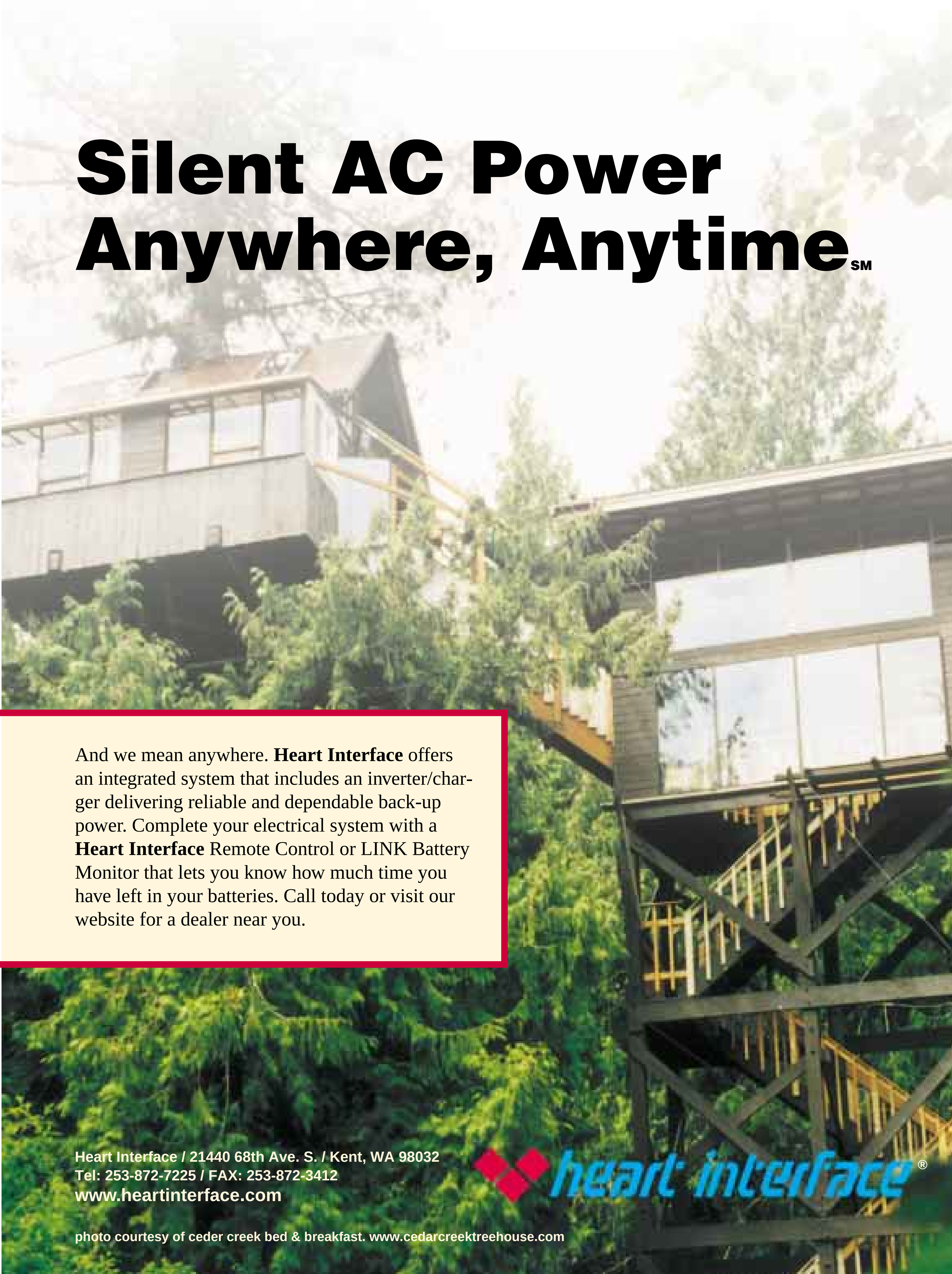
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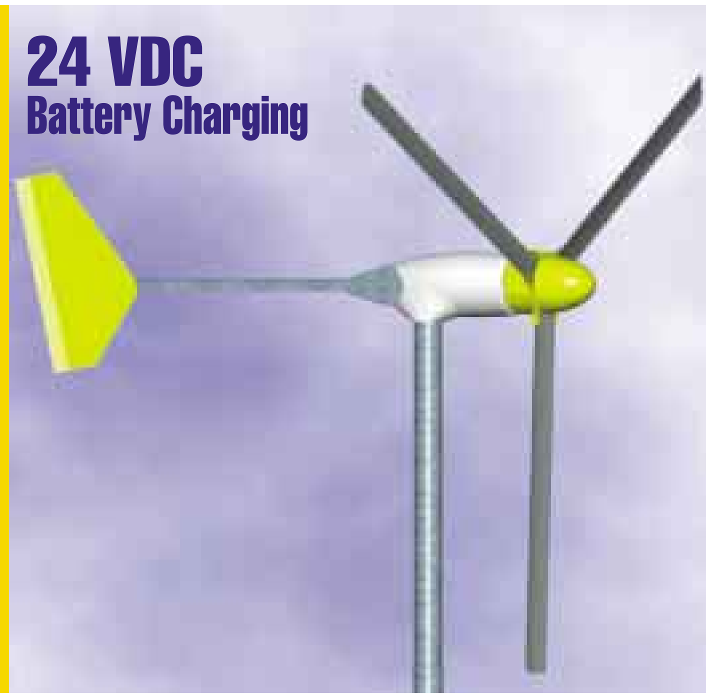

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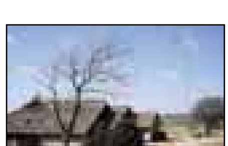
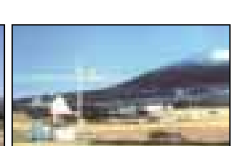


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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #79 October / November 2000

Features

Features

GoPower

Cover: Peter Jones' electro-psychedelic "Funky Windmill" spins a pattern of colored LEDs at dusk. See page 54.

Homebrew

Things that Work!

Guerrilla Solar

Book Review

Columns

More Columns

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Access and Info

Access Data

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Recycled Paper

Recyclable Paper

The photograph above shows the new utility intertied solar-electric system we installed at the Grant County Fairgrounds in John Day, Oregon. This permanent PV array is rated at 1,120 watts, and all the electricity it makes goes directly into the local utility power grid.

This project was the brainchild of Jennifer Barker, the director of the SolWest Renewable Energy Fair. She was assisted by a crew of local contractors, and a group of students who spent three days of their lives learning about solar electricity. Joe Schwartz and I taught the pre-fair workshop that was focused on installing the system. All the RE equipment was donated by its manufacturers—many thanks to Solarex, Trace Engineering, and Two Seas Metalworks for their generosity. We will publish a technical article about this system in our next issue.

After the installation was complete, I began wondering… What's a solar electric system like this worth? I know that the hardware was worth about US$8,000. I know that nineteen students worked their butts off for three days under the scorching eastern Oregon sun, and that must be worth a grand or so. But what's it really worth? What did we, in the collective sense, really gain?

We, as inhabitants and custodians of this planet, took a miniscule step towards ensuring our planet's future. Each PV module on that sixteen module array will save putting one metric ton (2,200 pounds) of carbon dioxide into our atmosphere each year. Each module, each year. Over the next twenty years, this small system will displace 320 metric tons of CO_2 that would have been produced to make the same quantity of electricity. A small step to be sure, but a step in the right direction.

We, as the local utility, gained another power source—a power source that is radically different from any we previously had. This power source runs on sunshine. It produces no pollution—no CO_2, no acid rain, and no nuclear waste. This power source produces electricity during peak consumption hours, when we need it the most. It's a power source bought and installed without using a single cent of utility capital. A power source that brings energy close to where it is used, saving us the losses, expenses, and environmental damages of long distance power lines. The energy from this source is donated to us, and we can sell it to our customers. (Are the utilities grateful for this gift of clean energy? See *Ozonal Notes* on page 134 for the answer.)

We, as the installers of the system, gained experience in utility-intertied solar energy. We learned something that we will want to do again and again—it just felt right. Our biggest reward is watching the utility meter recording the 5 KWH of solar energy that the system pumps onto the grid each day.

Not a bad weekend's work…

–Richard Perez for the SolWest PV Workshop

People

Joy Anderson
Anil Baral
Chip Boggs
Clara Boggs
Mike Brown
Roy Butler
Sam Coleman
Eric Hansen
Rod Hyatt
Kathleen Jarschke-Schultze
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Michael Welch
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Dave Wilmeth
Myna Wilson
Ian Woofenden
Rue Wright
Solar Guerrilla 0011

"Think about it…"

Freedom is something you assume. Then you wait for someone to try to take it away from you. The degree to which you resist is the degree to which you are free.

-Ol' Campbell via Utah Phillips

My Grid-Connected Solar House

Anthony Skelton

Anthony Skelton's 1,020 Wp array of twelve BP-585 PV panels in Leek Wootton, U.K.

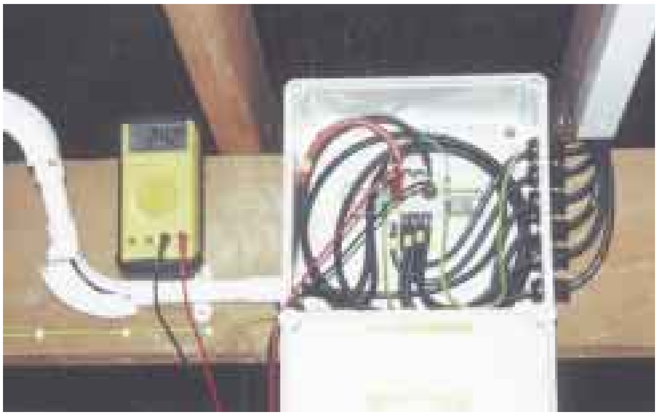
My interest in solar energy began when I was still in school. I was given an electronic kit that contained a small solar panel. Fascinated by the fact that this panel could generate electricity, I set to work building a solar-powered radio, one of the projects in the kit. It worked! Over the years, I have built various solar-powered items, including a stand-alone security system, garden lighting, and a solar-powered water garden and rock pool. My latest project was to connect twelve solar panels (1,020 Wp) to the mains electricity grid to generate power for my house.

Getting Permission First

The obvious place for me to install twelve BP-585 panels, each measuring 1,188 by 530 mm (46.8 x 20.9 inches), was on the roof. It's out of the way, and has almost no shading from trees or other objects. I contacted the local planning officer to see if planning permission was required, and in this case it was not.

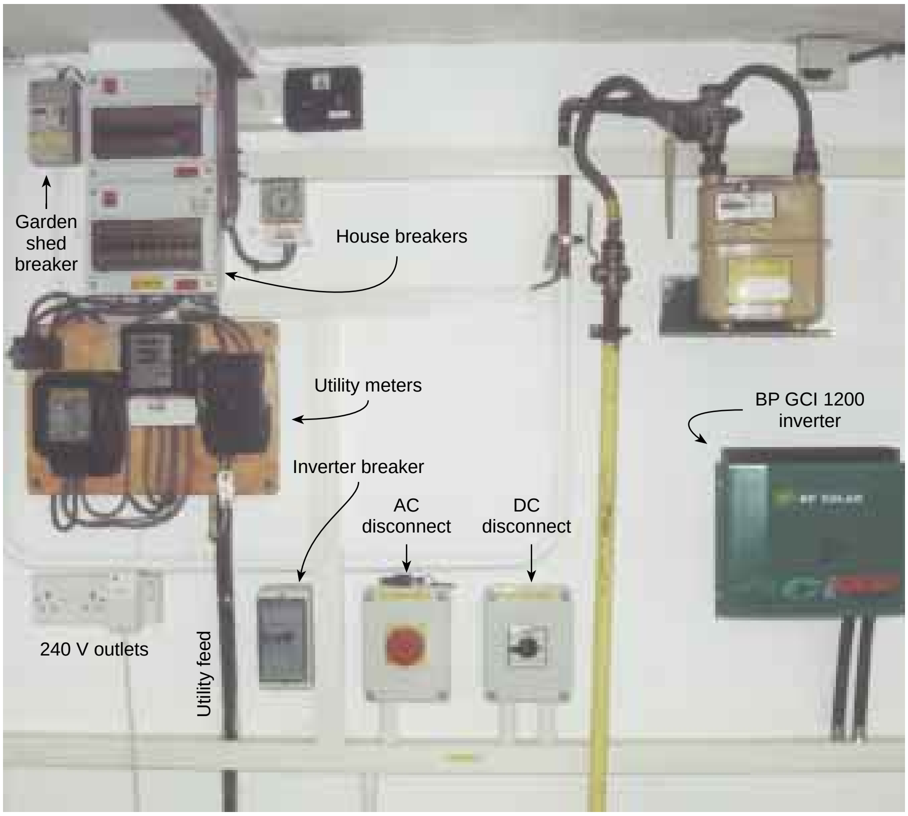
Because I wanted to connect to the grid, I had to get permission from my local electricity company, PowerGen. They were very cooperative in this matter, even though it was still quite an unusual request for them. After completing all the forms, permission to generate was given on the 5th of November, 1999.

Joint box in attic where solar subarrays are combined into one series string.

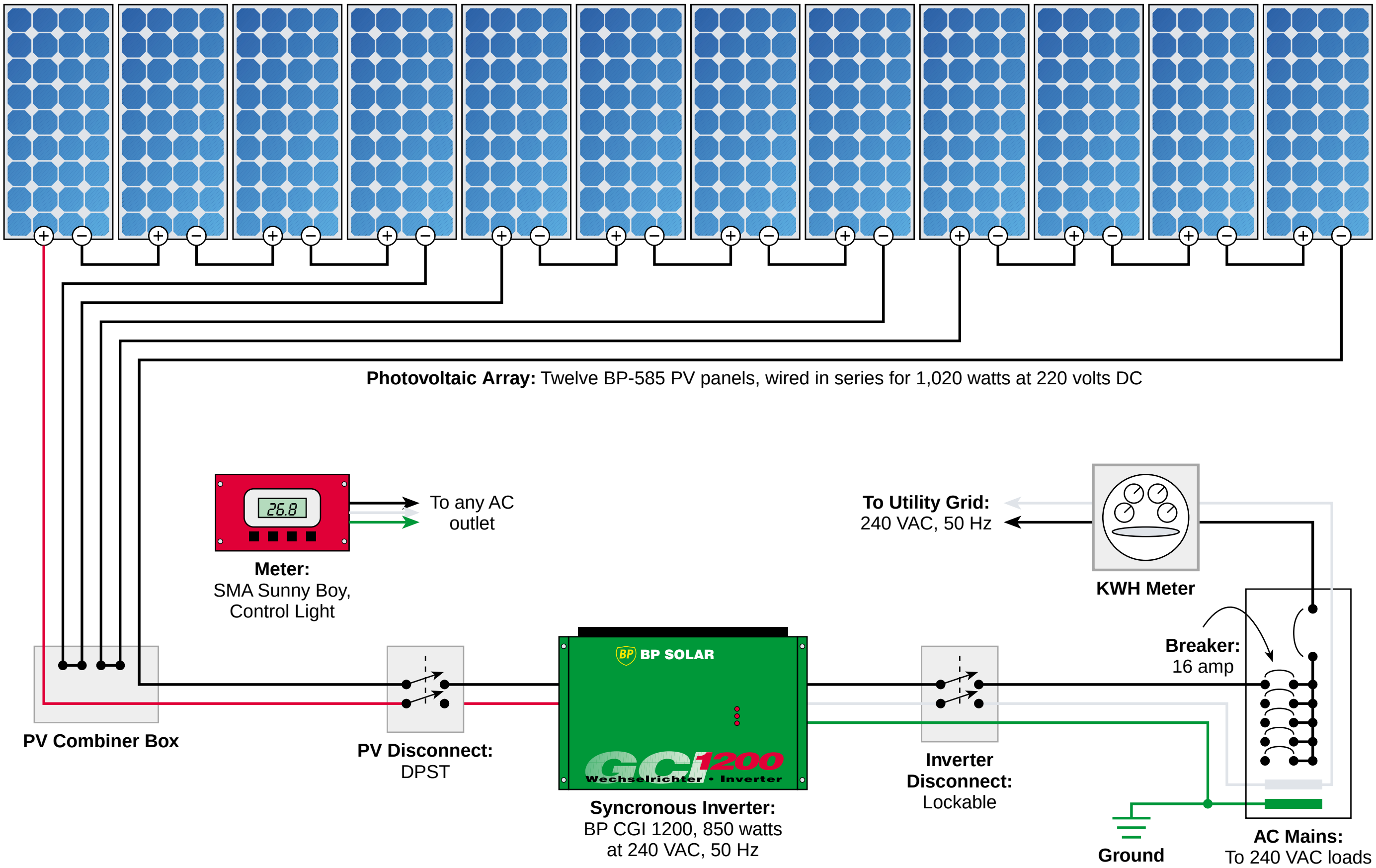


Phantom Loads!
Phantom loads are electrical loads connected to the power supply 24 hours a day. They do little more than run up your electricity bill. Examples are VCRs, televisions, radios, and many computers with external speakers. When you switch off these items, in most cases it does not switch off the mains supply. These items consume very little, but they are on for 24 hours a day. All these small loads soon add up. (See *HP37*, page 46, for an article on phantom loads.)

Whether you have a solar-electric system or not, it is a good idea to make a few checks for yourself. I set up a digital multimeter and a cord and socket set so that I could check each appliance for phantom loads. I solved the problems by either doing without the offending appliance or buying more efficient appliances.



Anthony Skelton's System



The Groundwork

Since it was winter, it was not a good time to be clambering about on the roof. I had twelve stainless steel brackets made to hold the PVs. These were pre-assembled and ready to go onto the roof when the weather was better. The two-pole DC disconnect and lockable AC isolation switch and the BP inverter were installed in the garage. A separate fuse board was installed for the system, and connected to the house distribution board that was just above it.

A DC disconnect switch was fitted to isolate the high voltage from the solar panels, and an AC disconnect switch was fitted to isolate the mains grid. As an extra, a modem was fitted to the inverter to transmit system data to a display in the house, via the existing mains cable. To make cabling easy and neat, trunking and plastic tubing (“conduit” to North Americans) was used. Once the cables were in the roof, I installed a large junction box to terminate all incoming cables from the panels on the roof. All the cables from the panels were wired in series in this box.

I was grateful for the help from Steve Wade of Wind and Sun (the company that supplied all the equipment). His technical assistance and advice during the planning stages and the final commissioning and setup were critical to the success of the project. When taking on this type of project, it is well worth having expert advice at an early stage.

Panels Up & Pull the Switch

A local builder helped me fit the brackets to hold the solar panels, and lift the three solar arrays onto the roof. The two days it took to fit could not have been better, with fine sunny weather. Working on the roof was not that bad after all, except for bruised knees! The connection to the inverter was straightforward, since I had done most of the work in the previous weeks.

Sunny Boy display panel. Information is transmitted at high frequency via the existing mains wiring.

Skelton System Costs

Items	*Cost (UK£)**	*%*
12 BP-585F solar modules	£4,500	69%
BP GCI 1200 grid connect inverter	1,095	17%
Sunny Boy inverter display and control	375	6%
12 stainless steel brackets for modules	120	2%
DC disconnect in enclosure	100	2%
Modem for inverter display	100	2%
Other sundry items	100	2%
6 mm^2 double insulated cable, 50 m	58	1%
4 mm^2 double insulated cable, 25 m	33	1%
AC disconnect in enclosure	25	0%
Consumer fuse board	25	0%
Total	£6,531	

* Includes 17.5% tax

Before we turned the first switch on, Steve came to the house to check over the system to make sure all was in order. I am pleased to say that it was, and I threw the switch. The green light on the inverter came on and within a minute, power started to flow from my solar panels into the electricity system. It was the first solar-electric system to be connected to the utility grid in the area!

What’s Going On?

A Sunny Boy control unit was installed in the house so I can see what is going on with the system at any time. It shows live information about wattage, total energy day by day, system status, voltage of the PV array, grid voltage, grid frequency, and resistance between power lines and earth. It’s also the user interface for the inverter.

Almost everything you might need to know regarding the performance of the system can be measured, displayed, or recorded with this unit. The most useful of these is probably “daily energy.” This shows each day’s KWH production for the last year. From this, spreadsheets or graphs can be generated, which clearly show any unusual days or possible problems. The information on the display is transmitted across the mains cabling at high frequency. By simply plugging the display into any mains outlet, you can see what is going on.

