, so I had done quite well.

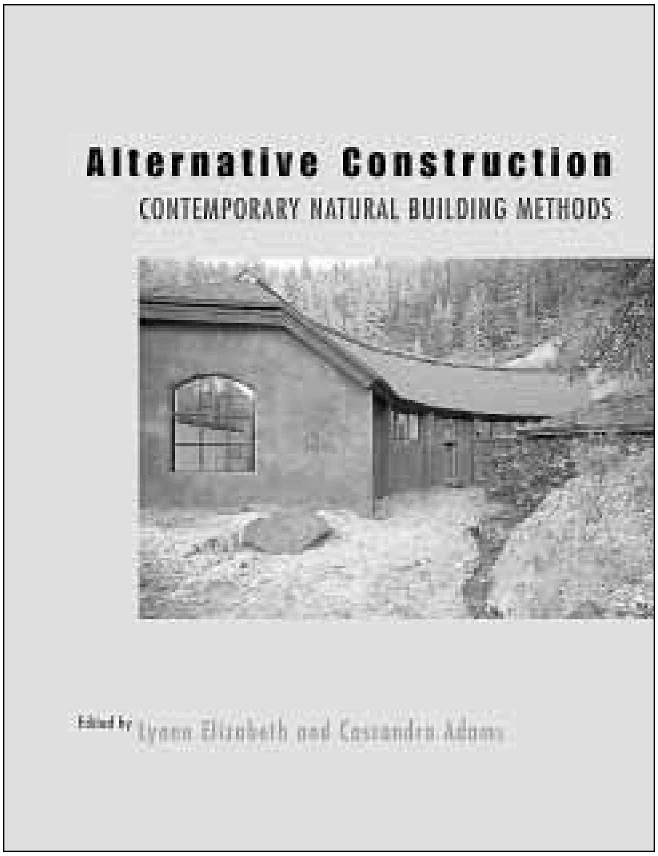
I was done being RE Queen, but my auntly responsibilities weren't over yet. As the kids were excused for recess, I listened to Anna and her friend Raven recite the first paragraphs of Lincoln's Gettysburg Address. They had to read it aloud to ten different people for a homework assignment.

Power Hungry

Knowledge is power, choice is freedom. Knowledgeable choice is what is going to save our planet and the future quality of life. Spread the word.

Access

Kathleen Jarschke-Schultze is posting her rural adventures online from her home in Northernmost California. Go to www.electronconnection.com, click on "Back @ Ranch" (for stories) or "Articles" (for earlier *H&H).* c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520
kathleen.jarschke-schultze@homepower.com



Edited by Lynne Elizabeth and Cassandra Adams
Reviewed by Richard Engel

As an energy nerd, this book won me over early on. Right after the introductory material, and before the editors start throwing us chapters on specific techniques, there's an entire chapter devoted to the energy performance of alternative construction technologies.

The main idea I took from this chapter was that there is no single alternative technology that shows top thermal performance across different climate zones. The authors show that hybrid structures, such as adobe inner walls surrounded by straw bale "siding," will provide the optimal combination of insulation and thermal mass. Their computer modeling of different material combinations shows that it is generally best to concentrate thermal mass on the indoor side of exterior walls and put the insulating layers on the outside.

Following the opening chapters, which also tackle building codes and structural engineering issues, we get into the heart of the book. Authors with terrific sustainable building credentials treat us to a chapter on each different technique—adobe, cob, rammed earth, modular contained earth, light clay, straw bale, bamboo, and earthen finishes. Bear in mind that this book is not a detailed how-to manual on all of these techniques. What you do get for your money is a balanced, thorough overview of the major alternatives to today's lumber-and-sheetrock homebuilding mainstream.

Real World Experience

The last section of the book is made up of a number of case studies of alternative construction projects in real-world settings, many in developing countries. Here we get past the theory and learn what really is and isn't working in the world of alternative construction.

You can learn from Habitat for Humanity builders that the best way to get poor people in the Third World to continue using traditional building methods is to encourage their wealthier neighbors to return to building with these methods voluntarily. This helps to remove the "poor folks' housing" stigma from these sustainable and time-honored techniques.

Or you can bone up on the latest variations and combinations of alternative and conventional methods, such as incorporating non-structural straw bales into concrete exterior walls. At the very back of the book, you'll find a generous bibliography and a long list of resource centers for the alternative builder.

Cheers to John Wiley & Sons and the editors and authors who pulled this impressive book together. Again, this is not a step-by-step guide, but if you're intrigued by alternative building and want to see which of the many existing techniques is right for your application, this book makes a great starting point.

Access

Alternative Construction: Contemporary Natural Building Methods, edited by Lynne Elizabeth and Cassandra Adams, 2000, ISBN 0-471-24951-3, 392 pages, hardcover, US$59.95 plus tax and shipping from John Wiley & Sons, Inc., Distribution Center, 1 Wiley Dr., Somerset, NJ 08875 • 800-225-5945 or 732-469-4400 • Fax: 732-302-2300 catalog@wiley.com • www.wiley.com

Reviewer: Richard Engel, Schatz Energy Research Center, Arcata, CA 95521 • 707-826-4345
Fax: 707-826-4347 • rae7001@humboldt.edu
www.humboldt.edu/~serc

HAPPENINGS

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

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

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

CANADA
July 7–8, '01; Green Choices: 1st annual Canadian Energy Fair. Kortright Centre for Conservation, Kleinberg, Ontario. 80+ free workshops: organic gardening, home-based learning, socially responsible investing, solar/wind energy, & more. Contact: Wendy Priesnitz at Natural Life Magazine, 800-215-9574 natural@life.ca • www.life.ca

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

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

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

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

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

NICARAGUA
July 31–Aug. 10, '01 (repeated Jan. '02), Nicaragua. Intro to PV for developing countries, course offers lectures, field experience, & eco-tourism. Taught in English by Dr. Richard Komp & Professor Susan Kinne. US$850. Contact Barbara Atkinson • 215-942-0184 lightstream@igc.org

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

NATIONAL U.S.
July 15–25, '01; American Solar Challenge, solar race on historic Rt. 66: Chicago to Los Angeles. 3 starts: Chicago; Rolla, MO; & Barstow, CA 800-606-8881 • hq@formulasun.org www.formulasun.org

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 Automobile, Quilted Insulated Window Shades, & more. US$25 + S&H, broadcast-quality tapes available. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 606-256-0077 • Fax: • 606-256-2779 aspi@kih.net • www.kih.net/aspi

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

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

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

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

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

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

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

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

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

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

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

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

ARIZONA
Glendale & Scottsdale, AZ. Living with the Sun: Lecture series by AZ Solar Energy Assoc. History & current overview of concepts, design, applications, & technologies on solar heating/cooling, architecture, landscaping, PV, & cooking. 7–9 PM, first Wed. of every month at Glendale Foothills Branch Library, & third Tues. of every month at Scottsdale Redevelopment & Urban Design Studio. Jim Miller • 480-592-5416

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

ARKANSAS
Sun Life Constr. by Design: Seminars 3rd Sun. of month on our passive solar earth-sheltered project. Hands-on, incl. ferro-cement, building dwellings for minimal materials expense. Loren Impson, 71 Holistic Hollow, Mt. Ida, AR 71957 870-867-4777 • loren@ipa.net www.Sun4Life.com

CALIFORNIA
June 4–21 & 23, '01. Arcata, CA. PV System Design & Install. course at Humboldt State University. Hands-on class. Info: HSU Extended Education, 707-826-3731 extended@laurel.humboldt.edu

Sept. 22–24, '01; Take Your Bedroom Off the Grid; Arcata, CA. Hands-on workshop: How to install PV as your budget allows. By Johnny Weiss. Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884 redwood.alliance@homepower.com www.igc.org/redwood

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

Rebates for PV & wind. CA Emerging Renewables Buydown Program, CA Energy Comm., 800-555-7794 • 916-654-4058
CallCntr@energy.state.ca.us
www.energy.ca.gov/greengrid

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

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
Sept. 8–9, '01. 10th Annual IRENEW Energy Expo. Hiawatha, IA at Prairiewoods. Electrathon cars, straw bale constr., wind, solar heat, PV, & energy conservation workshops. Iowa RE Assoc. 319-875-8772 • studegh@earthlink.net

July 1–Sept. 31, '01; Iowa Electrathon season. Reg. US$44 incl. fees for all events, insurance, rulebook, manual, & newsletter subscription. Iowa Electrathon, Nora Johnson, CEEE, Univ. of Northern Iowa, Cedar Falls, IA 50614
319-273-7575 • electrathon@uni.edu

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

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

MARYLAND
June 12, '01. Bethesda, MD. Seminar on RE. Potomac Region Solar Energy Assoc. & MD/DC/VA Solar Energy Industries Assoc. 301-593-4752 • www.prsea.org

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

MISSOURI
June 3–5, '01; Energy 2001: Kansas City. Energy Efficiency Workshop & Exhibition • 410-997-0763
Fax: 410-997-0764 • energy@epponline.com
www.energy2001.ee.doe.gov

MONTANA
Aug. 20–25, '01; Biodiesel workshop, Max Farm, Superior, MT. Incl. biodiesel & straight vegetable oil. See "COLORADO" for SEI access
SEI Biodiesel Coordinator: David Max
zenfuel@yahoo.com

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

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

NEW MEXICO
June 10–17, '01: Build Here Now 2001, A Natural Building & Permaculture Convergence, Taos County, NM. Passive solar, natural building, permaculture, appropriate technology, PV systems, community building, chicken tractors, & more. By The Last Straw Journal, Lama Foundation, & Permaculture Institute. $495. Lama Foundation, PO Box 240, San Cristobal, NM 87564 • 505-586-1269 • Fax: 505-586-1964
resistrar@lamafoundation.org
www.lamafoundation.org • www.strawhomes.com
www.permaculture.org

July 18–20, '01. Albuquerque. Photovoltaic Systems Symposium. Experts discuss PV systems—what works & what doesn't. Sandia National Laboratories • 505-844-4383
cjbrook@sandia.gov

July 17, '01. Albuquerque. Workshop on PV & the *NEC* by John Wiles. US$35. Sandia National Laboratories • 505-844-4383
cjbrook@sandia.gov

Moriarty, NM. Workshops on RE, energy conservation, sustainable living, & energy independence. "Proffit" From The Sun,
505-281-1300 days • 505-832-1575 eves & weekends • proffit@flash.net
www.proffitfromthesun.com

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

NEW YORK
Tax credits. Info on grid connection & tax credits: NY State PSC,
www.dps.state.ny.us/photovoltaic.com

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

July 24–25, '01; Increasing Productivity through Energy Efficiency; Tarrytown. ACEEE 2001 Summer Study on Energy Efficiency in Industry.
rlunetta@erols.com • www.aceee.org

OHIO
Perrysville, OH. RE classes: 2nd Sat. each month. Straw bale class 3rd Saturday, through Sept. Solar Creations, 2189 SR 511 S., Perrysville, OH 44864 • 419-368-4252
www.bright.net/~solarcre

OREGON
Sept. 15, '01; Roseburg, OR. Alternative Energy Fair, Umpqua Community College.
dallasit@internetcds.com

EORenew Workshops, '01; John Day, OR. June 1–3: Simple Solar Water Heating, a hands-on installation workshop. July 25–27: Pre-SolWest workshop; Upgrade our office to solar! Hands-on efficiency & solar upgrade. July 30: John Day, OR. Post-SolWest workshop. How to instrument your system for continuous data logging. EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • info@solwest.org
www.solwest.org

July 28–29, '01; John Day, OR. SolWest Renewable Energy Fair. Over 80 exhibits, demonstrations, workshops, & "Tour de John Day" electrathon race. See above for EORenew access.