There is a data port on the display panel that allows connection to a PC, so it is possible to print out data and graphs for any day or month. When I have time, this will be next on my list of things to do. The annual average energy production for a system like this is about 850 KWH. After three months, the display in the house indicates that the system is on target.

Why?

Why buy a system like this when the grid is connected to the house? What is the payback time for a system like this? These are the two most commonly asked questions. The answer to the first question is simple. I bought the system because I wanted to. My personal interest in solar technology inspired me, and I believe it is the power source of the future that I am able to use today.

The payback is a long time out, if you look at this purely in monetary terms, but I don't. When was the last time you heard a person walk into a car showroom and ask about the payback time on a new car? I rest my case.

The future of PV technology looks very bright, and from a personal point of view, I enjoy using it. To me, the environmental benefits far outweigh the monetary payback.

Access

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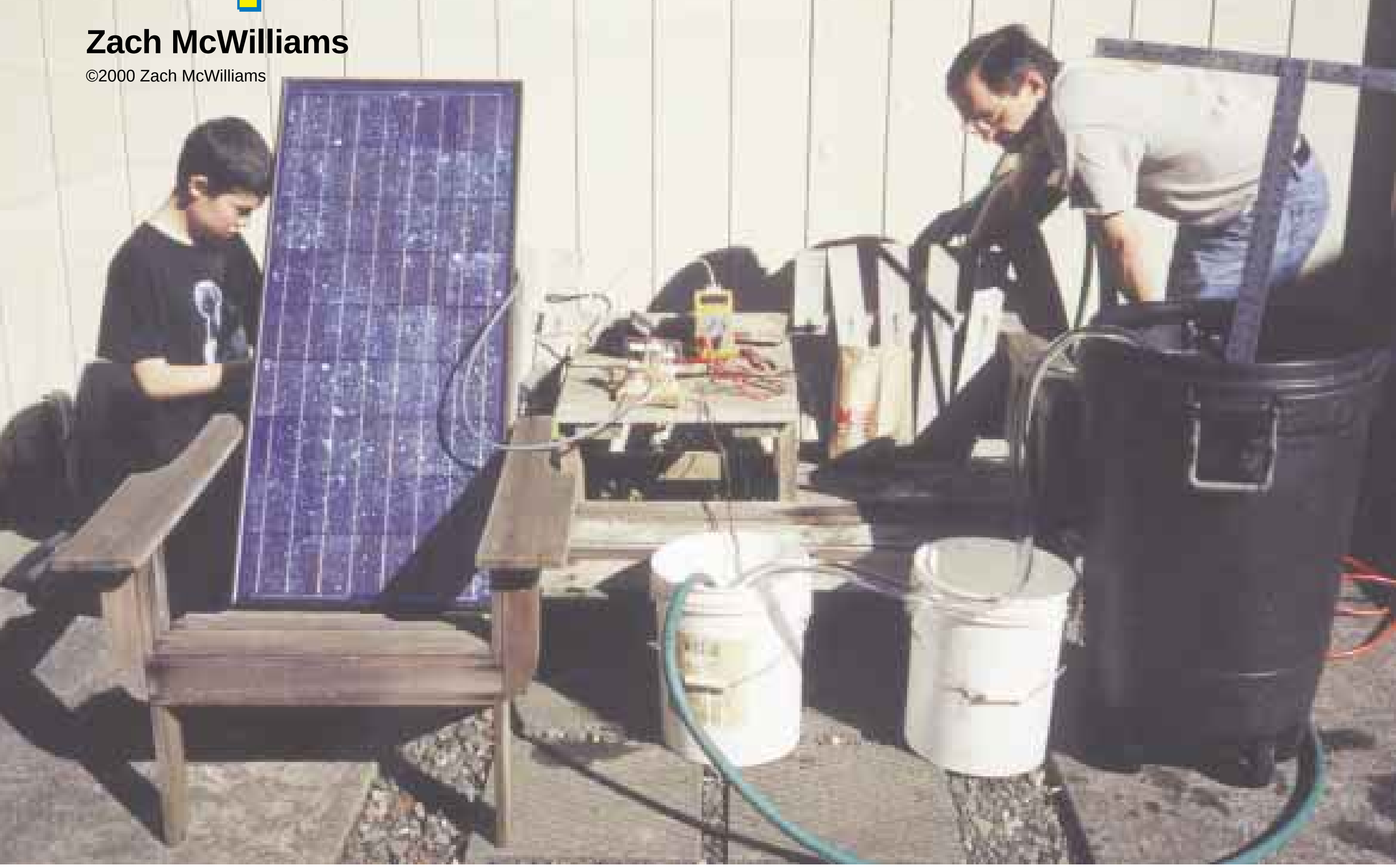
this is hot

Stupendous Solar Science!

Zach McWilliams



Zach monitors the readings on the laptop computer while his dad adjusts the water flow into the pump bucket.

What do you think of when you hear "winter," or "California's North Coast"? Sun and warm temperatures? I don't think so! North Coast winters are very bleak, and only once in a while do we enjoy a sun-filled day. Lucky for me, the sun came out long enough to do my solar science experiment.

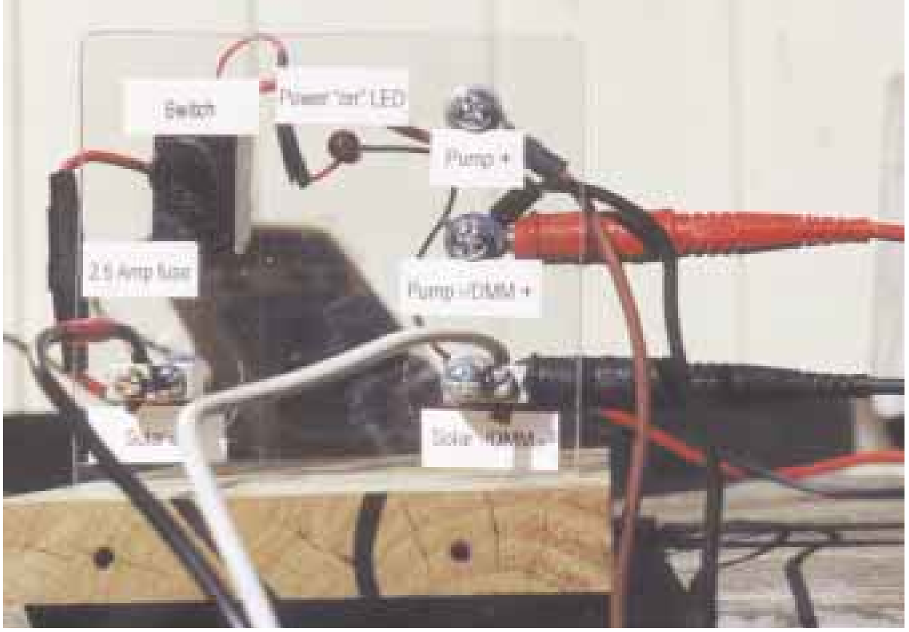
I'm Zach McWilliams, and I'm in the eighth grade at Pacific Union school in Arcata, California. My science project last year was designed to answer these questions: *Does the angle of the sun during the day affect a solar panel's output?* and *What is the energy generated by one solar panel capable of doing?*

In the course of the experiment, I learned how to set up an electrical circuit, use a digital multimeter (DMM) and monitoring software, and test the directional and shade sensitivity of a solar panel. These are skills useful to anyone interested in solar energy.

Parts & Setup

For my experiment, I needed a solar panel, so I called on Michael Welch of Redwood Alliance and *Home Power* magazine, who loaned me a 63 watt Solarex polycrystalline silicon solar panel (Thank you, Michael!). Then I needed something to measure amps and volts. A Radio Shack 22-805 digital multimeter (US$40), with PC interface, covered that. I also needed a load. A pump would work just fine. Online, I found Eric Jensen of Sunmotor International, who sent me a Rule 12 VDC pump at no charge (Thank you, Eric!).

After these main components, little things were needed. To do my project, I used a piece of wood that was about 6 by 5 inches (13 x 15 cm), and cut a slit at the end that went the width of the wood. Next, I put a piece of plastic that was about 1/4 inch (6 mm) thick in the slit. In the plastic, I drilled holes for an SPST switch, an LED, a 2.5 amp fuse, two screws for conductors, and two more



The home-built circuit board ready for action.

screws that were attached to a power bus. I then put all the components in place in the plastic.

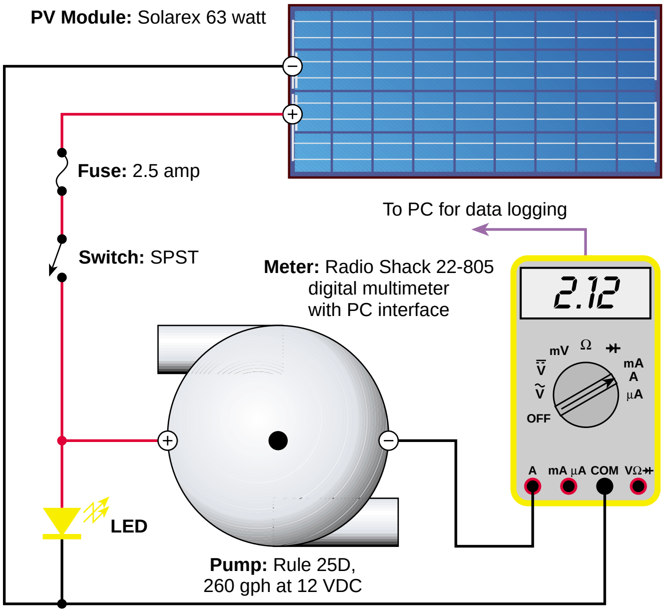
The idea was to let the solar panel power the pump, and hope the pump would move water from one five gallon bucket to another. To start, I put the solar panel on a chair outside, and hooked it up to my makeshift circuit board. Next, I connected the digital multimeter to the circuit board. Then I connected the digital multimeter to a 486 laptop with a serial cable to monitor the amps, so that I would have information to convert to graphs.

The digital multimeter came with a program to log the data onto a computer. We programmed it to log data every 15 seconds. So every 15 seconds, a reading would appear for the output of the panel. We just added up all these readings, and divided them by the total number of readings to find the average output.

The Radio Shack 22-805 DMM.

Then I attached the pump. Because the pump was rated at 500 gallons (1,900 l) per hour, I used a 2 meter piece of 3/4 inch vinyl hose to move the water. This reduced the rated output to 260 gallons (1,000 l) per hour (gph). From this I hypothesized that it would take several minutes to move five gallons (19 1) of water between buckets. I put the pump and tubing into the five gallon bucket for starters, and flipped the switch.

PV Test Schematic



Filling the trash can.

McWilliams Solar Project Parts List

Description	*US$*
Radio Shack 22-805 DMM, w/ PC interface	$40.00
Vinyl tubing, 3/4 inch inside diameter, 7 feet	3.50
Switch, SPST	2.00
Fuse, 2.5 amp	1.50
LED (light emitting diode)	0.95
Laptop computer, 486 PC, on hand	0.00
Plastic, 1/4 by 6 by 6 inches, recycled	0.00
Power bus, recycled	0.00
Rule 25D 12 VDC pump, donated	0.00
Solarex MAE000 63 watt module, borrowed	0.00
Steel screws, on hand	0.00
Trash can, 30 gallon, on hand	0.00
Bucket, 5 gallon, on hand	0.00
Wood base, 6 by 5 inches, recycled	0.00
Total	$47.95

It Pumps!

In less than a minute, I figured out that I needed a 30 gallon (114 l) trash can instead of a bucket. My first conclusion was that solar power works really well!

That's when the "revised hypothesis" struck me: How long would it take for the panel to fill the trash can at different times of the day? And what would be the average amperage? I decided to take one test in the morning, one in the afternoon, and one in the evening. My hypothesis was that the panel would do best—and the pump would pump fastest—in the afternoon, because there would be direct sunlight on the panel.

I set up the equipment the same as before, except that the pump tubing went into a trash can instead of the bucket. This would be the "morning test." It was slightly overcast, but I figured the panel would do fine. I flipped the switch, and the panel produced an average of 1.155 amps while the pump was running. It took nine minutes to pump 20 gallons (76 l) of water into the trash can.

Later, I did the "afternoon test." There was a change in the amount of sun and the output of the panel. It was very bright, and the sun was directly on the solar panel. The panel produced about 2.041 amps, and the trash can was filled in four and half minutes.

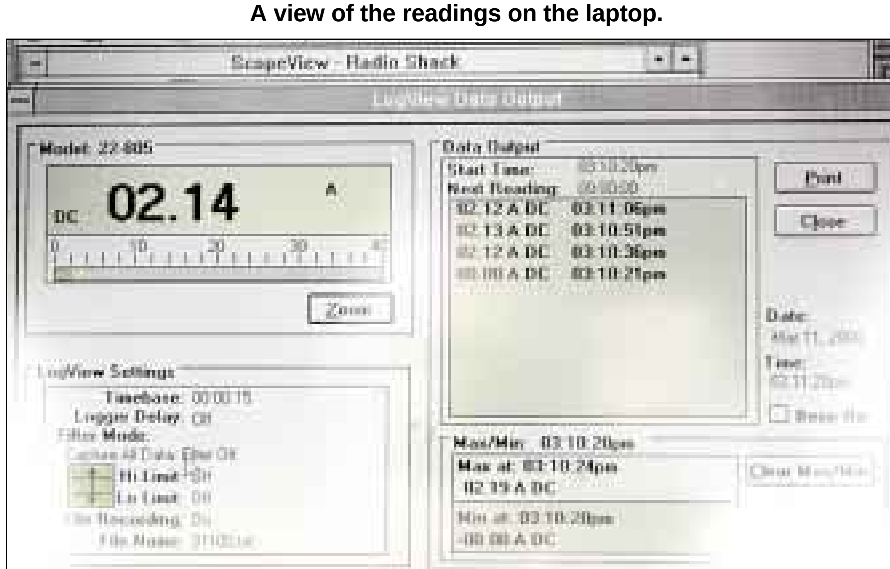
For my last test, I set everything up at about 5 PM. The sun was still out, and mostly on the panel. This time the trash can was filled in five minutes at an average of 1.763 amps. I was amazed at how little difference there was from the afternoon to the evening.

Experiment & Learn

By experimenting, I found out that the pump would only work if the panel was producing at least 0.80 A. The slightest shadow (like when my mom walked in front of the panel) would cause a pause in the circulation of water, and the amperage would drop.

During this project, I learned many things. I think that the most important one for North Coast solar users is that you should put your panels in a place that usually

A view of the readings on the laptop.



Output from Radio Shack Software into Microsoft Excel

***			
'LogView File; ScopeView Version:1.08			
'Copyright 1994-1999.			
'File Created: 11:13:20am Feb 19, 2000			
***			
'Timebase: 00:00:30			
'Hi Limit: Off			
'Lo Limit: Off			
'Filter Mode: Capture All Data; Filter Off			
***			
11:13:21am	0	A	DC
11:13:51am	1.12	A	DC
11:14:21am	1.11	A	DC
11:14:51am	1.14	A	DC
11:15:21am	1.13	A	DC
11:15:51am	1.14	A	DC
11:16:21am	1.14	A	DC
11:16:51am	1.15	A	DC
11:17:21am	1.15	A	DC
11:17:51am	1.15	A	DC
11:18:21am	1.16	A	DC
11:18:51am	1.16	A	DC
11:19:21am	1.17	A	DC
11:19:51am	1.17	A	DC
11:20:21am	1.16	A	DC
11:20:51am	1.17	A	DC
11:21:21am	1.19	A	DC
11:21:51am	1.19	A	DC
11:22:21am	1.19	A	DC
11:22:51am	0	A	DC
11:23:21am	0	A	DC
11:23:51am	0	A	DC
11:24:21am	0	A	DC

gets lots of sun. Also, for consistent output over time, you need to hook the panels up to batteries. This makes it so you can have the pump working nonstop, and you don't need a "direct sun connection" for the panel. For our test purposes, we didn't need batteries. But for real-world scenarios, you should use them for consistent output. Then you can power things inside such as lamps and other electrical devices too.

For a second test, my dad kind of took charge, and attached an additional 20 watt Solarex MSX panel to the circuit board. He then compared the results to the original ones. With the 20 watt panel added, the trash can was filled in an astonishing three and a half minutes, and the average amperage was 2.375! We then tried it with only the 20 watt panel, and the results came out more like the morning test for the 60 watt panel, though that test was done in the middle of the afternoon.

Stupendous Solar Science Test Results

Test	*Ounces Pumped*	*Pumping Minutes*	*Ounces per Minute*	*Avg. Amps*
Morning	2,608	9.0	290	1.155
Afternoon	2,608	4.5	580	2.041
Evening	2,608	5.0	522	1.763
Two panel	2,608	3.5	745	2.375
20 watt panel	2,608	11.0	237	0.973

Special Thanks
Thanks to Michael Welch and Redwood Alliance, for loaning me the solar panel and handing out advice, and to Kelly Larson for giving me great ideas. Also to Eric Jensen, of Sunmotor International, who sent me the pump. And last but not least, my dad, for all the editing, and for helping and supporting me throughout this whole thing!

I did this project for a school science fair. My classmates didn't get to actually see the panel hooked up, but I showed them my backboard, as well as pictures of the whole setup. They seemed very interested, and apparently enjoyed learning about my experiments.

I had a great time doing this project, and learned tons about solar energy. My "revised hypothesis" was correct. The panel did do best in the afternoon, and the pump transported the water at an astonishing rate. For all those people out there who like conserving energy and being self-reliant, I have one thing to say—Solar Rocks!

Access

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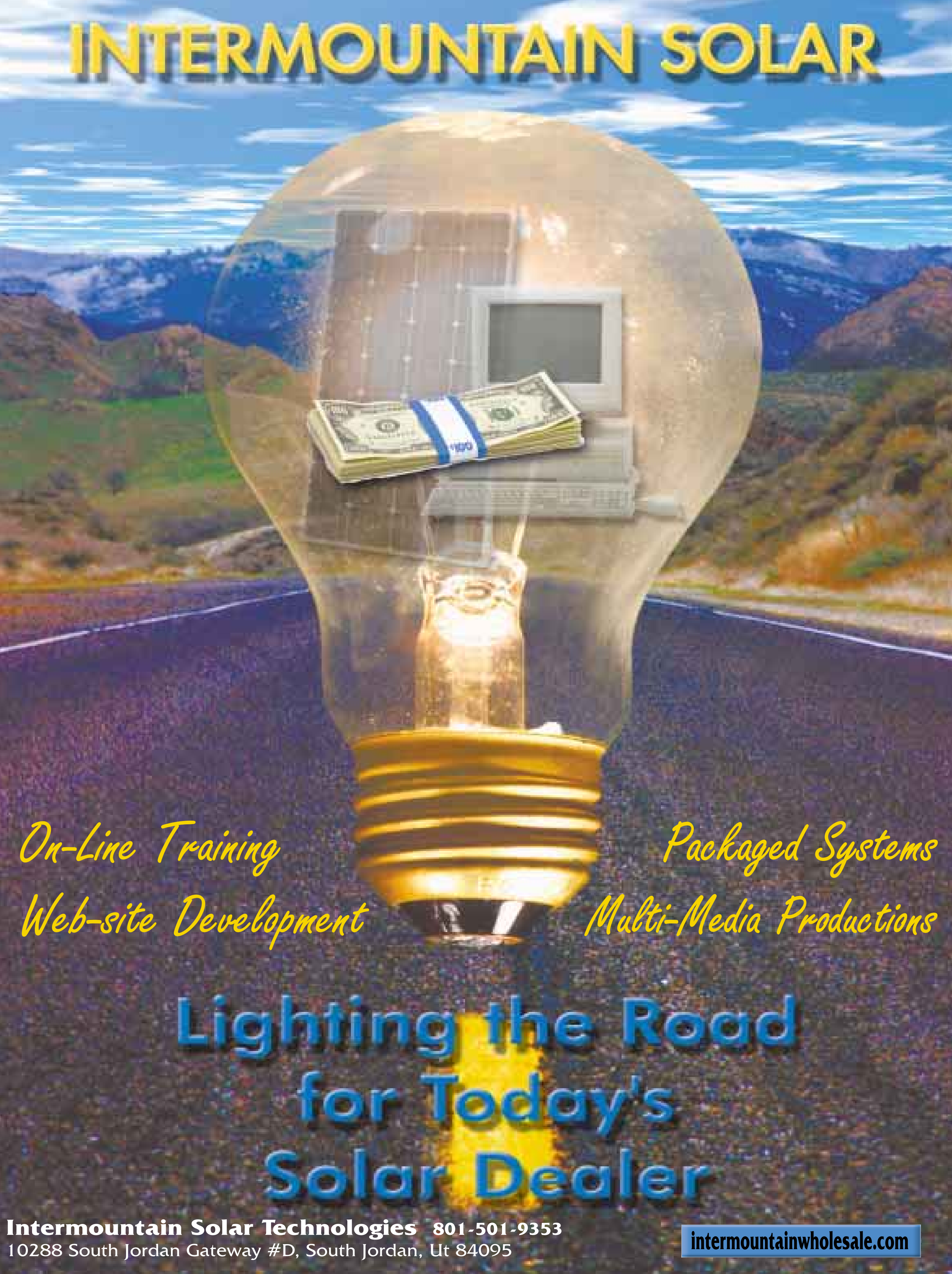
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In just one year, these Solarex Millennia modules will have generated an amount of electricity equal to the energy used in their production. Note: Actual photograph of Millennia modules with patented Integra™ frame.

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RE Novices Tackle PV/Gen Design and Installation

Chip and Clara Boggs

Clara Boggs (center), with friends Rick Rogers and Jim Beaver, in front of the power shed.

Three years ago, we knew almost nothing about renewable energy (RE) systems. Since then, we've gone through the process of choosing to build a renewable energy system, and designing and installing it. Our RE system has allowed us to go online with our computer, step up homestead progress, and enjoy some amenities. We'd like to share with you what we learned on this journey, focusing on the decision-making process, the power shed, and how these can relate to each other.

Where, When, & Why
RE systems differ from centralized power generation in their site dependency and sensitivity. Our homestead is located on 360 acres of rainforest in Oregon's Coast Range. The land is a long, hilly east-west valley in the Coquille River watershed. About half the land faces south, including the main homestead.

The climate is typical of western Oregon. The dry season lasts for about four months. Most of the 68 inch (173 cm) average annual precipitation falls from October to May. Being only fifteen miles (24 km) from the coast, temperatures are mild overall, and snow is an unusual event.

All projects on our property have been low capital, high labor input. The buildings are made of salvaged or native materials, with wood heat, gravity flow water, organic gardens, composting latrine, and other back-to-the-land amenities.

We bought the land in 1989. We had no intention of bringing grid power in, but as a tactic in negotiating for the land, we priced it anyway. US$15,000 would bring power 1/2 mile (0.8 km) from the corner of the land to the homestead. No thanks!

For two years, we lived with no phone or electricity. Generally, we enjoyed non-electric living (with a few exceptions). In 1992, we planned to leave the land for a year to make money. The future caretakers needed a phone for their business. We dug the trench, and the phone company gave us the cable.

Have you noticed that life is what happens while you make other plans? Well, our "one year" absence dragged out to five years, during which time we became involved in defending wrongly convicted people, which was mostly online work. We returned to Oregon in 1997, but two obstacles prevented us from moving back onto our land. First, the homestead was in acute disrepair. Second, even though there was a phone, there was no electricity for our computer, and our online justice work was becoming critical to more and more people.

The RE Decision Process
The first thing we needed to do was research. We had botched a few projects in our brief career as homesteaders. The lessons learned usually cost us more time than money. However, an RE system costs a lot, so we wanted to do it right. It justified a proportionately greater amount of research. We ordered all the back issues of *Home Power.*

PV, wind, or hydro? Wind was not a realistic option. Hydro held the greatest potential, but seemed more complex than solar. Admittedly, we didn't know enough about either resource to make a truly informed decision. However, we did know that hydropower would involve laying lots of pipe through thick vegetation on steep, unstable slopes. Then, too, there are clogged intakes, moving parts, and regular maintenance. Finally, the creek is 600 feet (180 m) from the house, while there's sun on the front porch.

The vented battery box is built onto two small pallets to keep the batteries off the floor. Twelve Interstate 6 volt, 350 AH batteries provide 1,050 amp-hours at 24 volts.

Our immediate need was for a few KWH per day—not for the ultimate potential of the site. We do hope to have microhydro power in the future. But PV, with no moving parts and some siting flexibility, seemed like the way to go.

Who & How
Since we are inveterate do-it-yourselfers, we had always assumed that we would install the system ourselves. However, after reading *What to Expect from Your RE Dealer (HP61,* page 40), we had second thoughts. The article did help us clarify our options:

DC power comes in from the modules, through the safety disconnect (left) and charge controller (right), and then goes to the batteries. Power for DC loads comes directly off the batteries through the DC load center (below).

- Have a dealer/installer do the whole works.
- Contact a full service dealer to design the system, supply the components, and advise us on installation.
- Design our own system, shop competitively from discount RE suppliers, and order everything and install it ourselves (possibly with no advice from the supplier).

With our experience level, we never seriously considered the third option. If we hired a dealer, we wanted to do the low-tech labor ourselves, as suggested in the article. Typically, the low-tech labor comes *after* load analysis and system siting, but *before* system installation. We did not know of a local RE dealer, so this presented another set of options:

- Perform the load analysis, system siting, and low-tech labor ourselves. Have the dealer install the system, paying for only one travel trip.
- Pay the dealer for two trips; first for the load analysis and siting and later for the installation.

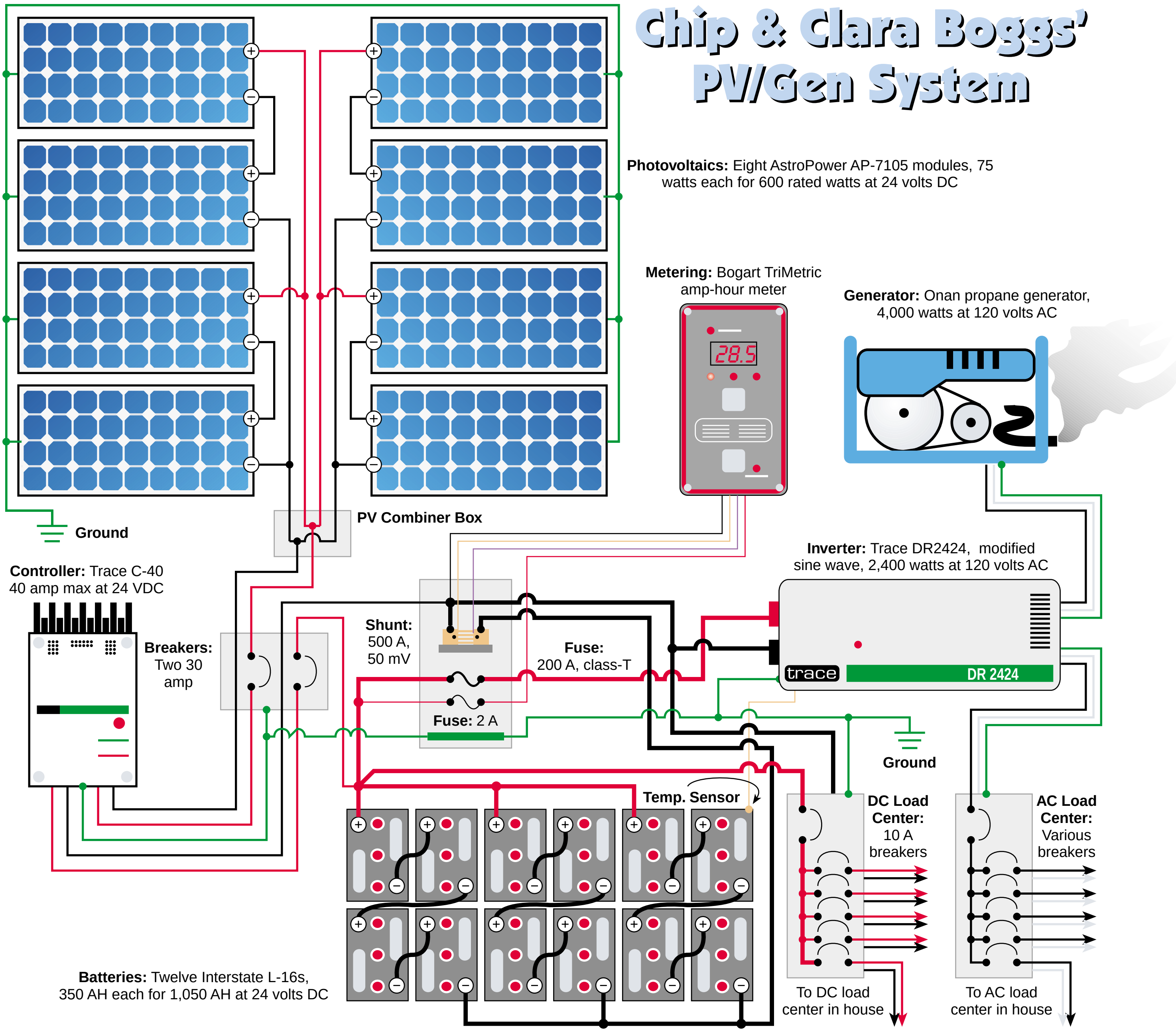
Load analysis and siting seemed easy compared to installation, so we chose the first option.

We ordered a Solar Pathfinder *(HP57,* page 32), and made a homebrew ammeter *(HP33,* page 82). Only the eventual users of the system can carefully analyze their loads, and determine what their lifestyle and electrical consumption will be. Doing this analysis was fun and easy *(HP58,* page 38).

The homebrew ammeter worked just as the article said it would. We measured the amperage of each appliance and multiplied by 110 volts to find the watts. We estimated the time each appliance was used. Adding standard losses for the inverter and overall system, we arrived at 1,769 watt-hours per day. With this data, we could generically size the system and estimate the cost. It appeared that we could afford a system sized to meet our needs.

I started wandering around the homestead with the Solar Pathfinder. At first, my self confidence wavered as I contemplated the numerous variables. Gradually, I realized that I had my own site knowledge that no

The AC output from the inverter feeds the AC load center. One circuit breaker goes to Chip & Clara's cabin, with lots of room for more breakers.



expert could duplicate. The Pathfinder quantifies the most important variable (solar access), but other variables can be integrated by more intuitive means.

I knew that PV modules, batteries, and inverter should be as close to each other as possible. So by siting the modules, I was spatially arranging the whole system. The best alternative was to build a power shed above and behind the homestead. Mentally summarizing the "low-tech labor" part of the project, I decided to:

1. Design and build the power shed.
2. Build and install the module racks.
3. Build the battery enclosure and place the batteries in it.
4. Dig the trench between the power shed and the house.
5. Run conduit and pull cable from the power shed to the house.

During this time, we met someone who had ordered a PV system from Real Goods and had installed it himself. The psychic pendulum started to swing back towards installing the system ourselves. At about this point, I realized that if I trusted myself to do the load

Clara Boggs at her PV-powered computer workstation.

Boggs System Loads

Item	*WH/day*	*%*
Computer	1,106	56.3%
3 CF lights	343	17.4%
Coffee maker	187	9.5%
Inverter, standby	160	8.1%
Laser printer/copier	31	1.6%
Word processor	32	1.6%
Visitor's computer	29	1.5%
Radio	24	1.2%
Washing machine	24	1.2%
Power saw	17	0.9%
Power drill	5	0.3%
Juicer	5	0.3%
Blender	3	0.2%
Total WH/day	1,966	

and site analysis and low-tech labor, that with some outside advice, I might as well attempt the entire installation.

Our next decision was which RE dealer to purchase our equipment from. We did not research this much, but called Real Goods, with whom we were most familiar. We knew that they could design the system, select the components, and advise us on installation. On the phone, we met Roger Breslin, who became our personal consultant.

Once we decided to cast our lot with Real Goods, we were not bashful about asking advice. Roger even helped us compare sites for the power shed and PVs (over the phone!). He recommended the site 50 feet (15 m) behind the house, even though a site 100 feet (30 m) away had slightly better sun. (Pruning can improve the nearer site over time.)

The Power Shed

In our county, a 10 by 12 foot (3 x 3.7 m) building is allowed without a permit. The system would not require this large of a building, but we knew the extra space would be handy. The nice thing about building a power shed is that you don't have to compromise on the design. Every element of shed design supports or enhances a feature of the RE system.

Equipment layout, doors, and floor plans were adjusted to the nearest inch to maximize use of the space. The building is oriented due solar south, and has a concrete slab floor for thermal mass and to support the battery bank. It has a large double-glazed window for passive solar heat, and a roof overhang that gives it sun in the winter but shade in the summer. Batteries don't like to get cold, and we didn't want to provide a heating system.

With the rack design in *HP57,* page 32, you can't adjust the summer angle *below* the roof angle. Our latitude is 43 degrees, so the ideal summer angle is 28 degrees. Also, airflow behind the modules is necessary, particularly in summer, so you don't want them lying flat on the roof. A roof angle of 11 degrees (2.5 in 12 pitch) provides summer airflow, but is also steep enough to shed our abundant rainfall.

We wanted to provide room for future modules. The roof overhangs 4 feet (1.2 m) on the north side and about 1-1/2 feet (0.45 m) on the other sides, giving a total surface area of about 16 by 15 feet (4.9 x 4.6 m). This will accommodate six racks, each holding four modules, or 24 modules total. Our initial system has two racks (eight modules), so we could triple the size of our array in the future if need be.

Generator

We focused on safety in our power shed design. A lengthwise interior wall separates the generator from the batteries and controls. This also doubles the wall surface inside the shed. The interior door is placed at the end of the wall to maximize unbroken wall space. Propane tanks are placed outside, under the 4 foot (1.2 m) roof overhang, separating them from the generator.

We put the generator in the room away from the house to minimize noise. The interior was plastered with a gypsum/perlite mix for acoustical absorption. The exhaust pipe runs out the north side of the shed. It then

The 4 KW Onan generator in the north room of the power shed. The air intake is under the wooden stand.

runs underground through a protective shroud of old stove pipe, ending at the top of a drainage ditch. The north door is 36 inches (91 cm) wide to facilitate generator removal for servicing. A 1/2 inch (13 mm) eyebolt is screwed into a rafter for hanging a chain hoist.

The generator only occupies 6 square feet (0.5 m^2) in the 50 square foot (4.6 m^2) room (the north half). This leaves enough space for the Staber washer and a clothes sorting table. There was even room left over for a few shelves for food storage. The exterior doors open out instead of in, to conserve space. In the south half, this leaves room for tool shelves.

System Design and Installation

I recommend generically sizing the system yourself, even if someone else is designing your system. *(The Solar Electric House* and *Real Goods Sourcebook* have good formulas.) Then let your dealer select the specific components. They will know product compatibility, application, and the best value for your budget.

Our inverter, charge controller, and battery bank were oversized so that only more PV modules would be needed to expand the system. Roger recommended eight 350 AH batteries, but we decided to go with twelve. We wanted to build easy expandability into the system, but knew it is best not to add more batteries later.

All the equipment arrived in excellent condition. Pulling everything out of the boxes, I was still unsure of how it was all going to fit together. After all the low-tech jobs were done, I finally had to start wiring. Roger sent me a wiring diagram, and it took me about a week to hook everything up. I was also helped by Chapter 12 of the *Solar Electric Independent Home Book,* which gives a step-by-step generic procedure for PV/Gen system installation.

Even during installation, I was still a little skeptical about whether everything would actually work. Finally, I removed the coverings from the modules and started charging the batteries—I got a real charge out of that. An electrician friend came over to install the final fuses, energize the breakers, and connect power to the house. We found a few shorts in the house wiring, but no errors in the RE system. In a few hours, we emerged from the “smelly darkness” forever!

System Operation

We record generator run times, battery waterings, and propane tank changeouts. We ran the generator 240 hours the first year, exceeding the break-even point of genny vs. PV module cost *(HP51,* page 66). In December 1999, we added eight more modules, doubling the array size. Generator use has been

Boggs System Costs

Item	*US$*
8 AstroPower AP7105 75 W modules	$3,032.40
12 Interstate batteries, 6 V, 350 AH	2,239.92
Onan generator, 4 KW, used	1,738.00
Trace DR2424 inverter	1,220.75
Wire, conduit, & misc. supplies	244.00
PV rack materials	215.00
Power shed construction	200.00
Trace C-40 charge controller	175.00
13 battery interconnect cables, #2/0	146.25
150 ft. twisted pair wire (for TriMetric)	138.00
TriMetric 2020 monitor	132.05
AC service panel, 200 A with breakers	120.00
DC service panel with breakers	120.00
2 inverter cables, 10 ft.	85.45
Cable, #2 & #4,140 ft. each	60.00
Safety equipment & hydrometer	50.30
Lightning protector	47.45
Junction box, 10 x 8 x 4 inches	37.95
Safety disconnect, 2 pole, 30 A	33.25
Power distribution block, 2 pole	28.45
Shunt, 500 amp / 50 mV (for TriMetric)	27.55
Trace battery temperature sensor	18.95
2 RK5-30 fuses, 30 A	7.50
Total	$10,118.22

Chip Boggs flips the AC load center's main breaker in the house.

reduced by two-thirds, and we have excess power for over half the year.

The larger than expected usage comes from Clara running her computer twice as much as I thought she would. But I can't complain, since the main reason we installed the system was to support the justice work she does on the Internet. Although the computer processor stays on most of the day, Clara turns off the monitor whenever possible.

We are not running any pumps, motors, compressors, or resistive loads (except for the coffee maker). The washing machine is usually run when the generator is on. There is no television. Most lights are compact fluorescents. The buildings are also wired for 24 VDC—we'd like to have a few LED lights which could be used without the inverter. A TriMetric system monitor is mounted on the front porch, where everyone can see it.

Lessons Learned

I would not make any changes in the system design, siting, or power shed. Most of the lessons came during installation.

The 1-1/2 inch conduit was tight for the main cables running from the power shed to the house (two #2 (33 mm^2) cables for AC and two #4 (21 mm^2) cables for DC). Both AC and DC cables were sized for 5 percent or less voltage drop. AC cable was rated for about 100 amps, and DC cable was rated for about 10 amps. Direct burial cable was used—the conduit was for physical protection only. The straight lengths were OK, but the wire seems to expand when it makes a turn. We also overlooked running the system monitoring (TriMetric) wires. So I had to dig up the conduit, already stuffed with wires, and force the cable through it.

I designed the power shed before the equipment arrived. I did not take into account which side of the inverter the battery cables must attach to. This made a difference of 3 feet (0.9 m), so my 10 foot (3 m) inverter cables wouldn't reach. This necessitated redesigning the entire layout of the battery and control room.

I built the PV racks as shown in *HP57,* page 32, but didn't take into account the large corrugations of the metal roofing. So I had to add 4 inch (10 cm) legs between the skids and the bottom of the rack, lifting the bottom of the rack over the corrugations. I also built the battery box before I understood the battery wiring. The positive main terminal is twice as far (10 feet; 3 m) from the inverter as the negative terminal (5 feet; 1.5 m). Oh well, that's how it's gonna stay.

Thanks

We are grateful to Roger Breslin at Real Goods for his patience with us. We called him about once a week for six months. He always returned our calls, and got other help when necessary. In a word, the service was exemplary.

In the same room as the generator, there's plenty of room for a Staber washer, laundry table, and food storage.

We are also grateful for *Home Power* magazine. We would not have attempted this without their decades of wisdom, experience, and inspiration. Specifically, our “top ten” most helpful *HP* articles were (not in order):

- *Grounding Separate Structures, HP65,* page 70.
- *Two In Maine* (power sheds), *HP40,* page 6.
- *What to Expect from Your RE Dealer, HP61,* page 40 (commentaries in *HP62,* page 99).
- *Generators as a Backup Power Source, HP51,* page 66.
- *Where and How to Mount PV Modules, HP57,* page 32.
- *Battery Rooms—a Cellular Home, HP33,* page 42.
- *Doing a Load Analysis, HP58,* page 38.
- *A Beginner’s AC Ammeter Project, HP33,* page 82.
- *Buying and Using a Digital Multimeter, HP60,* page 42.
- *Are Photovoltaics Right for Me?, HP1,* page 11.

Pioneering with RE

The decision to install the system ourselves was protracted. Someone else’s decision tree will be different, though it might resemble ours in some respects. Our installation goofs only cost us extra labor, and did not compromise the safety or efficiency of the system.