Sept. 8, '01; Seneca, OR. Oregon Tree Farmers of the Year. Sustainable forestry & sustainable living tour at Lance & Jennifer Barker's Morning Hill Forest Farm. See above for EORenew access.

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

June 4–Aug. 13, '01; Cottage Grove, OR. 10 wk. course researching & developing improved A.T. devices for NGOs in third world. Work on real problems, create original contributions. See above for Aprovecho access.

June–July; Energy Education Training. Locations in OR & WA. Classes: Addressing Residential Customer High Bill Complaints, Energy Auditor Training, Non-Intrusive HVAC Testing, Sizing Residential HVAC Equipment & Duct, Residential Water Conservation, Commercial Building Data Logging, Energy Management Certificate, Building Operator Certification, EZ Sim-Billing Analysis Software, Electricity from the Sun. Info: Northwest Energy Efficiency Alliance, Lane Community College, 4000 E. 30th Ave., Eugene, OR 97405 • 800-769-9687 or 541-988-4729
Fax: • 541-988-4723 • neei@lanecc.edu
www.nweei.org

Aug. 10–20, '01. Williams, OR. Adv. Permaculture Design Certificate Course—Keyline Water Management: A Whole Systems Approach. Become more competent designers. Cost: US$1,100. Seven Seeds Farm, 3220 E. Fork Rd., Williams, OR 97544 • 541-846-9233
sevenseeds7@hotmail.com

RHODE ISLAND
Energy Co-op is being organized to provide RE, energy efficiency & conservation services, & group purchases of "Energy Star" appliances & related products. Erich Stephens 401-487-3320 • erich@sventures.com

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

TEXAS
Sept. 28–30, '01; Texas RE Roundup, Fredericksburg. Exhibits, demonstrations, workshops, tours. Texas RE Industries Assoc. & Texas Solar Energy Society, PO Box 9507, Austin, TX 78766 • 512-345-5446 Fax: 512-345-6831 • R1346@aol.com www.renewableenergyroundup.com

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

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

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

VERMONT
June 1–22, '01; Sustainable Design, Building, & Land Use; Plainfield, VT. Explores history of ag., social ecology & design, organic ag., appropriate technology, alternative building, permaculture, ecological restoration, more. Institute for Social Ecology • 802-454-8493 • www.social-ecology.org

July 11–14, '01; PV System Installation: A hands-on, how-to installation to supplement distance learning with practical hands-on skills. SóL, PO Box 217, Carbondale, CO 81623 Fax: 559-751-2001 • SoL@SoLenergy.org www.SoLenergy.org

July 14–15, '01; SolarFest: Energy Fair & Solar-Powered Music Festival; solar energy workshops, sustainable living exhibits, music, children's activities, more. Middletown Springs, Vermont. 802-235-2050 • wwwsolarfest.com

WASHINGTON, DC
June 3–7, '01; Windpower 2001: Annual meeting of the American Wind Energy Association. Grand Hyatt. AWEA, 122 C St. NW Suite 380, Washington, DC 20001 • 202-383-2500 laura_keelan@awea.org • www.awea.org

WASHINGTON STATE
Energy Education Training, locations in WA & OR. See OR entry for info.

Oct. 11–14, '01; Guemes Island, WA: Microhydro workshop. Class & labs followed by tours, incl. Canyon Industries, turbine manufacturer. US$400. See "COLORADO" for SEI access • Local coordinator: Ian Woofenden, PO Box 1001, Anacortes, WA 98821 360-293-7448 • Fax: 360-293-7034 ian.woofenden@homepower.com

Oct.15–20, '01; Guemes Island, WA: PV Design & Installation workshop. Site analysis, system sizing, equipment, appliances, demonstrations, lab exercises, & a complete hands-on installation. US$550. See "COLORADO" for SEI access. See above for local coordinator.

Oct. 22–27, '01; Guemes Island, WA: Build Your Own Wind Generator workshop, with Hugh Piggott of Scoraig Wind Electric, Scotland. US$550. See "COLORADO" for SEI access. See above for local coordinator.

WISCONSIN
Amherst, WI. Midwest Renewable Energy Association (MREA) workshops. June 10, Solar Water & Space Heating; June 11–15, Utility Intertie Wind Installation; June 16–20, Advanced PV installation. Call for cost, locations, instructors, & more info. Significant others half price. MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 Fax: 715-592-6596 • mreainfo@wi-net.com www.the-mrea.org

June 22–24, '01; Renewable Energy & Sustainable Living Fair (MREF), Amherst, WI. Exhibits, workshops, & demonstrations. The best fair. MREA, 7558 Deer Rd., Custer, WI 54423 715-592-6595 • Fax: 715-592-6596 mreainfo@wi-net.com • www.the-mrea.org

June 23, '01, Amherst, WI. Xantrex Technology Inc. invites dealers to open house discussion forum at MREF after show hours on Sat. Space is limited, stop by Xantrex booth for invitation.

the Wizard speaks...

Population and Resources

Overpopulation and overuse of resources is the greatest potential danger for the environment. As population rises, so does the use of resources. It can take thousands of years for these resources to be recycled back into the environment. Thus, the present resource base of the planetary ecosystem is continually being depleted.

There are only two solutions to this situation, and both must be applied. The first is population control. Population must be greatly reduced. This will slow down environmental degradation. However, to actually reverse the trend, population control must be combined with resource recycling.

The aim here is to get as close to one hundred percent recycling as possible. In this way, resources can be continually returned to the environment in a useful form. Or they can be reused, instead of taking new resources out of the environment. Combined with population control, this process will regenerate the ecosystem and keep it operating at an optimum and stable level.

We cannot continue with “toilet to ocean” and “wastebasket to landfill” practices. We cannot take more than a certain amount of total resources out of the environment without any replacement. We are courting ecosystem collapse if we do. These two complementary solutions can be achieved if the will to implement them exists. If not, so be it.

Adopt a Library!

When Karen and I were living with kerosene lamps, we went to our local public library to find out if there was a better way to light up our nights. We found nothing about small scale renewable energy.

One of the first things we did when we started publishing this magazine thirteen years ago was to give a subscription to our local public library.

You may want to do the same for your local public library. We'll split the cost (50/50) of the sub with you if you do. You pay $11.25 and Home Power will pay the rest. If your public library is outside of the USA, then we'll split the sub to your location so call for rates.

Please check with your public library before sending them a sub. Some rural libraries may not have space, so check with your librarian before adopting your local public library. Sorry, but libraries which restrict access are not eligible for this Adopt a Library deal—the library must give free public access. — Richard Perez

To Adopt a Library write or call

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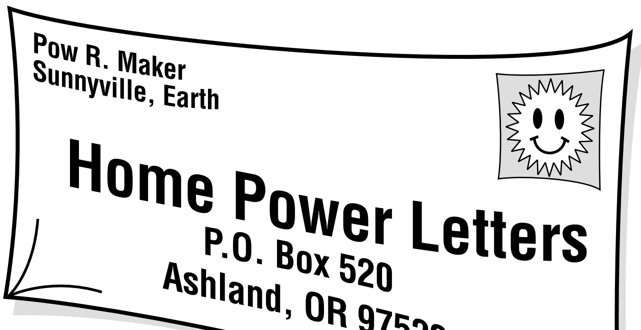


Flex Your Power

Hello, I am writing to offer my thoughts and ideas on the current energy crisis. It seems to me that our energy "crisis" is more of an inflammatory campaign designed to make consumers and "ratepayers" receptive to the idea of bailing out the failed utilities. This is ironic because I believe the utilities have not failed; they have succeeded in taking taxpayer money to pay their debts. Shame on all those members of our government who support this idea, and have responsibility for acting in "our" interests.

Over the past couple of years, I have educated myself about renewable energy. I have taken advantage of California's Emerging Renewables Buydown Program, by installing a 1 KW solar array on my rooftop, as well as small wind turbines. In addition, I have replaced all appliances and lighting with the most energy-efficient models possible. I did all of this on my own, and long before the current "crisis." California did not spend much, if any, money or time to make people aware of the buydown program, or renewable energy in general. I believe only about ten percent of the *taxpayer* money that was set aside for this program went to consumers. The rest went to the utilities. From what I read, see, and hear, these imbalances obviously persist.

The current "Flex Your Power" marketing campaign (funded by yet another minor percentage of public funds with the majority going to utilities) is a positive step in the right direction, but weak in its approach and message. California should allocate *much* more of the money we are wasting on bailing out the utilities and cleaning up their mess, on aggressive programs to educate people. People should learn how they *can and should* harvest some, if not all of their own energy from the sun and the wind.

We should provide education and funding in the form of tax credits and additional buydown funds (simply take it from the money that would otherwise have gone to the utilities). Create a program that gives every registered voter a compact fluorescent bulb or two or three or…as many as the state can afford with the billions we are *giving* to energy producers outside of our state. Focus on conservation and reducing demand overall, not just during peak hours as the pathetic Flex Your Power commercial suggests. It suggests that we clean our dirty socks at night, further adding insult by suggesting that somehow this will prevent young schoolchildren from having to sit in the dark during class time! Please.