Looking back, we’re glad we did it ourselves. The project certainly built our technical self-confidence. Adding the extra PV modules was a snap, and we’re looking forward to microhydro. Even with such user-friendly equipment available these days, there is still a pioneering aspect to RE, an aspect which is enriched by doing it yourself.

Access

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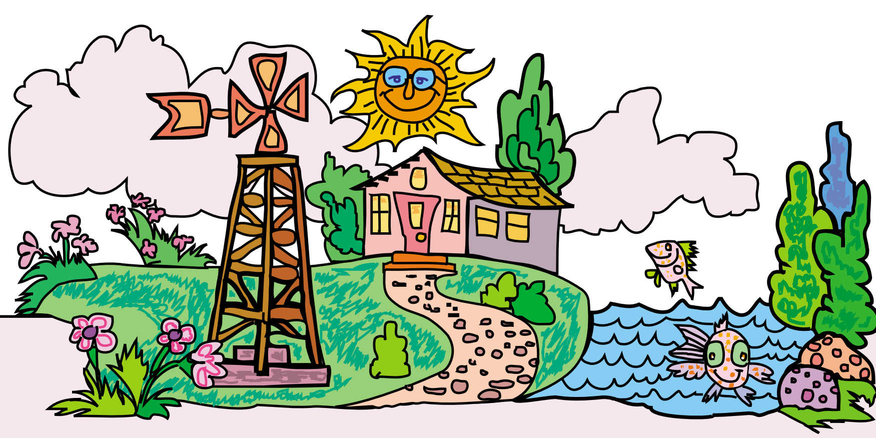
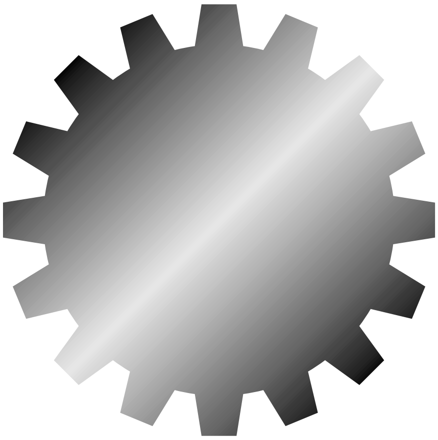
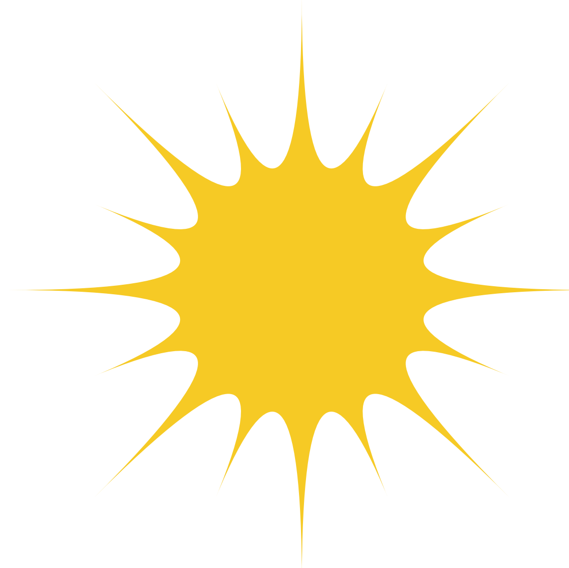






Hydronic Heating on Renewable Energy

Rod Hyatt

The Edisons' 800 square foot (74 m²) studio is made of straw bales that have been stuccoed. Like the main house, the studio is solar-hydronically heated.

Off the grid and can't power the pumps and controls for a heating system? Yes, you can. The answer is DC hydronic heating—a natural extension of using the sun's energy in your energy-conscious home.

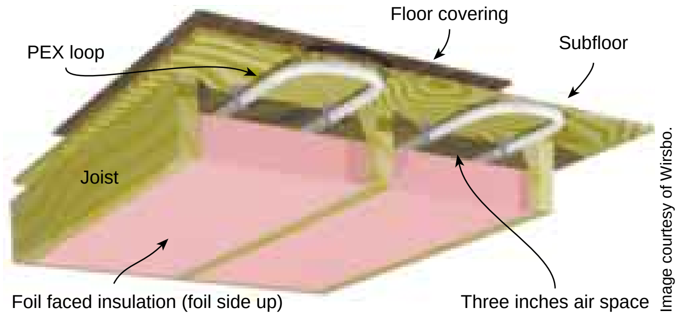
One of the most overlooked aspects of solar energy is hydronic heating, which you might have heard called radiant floor heating. The concept is simple, and a must for any solar-powered home. Hydronic heating works by circulating heated water through or under your floors. This can be easily integrated into the construction of a new home, or installed in an existing home. Many systems can be installed by the homeowner. Add solar hot water panels, and the sun will help you heat your home.

Forced-air heat is often not suitable for off-grid homes because the power consumption is far too high. And conventional radiant floor heating systems are generally not suitable because of the large amounts of electricity the pumps guzzle. The answer is low voltage DC pumps.

There are other advantages to these systems for homes on and off the grid. Top among them is the reduction in dust and dry skin, which are problems caused by forced-air heating systems. Also, an efficient system can use up to 40 percent less fuel, according to the National Energy Association. And you just can't beat a cool evening spent watching TV lying on the warm floor under a blanket, or stepping out of the shower onto a heated floor.

The straw bale studio in progress.

Hydronic Loops Under a Wood-Framed Floor



We've heated our basement with radiant floor heat for several years now. Not only does it make our bottom-floor family room and office comfortable, but it reduces the need for heating on our main floor.

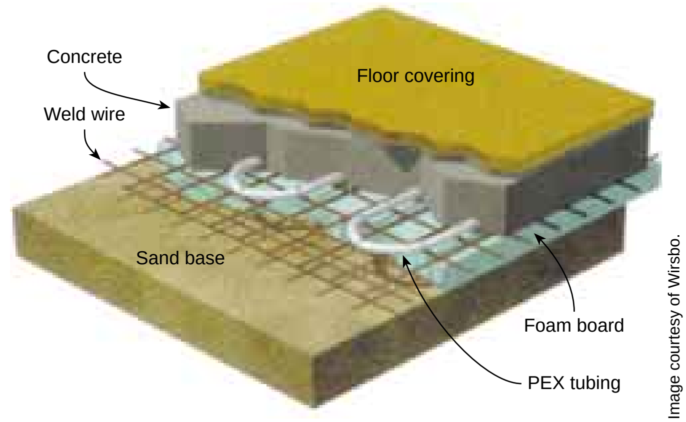
As a designer of low-voltage DC hydronic floor heating systems, I've worked with people in all walks of life. They come to me with a variety of budgets, whether building their dream home or restoring a 30 year old monstrosity (like mine!). Hydronic heating can be used in nearly all homes. Outside, it can even be used to thaw icy driveways.

Three Main Uses

I've found that there are three main applications for hydronic heating systems. First is new construction. At this stage, the heating system can be custom designed for your house.

Second is retrofitting existing homes. This can be an easy or difficult undertaking, depending on the style of the home. The homes best suited for this have crawl spaces or unfinished basements. We've found that the cost of these systems can be comparable to forced-air heating. So it becomes a viable option for a city or suburban home that depends on the local electrical utility.

Hydronic Loops In a Slab Floor



Third is retrofitting a hydronic heating system into an existing solar-powered home. Often, a conventional hydronic heating system uses too much energy to operate on a solar-electric system. However, DC-powered pumps—and the fact that many AC components aren't needed—can bring a hydronic heating system within the power boundaries of an independently powered home.

Recommended Pump

Hydronic systems can be designed with very low power requirements. In the systems I've designed, the heart of the system is the El-SID (static impeller drive) pump manufactured by Ivan Labs of Jupiter, Florida. These pump motors, which come in 3.5, 5, and 10 watt sizes,

When it's finished, this 4,800 square foot (445 m^2) straw bale structure will be the Edisons' dream home.

The Edisons' home, waiting for concrete to be poured. PEX tubing is tied to the weld wire to hold it in place during the pour.

have no moving parts. The pump has an inductive magnetic drive that magnetically spins the propeller in the pump. Because there are no seals or moving parts in the motor, it has an extremely long life and makes no noise. These DC-powered, low-voltage pumps can be operated directly from your home's thermostat. No other controls are needed.

Normally, an inverter is required to change battery (DC) power to AC home power. With this DC system, the inverter does not have to be sized to run the heating system. As a result, it works well as an addition to systems that don't have inverters. Or if you have an inverter, you won't have to upgrade to a larger inverter. Because it's a DC system, it can operate directly from your batteries. In a grid-powered home, a simple AC/DC wall cube makes a great power source for these pumps.

Each 10 watt pump has the capacity to circulate hot water through 600 feet (180 m) of half inch (13 mm) tubing. I recommend PEX (cross-linked polyethylene) tubing. PEX is fast becoming an industry standard because of its successful track record in Europe.

The size of the system depends, of course, on your climate and the size and type of your home. The entire operating system for most homes consists of a DC power source, as well as a number of 10 watt El-SID pumps turned on and off directly by a thermostat. The pump and thermostats are the only moving and electrical parts in the entire system.

Sizing Your System

Here's how to figure what you will need for your home in an average climate. Consideration of your climate and BTU heat loss calculation could increase or decrease these figures. These are approximate examples only.

First, figure out how much tubing your home will need. A good formula is 125 percent of the square footage of the floor area you want to heat. A 1,200 square foot (110 m^2) home, for instance, would need 1,500 lineal feet (460 m) of tubing. PEX tubing is best used in lengths of 250 feet (75 m). In these low temperature systems (they generally run at temperatures of 100–120°F; 38–49°C), heat duration peaks at 250 feet. So by the time the water's gone much more than 300 feet (90 m), it has expended its heat.

By stamping and staining the concrete, the Edisons have eliminated the need for any floor covering. You'd never know there were heating tubes underneath.

A single El-SID pump will support two loops of 250 feet each. For example, a 1,200 square foot home will need 1,500 feet of PEX, and will require a total of three pumps and six 250 foot loops.

Tubing & Insulation

During construction of a home, the tubing can be installed directly in an insulated concrete slab floor. An insulated slab is a concrete floor that usually has about 2 inches (5 cm) of rigid foam board under it, and a thermal break around the edges. Often, we put 2 inch foam board right down on a prepared dirt or sand bed.

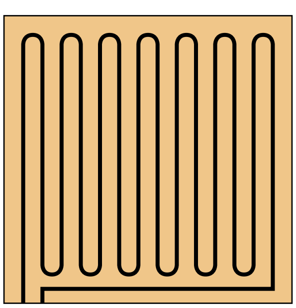
I often use 6 by 6 inch (15 x 15 cm) weld wire to meet the metal requirements of the floor. This works well in hydronic systems, since the weld wire makes an excellent structure to attach the PEX tubing to.

A well insulated home in an average climate will require the tubing runs to be spaced about 10 inches (25 cm) apart. After the tubing has been fastened to the weld wire, the standard concrete floor is finished right over the tubing. Concrete depth is usually 4 inches (10 cm), with the tubing laid approximately in the center of the slab's depth. You have several options as to what pattern to run the tubing (see diagrams below).

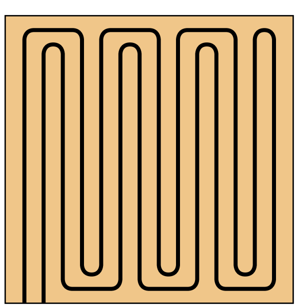
For standard wood-framed floors, the tubing can be tacked right to the underside of the floor between the floor joists or TGIs. Generally, two runs (one loop) of PEX tubing are attached to the underside of the floor between each floor joist. Once the PEX is installed, insulate the cavity with a foil-faced insulation.

A tangle of tubes come together at the location of the future manifold in the main house.

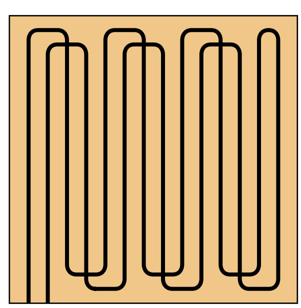
Suggested Loop Patterns



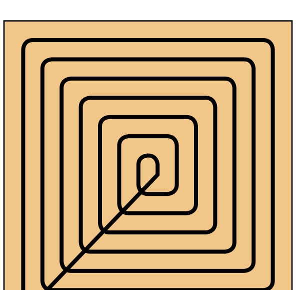
Serpentine



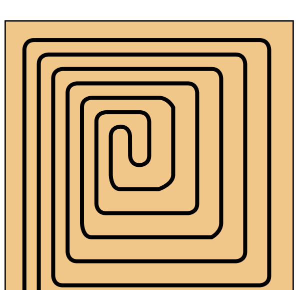
Double serpentine



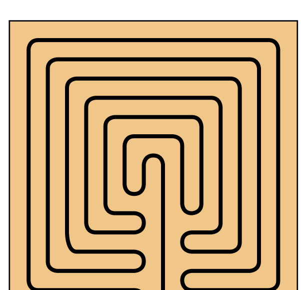
Overlapping serpentine



Single spiral



Double spiral
(variable density)



Split double spiral

Face the foil up, leaving a 3 inch (7.6 cm) air space between the top insulation foil and the underside of the floor. This works to reflect the heat back up through the floor. The PEX tubing should not touch the insulation. It's not necessary that the PEX be in direct contact everywhere on the underside of the floor; part of the heat transfer takes place by heating this 3 inch air cavity.

Concrete is most often used for radiant heating systems, especially in construction in the United States, and a layer is often poured right over wood floors. Its value is in its ability to retain warmth, although it does have a slow reaction time. On the other hand, the response time of radiant systems placed under wood floors is much faster.

Tubes gathered and ready for a manifold.

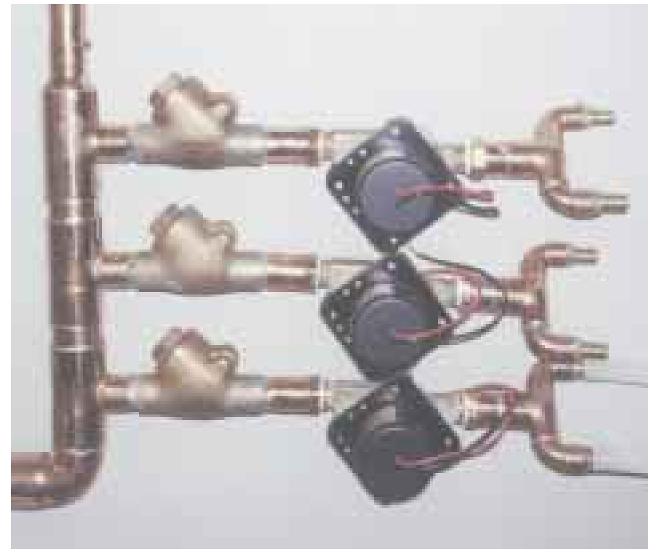
And because wood floors are on main and upper levels where the sun shines and heating needs change more often, the quicker response is a benefit. (A concrete mass works great in the basement where you want a slow, even heat.) Combine the quicker reaction time with the relative simplicity of installation and the cost savings, and the benefits of installing a system right under an existing floor can even out with those offered in a concrete-poured system.

Building the Manifold

The next step is the creation of a simple manifold. A manifold is a feed and return junction that delivers an even flow of warm water to and from the floor loops. They are often built out of 1-1/4 or 1-1/2 inch copper tube fittings. They can be custom built to accommodate the pumps and connect all the feed and returns of the PEX loops. Each pump (with two loops) can be operated as one zone.

We like to use an injection loop and pump. This is a wonderful way to turn your passive solar-heated rooms into giant solar collectors. For example, consider a two-story home with large south-facing windows on the main floor. The sun shines on the floor all day long. The warm water from the sun-heated floor will circulate to the cooler places and basement.

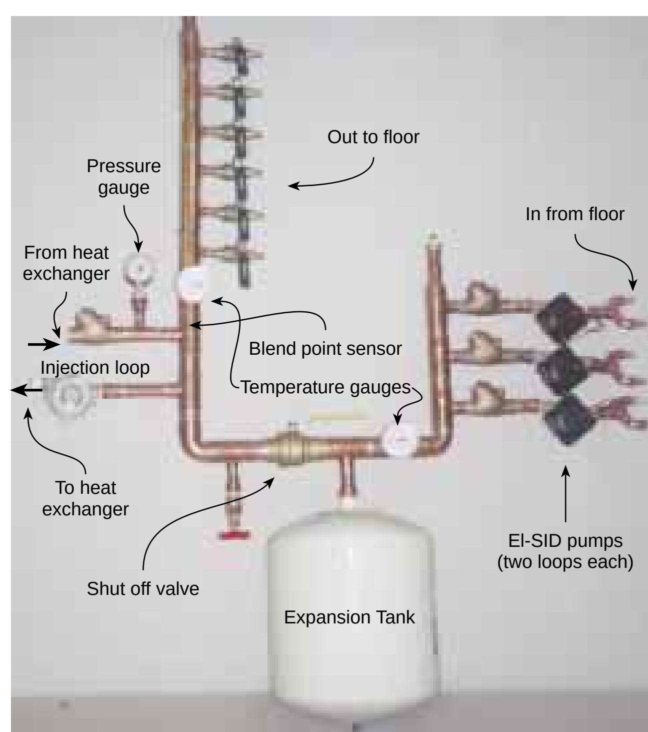
The injection loop pump will not inject heat into the system until the system's temperature drops to a particular setpoint. With the sun shining and warming this portion of floor, it may supply enough heat to maintain the temperature of the entire house (see manifold photo with injection loop).



Static impeller drive (SID) pumps from Ivan Labs are the secret to the low wattage of the studio's hydronic radiant-floor system.

The injection pump consists of an El-SID pump that's similar to a zone pump, but has a built-in controller. There are also two sensors. One is placed on the manifold just below the injection-loop blend point, where it monitors the system's temperature and determines when to turn the pump on and off. The other is placed outside, usually under the north eave of the home. It monitors the outside temperature, giving the

An example of a DC manifold with three zones.



indoor system a heads-up of outdoor temperature changes, like those caused by the rising sun. This system of injection pump and sensors is often called an outside reset.

The manifold is relatively easy to construct, but can be time consuming. Often we build the manifolds for the customer's particular home. When the manifold is complete, we attach the PEX loops to the manifold and hook up the heat source. Voila! Warm, clean, quiet heat.

Where to Find Heat
Heat can be supplied by a direct gas-fired boiler. A tank with a heat exchanger can heat the home, as well as supply all the domestic hot water you need. Hot water solar panels are an excellent asset for this system, and can supply heat for both the home and for domestic water. Another option for a heat source is a wood/coal-fired boiler. Some systems, like the one I use in my own home, use all three. The heating system can be installed by homeowners who have basic plumbing skills.

Avoid Cast Iron
When plumbing and heating contractors install radiant floor heating systems, they have a difficult time not using cast iron boilers and pumps. However, cast iron is thick and heavy, and it rusts as it ages. Yes, you can purchase more expensive specialty components (like oxygen-barrier tubing) to slow this process. But the cast iron will still decay and send all that rust through your heating system.

Can you imagine all that gunk and abrasive rust circulating through your pumps, valves, and tanks? The goal is to install a clean radiant heating system that will last forever. The best choices are stainless steel, copper, PEX, and brass.

Boilers are most often cast iron, but I prefer boilers that are made of nonferrous metals. Cast iron boilers were once the only choice. But copper and stainless steel boilers are becoming more readily available. Their efficiency ratings range from 80 to 98 percent.

Radiant Heating in the Rockies
Last spring, I was contacted by Richard and Maura Edison, a young professional couple in Boulder, Colorado. They asked me to design a solar hot water and radiant floor heating system for their new 4,800 square foot (445 m^2) home and 800 square foot (74 m^2) studio, which are both straw bale. They started their dream years ago by purchasing 100 beautiful acres in southern Colorado, west of Pueblo.

Maura Edison came up with the floor plan of the home and studio. The heart of the power system would be a Trace PP 5548D double inverter power panel, with a dedicated, battery-direct 1,000 watt 48 volt Exeltech inverter to run their finest electronics.

The Edisons had studied up on all the solar hot water panels available, and had come to the fast conclusion that the best on the market was produced by Thermomax. After working with a number of systems, I have also found Thermomax to be the highest producing and best quality product on the market. The evacuated heat tube technology has the highest heat collecting abilities per square foot of any system on the market. Each collector is 80 by 87 inches (203 x 221 cm), and contains 30 tubes.

Edison Studio Heating System Costs

#	*Component*	*Cost (US$)*
1	Aquastar 125LPL recirculating boiler	$695
	1,000 feet 1/2 inch PEX tubing	480
2	El-SID 10B pump, 12 V 10 W	378
1	March 809-BR-HS-12 pump, 12 V 40 W	239
1	15 gallon insulated water tank	129
1	Amtrol expansion tank, with liner	95
1	Mixing valve for domestic hot water	95
12	1-1/4 x 3/4 x 1-1/4 inch copper tee*	84
1	Crimping tool	50
1	Honeywell Aquastat (submersible thermostat)	49
2	Check valves, swing type*	42
1	Thermostat	39
2	Temperature gauge	38
4	3/4 inch ball valves, full-port*	28
10	3/4 inch sweat to 1/2 inch female thread*	20
2	Air purge with key*	20
	5 feet of 1-1/4 inch tubing*	20
1	Pressure gauge	13
2	1-1/4 inch copper street elbow*	10
8	1/2 inch Pex to 3/4 inch sweat/barb*	8
4	1/2 inch street elbow*	8
1	Filling spigot*	8
2	1/2 x 3/4 x 1/2 inch tee*	6
2	1-1/4 inch to 1/2 inch reducer*	6
2	1/2 inch female sweat to threaded*	4
	Engineering	0
	Tech support	0
	Total	$2,564

*Manifold components

Eight Thermomax panels, with thirty evacuated tubes each, generate hot water for space heat and DHW.

Finding the space to place the eight Thermomax panels on the roof was not a problem at all. And because each Thermomax panel only holds about 1 liter (about a quart) of water, there was no concern about weight in the roof design.

The system design called for the heat to be sent to a 120 gallon (450 l) storage tank via an internal heat exchanger. The heat would then be dispensed to the different floor zones as it was called for. The Edisons have not decided where they will send the excess heat available in the summertime. I suggested a large hot tub or pool.

Paul Huber at EcoStruct was contracted to build this home and studio. After he took on the job, Paul called me to fax the floor plans. My fax machine spit out seven pieces of paper, each a different segment of the house and studio. It took me an hour to tape all the pieces together to make a floor plan.

It was the most ingenious floor plan I had ever seen. The exterior walls had a total of 28 corners. I was getting dizzy just thinking of stacking the bales up on such a labyrinth. I could see that it would take an extremely talented builder to complete such a wonder. There was no doubt that the result would be a fantastic beauty, as you can see in the photo of the nearly completed studio.

The hydronic heating system for the studio has a very simple one-zone, one-thermostat operation that will also provide domestic hot water. The power demands are so low that very little consideration needs to be taken in sizing the home's power system. Because it is all DC, an inverter has no part in this plan.

There have been many studies on straw bale wall construction and its insulation value. One University of California study estimated that a standard 18 inch (46 cm) wide straw or rice bale equals R-26. Research by Joe McCabe at the University of Arizona with the same size bale found an insulation value of R-42.8.

Because there are many variables, such as the moisture content of the bales, it's difficult to determine the building's heat loss and come up with an accurate pump run time. I estimated that the pumps will run for an average of six hours in each 24 hour day. That would give a total power load of 390 watt-hours per day. You can burn up more power watching TV than it takes to run this heating system.

The home will have a much larger and somewhat more complex heating system. But the point is, you don't need a lot of power to support it, and you can have a wonderfully heated home using renewable energy.

Comfortable Radiant Heat

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Access

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Richard and Maura Edison have a Web site about their straw bale house: http://members.aol.com/rcedison2


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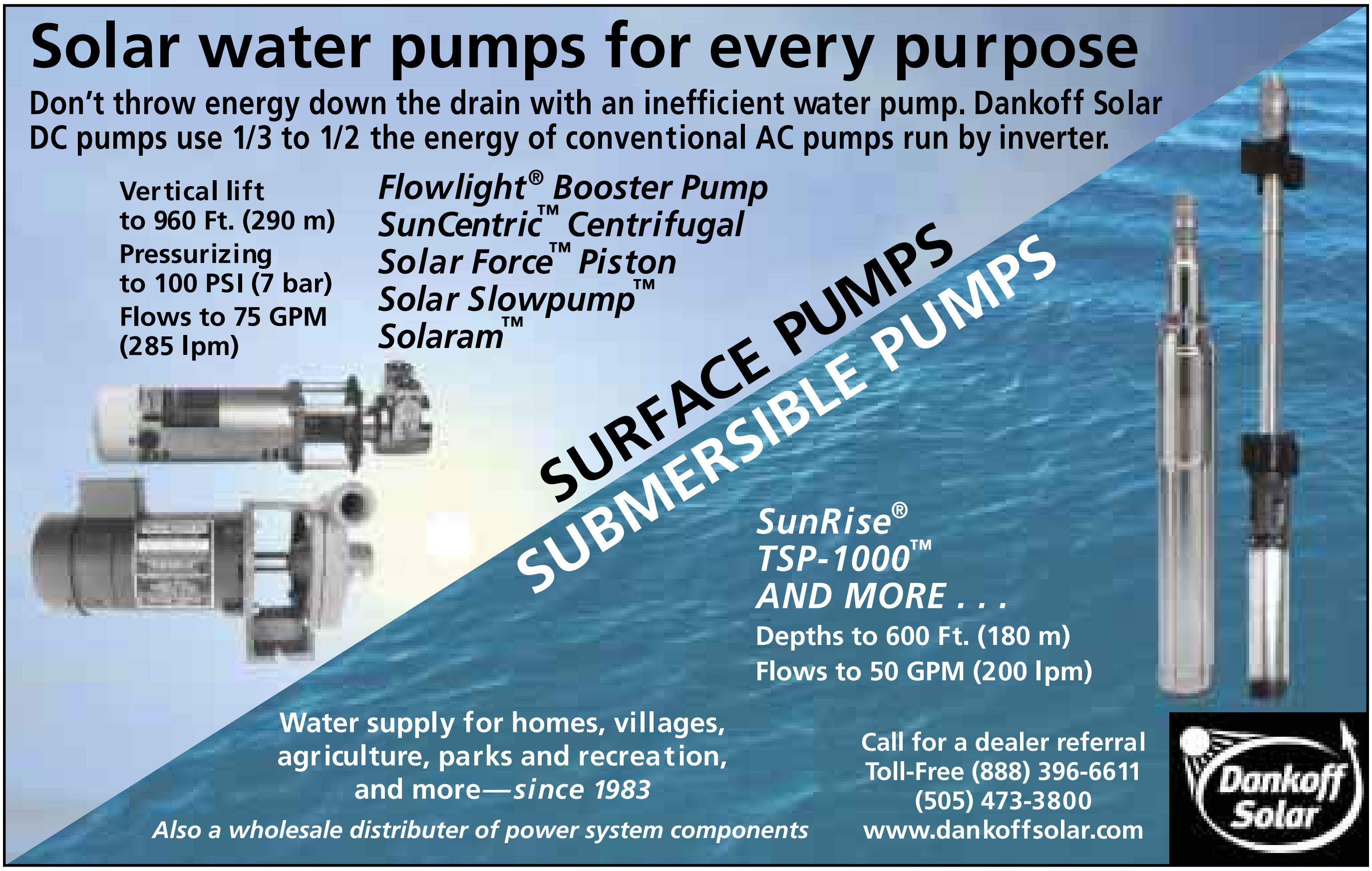
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Maine-Built Windmills From Scratch

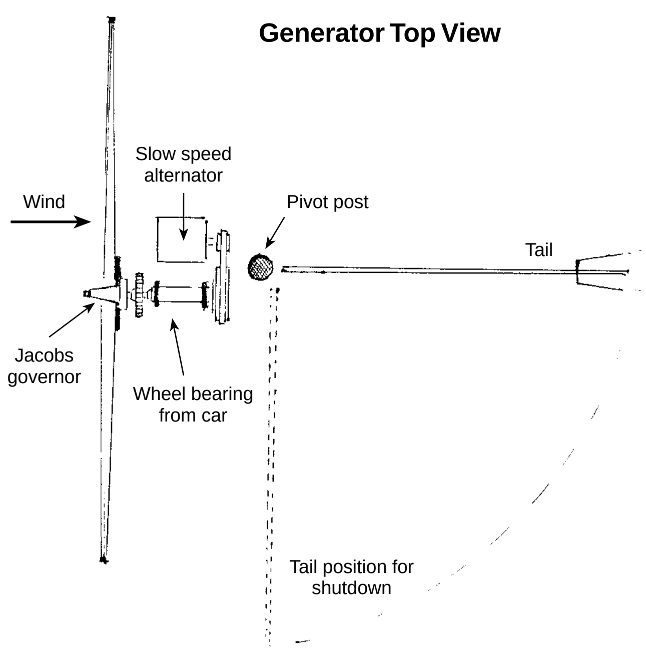
Everett Russell

One of Everett Russell's two home-built wind generators with a 14 foot rotor diameter.

I have been building windmills since 1937. These windmills are strong and practical. Unlike many others, mine are built from scratch. Some people say building windmills from scratch is not practical. I disagree. I believe my machines are not only practical, they're rugged, they continue to serve me well, and they have passed the test of time.

Right now I have two working windmills—both 14 feet (4.3 m) in diameter and about 500 pounds (225 kg) each. They both generate at 120 volts. One puts out 10 amps, and the other generates 20 amps, at about 225 rpm in a 20 mph (9 m/s) wind. The alternator that puts out the 20 amps is a larger alternator; its rotor is 4-1/2 inches (11 cm) long. The 10 amp alternator rotor is 3-1/2 inches (9 cm) long and it has a smaller diameter as well. The total cost of each machine is less than US$500.

The windmills power the machine shop where my approach to windpower continues to evolve. They also run a variety of yard and garden equipment such as an electric lawnmower, chainsaw, and power tools. My wind power system is separate from the utility grid. I use standard utility service in my house.



The system is 120 volts DC. I have several strings of ten 12 volt batteries, salvaged from a junkyard. Many shop tools will run on 120 volts DC as well as AC, like drills, lawnmowers, light bulbs, grinders, electric saws, etc. My lathe, however, has two 40 V shunt-wound DC motors in series. I can drill holes all day in the shop without wind, using the energy in the batteries. But to work on the lathe, it is best to wait for a windy day. I can't use this system directly in my home because many of the appliances run only on AC—refrigerators, VCRs, TVs, and other things. But no inverter is needed for my shop tools.

Looking up from below: the genny's tail structure is folded to the side.

My system for working on my windmills is a bit unusual. I climb to my 46 foot (14 m) windmill platform by a series of very secure stairways and ladders. Once I reach the top platform, there is one final ladder to climb. This last ladder is mounted on the main frame of the windmill itself. When the windmill turns into the wind, the top ladder pivots right along with it.

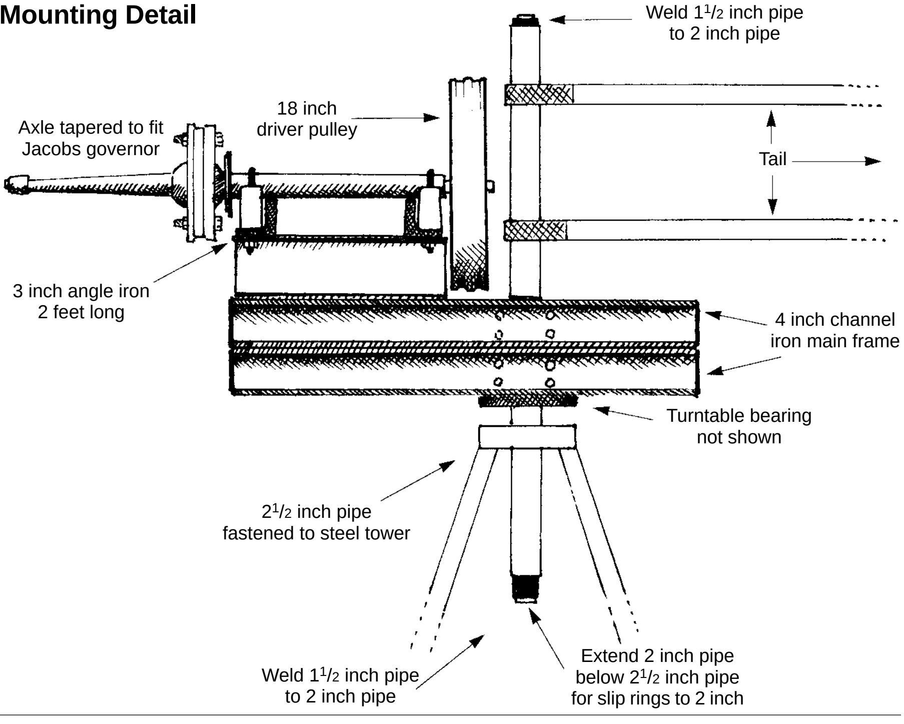
Built From Scratch

When I say my windmills are built from scratch, I mean it. They can be put together with material found in most any junkyard. Among the scrap metal parts that I've recycled to fabricate my present system are 4 inch (10 cm) channel iron, angle iron, pipe, and about 15 inches (38 cm) of the rear axle housing of a car. I use my 16 inch (40 cm) lathe to machine the taper into the extra 10 inches (25 cm) of axle (propeller shaft) to fit a Jacobs governor. I also thread the end of this shaft so the governor can be bolted in place.

The Jacobs governor governs at a certain speed whether it is loaded or not. If the alternator stops working, the machine is still protected from overspeed. This governor system is similar to a flyball governor, but the blades take the place of the flyballs. They move outward against three strong springs, and at the same time they turn, giving more pitch and slowing the prop. The prop can't turn faster than 225 rpm. Tom Hill has Jacobs governor and blade plans that he sells for US$12.50.

I manufactured my own slow-speed alternator from plans I found in *Alternative Sources of Energy* magazine, volume #38. The alternator is made from a large three-phase induction motor (10 to 15 hp). A lot of machine work is involved. The stator has to be rewound for the voltage and speed you want. It has a wound

Mounting Detail



The top ladder section is affixed to the genny and yaws with it.

field, so it has sliprings and brushes. The brushes and sliprings are where I have had the most trouble.

I use a Jacobs-type shutoff. Pulling on a rope from the ground pulls the tail perpendicular to the blades so the prop faces into the wind. The rope is fastened to a cleat at the bottom of the tower. When the rope is unfastened from the cleat, a spring pulls the tail back 90 degrees so it is parallel with the blades. The blades are then edgewise to the wind, and the machine is shut down. There has to be tension on the rope to keep the machine running. If the rope breaks, the tail will swing back to the off position.

I use an 18 inch (46 cm) driver V-pulley on the propeller shaft. On the machine with the larger alternator, there's a 4 inch (10 cm) V-pulley on the alternator, which speeds the alternator up 4-1/2 times. The machine with the smaller alternator has a 3-3/8 inch pulley because of the machine's higher cut-in speed. I also manufacture the Jacobs governor and blades, but they could be bought, or a fixed blade, side-facing prop could be used.

Machining the Parts

The main frame is made of materials from a salvage yard, such as channel iron, pipe, and angle iron. I don't have a steel tower. I have a 45 foot (14 m) center wood post with a 2-1/2 inch pipe bolted to the side with U-bolts. I am not happy with it, since more pipe is needed and it's difficult to use sliprings. But I couldn't afford an all-steel tower.

Inside the 2-1/2 inch pipe, I use a length of 2 inch with 1-1/2 inch pipe inside that, cut longer than the 2 inch pipe and welded together at the ends. These two pipes are the yaw pipes. Then two lengths of 4 inch channel iron are welded to a 4 inch length of 2-1/2 inch pipe. By using four bolts, the channel iron is clamped to the 2 inch pipe with 1-1/2 inch pipe inside of the 2 inch pipe. Then another pair of pieces of 4 inch channel iron above the first two are also clamped to the 2 inch yaw pipe.

The cut end of the axle is bearing mounted and attached to an 18 inch drive pulley. The bearing housing is mounted with U-bolts to the bird's frame.

The other end of the axle is also bearing mounted and U-bolted. A short section of axle is machined to a taper that will accept a Jacobs governor.

Detail of the underside of the drive shaft mounting. The furled tail is visible in the background.

Two more 4 inch (10 cm) pieces of channel iron are cut shorter, with two pieces of 3 inch (7.6 cm) angle iron bolted across them for the pillow blocks to sit on. These hold up about 15 inches (38 cm) or longer of the rear axle housing from a rear wheel drive car. It has to be the ball bearing type. This gives me a very rugged thrust bearing (wheel bearing), since it often goes the life of a car—like 150,000 miles. The housing is soft and can be cut off 15 inches or longer with a pipe cutter.

That end of the housing has to have a bearing, which has to be fitted, and the axle must be cut off at least 4 inches (10 cm) beyond the bearing. This is where the driver pulley goes. On the other end (where the wheel of the car used to go), fasten an extra length of axle cut about 10 inches (25 cm) long, which can be tapered for the Jacobs governor. To make the taper for the Jacobs governor, machine 1-1/4 inches to the foot (3 cm per 30 cm) about 3 degrees on each side of the lathe center line.

To fasten the extra length of the axle (10 inches long or longer) to the length of the axle in the housing, you will need to drive out the studs in both flanges and use 1/2 inch (13 mm) plate in between. Drill the same number of holes in the plate as in the flanges, and bore out the center of the 1/2 inch plate to just fit the little hubs where the car wheel went. Then bolt the two flanges together. This is simplified, but a machinist should be able to understand this description.

With the housing bolted down with U-bolts (9/16 inch (14 mm) diam.) to 3 inch (7.6 cm) angle iron with pillow

Jacobs Prop Speed vs. Alternator Speed

	Alternator rpm	
Prop rpm	*For 4 inch Pulley (1 to 4.5 ratio)*	*For 3-3/8 inch Pulley (1 to 5.3 ratio)*
100 *	450	533
120	540	640
150	585	800
200	900	1,067
225 **	1,013	1,200

**10 mph wind*
***20 mph wind*

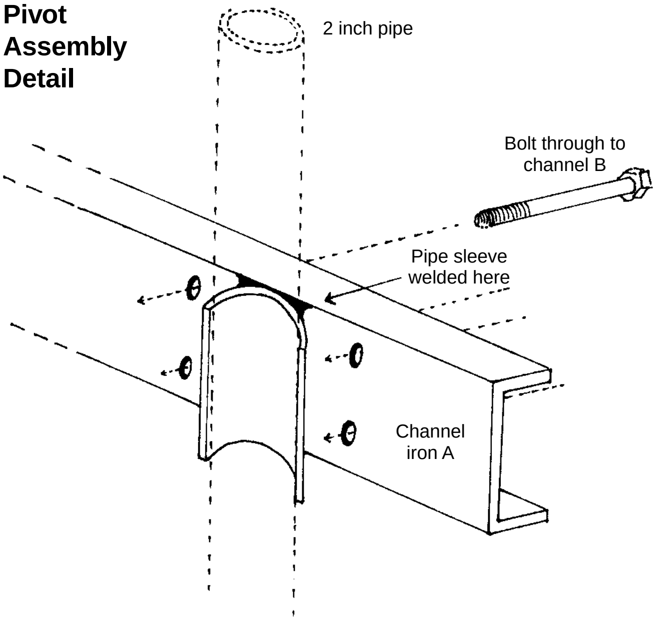
blocks between, you have a very solid machine. If you don't want a flyball governor and want to use a side-facing governor, you wouldn't need the short 10 inch axle. You could bolt the fixed blades directly to a plate which could be bolted on the long axle, the same as in a car. By the way, the backing plate is not needed, so cut it off, but leave the part between the end of the housing and the bearing retainer.