If the elected and appointed officials of this state would open their eyes to the path of renewable energy, and the immediate gains in aggressively reducing demand, the so-called crisis could turn into a glorious epiphany for all. We would not appear as scared children admitting we made a mistake and backpedaling on past decisions. Not only does that scream weak leadership, but it very much negatively impacts voter confidence in the decisions made by our government. From an environmental standpoint, the appeal of renewable energy is tremendous, and we would not have to relax our environmental regulations as our little shrub in the White House has suggested.

From an economic standpoint, California is home to several manufacturing facilities that would boom, thus allowing California to lead a second round of silicon-based economic growth. This could potentially create tens of thousands of jobs in the process (raw materials acquisition, manufacturing, installing, and maintaining, among many others). Then the rest of our country can again point to California in admiration, rather than mocking our situation. Success in the face of strong adversity is the proudest accomplishment our government can attain regarding the energy situation here. Not to mention the huge amount of well-deserved respect that would be earned for the current administration.

Let's give the power to the people, not to the corporations and utilities. If Californians independently produced some or all of their own energy, and demand was significantly reduced, power generators would be begging us to consume more of their dirty power by bringing the rates down sharply. Californians would be negotiating from a position of power, rather than the sad, weak, powerless position we are in. Moreover, the "not in my backyard" buzz would backfire in the face of power generators, who have thrown that statement in our face at every opportunity in an attempt to redirect blame for our current situation. A new battle cry from consumers/ratepayers will be, "Yes! In *my* backyard…on *my* roof. I want responsibility for *my* energy production and *my* consumption." Let the utilities take responsibility for running a business on reality-based profit and loss.

As a final note, I would like to say that recently I have noticed there is an additional charge on my PG&E bill labeled "Emergency Energy Procurement Surcharge," or something to that effect. I want to make a clear statement on how I feel about that new line item: "I have not, nor will I ever, pay this charge." Enlightened and empowered in California, Gerry Blau, gerry@andnow.net

Hello Gerry. Thanks for your good critique, which echoes what I've heard from many other readers and our own crew. One idea stands out—Californians should join you in exercising their right to civil disobedience by refusing to pay the bailout costs that show up on our bills. Thanks for that wonderful idea—let's get a movement started.

Just after we received your letter, one of the world's largest investor-owned utilities, PG&E (aka Pacific Greed & Extortion) filed for Chapter 11 bankruptcy in the courts. The day before filing, they distributed about US$50 million in bonuses to their management. It's too late for us to delve into their shenanigans in HP83, *but you will be reading about the effects of this in the next issue of* Home Power. *Michael Welch*

California's Energy Crisis: Bankruptcy, Smoke, Mirrors, & A Few Happy Campers
[Ed. note: This was originally submitted as an article after our deadline, but we and the author felt that it was timely enough to publish in the *Letters* section of this issue.]

"We take the risk if our costs go up," acknowledged Gordon Smith, Pacific Gas & Electric's (PG&E) chief executive in 1997, referring to AB1890, the law that restructured California's then US$23 billion power market (quoted in a *San Francisco Chronicle,* article, January 22, 2001). That didn't stop PG&E, or the other investor-owned utilities (IOUs), from pleading their case to Gov. Davis and state legislators when wholesale prices started to climb through the roof last summer, while retail rates for the customers remained frozen in time.

More than any other special interests, PG&E and Southern California Edison shaped AB1890, a 100-page-long law that restructured California's electricity market. The law's most generous financial provisions delighted both investor-owned utilities. Each reaped US$10 billion in profits between 1998 and April 2000 due to provisions that allowed them to charge ratepayers for past debts under a compressed schedule.

AB1890 delivered billions in revenues to PG&E's parent corporation, yet sank the distribution company—all that was left of their previous monopoly—on April 6th, as the difference between wholesale and retail rates reached US$9 billion. Despite all of the effort by Gov. Gray Davis and state lawmakers to keep PG&E afloat, the utility still turned its fate over to a federal bankruptcy judge. This move could help the level of rate increases in California rise from the 40 percent approved by the California Public Utilities Commission (CPUC) last April to as high as 100 percent!

There is no doubt that these developments have been great for business for vendors of solar, wind, and other small-scale renewable energy systems. Orders for solar and wind-electric systems have jumped in 2001. Bergey Windpower sold forty units in January. That compares to total sales of six in 2000. Joe Guasti sells small wind turbines to folks who live in the hills near San Bernardino. "I've been overwhelmed," he proclaimed. "People are really getting concerned about the energy situation, and they are tired of being at the mercy of the power company. After conservation, a small wind-electric system is their best way to further insulate themselves from these rate increases," said Guasti. In Sacramento, Solar Depot reports brisk sales of PV systems. "I have 20 to 25 customers who are serious about purchasing a system. If the crisis continues, we will see more people pay attention to alternative energy," commented Roy Mizany, vice president of Solar Depot.

According to Sandy Miller, an economist at the California Energy Commission, applications for buydown funds (which can cover up to half of the cost

Escalators work with or without the blackout.

of a grid-connected solar or small wind-electric system) in January and February have already topped the application totals for all of 2000! The amount of capacity added to California's grid during the first two years of the energy commission's buydown program has been less than 3 MW. This is a drop in the proverbial bucket, when you consider the state is desperately seeking to add 5,000 MW to the state's power supply this summer.

The rise in wholesale and retail electric rates boosts business for small renewable systems in the short run. Over the long haul, however, the approach being taken by Davis and his colleagues in Sacramento poses perils for a sustainable future energy supply.

The state government has entered the power business and has taken the unprecedented step of buying electricity to keep PG&E and Edison afloat. The open-ended taxpayer tab for purchasing power at record-high prices will require the largest public bond issuance in state history. Estimates of the taxpayer bill for the solutions enacted by the Davis administration (with the help of the California legislature) could easily exceed US$70 billion. This would lock Californians into power purchases from out-of-state companies peddling high-priced electricity generated by fossil fuels for years to come.

Enron, Reliant, Dynegy, and El Paso Natural Gas all hail from Texas. These good old boys are raking it in, transferring billions upon billions of dollars from California residential consumers into the pockets of Texas corporations. With George W. in the White House, chances for enlightened leadership at the top are dim indeed. And with IOUs still largely calling the shots at the public utility commissions and state capitols, it is no wonder that many communities and individuals feel powerless.

As rates climb and California endures what the California independent system operator predicts will be 34 days of rolling blackouts, growing numbers of residents, businesses, and local governments may well investigate installing new solar and wind-electric systems. Yet even today, the influence of entrenched special interests on the political process continues to sabotage a long-term, stable market for the very technologies that offer the most logical answers to an unreliable grid.

The state's three IOUs, which include San Diego Gas & Electric, contributed nearly US$4.2 million in campaign contributions to state office holders, parties, and other political causes in 1999–2000. They also invested US$5.9 million in state lobbying activities. These political investments may explain why some of the most logical solutions to the power supply crisis in California—namely renewable distributed generation technologies—are barely in the mix of policies Governor Davis and state legislators are pushing as the answers to the supply crisis. Locking into long-term power purchase contracts with fossil fuel captains from Texas, and accelerating the siting of scores of new natural gas plants, tilt California in the wrong direction.

The California Solar Energy Industries Association (Cal-SEIA) gave zero campaign contributions in the 1999–2000 election cycle. They invested a mere US$34,000 in state lobbying during the same time period. The amount of state funds that have flowed to the solar energy industry since deregulation so far is less than US$10 million.

One of the prime incentives for California residential consumers to invest in grid-connected PV systems is the current state law that allows them to sell electricity they can't consume on-site back to the utility grid at attractive retail rates. These sales are commonly referred to as "net metering" because your meter literally runs backwards when you sell your solar energy back to the utility.

This opportunity to offset one's ever-increasing utility bill has been restricted to systems 10 KW in size or less. Language included in ABX1 29 by Christine Kehoe (D-San Diego) raised eligibility to systems one hundred times as large—1 MW. While one would never see a residential grid-connected or off-grid system that large, this change in the law would provide incentives for large-scale solar-electric systems on the rooftops of businesses. In these times of supply shortages, why limit solar energy systems in any way at all?

Language in the legislation would also remove a completely arbitrary cap on solar net metering sales. Because of this law, California consumers cannot sell back more than a tenth of single percent—a total of 50 MW—of the entire state's peak electricity needs from electricity they generated from any source on their rooftops and backyards.

ABX1 29 was also purported to finally remove yet another obstacle to widespread reliance upon solar energy. Among the artifacts of the previous monopoly era of regulation are so-called "standby charges." The idea behind them was to cover costs associated with the utility providing electricity if a private power plant tripped offline for maintenance or other reasons. These charges are still being imposed today, and can add up to more than US$7,000 annually on a 100 KW solar-electric system. Five proposed installations of PV at U.S. Post Offices in the service territory of Southern California Edison were abandoned because of these utility charges.

The only special interests opposed to the three changes in the state's solar energy policy—increasing eligibility for net metering to systems up to 1 MW, removing a cap on solar energy net metering sales, and removing standby charges—were PG&E and Edison. On April 3rd, new amendments to ABX1 29 suddenly appeared. Under the revised bill, the three changes would still go into effect immediately, but they would be repealed at the end of 2002! At that point in time, California would go back to limiting our consumption of solar energy by reinstating standby charges, the 10 KW cap on eligibility for net metering, and the 50 MW limit.

What makes this abrupt about-face even more insidious is that the prime message Cal-SEIA tried to convey to state lawmakers was the need for consistent and *long-term* policies to build momentum and manufacturing capacity. The signal sent by this new law reinforces the stop-and-start inconsistency that has marred U.S. state and federal energy policies over the past few decades.

Why does sunny California, of all places, limit our reliance upon on-site grid-connected solar and wind energy systems? Utilities don't like the idea of consumers becoming empowered by their own independent sources of electricity. They may complain about how much the owners of their former fossil fuel power plants are gouging them, but they would just as soon not see small renewable energy generators popping up throughout their distribution grids. Even if this seems to be the natural evolution for a power market plagued by blackouts, short on supply, and blessed by ample renewable resources that could generate an additional 10, 20, or even 30 percent of California's current total electrical energy supply.

It is time for Governor Davis to recognize that the distribution system is where state investments show flow. Davis could help transform California's grid into a world-class example of innovation featuring solar, small wind, fuel cell, and clean distributed generation and storage technologies.