Bearings

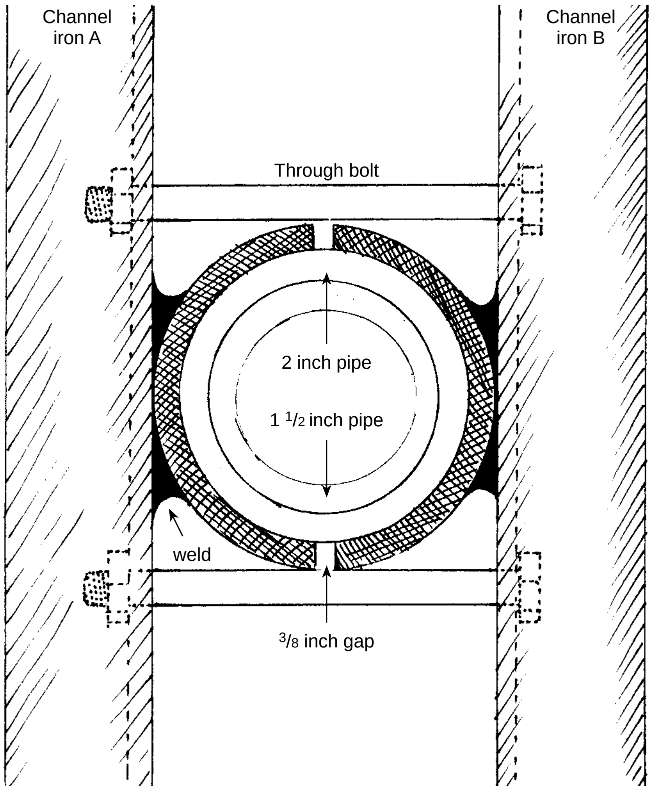
A wheel bearing from a car is now a propeller shaft bearing. When about 15 inches (38 cm) of the housing is cut off, you have a bearing fitted in the housing already. This bearing has to be a ball bearing type—roller bearings won't do. A ball bearing is needed to take the thrust. On the other end of the housing, a ball bearing has to be fitted. Also, the axle has to extend out from the housing about 4 inches (10 cm) for the driver pulley to be mounted.

For the yaw bearing, I fitted a tapered roller bearing from a 1-1/2 ton truck at the top end of the 2-1/2 inch pipe (which is fixed in the tower).

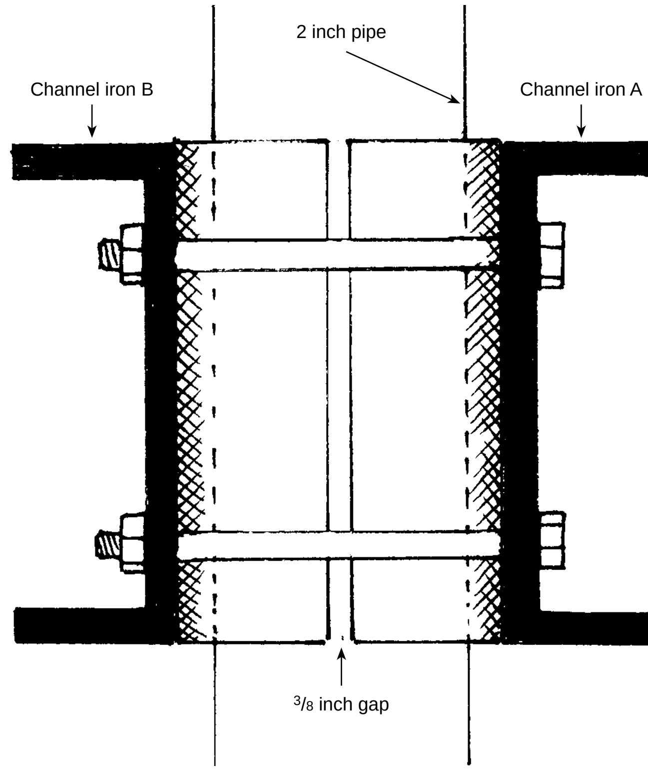
Pivot Assembly Detail



Main Frame Assembly: Top View



Main Frame Assembly: Side View



Lifelong Passion

Back in the ‘30s when I first got interested in wind power, my father was not very happy about it. I was just a teenager at the time, and wanted to buy some windmill plans. The price of the plans had been marked down from $2.50 to $1. My father insisted that it was still way too much money to spend on such a thing.

But I went ahead and ordered the plans from J. Leo Ahart in Dow City, Iowa. Ahart was a contemporary of Duncan, editor of the classic *Autopower.* I have the original 1937 copy of *Practical Electric Magazine* in which I found the ad for the windmill plans.

My father was quite angry with me for spending a dollar that way. But the wind power bug had caught me. It wasn’t long after this that I had a windmill down by the shore generating electricity to light a small cottage we had there. Over sixty years later, I’m still excited about tapping the power of the wind.

Author Everett Russell: designer and builder.

Access

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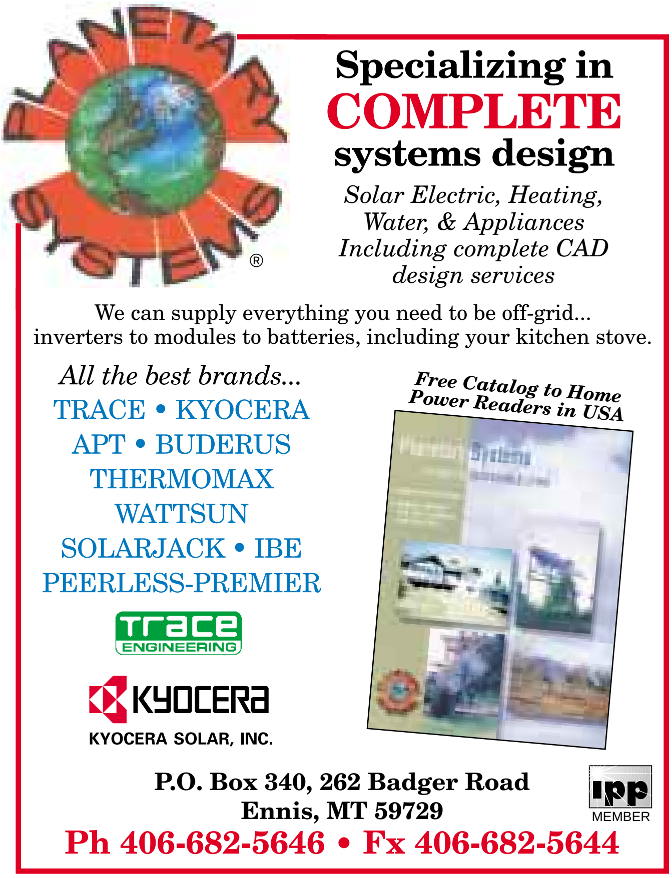
Tom Hill, 149 Sunset Hill Rd., Boyertown, PA 19512
610-367-7210 • Jacobs governors, blades, and plans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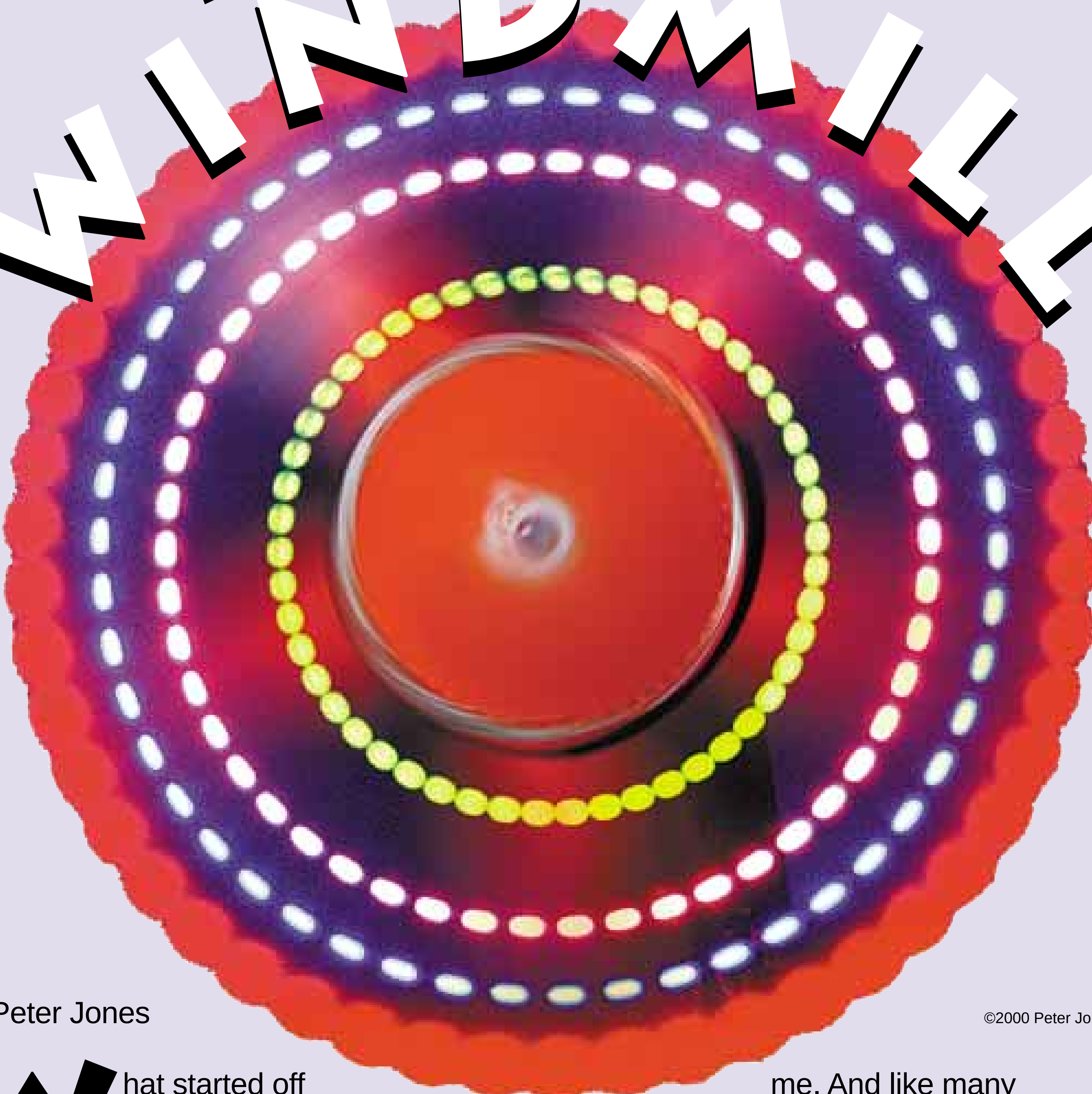


Peter Jones

What started off as an interest in wind energy several years ago turned into an obsession that has never left me. And like many obsessions, by its very nature it tends to be evangelical. So whenever possible I try to spread the word!

The Funky Windmill is a kinetic sculpture made of recycled parts. It uses wind energy to light up the LEDs on the windmill—a good demonstration of recycling and renewable energy. In itself, it serves no useful purpose other than as a garden ornament that looks really good in the dark. But I hope that it will act as a catalyst for youngsters, and kindle an interest in renewable energy and recycling.

The project I describe here is made of recycled parts, with the exception of the blue and white LEDs, which I was unable to source from old equipment, and (sadly) had to buy new!

Details of the construction are kept to a minimum, since actual building will depend upon what materials are available. The windmill is built around a stepper motor from a computer disk drive attached to an automotive cooling fan. There must be tens of thousands of old hard disk drives and 5-1/4 inch floppy disk drives knocking about. These contain beautifully engineered stepper motors that are ideal for use as small AC generators. (The steppers used in 3-1/2 inch drive units are too small to be of any use.)

Cooling fans from automobiles are readily available from car breakers' yards (junkyards). Most European cars built in the last ten to fifteen years use electric cooling fans, so I guess the same must go for North American vehicles. These are ideal for the job.

Theory of Operation
Stepper motors are built to a very high degree of precision, and are generally overengineered. Many have shaft bearings of the size used on skateboard wheels! They generally consist of a series of radial coils wound on formers with metal or ferrite cores, and have a multi-pole magnet fitted to the rotating shaft. Impulses fed to the coils will cause the magnet to rotate in steps of anything from 1.8 to about 8 degrees, depending upon the design.

When the shaft is turned, the rotating magnet induces an electric current in the coils, and it behaves like an AC generator. Coil configuration varies from type to type, but the most common ones have four wires coming from two sets of coils. Some have six wires where the two sets of coils are centre tapped. The windings can be identified by using a continuity tester. If you don't have a tester, you can identify them by trial and error using an LED and twisting the shaft of the motor back and forth.

Motors with small steps will give the best type of display on the windmill. Being AC generators, they will cause the LEDs to strobe, giving the effect of a series of coloured dots as the blades rotate. The smaller the steps on the motor, the closer together the dots will be.

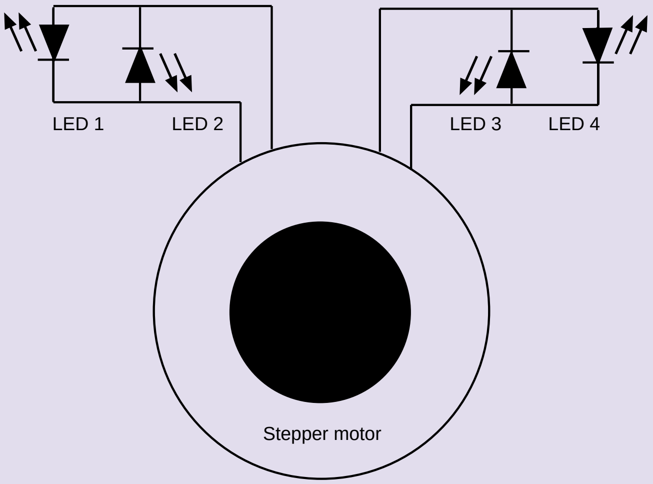
In a conventional windmill, the generator would be fixed, and the rotating blades fitted to the shaft. But in this design, the stepper motor is fixed to the rotating fan, and the shaft fitted to the body of the windmill. This is done so that the electricity generated can be fed directly to the coloured LEDs on the blades of the fan.

Fan Selection
Vehicle cooling fans come in a multitude of sizes and designs, with as few as four or as many as fifteen blades. The blade design will generally be that of an aerofoil, so it is important that the flat or concave side of the blades face the wind. However, because the fans are designed to be driven by a motor, you'll find that when they're blown, the direction of rotation is wrong for the aerofoil, and the thin edge of the blade leads.

In a proper wind generator, this would be very inefficient, but it presents no great problem here. In fact, it tends to limit the upper rotational speed, protecting the LEDs. I have constructed several units using different types of fans and stepper motors, and they all rotate happily in a gentle breeze.

Electronic Connections
The construction shown in this article uses a stepper motor with two independent sets of coils. The motor generates AC when it's spun, and the output from each coil set is constantly changing in polarity. LEDs have an anode and cathode, so when used on direct current (DC), it is important that they are connected the correct way 'round. When connected to an alternating current (AC) source, they will strobe at the frequency of the generator, no matter which way they are connected.

Left: Funky Windmill at dusk.
Below: Schematic.






From left to right: Testing the stepper motor with LEDs. Fitting the windmill's shaft onto the motor. Installing the stepper motor inside the fan. Shaft attached to the fan, and facing the right direction.

If two LEDs are connected back-to-back to an alternating current source, one will be on when the other is off, and vice versa. So with a stepper motor having two coil sets (four wires), it's possible to use four LEDs (see diagram). If a six-wire (effectively a four-coil set) stepper is used, eight LEDs can be driven.

I used no current limiting resistances or reverse polarity protection diodes, and I was a little worried at first that at high wind speeds the LEDs would blow. But despite some pretty strong winds, all's been well so far!

Construction

Very few parts are needed for construction. They are:

- Fan
- Stepper motor
- Metal rod or tube for main body
- Yaw bearing
- Tail
- LEDs

The windmill is built from recycled materials, so the exact construction will of course depend upon which bits and pieces are available, and what type of tools are to be used. The sort of person who would be interested in making one of these things will probably have a shed or basement full of junk just ready to be utilised.

No specialized tools are required, though a hot melt glue gun will make life a lot easier when it comes to sticking down wires and fixing the stepper to the fan. But two part epoxy will do the job just as well, if not perhaps as quickly. Access to a small electric welder is always useful when it comes to fabricating metalwork, but again it is by no means essential.

The simplest way to attach the stepper to the fan is just to glue or bolt it to the reverse side (facing away from the wind). This will depend upon the design of the fan. Some have a flat disk at their centre, while others have a convex moulding at one side with a recess at the other. Gluing the motor to the reverse side leaves the motor exposed to the weather, requiring regular greasing to prevent water getting at the innards.

My preferred method is to install the stepper inside the centre boss of the fan (see photo), with the shaft poking out of the back. If this method is used, check that the fan will be facing in the correct direction. Some vehicle cooling fans blow through the radiator from the outside, while others suck air into the engine compartment, so the recess can face in either direction.

Whichever way the stepper is fitted, try to get it as central as possible to reduce any vibration, which will be inevitable if it's eccentric. The shaft of the motor has to be fixed to the body of the windmill. Motor shafts vary in size, and there is usually a stainless steel cylinder about half an inch (13 mm) in diameter fitted to the shaft. I've found that a length of steel tube about eighteen inches (46 cm) long is the easiest thing to attach to the shaft, either by welding, or as a sleeve that can be drilled and held with a set screw.

A tail is needed at the back of the metal tube to ensure that the fan faces into the wind. A piece of aluminium, mild steel, or plastic can be screwed, welded, or fitted with brackets. I used a piece of steel from an old external hard disk case from an Apple computer. The shape is not important, but the tail should be about six inches (15 cm) high.

Once the tail has been fitted, find the balance point along the body. This will be the best point to support the windmill, and some sort of yaw bearing will be needed. An old bicycle wheel hub makes an excellent bearing. The spindle can be fixed directly onto the body of the windmill, and the hub clamped onto the supporting pole. Grease the bearings well before fitting. It's also worthwhile to put a plastic cover at the top of the hub to keep rain out of the bearings.

Light It Up!

To fit the LEDs onto the fan, drill holes through the blades and push the LEDs through from the back. Most fans are made from a flexible type of plastic, so a good tight push fit can be achieved. It's better to avoid imbalance by distributing the LEDs around the fan, rather than fitting them all to one blade. The wires on the stepper will not be long enough to feed out to the blades, so they will have to be extended. Wires can be run down the back of the blades and taken to the stepper through small holes, which can be sealed with glue.

All connections should be soldered, and care must be taken while soldering the LEDs not to overheat them. Holding the leads with a small pair of pliers to act as a heat sink will prevent this. I used red, green, blue, and white LEDs. The red and green ones came from old bike lights. The blue and white ones are hard to find in old equipment, since they've not been available for too long and are still relatively expensive compared to the red ones. Hyper-bright types will give a much better effect than those of low-intensity LEDs.

I finished off the front of the fan by gluing on a slice of plastic cut from an old, floating ball valve. A plastic lid from a container would have been just as good. Paint all the metalwork to prevent rusting, and the job's finished. Now whatever the weather forecast may say, whenever you build a windmill, you can guarantee that you're in for a week of still weather, staring at it while waiting for something to happen!

The effect is certainly worth waiting for, and it makes a great kinetic sculpture for the garden, doubles up as a weather vane, and can be built for next to nothing out of junk!

Access

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The Funky Windmill—built with (mostly) recycled parts—assembled, painted, and awaiting action.

The Grand Experiment AKA MREF 2000

Tehri and Roak Parker

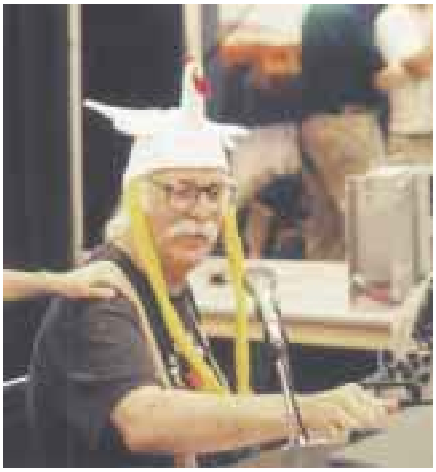
It was dubbed "the grand experiment" by Mick Sagrillo, noted wind guru and president of the Midwest Renewable Energy Association (MREA). In June, the MREA took the 2000 Midwest Renewable Energy Fair (the largest renewable energy fair in the known universe) on the road to Madison, Wisconsin.

This experiment was loaded with "research" questions. Could the MREA move our hometown energy fair from the sleepy burg of Amherst to the bustling metropolis of Madison? Would our exhibitors, vendors, and fairgoers follow us to a new location? Would our members support the move? If we built it, would they come? Would the staff revolt? Could we pay the bills? What would *Home Power* say? Were we crazy enough to pull it off?

The Hypothesis

Moving the fair to Madison for a year was a bold decision for our organization, and one that we did not take lightly. Countless hours over several years were spent at board and committee meetings discussing the pros and cons of moving the fair. Budgets were prepared (and re-prepared), plans were made (and re-made), scouting trips were taken (and re-taken). In the end, the board decided that we should give it a try, for one fair, in Madison.