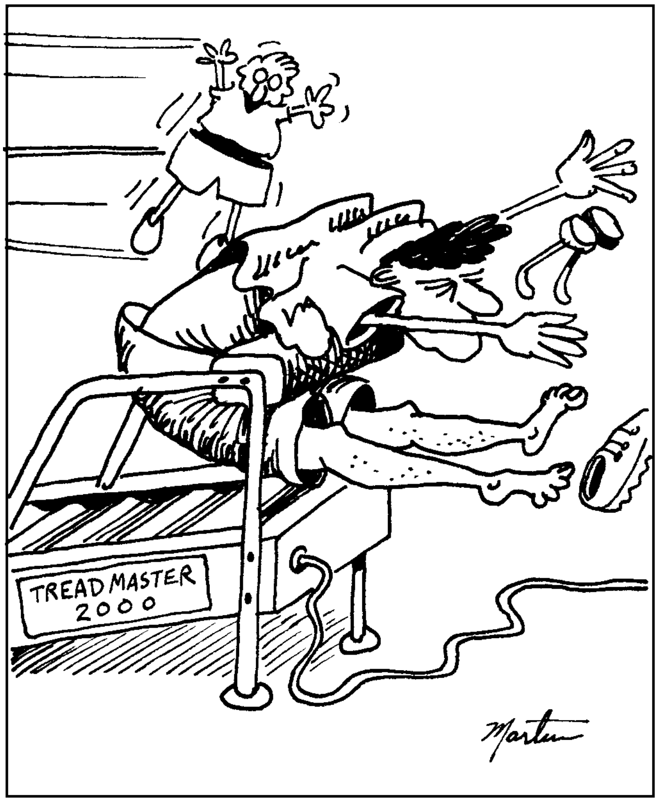
California could shift to a power supply system that is flexible, agile, and clean. The proposals dominating discussions in Sacramento today could freeze California in time, locking out the real long-term solutions being offered by domestic innovative clean energy firms that are just starting to see their business improve because of the power crisis.

The clout of deregulated power suppliers hailing from Texas needs to be put in check by broadening the market in terms of more buyers and more sellers. This power crisis represents an opportunity to encourage innovation, more local control, greater accountability—not monolithic responses that freeze us into long-term commitments that may very well foster bailout after bailout.

California can solve this energy crisis without increasing air pollution, without sending billions to out-of-state generators, and without worrying about what natural gas prices are going to do over the next few years. The answer to our electricity supply challenge lies in our very own backyard with renewable energy, a source that consumers have always identified as their favorite. Peter Asmus • pthfind@ns.net. Peter is author of *Reaping The Wind,* and *Reinventing Electric Utilities,* both by Island Press.

Boiled in Hot Water

Dear Richard Perez, I was surprised at your advice to Jim Thomas (in the *HP82 Letters* column) concerning radiant floor heat. You advised, "Go with a propane or natural gas-fired boiler for backup"—even though an article in the same issue by Dan Chiras described the pitfalls of using a boiler in a house with home-generated power. Dan explained that his state-of-the-art boiler was an electrical hog, drawing 266 watts. It had to be removed from his house, and replaced with a more appropriate source of hot water, a gas-fired water heater. For more information on using a water heater (instead of a boiler) to provide heat for a house with



Blackouts at the gym.

radiant floor heat, see an article posted on the Web: www.jlconline.com/jlc/archive/energy/water_heater_heat/index.html.

Boilers are designed with certain assumptions, one of which is that it's important to conserve fossil fuel, but it isn't important to conserve electricity, because "electricity is cheap." Partly, this is a result of the way energy efficiency for boilers is usually calculated; electrical usage is usually not factored in. And partly, this is because of the fact that for most Americans, electricity really is cheap, because of various government subsidies. Appliances designed for off-grid use must factor in the cost of alternative electricity. For example, most gas-powered clothes dryers are designed to tumble the clothes for five minutes after the gas burner turns off, to try to extract every last BTU from the steel drum. But those who live off the grid, where propane usage is of less concern than electrical usage, would rather have a dryer stop wasting electricity when the gas burner goes off. (It should go without saying, of course, that the best way to dry clothes is to use a clothesline, not a dryer.)

By the way, I like your masthead, which lists "people," without any titles. Sincerely, Martin Holladay, Sheffield, Vermont • holladay@sover.net

Hello Martin. There are relatively efficient propane boilers that use only small amounts of electrical energy. In any case, this is a backup source. If the solar portion of the system is well designed, then the home will rarely have to resort to the backup heater. I agree with you on the clothesline—it's what we use here—we have no clothes dryer. Richard Perez

No-Phantom GFIs

Dear *Home Power,* After the last month's publication of my article on phantom loads (*HP82,* page 40), I've been told by Scott Jochim, an electrician who specializes in renewable energy, that Leviton GFIs (Model 801-6599) have no phantom load. I installed one the other day, and sure enough, he's right. This adds another strategy for those who want to cut down on phantom loads to optimize an RE system: install Leviton, non-LED GFIs. Interestingly, Trace publishes a list of acceptable GFIs in their inverter manuals. Best wishes, Dan Chiras danchiras@qwest.net

More Phantom Info

Kudos to you and your authors. As usual, another fine issue. Dan Chiras' control of plugged-in phantom loads might also be approached by making more extensive use of remotely switched outlets. Some houses use conveniently located wall switches to control table or floor lamps located elsewhere in the room. Double-gang boxes can hold four outlets—one pair switched for lamps, the other switched for a stereo or TV. For ground-fault protected outlets, double-gang boxes can hold both the outlet and a switch. Even 220 V outlets, such as for an air compressor, can be switched by using a DPST wall switch. Retrofitting is feasible if you have the right "fishing" gear, but of course doing it before the walls are covered is easiest. Costs are minimal compared with using a lot of all-in-one single-gang switched outlets, although those install more easily because existing single-gang boxes can be used.

Mechanical timer switches can be useful wherever it is not convenient to manually turn off the outlet, such as for a bedroom TV. They are commonly available in a variety of durations. We use an Intermatic twelve-hour switch to run the house ventilation fan for from thirty minutes to twelve hours, and it has worked great for ten years. Mechanical timers can also be used to eliminate arguments that might begin with, "Why can't you just remember to turn off the…"

Peace and harmony! Keep up the great work! Jerry Borshard, Plano, Texas • jcborshard@intermedia.com

Get Real

Michael Welch's *HP82 Power Politics* column on the new energy department opens with Ralph Nader's dubious rationalizations that Al Gore's loss to George Bush was his own fault. That may be his view and that of some others who supported Nader. My view, and one Mr. Welch and others who voted for Nader should consider, is that Nader was merely a protest candidate who had no chance to win. Whatever the reasons (perhaps Bill Clinton and Monicagate more than anything else), the 2000 presidential race was a very tight election, and Nader and his supporters handed the election to George Bush.

This is not to say that people who feel strongly for a particular candidate shouldn't vote for who they want. But they should not thereafter delude themselves as to the consequences of their actions and choices. Nader and his supporters should have considered what the long-term repercussions of helping to put Bush into the White House would cost the nation and the world.

Those who profess to care about the environment and renewable energy, not to mention social justice, future Supreme Court appointments, and a multitude of other progressive issues, lost an opportunity to at least hold the status quo, if not make additional improvements.

Mr. Welch rationalizes that Bush's election may carry a "silver lining" because it "may give a solid boost to the environment, energy conservation…and renewable energy," or will cause a "small resurgence of volunteers, memberships, and donations for environmental non-profit organizations." This appears so naive as to be as disingenuous as stating, “we had to bomb the planet in order to save it.” Bob Yoesle, Bickleton, Washington ryoesle@bentonrea.com

Hi Bob. Thanks for your note. Your opinion is respected (and we will even print it!). Lots of folks agree with you, and just a couple of years ago, you could have counted me in that category. But not anymore. U.S. environmental and social justice issues are a mere drop in the bucket compared to the international damage that will be done by Bush or would have been done by Gore. Unless we finally do something about corporate meddling in the rest of the world, our environment is doomed. Neither Bush nor Gore are up to the job. Compared to the potential, the differences between Bush and Gore are merely a blip on the radar screen. Michael Welch

Cool Tube

Richard, I found this great television and thought you would want to tell everyone. It is a Phillips Magnavox, 19 inch, model #19PR21C1, and it works great on a Trace U2512 inverter. My old television would come on at high volume after it was completely turned off to avoid the phantom load. This television does have a phantom load of 19 watts, but the volume is retained at normal load and the memory is also retained (the pre-set channels). The best part is that when the television is turned on, it does not tell me there was a power outage and request me to input new settings such as the clock and the channels. Except for the phantom load, this television is solar-friendly and less than US$150. Gary Gneiting • ggneiting@qnet.com

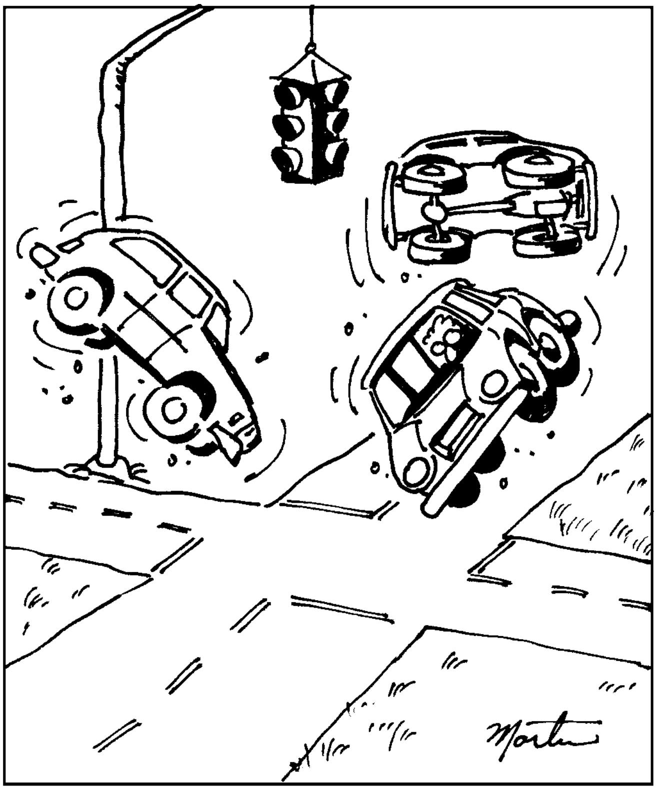
PV Payback

Dear *HP,* I would like to thank you all for your efforts in putting together such an informative and interesting resource. Since I was a kid, I have been amazed and intrigued by that “big burning mass of gas and matter in the heavens.” I felt it was more important than any of us realized at the time. With your publications, I continue to learn more about the products and the people that make utilizing such a free and impressive resource a reality. I would also like to thank everyone (staff and readers alike), for the honesty and willingness to note troubles as well as alternative solutions.

My question involves an article from *HP80* entitled, “PV Payback.” First I would like to thank Karl Knapp and Theresa Jester for their efforts and analysis. I’m pleased to hear about the quick energy reimbursement period. I do question, however, when totalling the amounts of invested energies for each individual component of a typical RE system, just how long it could take for the energy gains from, say, a solar array, to produce enough power to overcome the system’s invested total. If power gains were not to reach over the invested total for the system over the service life of that same solar array, you’ve actually utilized an RE system that has you forever trying to out-generate invested conventional energy. I don’t mean to sound negative, but it’s just a question I asked myself as I pondered RE implementation.

Thank you again for your efforts and sharing of thoughts, ideas, and visions. Free energy is all around us, but it’s surprising how few people can utilize it. Sincerely, Chris Darul, Vermont • re42@sover.net

Hello, Chris, If I understand the question correctly, you are interested in knowing about the energy balance of the entire system. The answer to this varies substantially depending on the specific installation details. But based on the literature we reviewed in preparing for our analysis, batteries can add a lot (two to three years), depending on how long they last. Inverters do not add much—less than a year. And mounting structure components add six months to a year for most basic systems (this component seems to vary the most from site to site). The structure can have very low energy and materials requirements in building-integrated PV applications (even negative, due to other materials that may be displaced). Some new innovative strategies also save energy by incorporating building insulation as part of the structure.



Blackout bumper cars.

We would welcome the opportunity to conduct an analysis of total systems, but have not pursued finding someone to support the research. There appears to be sufficient information in the literature to piece together a range of something like four to eight years for energy payback for PV systems, including all losses and balance-of-system components. The PV industry continues to drive down the cost not just in dollars, but also in energy and materials requirements. Some of the improvements being made were highlighted in a recent IEEE paper presented in Alaska. This (and a few other papers) are posted on the SSI Web site at www.siemenssolar.com/Energy_paper_index.html. I can provide a bibliography to back up my summary here to any interested reader on request. Karl Knapp karl_knapp@city.palo-alto.ca.us

3 KWH Per Day

Dear *Home Power* crew, I am responding to the letter by Andy Swingler from the the *HP81 Letters* section. I agree with his conclusion that most people can exist on 3 KWH per day. I just think a few points need comment. In his load analysis, I did not see mention of a refrigerator/freezer. This one "necessity" of modern life must be included in any load analysis. Keeping food cold is probably the largest energy draw in our energy efficient home (about 45–50 KWH per month). To move refrigeration to natural gas or propane is unreasonable for the average American. Therefore, his calculation may require some tweaking.

As I read *Home Power,* I am amazed by how much sun other parts of the country appear to receive. Large bodies of water such as Lake Ontario often create significant cloud cover. Solar technologies do not work well in the winter where I live. We just spent our first winter in our energy-efficient home that uses passive solar as one of three heating sources. Because of the passive solar part of the design, I was very aware of available sun. During the four months from November through February, we averaged one day of sun per month and maybe two to three days per month with sun for one to three hours. The rest of the time it is usually hard to tell where the sun is in the sky due to all the cloud cover. Approximately one million people live in this county. There are many other people who choose to live along the southern shore of Lake Ontario and the four other Great Lakes. Therefore, you have millions of people who cannot use solar technologies to meet their energy needs. The solar calculations of Mr. Swingler may work well for some parts of the country, but his premise must be changed for places similar to where I live.

We rely primarily on wind power to remain off the grid, with a solar boost during the generally sunny summer months. Our wind resource is not great, but moderate. Therefore, we have to rely on a larger turbine than other areas of the country may need. The cost for our 3 KW turbine, 105 foot tower, four solar-electric panels, batteries, inverter, wiring, etc. was approximately US$20,000. This cost does not include the 9 acres of rural land we had to purchase or the many month struggle we had to go through to get the turbine approved against the neighbors' objections. There is no way the vast majority of Great Lake region inhabitants could afford the renewable energy costs.

As I stated previously, I do believe most people on this planet can live within the 3 KWH per day range. Will they? Only when forced. In our home of two adults, one child, two dogs and a cat, we average 180 KWH per month in the winter and 120 KWH per month in the summer. The average energy consumption per household in Rochester, New York is 600 KWH per month. As I look at my neighbors, I doubt many of them would change their energy pattern. Why should they? The cost of electricity is a miniscule part of their income. The environmental issue is not their concern at this time. Fifty percent of Rochester's electricity comes from a nuclear power plant that is ten miles from my home. Thirty percent comes from a coal-fired plant. Do most people care?—No!

Do I feel the energy conservation and renewable energy fight is hopeless?—No! In addition to reducing my energy usage footprint on the planet, I hope my example will spur others to consider alternatives. Our governments (and populace) are not yet ready to reduce energy consumption. In their minds, reducing energy use means stagnation and a hurting economy. The grassroots approach espoused by our *Home Power* leaders (including pestering government officials) seems our best bet at this time.

This long-winded tirade was mainly started to remind people in other ecosystems that the methods of energy production that work for them will not work everywhere. It is not intended to slight Mr. Swingler in any way, just to remind people about the complexity of the problem. I suspect most *Home Power* readers cannot fathom living in a place where the sun is rarely seen. Douglas Stockman, N2ZYE • dstockman@pol.net

Mr. Stockman should be commended for the installation of his family's RE system. It is very true that the level of available daily solar insolation varies greatly with geography. I live in Vancouver, BC, Canada, where the sun also rarely makes an appearance in the winter months, so I can confirm the validity of Mr. Stockman's concerns.

Mr. Stockman's concern is not with the availability of the solar resource, or even the wind energy. It is with the *relative economics of harvesting this energy to meet his family's small energy requirements. I am writing this sitting in a café in central China, and there are millions of people around me who happily do with much less than 200 KWH of electricity per month, simply because of the economics. I suppose one could argue that economics is the forcing effect that Mr. Stockton mentioned.*

I do have an idea on how to address this economic problem. The solution lies in business and marketing. It's the same ultrapowerful force that as a society makes the brand of shoes on our feet or the value of our cars define our level of enlightenment. Surely if someone can convince us that spending $50K on an SUV is a good idea, then it must be possible to step up the cool factor of RE technology.

Consumers love to possess the latest technology, especially if it is marketed properly. I know many people view the grassroots approach as Joe solar hippy exchanging with Sue solar hippy wannabe. This almost has a reverse marketing effect as, sit down for this one, a significant portion of our society doesn't think "enviros" and "hippies" are really that cool. It is evident that only a small section of society wants to follow this lifestyle, while the majority follows the corporate marketing propaganda.

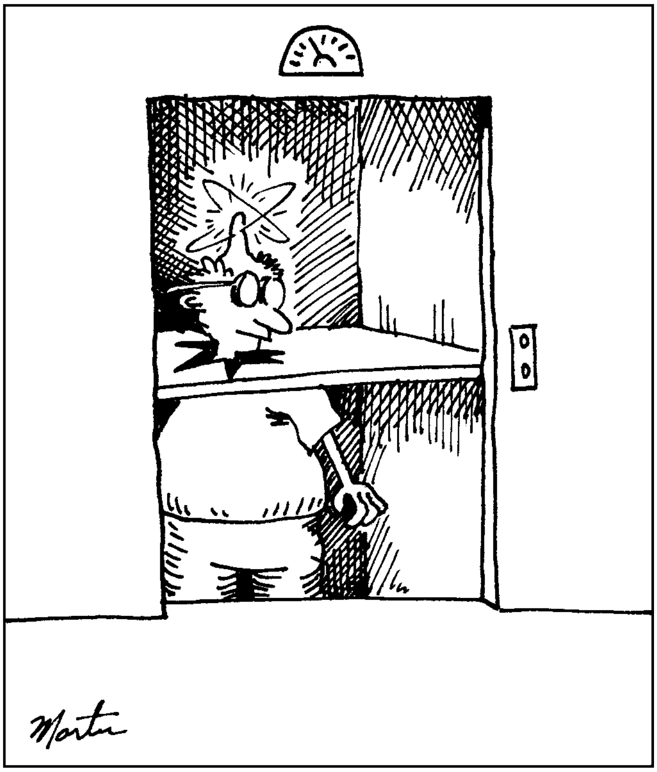
So the answer is to simply play with the big boys. Don't sell the technology based on its environmental or economic benefits; Nike has proven that this simply is not necessary. Hype it up. Make it the in thing. Get a few solar collectors on your house, jump in your BMW, and go brag to your friends so they get some and brag to their friends. The key thing is that the technology has to be reliable and effective for the benefits to be long term. With my business, I am still feeling the effects of bunk solar installed in the early '80s.

My new RE company is focused on the most cost effective and life sustaining area of sun energy—warmth, aka solar thermal. We specialize in importing and distributing ultra-efficient and high performance evacuated tube solar collectors. The key point to our marketing strategy is that our products work. No BS. Our sales pitch is simple: We physically demonstrate that even in low sun conditions our heat pipe tubes make significant heat. This is usually enough to surprise a few people as they quickly remove their fingers from the hot manifold.

Then we sell the "cool factor." People seem to be easily convinced that they want to be the first on their block to have the latest technology, especially when it can be prominently displayed on the roof of their home for all to see (the glass evacuated tubes look pretty neat). Then the issue of economics arises. Our products seem to have an economic payback of about 10 to 15 years at today's energy prices. While this is not attractive from an investment point of view, it is six of one (gas or electricity) compared to half a dozen of the other (the new cool solar tech), when all the math is complete. Furthermore, it makes much more economic sense than the $50K SUV. So, now we have happy customers who are "enviros" and don't even know it. They just think they are cool. Andrew Swingler, SwingSys Technologies • andys@ece.ubc.ca www.swingsys.com

Guerrilla Solar Rogues
Richard, I get a kick out of your masked sunmen. As far as I'm concerned, they should all be lined up to pose for statues for a federal park as modern American heroes. George Heiner, Sierra Vista, Arizona gheiner@starband.net

Wisconsin Needs Global Warming
To the editor of *Home Power,* I've been pondering the issue of Bush and his cronies' plan to tap the oil reserves in Alaska, and I've come to the following conclusion: Let 'em. In fact, let's just suck all of the oil out of the ground as quickly as we can. Encourage people to drive gas guzzling SUVs. Tell all your readers to go back on the grid and turn on all their lights. Keep the hot tub heater turned up as high as it will go. Get rid



Blackouts gave Pat a new perspective on elevators.

of those energy saving appliances and go back to the electric hogs. Buy off-road ATVs and jet skis and snowmobiles. Let's use up all of the gas and oil and coal as fast as we can.