We hypothesized that by taking the fair to an urban area, we would be able to reach a new audience. Madison, Wisconsin is the closest big city to our home



Rogers Keene hosts Rooster Radio—news, music, commentary, personal ads, and jokes.

in Amherst, and is a liberal and friendly city—an easy choice for our first road trip. We knew that we would draw new fairgoers from Madison, and hoped that we would tap into the large metro areas that are within easy driving distance of Madison (Milwaukee, Chicago, Rockford, etc.). With an airport in Madison, we also could try to stimulate interest from farther afield.

The Madison location also allowed us to host the American Solar Energy Society's Solar 2000 conference. By combining our fair with the Solar 2000 conference, we felt that we would be able to draw solar professionals and academics to the fair. We would also open up the ASES offerings to our typical audience of homeowners and do-it-yourselfers.

The Experimental Design

Volunteers, staff, and board members worked long hours at this year's fair. But the real work of putting on the event was the planning and design, which occurred in the months and years before the fair. We started with a new and improved name. The official title of this year's event was the Midwest Renewable Energy Association's Renewable Energy and Sustainable Living Fair. (OK, we knew it was a mouthful when we chose it.)

Our intention was to develop a title that our old friends would recognize (hence the first six words), while at the same time expanding the title to include a broader range of topics. We felt that the new title, while a bit wordy, more accurately described what actually happens at the fair—renewable energy and sustainable living. We also believed it would draw a broader audience to the event.

A site had to be chosen for the fair. After a great deal of shopping around and negotiating, we settled on the Dane County Expo Center. This site, while not ideal, had many great attributes. First, the setup of the Expo Center let us control access to the fair (something no available outdoor site in Madison could offer). Controlled access is a priority at the fair because the revenue we make from admissions needs to sustain the organization throughout the year.

The Expo Center also had great rooms for our workshops, complete with AV equipment and plenty of seating. Finally, it was one of the few places in Madison where we

Gary Chemelewski of Exeltech takes time for the details.

could offer on-site camping. In short, the Expo Center had everything except atmosphere. We realized that creating a festival atmosphere in a concrete building would be a challenge, but with no better site available, we set our minds to the task.

Bil Becker, a professor at the University of Illinois, Chicago (UIC), became our major "atmosphere volunteer." He led a group of graduate students and UIC alumni in the design and construction of exhibition

Ian and Don spread the word at the *Home Power* booth.

Steve Wilke promotes Bergey's new bird.

structures that emulated the towers and tents that have come to represent the fair. The completed structures included five 20 foot towers with fair banners, information kiosks, and bookshelves. The central meeting place was a 30 by 40 foot geodesic dome tent—the village square.

We also set about to increase the "meat" of the fair (sorry vegans). New educational offerings were planned. For beginners, we developed a series of short introductory discussions to be held in the village square. These discussions covered a wide range of topics from electrical utility deregulation to building stone circles. To meet the needs of more advanced students and Solar 2000 attendees, extended half day and full day workshops were developed.

And finally, for folks wanting to learn about living with renewable energy, we planned "homeowner poster sessions." Homeowners were invited to show photos of their houses and systems, share stories about living with renewables, and answer questions in a small group setting.

The Test

The grand experiment became a grand reality on the weekend of June 16–18, 2000. Throughout the weekend, over 15,000 people visited the fair (a 23% increase from 1999).

Attendees came from every state in the U.S. except Mississippi. They traveled from nearly forty countries, including Nicaragua, Cuba, Scotland, Panama, Mexico,

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MREF 2000 RE Gear Report

Joe Schwartz

Many RE equipment manufacturers unveil new products at the Midwest Renewable Energy Fair. MREF 2000 presented happy fairgoers with a windfall of new RE hardware. Here's some gear that stood out.

Hydro

If I had to pick the renewable energy source with the most significant hardware advances in the past year, it would be small-scale hydro—without a doubt. Five new machines are making their way into the RE market. And three of them address the all too common dilemma of what to do with a low-head hydro site.

Ron McLeod's Nautilus uses a Francis runner to fill the low head-high flow niche.

Ron MacLeod's Nautilus hydro turbine turned more heads at the fair than any other piece of hardware. The turbine housing's scroll design is nothing short of beautiful. It has an enticingly organic look to it. Picture the spirals of a seashell in cleanly welded stainless steel. Ron has worked with utility-scale hydro turbines for over twenty years, and his new turbines reflect his expertise.

MacLeod's line of turbines are sized for large residential to village-scale hydroelectric generation. The Nautilus is an ultra low head, Francis-style turbine. It's designed for sites with 4 to 18 feet (1.2–5.5 m) of head. Two runner sizes are available, eight and ten inch (20 and 25 cm). At 1,330 gallons per minute (2.98 cf/s; 84 l/s), the 10 inch runner is capable of a 550 watt output with

Left: Efficient and natural building materials round out the energy focus.

Right: Traditional skills are the backbone of sustainable living.

Japan, China, Canada, Turkey, Australia, India, Kenya, and South Africa. A whopping 75 percent of the people at the fair were first time fairgoers. Two hundred and fifty Solar 2000 conference attendees (almost one third of their total attendance) visited the fair for at least a day.

There were also a record number of exhibitors at this year's fair. A total of 208 exhibit booths were sold to 149 different exhibitors. Twenty five new exhibitors joined us this year, including manufacturers like Kyocera, sales booths like The Chi Machine, and non-profits like Midwest Organic and Sustainable Education Services.

Over 100 workshops were offered throughout the weekend. Topics ranged from the technical to the philosophical. Sixteen introductory discussions were held under the dome in the village square (our central meeting place). The seven half-day and full-day workshops we offered were attended by 167 people.

This was also a year of great media events and fantastic keynote speakers. On Friday, Talk of the Nation's *Science Friday* broadcast live from the fair.

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a head or vertical drop of only four feet (1.2 m). Maximum output of the turbine is 3.5 KW. MacLeod is also manufacturing an open flume turbine called the Neptune. It has similar head, flow, and output characteristics. The Nautilus turbine displayed at the fair even had the flatlanders wishing they had 1,500 gallons per minute to spare!

Paul Cunningham and Bob Fife from Energy Systems & Design (ES&D) came down from New Brunswick, Canada to attend the fair. They displayed two new hydro turbine designs, along with their popular Stream Engine turbine. Like MacLeod, Cunningham has been hard at work drawing amps out of low-head hydro sites. His new low-head turbine produces 200 watts at roughly 700 gpm with only 3 feet (0.9 m) of head. At 9 feet (2.7 m) of head, the turbine's output can be over 1,000 watts. ES&D's low-head turbine uses the same field-proven permanent magnet alternator as their Stream Engine.

On the other end of the hydro spectrum, ES&D has also come up with a new high-head, low-flow turbine design. This turbine, called the Water Baby, will retail for about half the cost of ES&D's Stream Engine. ES&D is ramping up production for both of their new machines.

While Don Harris from Harris Hydroelectric wasn't displaying, we were all happy to see him at the fair. Don's been working on a new permanent magnet alternator for his turbine that promises great efficiency and durability coupled with a Pelton-style runner. Keep an eye out for this turbine as well.

Wind

Above water, two new wind gennys were displayed at MREF 2000. Tod Hanley and Steve Wilke from Bergey Windpower gave fair attendees the full tour of Bergey's new wind turbine (soon to be in production). The Bergey XL.1 is a low-cost, residential-scale machine backed by a full five year warranty. The turbine has an 8.2 foot (2.5 m) rotor diameter and a relatively low rated rotor speed of 490 rpm at 24.6 mph (11 m/s). The XL.1 includes their new "PowerCenter Multi-Function Controller." This controller incorporates an electronic boost circuit reported to increase turbine output at low wind speeds. It was a treat to have Tod Hanley, the turbine's design engineer, on hand. Tod provided detailed and thorough answers to fairgoers' technical questions related to the XL.1.

Host Ira Flato interviewed fair workshop presenters, entertained questions from the fair audience, and fielded calls from across the U.S. Mark Hertsgaard, NPR correspondent and author of *Earth Odyssey,* the story of his global journey to investigate environmental crises, was a guest on *Science Friday.*

Hertsgaard also presented a keynote speech at the fair on Saturday. More than 500 people attended the keynote to learn more about the environmental crisis facing the planet. The closing speaker for the fair was Green Party vice presidential candidate Winona LaDuke. LaDuke spoke to a full house (about 800 people) on our connection with the Earth, and how it should guide our actions.

During the fair, Rob Roy built a replica of Stonehenge out of straw bales and planks in the village square. Rogers Keene hosted Rooster Radio, an in-house broadcast that featured news, music, commentary, personal ads, and jokes. Doodle Doo, the fair's official mascot, was spotted around the Expo hall riding wind generators, sitting on solar panels, and making the world safe for renewables.

Footprint Follies, a group of performance artists and activists from Milwaukee, paraded through the fair on stilts, banging drums, fifing fifes, and explaining our "ecological footprint." And Puppet Farm, a children's entertainment group out of northern Wisconsin, brought Sunny the giant bicycle riding puppet, built a 25 foot tall rooster out of recycled plastic, and lead a march against the Corporate Rats.

The Results

So, what are the results of the grand experiment? Was the fair a success? You bet. We moved the fair to an urban area, drew in a new audience, hosted the Solar 2000 conference, and lived to tell about it. We also made a lasting impression on the city of Madison.

Bergey's new XL.1

African Windpower, out of Harare, Zimbabwe had a 1 KW turbine on display at the Dankoff Solar booth. Although AWP's turbines are not currently being commercially imported into the U.S., the machine is impressive, and would be a welcome addition to the U.S. wind market. The turbine is the result of the "heavy metal" approach to wind turbine design. It is large, heavy, low rpm, and quiet. The turbine has a 11.8 foot (3.6 m) rotor diameter and a very low rated rotor speed of approximately 400 rpm at 26 mph (12 m/s). This is a large rotor diameter for a 1 KW peak machine, making it an exceptional performer in the low to moderate windspeed regimes common in many locations.

Inverters

In 1993, Trace Engineering revolutionized the RE industry with their SW-series inverters. It looks like they're about to do it again. Trace debuted their new Sun Tie (ST) line of batteryless, utility interactive inverters at the fair. These inverters are targeting the rapidly growing market for grid-tied photovoltaic generation. Four models of ST inverters are available: 1, 1.5, 2, and 2.5 KVA.

The ST is designed to accept output from both traditional crystalline and new thin film modules (up to 125 VDC open circuit). The conversion efficiency of the ST inverters is over 90 percent, and peaks as high as 94 percent. Maximum power point tracking (MPPT) circuitry samples the array voltage and current once a minute, adding to the net efficiency.

All ST-series inverters include both DC and AC disconnects, and overcurrent protection via circuit breakers. This eliminates the need for any additional protective devices in most applications. The 1.5 and 2.5 KVA units feature onboard PV ground fault protection, a fused PV combiner board, and a surge arrestor. An optional futuristic-looking rain shield is available for all units, allowing outdoor mounting of the inverter in exposed locations.

Vanner Power Group also introduced their new RE24-4500 DGT inverter at the fair. The RE24-4500 DGT is a 4,500 KVA utility interactive, battery-based inverter. A unique feature of this inverter is its split-phase 120/240 VAC output. This allows you to run both 120 and 240 VAC appliances from the same inverter, which isn't possible using any other inverter on the market. The inverter has a true sine wave output, and peaks at 90 percent efficiency in utility interactive mode, and 92 percent when inverting.

During the week that the fair and Solar 2000 were in town, the Dane County Board of Supervisors declared Madison the Renewable Energy Capital of the World. June 14–21 was also proclaimed Renewable Energy Week by both the mayor of Madison, and the Dane County Executive.

Probably the most important legacy left behind by the fair is the 5 kilowatt photovoltaic array that was installed on top of the Arena at the Expo Center. This array will remain on the building, providing clean, quiet renewable energy for the citizens of Madison through Madison Gas & Electric's green power program.

Are we taking the fair to Madison next year? Nope. This was a one year move right from the start. While Madison was a great fair and a great learning experience for us, it was also significantly more work than putting on the fair in Amherst. And of course it did not have that hometown fair flavor. We are happy to be returning to Amherst for 2001.

Will we ever take the fair to an urban again in the future? Well, that remains to be seen. It is not out of the question, but for now our mantra is "There's no place like home!" Don't miss next year's Midwest Renewable Energy Association's Renewable Energy and Sustainable Living Fair, June 22–24, in Amherst, Wisconsin.

Access

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Two additional modules are available to complement the RE24 inverter. A DC power center provides breakers for DC inputs, DC loads, inverter to battery wire runs, and metering. An AC module includes AC breakers and a generator/utility grid interface. Each module enclosure incorporates parallel raceways for a super clean installation. The electricians in the crowd all gave these spacious enclosures and raceways the big thumbs up.

There's More

Hal Newman represented UniRac, and their new line of PV mounts. Both roof/ground and top-of-pole mounts were displayed. UniRac has streamlined the parts count in their mounts. The result is a low cost PV mount that's modular in nature and relatively inexpensive to produce.

With all the promising new RE equipment on display this year at MREF, it was difficult to take it all in. I'm sure there's some new gear that I missed. What to do? Make the trip to the Midwest Renewable Energy Fair next year and check it out for yourself!

Access

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Solar-Powered ARRL Field Day 2000

Roy Butler (KC2FSW),
with Debbi Koehler (KB2WEY)

Author Roy Butler, right, and Roy Koehler, KLARA president, left.

When I joined my local amateur radio association in February, I introduced myself as KC2FSW, and the owner of Four Winds Renewable Energy. Several of the members asked me, "Does that solar stuff really work?" Well, I hear this question almost every day in my business, and the best answer I've found so far is to show 'em. When I found out about the association's Field Day, and that extra contest points were awarded for the use of solar power, I saw the perfect opportunity to demonstrate what solar energy could really do!

During the last weekend of June, ham radio operators all over the U.S. gear up to set long distance contact records and practice emergency communications skills. During this annual event, amateur radio operators set up field radio communications stations, get on the air, and contact thousands of other operators in the U.S. and Canada.

Field Day

The ARRL Field Organization has been effective in establishing emergency communications nets during floods, hurricanes, fires, earthquakes, and other major disasters. Members of formal emergency organizations such as the Amateur Radio Emergency Service (ARES) and the Radio Amateur Communications Emergency Services (RACES) regularly participate. Field Day is a competition as well as a trial run for emergency communication skills used during disaster situations. The ARRL estimates that more than 35,000 hams participate in Field Day every year.

On June 24th and 25th, the Keuka Lake Amateur Radio Association (KLARA) set up operations on a 170 acre hilltop farm. The farm is owned by New Life Homes-Snell Farm, a group home for adolescent boys ages 12 to 18, and is located between Howard and Bath, New York. Debbi Koehler is an active member of KLARA and works at Snell Farm. She helped make arrangements for KLARA to use the site for the Field Day.

Roy Koehler, Debbi's husband and KLARA president, says, "It's a great way to fine-tune our emergency communication skills. We use generators and solar collectors for power, and set up antennas in fields and trees. Our goal is to put together self-sufficient, working stations quickly and begin making contacts. We also enjoyed introducing the boys at New Life Homes-Snell Farm to the wonderful world of ham radio."

Setting Up

The day before the event, the Four Winds crew and some of the KLARA club members set up a 256 watt Uni-Solar array (four US-64s) and a Whisper H500 wind generator on my 10 foot demo tilt-up tower. The EZ-Wire Center that comes with the Whisper was also used as the solar charge controller, system monitor, and DC load center. A Brand Power Meter monitored the output of the Portawattz 1000 inverter, which powered an old Tempo-1 tube rig. Four ancient 220 amp-hour golf cart batteries were used for our 12 volt battery bank.

I didn't really expect to get any serious power out of the wind generator with that wimpy 10 foot tower, and I wasn't disappointed. I didn't have the opportunity to evaluate the event site for wind potential beforehand. When I arrived on site and saw the trees, I knew right

ARRL Field Day Transmitter Details

Band (Meters)	*Mode*	*Power Source*
80	CW	5 KW Kohler generator
40	CW	12 V battery
20	CW	5 KW Kohler generator
15	CW	5 KW Kohler generator
80	Phone	Solar
40	Phone	Solar
20	Phone	Solar
10*	Phone	Solar
6	Phone	Solar
2	Phone	Solar

*Mike Hanna's personal solar-electric setup.

away there was little wind power potential at the 10 foot level.

I decided to set it up anyway, primarily to show off the wind generator and the demo tilt-up tower. I let everyone know that this was *not* the right way to install a wind generator, and not to expect too much. Our total wind power production for the event: zero! Next year I'll either increase the size of the solar array or try to get a wind genny above those trees.

The only serious problem we encountered during the event was power distribution. Logic dictates grouping the radio stations close together for ease of wiring and limiting line loss. But if we'd planned the distribution system for our wiring convenience, the stations would have been so close that RF interference would have been excessive.

The solution was to locate the CW radio stations at the far end of the field. We would then power them with the generator in the camper used by the club secretary (aka "the old man"). His RV has a Kohler generator to power his radio (and his air conditioner!).

Sun & Clouds

For the first day of the event, we had good solid sun. When the contest started at 1 PM, we were getting 16 amps of solar power to the batteries. We averaged 6 to 9 amps of DC load for most of the day, and the solar kept right up with that, with a total for the day of 96 amp-hours to the batteries.

After sundown, the power draw decreased, since most of the operators shut down for the night. We discharged the batteries 30 percent on the first day. The second day of the event was heavily overcast, with a maximum array output of 4 to 5 amps. By the time the contest officially closed at 1 PM, we had managed to get about 20 amp-hours into the batteries. The batteries had been discharged a total of 45 percent.

ARRL Field Day at New Life Homes-Snell Farm.

Our PV system was able to provide power for a total of five amateur radio stations for the 24 hour contest period. Mike Hanna brought his own separate solar-electric system to power his transmitter. An interesting side note: The only non solid-state radio at the event was a Tempo-1, a multi-band HF tube radio (which doubles as a space heater—just kidding, Glenn!). It consumed 186 watts in receive mode and over 300 in transmit mode! The Brand Power Meter showed a usage of 2,088 watt-hours for a duty cycle of eight hours in receive and two hours in transmit. Now here's a good demonstration for energy efficiency if I ever saw one. With the usage of all solid-state radios, we would have had little or no net discharge to the battery bank!

Talking Solar

There were ten operators at the event, and twenty-five guests. Seven transmitters were in action. We made three hundred contacts, and they included over twenty U.S. states, Canadian provinces, the USS Yorktown, and Zambia and Johannesburg, South Africa. Our group doesn't do Field Day primarily for "points," as many ARRL groups do. But if they gave out points for having fun, we'd be strong contenders.

I'm already looking forward to next year's event. We're going to pull out all the stops and solar power all the radios, *and* the coffee maker. I'm not so sure about the old man's air conditioner though! Anyway, it looks like we have a bunch of hams who now believe in the potential of solar energy!

Access

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Things That Work

Tested by Home Power

Light Corporation's Solaris™ Solar Lantern

Tested and Reviewed by Joy Anderson

When I first moved to Vashon Island, Washington this past May, my RV home was parked in the trees for three weeks, with no sun on the PVs. So I had to use as little energy as possible. I tried candles for light, but they weren't quite bright enough for me to see my laptop keyboard. No problem—I had a Solaris™ solar lantern kickin' around. Every cloud has a silver lining, and this one was fluorescent.

School of Hard Knocks

This is one burly unit—it has survived over six months of bouncing around in my roving RV. Once, I left it on top of the loft over the cab and I drove off. It rolled off the loft, bounced off the cat landing platform, hit the floor, and rolled to the back of the rig, colliding with everything in its path.

I heard the thumping in the back as I was driving down the curving mountain roads, but I had no idea what was bouncing around. I pulled over to check it out. When I saw the lantern on the floor in the back, I was worried. But nothing was broken, and the light came on (as it always does) when I flipped the switch.

Well Designed

The Solaris lantern is lightweight and very portable. The switch is easy to find in the dark—it's right on top of the unit under the handle. I like the handle because it's easy to grab, comfortable to carry, and can be hung up on a hook. The bright yellow case makes it easy to find when it's getting dark. With the clear saucer-shaped plastic disc above the bulb, the light is not blinding.