Those reserves sitting underground are just driving all those oil and gas execs crazy. Why save them when profits can be made now? Many folks don't see the need to conserve when all those fossil fuels are just sitting in the ground not doing anybody any good. Why save them for the future when we can use them right now to gas up the old SUV? Some people can't have any cash in their pockets without spending it, and some folks can't have any fossil fuels in the ground without wanting to suck them out.

So I say, use up all the fossil fuels as fast as possible. The faster they're gone, the sooner we'll all have to revert to renewables. Once all the fossil fuels are gone, they'll be gone. No going back. No excuses not to develop new renewable technologies.

Oh, I know there are a few drawbacks to my plan. We may all choke on the emissions, and global warming may be a problem. But I live in northeastern Wisconsin, and we could use some global warming up here. And the good part of global warming is that if the ice caps melt, the level of the Great Lakes will rise. Right now I live eight miles from Lake Michigan. I'm hoping for lakefront property soon.

My idea could be the biggest boon to renewables since energy credits. So I say, "Let's start drilling!" Lynn Sagrillo, Forestville, Wisconsin • sagrillm@uwgb.edu

Hello Lynn. Your concept has obvious merit. A concrete fact, baldly true, just on the face of it! You are truly one of the last great Gothic thinkers! I could use beachfront property too.

Your concept reminds me of when we were trying to stop the war in 1966. The concept was to vote Republican, and accelerate the revolution. It didn't work, but it sure made us laugh. Richard Perez

Solar Spirits

This is an open letter to all people involved in the energy arena, whether it be fossil fuels, renewables, efficiency, fuel cells, or Stirling engines. I hope it will stimulate discussion about the direction we are headed with our industry. I see clearly that while all concerned have good intentions, pursuing the goal to supply more energy or even to maintain the current level of consumption will result in dire consequences.

For the first 199,000 years of human civilization, the population never exceeded one billion people globally. During the last one thousand years (1/10 of 1 percent of human history) we have increased by another five billion people. The sudden population explosion coincides with the discovery of coal (900 years ago) and then oil (140 years ago). Before the advent of coal and oil, human populations were always limited by the amount of energy that plants could absorb from sunlight (photosynthesis). Reproduction and survival, fundamental factors in population growth, directly correlate with the amount of plant food (and animals feeding on same) available in a given area. We refer to these food resources as being a result of *current sunlight.* This balancing factor worked well for tens of thousands of years, maintaining a stable human population size.

Enter the discovery of ancient *sunlight energy* in the form of coal and oil, which are essentially fossilized sunlight. With these concentrated energy sources, humankind progressed rapidly in the areas of agriculture and technology. Tools and machinery enabled humans to clear and cultivate more land to feed greater numbers of people. Radically increased production led to an unprecedented population explosion. Human numbers, remaining under a billion for our first 199,000 years of civilization, doubled to two billion in 850 years, and reached 3 billion in just another 100 years. We now add another billion people every 12 years to an already strained ecosystem.

This rapid and dangerous growth rate is tied very closely to the discovery of vast reserves of *ancient sunlight energy* (fossil fuels). The environmental consequences of unchecked population growth can be seen everywhere, and are reaching frightening proportions. All of our planetary resources are shrinking rapidly. Plant and animal species, soil fertility, water tables, rainforests, coral reefs, and ice caps have all been reduced and degraded by human activity. Oil reserves are rapidly disappearing too as growing populations demand and consume more and more of the byproducts of ancient sunlight (see the *State of the World* report by the WorldWatch Institute).

So if we accept the premise that increased energy usage and availability lead to explosive population growth that results in increasing environmental degradation and destruction, we are faced with a dilemma. Can we still seriously search for and develop means to meet or exceed current energy usage when all the indications are that our efforts will have disastrous results? Something seemingly as good as a free solar/hydrogen economy would actually exacerbate our current environmental problems. Regardless of the energy source, solar or otherwise, abundant energy tends to trigger unchecked consumption and growth.

For tens of thousands of years, our ancestors lived sustainably by using only the energy of current sunlight. While I do not advocate returning to the Stone Age (although we may be hurtling in that direction), we do need to rethink deeply and carefully the way we use energy. For example, why design an award-winning energy efficient solar home of 2,000 square feet (or often, much larger) when most of the world's peoples live successfully in spaces of 1,000 square feet or much less? In our examination of the way we relate to and use energy, we need to reevaluate our society. Nothing less than a fundamental spiritual and cultural transformation is likely to alter our path. Mere reforms often foster a false sense that things are being taken care of, when indeed, nothing critical is being accomplished.

Our industry's actions often seem more like a costume change than a fundamental shift in perspective. Much of our thinking is at the core of these problems for which we need to take greater responsibility.
Chip Mauck, Northwood, New Hampshire
fonature@tiac.net

Chip, I agree. Population growth and the accompanying resourse use is the major problem. The solution is simple, but requires will and cooperation. Population must be reduced. Recycling must be instituted, as close as possible to one hundred percent. Also, the solar/wind/hydrogen energy economy must be substituted for the present fossil fuel energy economy. However, with the present competitive political and economic reality worldwide, this will be difficult, to say the least. We can hope the rest of the world wakes up, and until then, we can do what we can. The Wiz

California Buydown Inspiration
Hi Eric, I downloaded and read your article concerning the California RE buydown program (*HP82,* page 48). Several weeks ago, a co-worker showed his home experiment to me. He had connected a couple of PV panels to his PC to see if he could run it with the sun's energy. "Holy cow!" I thought, as I realized that here was a way to save money *and* help the environment.

After a little research (okay, a *lot* of research…), I signed a contract on Saturday, April 14 with Carlson Solar in Hemet, California to install a solar-electric system rated at 10 KW at my house in Palm Springs. I refinanced the house to pay for the system, which will be installed the first week of June, 2001.

Scott Carlson is installing the system with room for future growth, since the CEC does not limit the number of rebates per household. In other words, we can install 10 KW now, and another 10 KW later for the same rebate amount—for a total of US$56K+ in rebates!

The initial system consists of 96 Kyocera 120 W panels, two Trace ST 2500s, one Trace SW4048, eight batteries, and all the necessary hardware to accompany the major components. The batteries aren't included in the rebate program, but we wanted some backup capability.

The rebate was calculated using the number of panels multiplied by the actual power output of each module. The product was then multiplied by their efficiency rating, and finally multiplied by the US$3 per watt buydown. It worked out to: 96 panels x 105.7 watts each x 0.94 efficiency x US$3 = US$28,615. This reduces the total cost of the 10 KW system to US$50,000, or US$5/watt installed.

Your article was the first I've seen in the magazine that actually had anything good to say about what's happening here in California. I hope more people take the lead. I'm now looking into trading in my 1995 Corvette for an EV-1 (if they still sell them…). There are *tons* of incentives for the purchase of a ZEV here in California. That might be another article for you to pursue. Thanks for the great article, and for a magazine that served as an inspiration to me! REgards (I like that!), Jim Haggerty, Yamaha Motor Corporation
714-761-7867 • haggerty@teleport.com

Hi Jim, Congratulations on buying 25-plus years worth of clean, green electricity! See page 22 in this issue for an article on time-of-use metering for EV charging combined with net metering. Best REgards,
Eric Hansen

Ozonal Notes

Richard Perez

California's Third World Utility Grid

Now that California has reached developing nation status, and its utility grid has attained third world reliability, Californians need to examine their situation and their options. What's the problem? Well, for starters, the lights keep going out…

While the politicians and the power brokers point fingers and argue about who is to blame, the California PUC has approved rate increases of up to 46 percent. According to the *LA Times,* 28 March, 2001, the California legislature is considering floating a bond issue to the tune of 12 billion dollars (the largest ever in U.S. history) to keep its utilities functioning. It's costing Californians about 2 million dollars per hour to prop up their failing utilities and keep the lights on. This entire mess reminds me of electric power in South America.

This problem is not going to go away, not even if the state of California throws billions of dollars at it. The Pacific Northwest is expecting a drought this summer, and vastly reduced hydropower. As every *Home Power* reader understands, you can't consume more than you produce. Eventually, whether it's flat batteries or a failed grid, overconsumption catches up to you.

California's pleas for less consumption and for energy efficiency have largely fallen on deaf ears. Folks who have spent the money for efficient appliances and who do practice conservation are blacked out with everyone else. What's the point of conserving if your neighbors are energy hogs? What's the point of conserving if you get blacked out with everyone else? This attitude has even spread to entire cities that are refusing to shut off the lights on demand (Lodi, California, for just one example).

I Told You So!

Over the years, I've taken huge amounts of criticism for my attitudes regarding utilities. I've always said that they were in it for the money—consumers and the environment be damned. *Home Power* readers are now telling me that I have been right all along, and encouraging me to sock it to the utilities. Not that I need much encouragement…

Let's face it, even before the blackouts, utilities had the worst public relations picture imaginable. Consumers had no choice but to pay the power bills if they wanted to keep the lights on—the utilities have a monopoly. All of us had no choice but to tolerate the pollution generated by utilities because they were providing an essential public service.

The California blackouts have revealed the utilities' true nature to the entire nation. The utilities are multibillion-dollar companies that have been granted public monopolies. And they are failing to fulfill their duties in order to protect their profits.

Now these utilities have secured over 40 percent rate increases from their ratepayers. They got the government of California to float the largest bond issue in U.S. history to bail them out and secure their profits. At the same time, the very same utilities have been refusing to pay California's independent wind farms since last November. The motives of these utilities are now very evident—profit before service and the environment.

They Could Have Had Solar Energy

During the last four months, Californians have spent over 7 billion additional dollars to keep the lights on and to secure their "public" utilities' profits. If this money had been spent on photovoltaics instead, California could have had over 2 billion watts of PV pumping about 10 billion watt-hours of energy into California's grid every day.

And these PVs would keep doing this for at least the next twenty-five years, with minimal operating cost and no pollution. Instead, Californians have empty pockets. And further, they face more blackouts, and an energy situation that threatens to cripple one of the most productive economies in history.

Californians are being played for chumps by their government and their utilities. The only way to protect yourself against blackouts and high utility rates is by following the example of savvy people in developing nations—set up an independent energy system.

Charge When the Charging is Good

When Karen and I were in Colombia in 1992, they were in the middle of a drought. Colombia is over 70 percent powered by hydroelectricity. There were rolling blackouts over the entire nation. Colombians were buying inverter/battery systems and generators. When the grid was up, they'd use it to recharge their batteries. Then they'd run on that stored power when the grid was down.

The general attitude was, "Hey, I don't care if the grid is further stressed out by recharging my batteries; at least the lights are on in *my* home." In the business districts, the sidewalks were lined with portable generators belching noise and pollution. Extension cords snaked from each generator, through the front door, and to the business' appliances.

Now Californians can catch up to Colombian standards of living and do the same thing—install inverter/battery systems and buy generators. The schematics in *Home Power* show you how to do the wiring, and *HP* advertisers will happily sell you the gear. But is this a real solution? No—it still doesn't keep all of the lights on in California all of the time. All it does is keep the lights on at your house regardless of how irresponsible California utilities become.

If you go this route, you will have to start to think like off-grid folks. Since you are on battery-stored energy, you must pay attention to energy efficiency. Replace incandescent lighting with fluorescent. Buy a new, more efficient refrigerator, and eliminate phantom loads. This will make your stored energy more effective, and lessen your load on the shaky grid once it returns.

Throwing Solar Energy at the Problem

Very few Colombians were using solar-electric systems when Karen and I were there. It is a step, however, that many Californians have already taken, and that many more are considering. California already leads the world in solar-electric power production, mostly thanks to off-gridders.

Californians would be wise to put up PV arrays, and use the sun for their electrical energy instead of the grid. In this scenario, a home could become totally energy independent and not require the grid at all. This is the situation with our off-grid readers, and they've been doing it for years.

What's It Going to Cost?

Consider that each California household has already spent, in just the last four months, over US$500 each to prop up their utilities. Consider that each household's electric bill is going to go up by about half. Consider that just the interest payments on the new bond issue are going to cost each California household about US$100 per year. And the lights still keep going out. Solar energy is starting to look like a really great deal here.

Giving a California home an efficiency job and putting in a solar-electric system costs less than a new car. The system will produce clean electricity for at least twenty-five years. There will be no blackouts, brownouts, or poor power quality for that home. And all this will cost less than a new Buick. You pay your money and you make your choice.

Power Bill? We Don't Need No Stinking Power Bill!

Does an independent power supply exempt anyone from a power bill? Sadly, no. The California energy crisis is being financed by the taxpayers. So even off-grid Californians, folks who haven't paid a power bill in years, are paying for California's energy debacle through their taxes. If you want to hear someone wax poetic about the injustice of this situation, just ask an off-grid Californian.

California Today…

Will the power problems in California stay confined to California? No, not likely. The potential for blackouts is in every state. And since the nationwide power grid is so interconnected, problems in one state can affect the power supply in other states. Nationwide, expect power costs to go up, and reliability to go down. When electricity is in short supply, utilities fire up their natural-gas powered generating plants. So expect natural gas and propane prices to rise, and supply reliability to go down.

The only option that has energy reliability and a fixed energy cost is renewable energy. The price of sunshine and wind has been the same forever, and it won't go up. These energy sources are freely offered and regularly available. The only real option is to join the over 180,000 American households that power themselves using renewable energy. If you wait for government and utilities to figure this out, you're going to spend a lot of time in the dark. Just go ahead and do it, for yourself and for your family.

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Q&A

Lightning Protection for Buried Line
Hi folks, After adding to my solar array, I find myself flush with electricity. I'm considering running inverter power out about 250 feet to my garage. I have heard somewhere (in *HP*?) that long 110 VAC lines are a doorway for nearby lightning strikes to get into the system, especially I suppose, into inverters. Is this so? Is it only if the wire is buried? How about if the wire is *on* the ground, or on the ground but in plastic (plumbing) pipe? Is there a grounding or lightning arrestor strategy that will close the door? Jim Sluyter, Bear Lake, Michigan • fsfarm@mufn.org

Hello Jim, Bury that 120 VAC line from the inverter to the garage and you'll have the maximum lightning protection. Underground is the best place for this line, and offers minimum exposure to lightning-induced transients. These buried conductors can still be a path for lightning that enters the system elsewhere. But being buried greatly increases the chances that any lightning on these conductors will jump through the insulation and go to earth.

See the back issues of HP *for several articles on lightning protection. I assumed you are taking the normal precautions—grounding the array, using MOVs and SOVs, and carrying a common equipment ground through the system. Richard Perez*

Free Money for RE
Hi Eric, I just read your article in *HP82* concerning California state funds for RE installations. I wonder if you have a source for current information on the availability of funds in other states, as well as federal programs. Tim Nagy • tpnprod@earthlink.net

Hello Tim, Yes, check out this page on our Web site for information on all the states' incentives: www.homepower.com/stateincentives.htm. Eric Hansen

CEC Buydown for Batteries?
Hello Eric, Your article in *Home Power* was very informative and current. You stated in the paragraph about approved manufacturers that batteries, microhydro turbines, and domestic hot water heaters were not included. Could you elaborate on this? What does this mean from a battery perspective? Any further insight or information would be helpful and appreciated. Simon Wiles • simon@surrette.com

Hello Simon, It's my understanding that the CEC is only providing buydown funds for utility-intertied equipment. Because batteries are not essential (from their perspective) to utility-intertied systems, they do not want to provide California state funds for them. You can install a system that includes batteries, but the program will not pay for the batteries.

I strongly suggest ordering the information packet from the California Energy Commission (CEC) for the fine-print details. Their contact info is: California Energy Commission, Emerging Renewables Buydown Program, 1516 Ninth St. MS-45, Sacramento, CA 95814 • 800-555-7794 or 916-654-4058 CallCntr@energy.state.ca.us www.energy.ca.gov/greengrid/index.html. Request the information and registration packet titled, Volume 3, Emerging Renewable Resources Account. *Eric Hansen*

Do You Live on a Windfarm?
The question I must ask is, "Did the high-tech university professors and wind gurus of the 1980s and '90s take consumer wind turbine design in the wrong direction?" I think so, for many reasons.

It would seem that about 95 percent of the modern wind turbines designed today have been designed for use on your basic "windfarm." Windfarm turbines have only two or three blades, and they are typically very skinny blades. Don't get me wrong, the reasoning behind the design of the modern wind turbine is very technologically sound. But the real question should be, "How many of us live on windfarms?"

In other words, we live where our homes are and most of us simply don't have the luxury of placing our wind turbines on the windiest hills and valleys of America, where gale force gusts are a daily occurrence. Universities and power companies have this privilege, and the modern wind turbine works best in these special spots. Most of today's wind turbines are modeled after designs made by universities that have spent hundreds of millions of dollars in research trying to create the most efficient designs for very windy "windfarm" areas, but what about the rest of us?

It occurred to me one day when I was driving down the road and saw an old farmstead-type multi-bladed water pumper. It was turning like crazy in a slight breeze, while one of the popular modern wind turbines standing right next to it was motionless.

After doing much research work, I have concluded that in less windy areas, more blades and bigger blades are definitely better. True, at higher wind speeds there is more turbulence and less efficiency with big multi-bladed fans, but in the real world, who needs efficiency on days when there's plenty of wind, and most of us are praying that our regulators kick in? For the majority of us, getting maximum efficiency is more important on less windy days. Ron Graefe • oicu2@oicu2.com

Ron, You are definitely right that that we need larger wind turbines for places with lower winds. The same applies to days when there is not much wind, even in windy places. A lot of people are fooled by marketing hype about machines with low cost per watt. It's not the maximum power output you need to look at; it's the size of the rotor blades. In most normal windspeeds, the rotor size will determine the power output.

I disagree with you about the detailed design of the rotor. It's not rocket science, and it didn't cost millions of dollars to work out that a three-bladed rotor will run much faster than a multi-bladed rotor. To produce electricity, we need high revolutions per minute, and the best way to get them is with fewer, narrower blades. Putting more blades on a wind turbine does not give you access to more wind power, it just gives you more torque and less speed. That's fine for pumping water, but it's not the most direct route to putting charge into your battery.

Multi-bladed rotors are good at starting up in low winds, it's true. But a wind turbine needs to do more than just turn—it needs to run fast enough to kick out battery voltage before you see a result. If you see a multi-bladed machine "turning like crazy," it is probably not connected to anything, and it is probably not running fast enough to charge batteries, unless it is very small, which takes us back to where we started. Keep up the research! Hugh Piggott, Scoraig Wind Electric hugh.piggott@enterprise.net • www.scoraigwind.co.uk

Ron, Interesting points, although somewhat mistaken. It is true that wind farm equipment is optimized for higher wind speed areas. But the only similarities between wind farm equipment and home-sized systems is that they both have blades, use the wind as a fuel, and generate electricity. That's it!

Home-sized turbines were developed in the U.S. in the late 1920s and '30s. Their development actually came out of experimentation with farm windmills. The experimentation originated with farmers, not university types, trying to power another new technology, radio. Connecting a generator to a water pumper was very dissatisfying because it was so inefficient. That's where the idea of aircraft-type propellers came from. The idea worked. The rest is history, except for the number of blades.

Again, folks experimented with all sorts of blade configurations, combinations, and orientations. What worked, and what is currently available in the marketplace as a result of all of that experimentation, are wind generators with two or three blades.

Wind farm equipment actually grew out of those home-sized turbines, not the other way around. In addition, home-sized turbines operate at considerably lower wind speeds than wind farm equipment. Mick Sagrillo, Sagrillo Power & Light • msagrillo@itol.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 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 so that our readers can actually use the information.

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 which are short (less than fifteen 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 the feeling of our style. System articles must contain a schematic drawing showing all wiring, a load table, and a cost table. Please send a double spaced, typewritten, or printed copy if possible. If not, please print.

Written Release

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. This will help us respect the privacy rights of individuals.

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We reserve the right to edit all articles for accuracy, length, content, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get published first.

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You can send your article via Internet to richard.perez@homepower.com as an attached ASCII TEXT file. If you are sending graphics, or articles with embedded graphics, then use this email address: ben.root@homepower.com

It is wise to telephone or email ahead of electronic file submission. This is particularly true concerning graphics files. There are many, many, many ducks and they all need to be in a row....

Got any questions? Give us a call Monday through Friday from 9–5 Pacific Time and ask. This saves everyone's time.

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The Home Power Index: Issues 77 through 82

Listed alphabetically by subject: First number is the issue, second number is the page.

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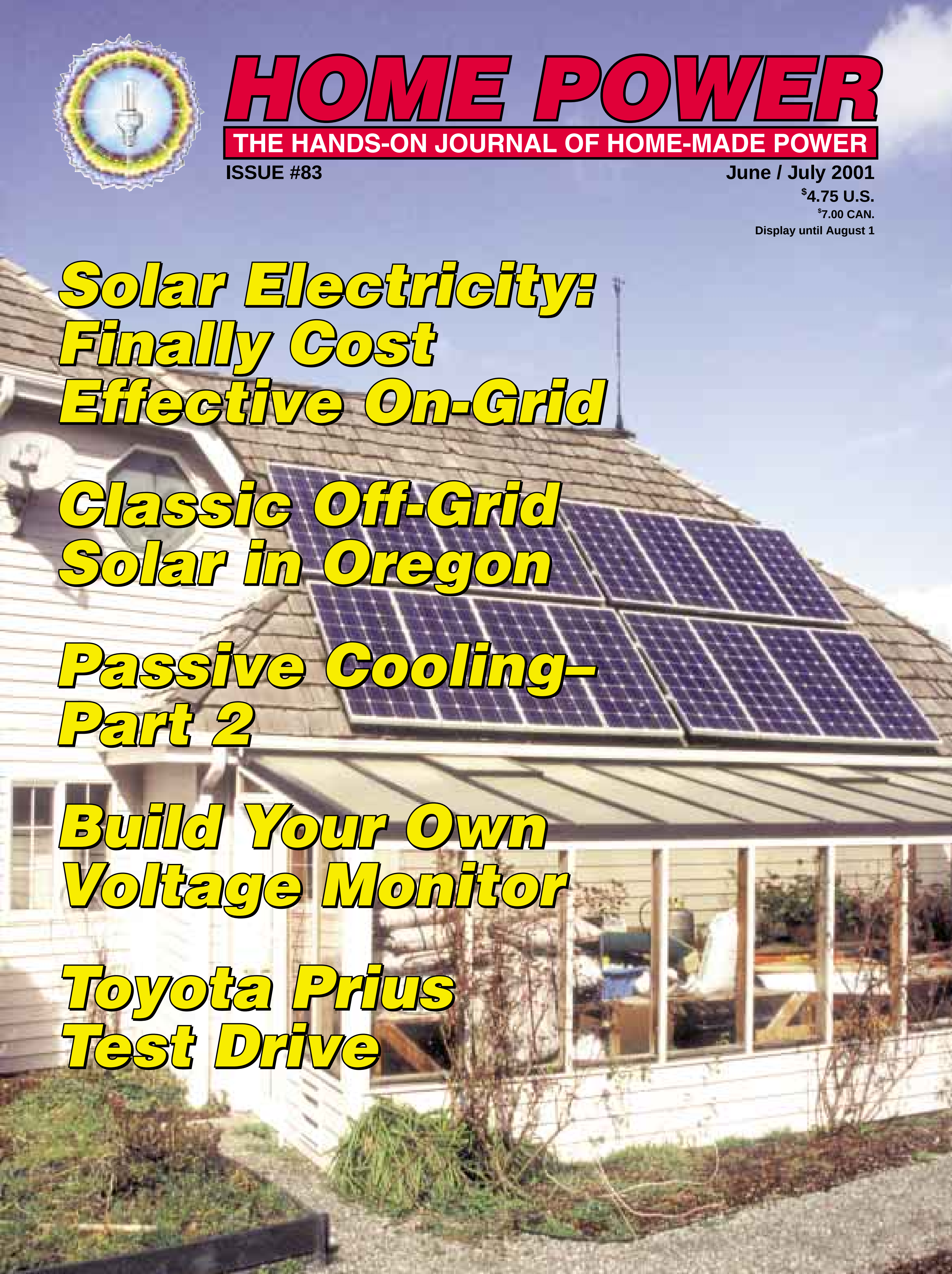

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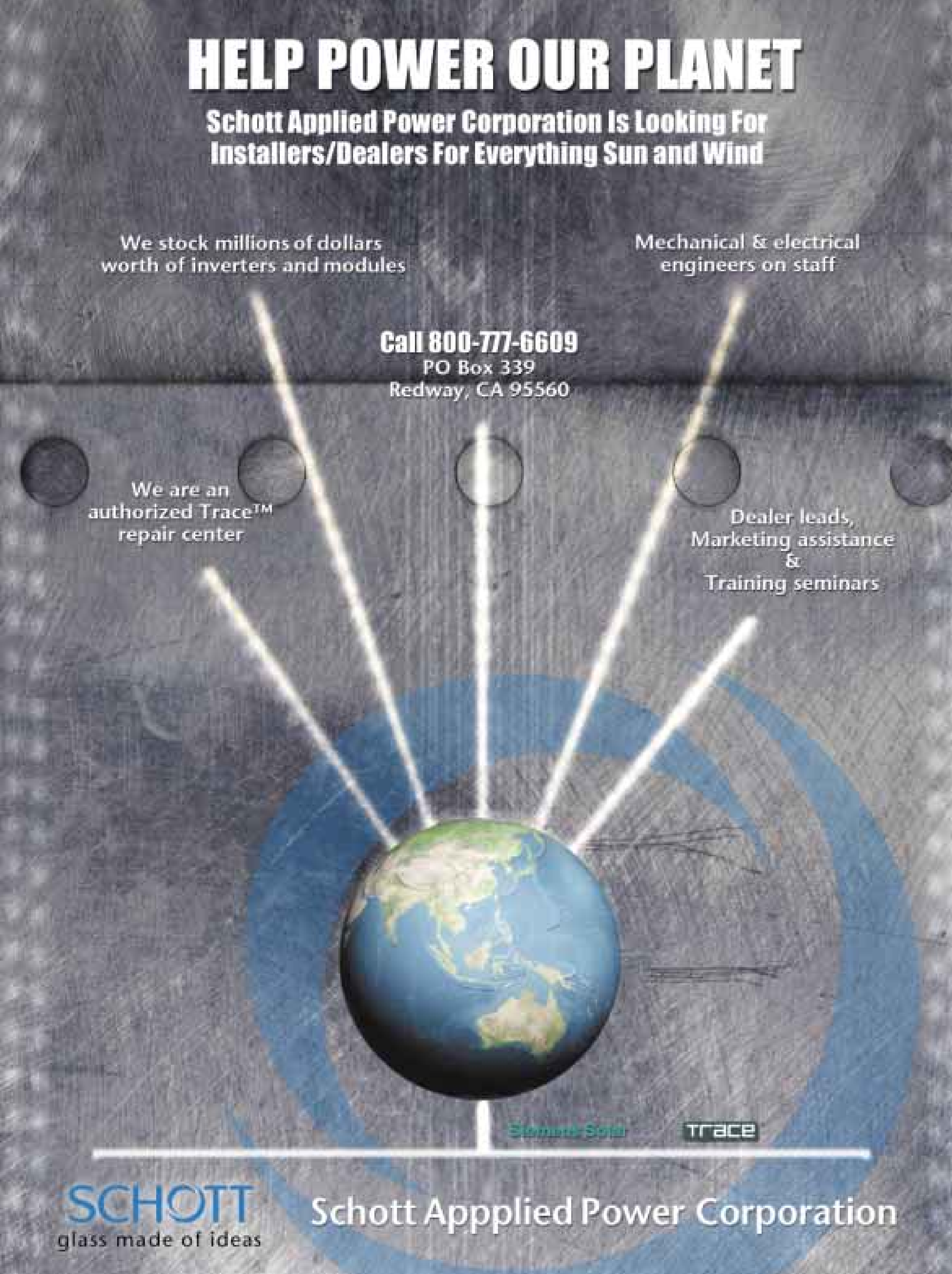
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Carton Size in Centimeters (LxWxD)	109.0 x 71.0 x 9.0
Carton Gross Weight	42.0 lbs. (19.1 kg)
Number of Cartons per Pallet	20
Number of Modules per Pallet	40
Max. Pallet Dimensions (LxWxD)	59.0 x 43.0 x 39.0
Max. Pallet Dimensions	57.0 cu.ft. (1.62 cu.m)
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No. of Modules per 40' Container	1280

KC80

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Dimension C	24.13 in. (613.0 mm)
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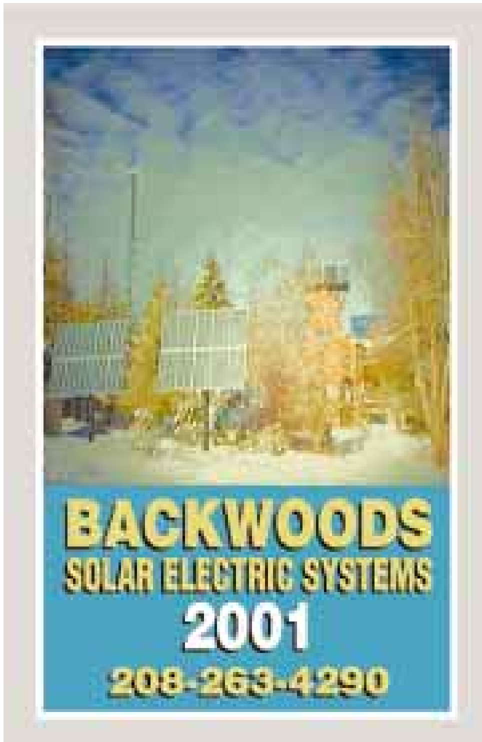

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NOW: I use renewable energy for (check ones that best describe your situation)

- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
- ☐ Recreational electricity (RVs, boats, camping)
- ☐ Vacation or second home electricity
- ☐ Transportation power (electric vehicles)
- ☐ Water heating
- ☐ Space heating
- ☐ Business electricity

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- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
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RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ☐ Solar power
- ☐ Wind power
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- ☐ Biomass
- ☐ Geothermal power
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- ☐ Other renewable energy resource (explain)

The GRID: (check all that apply)

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

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(continued on reverse)

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❑	❑	Wind generator	❑	❑	Thermoelectric generator
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❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
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