The U-shaped compact fluorescent (CF) bulb is well protected inside the unit. Because CFs are very efficient, the charge on the battery pack lasts a long time. It gets 4.5 to 6 hours of run time per full charge, and takes 2 to 3 hours in bright sunlight for each hour of run time. This lantern has an active low voltage disconnect (LVD), which prevents overdischarging the batteries. When the voltage gets low, the LVD activates and the light shuts off.

The bulb is a 6 watt compact fluorescent that puts out 350 lumens initially and 430 lumens max. This bulb should last for years, but when I need to replace it, it will be easy to change. I'll just unscrew the top of the lantern from "lock" to "open," and lift out the old bulb.

Cool Features

This lantern has some neat features, but by far the coolest thing is that it comes with its own charging source. The LM-3 Uni-Solar triple-junction amorphous PV panel is 8-1/4 by 11-1/4 inches (21 x 29 cm), and is rated for 2.68 watts. It's small, but it's enough to trickle charge the battery and keep it full (if you keep the PV plugged in to the unit). It can also run small electronic devices like a radio, cassette player, or MP3 player.

With all the abuse I've heaped on this lantern, the only thing that has come loose is the jack where the solar panel cord plugs in to the base. All I've had to do is tighten the hex nut on the outside of the jack a couple of times and it's been fine.

This lantern has also been cat tested. For starters, the rugged plastic case is too tough for cat teeth to gnaw through. And while the unit weighs only about 2 pounds (0.9 kg), the base is heavier than the top, so it's not easy to tip over when rubbed against. With much persistence and chin rubbing, the lantern will tip over, but it stays lit and keeps on shining.

Gardening at Night via Solar Light

One night, the solar lantern really saved my butt. I had planned to leave my place on Vashon early the next morning to head down to Oregon for magazine deadline. I was on a tight schedule, and had several hundred dollars worth of black bamboo to plant before I left. I called up my friend Maddy. She came over and we started planting bamboo.

As with most projects, this one took much longer than we expected. Soon the sun had set, but we still had a lot of work to do. The solution was close by. I ran up the hill and brought back my solar lantern. We kept going until midnight, and so did the lantern.

Joy has seen the light—and it's solar-powered.

The lantern took a beating and got covered in dirt. Later I opened it up to check out the innards. I unscrewed both the top (bulb compartment) and bottom (battery compartment). All was clean and dry inside. Congratulations to the manufacturer—I found nice tight seals that are also easy to open.

User-Friendly Energy Storage

When I opened up the bottom of the lantern, I checked out the battery pack. The lantern uses Quest batteries, made by Harding Energy, Inc. The manufacturer claims at least 500 charges before the battery pack needs to be replaced. The battery pack in this unit is nickel metal hydride, which is really great because I can use as much light as I want and then charge the unit when there is sun. I don't have to completely discharge the battery each time I use the lantern, as I do with my two solar flashlights that use NiCd batteries.

Waterproof Charging

They say that if you don't like the weather in western Washington, wait five minutes. I love it when the weather changes, but a non-waterproof lantern does not. While the lantern is rugged and has a coated circuit board for water resistance, it is not completely waterproof. I wanted to keep the panel out in the sun and the lantern out of the weather.

I tried some different setups, with the panel outside and the lantern inside. Since the cord is only 6 feet (1.8 meters) long, there weren't many choices. It was just long enough to snake through the loft window in my RV, with the panel on the roof. Unfortunately, when the wind blows, the panel doesn't stay in place. I suppose I could homebrew a longer cord, but the standard cord is sealed coming from the PV, and it already has the correct male plug end.

On one visit to Agate Flat for magazine deadline, I put the lantern inside the trailer I was staying in, with the panel outside on the step. The wind blew the trailer door closed, slicing the insulation and creating a small bare spot on the wire. As I wrapped the wire in electrical tape, I brainstormed.

I needed something to keep the rain off the lantern while the panel was charging the battery. So I bought a Sterilite 20 quart (19 liter) plastic tub. The lantern fits well in the tub, with room to spare. The solar panel sits right on the recessed lid of the tub, and the wind hasn't blown it off so far. And while the lid fits snugly on the tub, there is a small gap on the edge for the cord to come out without getting pinched.

The tub works great. The one drawback is that the tub is the perfect size for perching, and when The Bean sits on the panel, the cat gets charged but the lantern battery doesn't.

Appropriate Technology
This solar lantern is a good example of appropriate technology. Recharging the battery pack right in the unit using solar energy is a great idea. It eliminates wasteful throw-away batteries, and the need for a separate battery charger.

The Solaris solar lantern with PV costs US$169 and is available from Light Corporation. The whole unit is portable and ruggedly built, and is useful for emergencies and everyday use, in homes and RVs, in boats and treehouses. Come to think of it, this lantern would be useful just about anywhere on the planet.

Access
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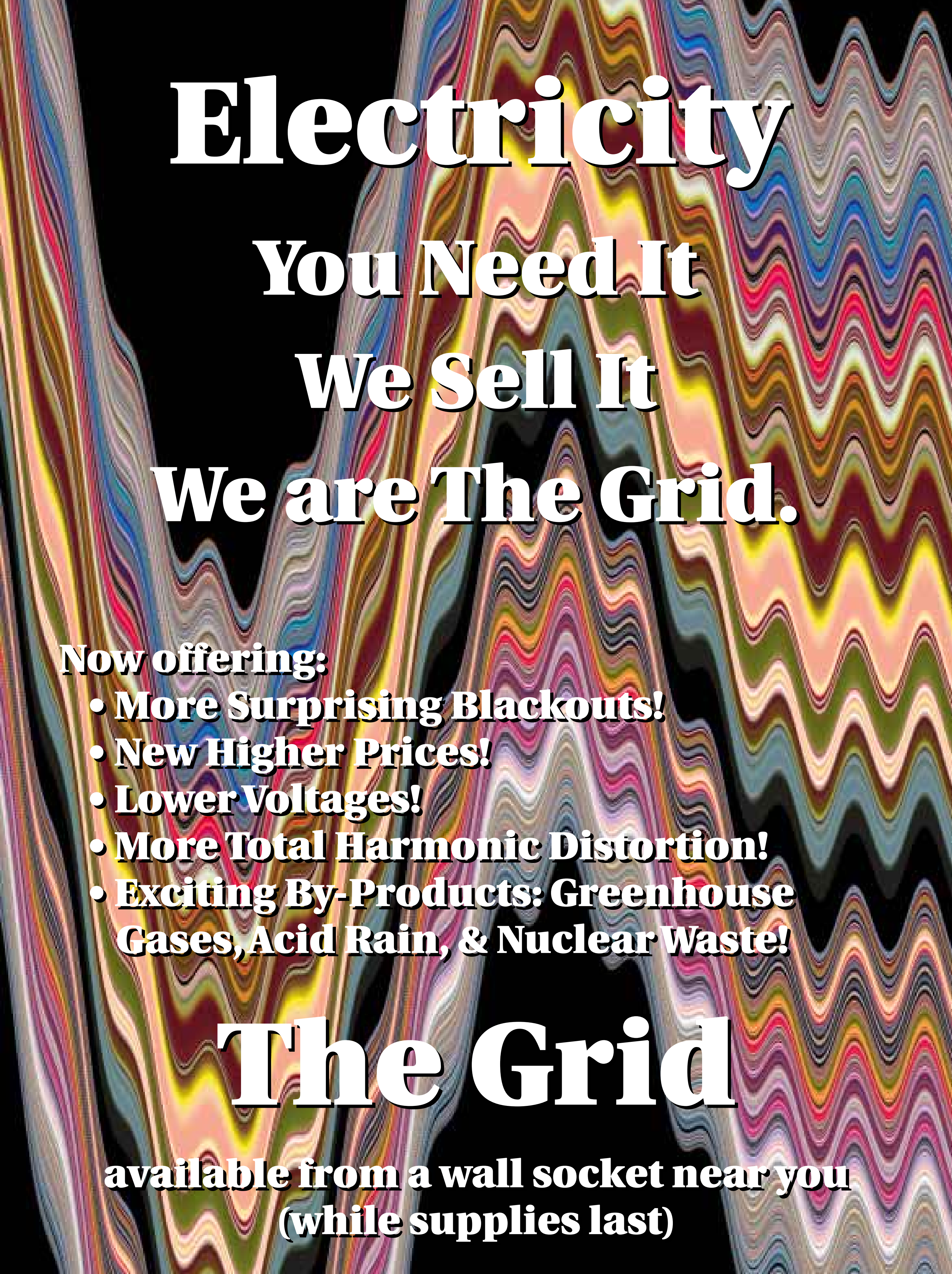
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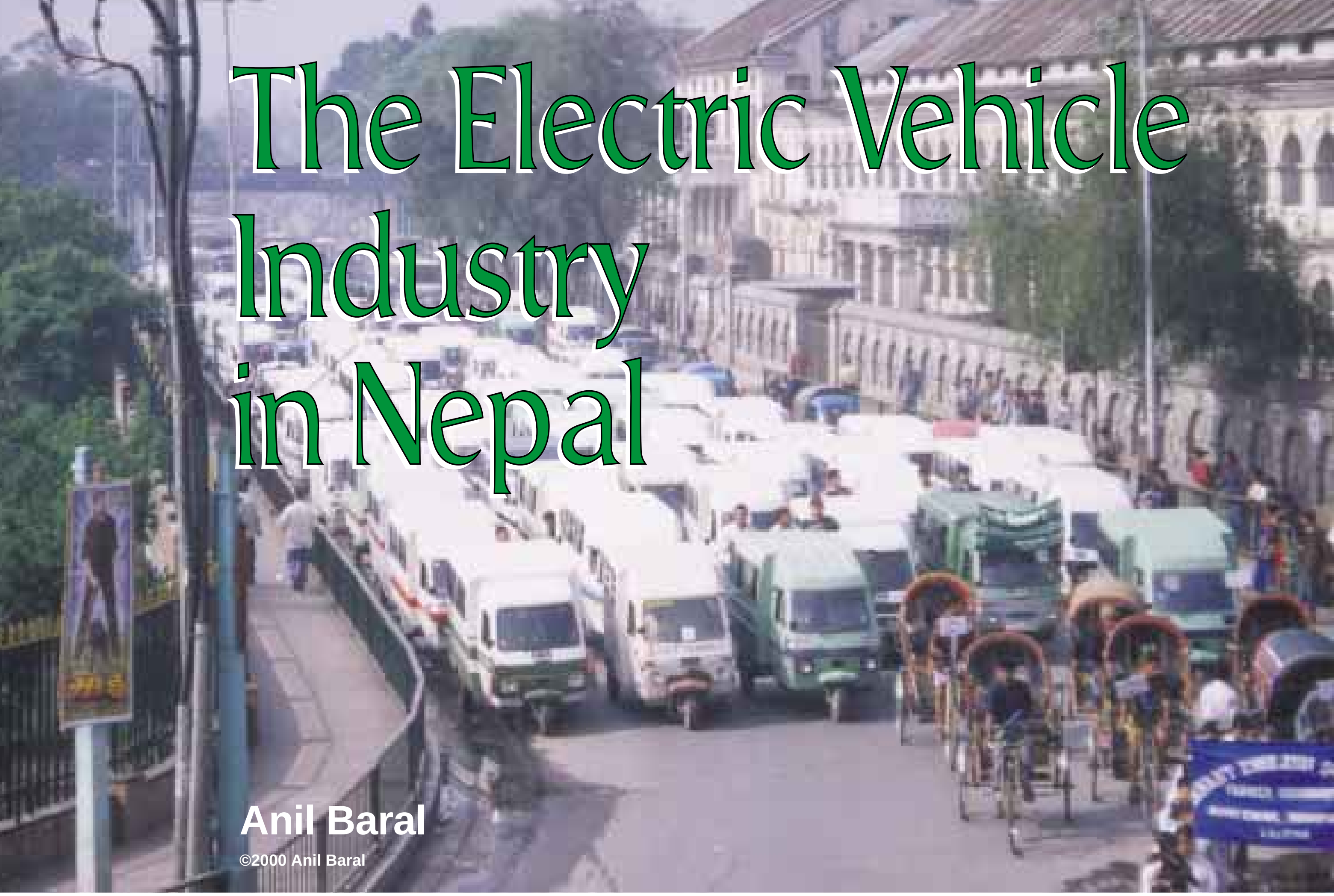


The Electric Vehicle Industry in Nepal

Anil Baral

Nepal was a forbidden land until the 1940s. As it opened to the outside world, tourists came pouring in to explore the untrodden land, virgin forests, rivers, lakes, and the majestic Himalayas. In the '80s, the symptoms of haphazard urban growth had begun to appear in Kathmandu, the capital of the country and entry gate to Nepal for tourists. Air pollution and traffic congestion from an increasing number of mostly old and worn out vehicles became everyday concerns of people in the Kathmandu valley.

Safa Tempo

Concerned authorities were grappling with these problems, and how to amend the tarnished image of Kathmandu in the international community. Then electric three wheelers—popularly known as safa tempos—came onto the scene. The term "safa tempo" is a Nepali name for a battery operated three wheeler. "Safa" in Nepali means "clean," since it is a zero emissions vehicle. "Tempo" is a generic name for three-wheeled vehicles.

Global Resources Institute (GRI), a U.S.-based non-profit NGO, built their three-wheeled model of a battery operated EV in the early 1990s. No one suspected that it could become a major force of public transportation and give a breath of fresh air to Kathmandu. In 1996, the GRI project ended and the private sector strode into the EV industry. Between then and now, the number of safa tempos on the roads has increased dramatically. This was due to government incentives and support for the EV industry, and the private sector's dogged determination to make it a financially viable venture—a feat seen nowhere else in the world. Currently, an impressive 550 safa tempos are providing public transportation.

A safa tempo is a small, three-wheeled vehicle used to provide public transportation service. Generally, low and middle income commuters use safa tempos as a means of daily transport. A few safa tempos are also being used in offices for ferrying staff, delivering mail, carrying solid wastes, and for hospital use.

The vehicle uses a 22 horsepower motor, and has a gross vehicle weight of about 1,050 kg (2,300 pounds), including one set of batteries. A safa tempo can carry

720 kg (1,600 pounds), which means twelve people including the driver. The maximum speed an empty safa tempo can attain is 40 km per hour (25 mph). The average speed with a full load of passengers is 25 km per hour (16 mph).

Cost Effective

These commercially operated electric vehicles are simple and low-cost technology in comparison to EVs operated elsewhere in the world. The cost of a safa tempo with two sets of batteries is either Rs. 505,000 (US$7,214) or Rs. 525,000 (US$7,500) depending upon the type of batteries installed. Safa tempos are assembled in Nepal, with the majority of parts coming from abroad. The chassis is from India, the motor is from England, and the batteries, DC-DC converter, speed controller, and metering come from the USA.

Two models of lead-acid batteries are being used in safa tempos in Nepal. They are Trojan T-105s and Trojan T-125s, both manufactured in California, USA. The T-105 gives a range of 55 to 60 km (34–37 miles) per charge, and the T-125 gives 65 to 70 km (40–43 miles) per charge.

Safa tempos run with twelve 6 volt batteries, for a total pack voltage of 72 volts. The cost of one set of Trojan T-105 batteries is about Rs. 60,000 (US$857), and one set of Trojan T-125 batteries is Rs. 70,000 (US$1,000). The capacity of the T-125s and T-105s for five hours of discharge is 197 and 187 ampere-hours respectively. Once the set of twelve batteries is discharged (which usually happens by noon), it is exchanged for a fully charged set of batteries at a charging station.

Private Sector Initiative

No safa tempos would be running today had the private sector not ventured courageously into this market and withstood the challenges. They played a key role in popularizing safa tempos by manufacturing the vehicles at a reasonable cost and providing associated services such as charging and maintenance in a cost-effective way. While EVs in other parts the world are far more expensive than gasoline vehicles, safa tempos are available at quite reasonable prices compared to their petrol and diesel versions.

The role of the private sector in infrastructure development for the EV industry is substantial. There are currently five EV manufacturing companies in Kathmandu, with a total production of about sixty per month. The investment capital for manufacturing came mainly from the entrepreneurs themselves, with only a small number of loans.

The operating cost of a safa tempo is Rs. 7 (approx. 10 cents) per kilometer, including depreciation cost of the batteries and vehicle, and a driver's salary. The average fare per km for a passenger is Rs. 1.25 (2 cents). A safa tempo carries a total of eleven passengers, and the average profit comes out be Rs. 6.75 (approx. 10 cents) per km. The average vehicle covers a distance of 110 to 130 km (68–81 miles) per day, so the profit per day comes to about Rs. 743–878 (approx. US$11–13) per day. The payback period is three to four years depending upon whether an entrepreneur has invested fully by himself or has borrowed from a bank.

The charging system infrastructure is also largely the result of private initiative. More than 75 percent of the chargers currently in use are manufactured in Nepal by four companies: Lotus Energy, Digitech, Everest Machinery and Electronic Complex, and Guraya. The technology of locally produced chargers ranges from manual to digital. The quality is quite comparable to those imported from abroad.

There are twenty-six charging stations located at different points along the routes. Charging stations are recording good profits. Martin Chautari (a non-profit advocacy organization) did a study, a project advocating alternative fuel vehicles (AFVs) in Nepal. It shows that twenty charging stations have been

Safa tempo—Nepal's zero emissions, three-wheeled vehicle.

Partners—economic growth and environmental protection.

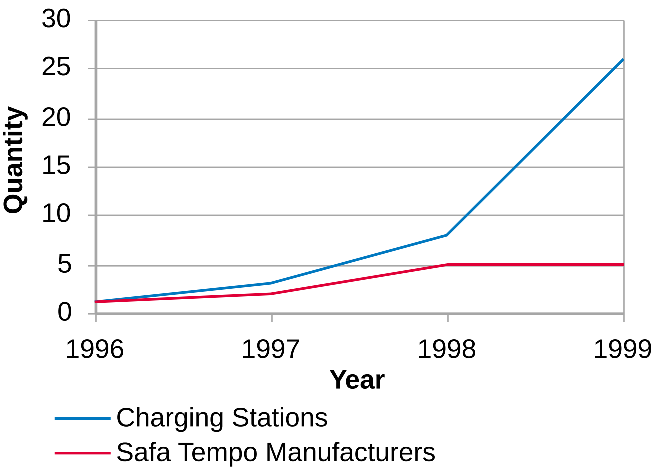
The EV industry is emerging as an important avenue of employment in the poverty ridden and resource-strained country of Nepal. According to a study conducted by Martin Chautari, there are 133 technical and nontechnical personnel employed in the 26 charging stations. Add to this the 550 jobs created for safa tempo drivers, and the jobs created by charger manufacturing, and the number looks quite impressive—well above 800 jobs.

Revenue generation from charging stations is also quite significant. Approximately Rs. 14 million (US$200,000) per year is collected by the Nepal Electricity Authority in revenues from 26 charging stations. As the EV industry expands, the possibility of employment generation in battery recycling plants within the country cannot be denied.

financed by the private sector entirely, while the remaining six charging stations have received loans from banks. The total investment in charging stations and safa tempo manufacturing alone has already exceeded Rs. 300 million (US$4.3 million).

The chassis for safa tempos have been imported from India. Now Hulas Motor Company and Kanchanjangha Auto Industry are developing a chassis to be built in Nepal. Other ancillary equipment for safa tempos is also manufactured in Nepal. These include pot boxes, forward/backward/reverse switches, and forklifts.

Growth of the EV Industry in Nepal



Institutional Structure & Support

The EV industry as a whole is forging ahead towards the process of institutionalization. To protect the interest of EV stakeholders, various institutions are emerging. There are associations of safa tempo owners, charging stations, drivers, and manufacturers. The most notable of them is Clean Locomotive Entrepreneurs' Association of Nepal (CLEAN), an association of safa tempo owners. It spearheaded the polluting vehicles drive-out campaign, and resisted the onslaughts of polluting vehicles (diesel Vikram tempos), which is quite remarkable.

CLEAN has made considerable inroads in improving quality service to customers, while at the same time creating a conducive environment for more safa tempos in the Kathmandu valley. The organization often acts as a mediator in resolving conflicts among manufacturers, owners, charging stations, and drivers, and unites all stakeholders for the betterment of the EV industry. The constitution of an umbrella organization of EV stakeholders is underway now. Many believe this will strengthen the position of the EV industry, and shield it from the threats of competition in the market from other means of transport.

The EV industry has also enjoyed considerable support from the outside. The government has provided incentives in the form of import duty concessions and VAT (value added tax) exemption for EV manufacturing. The charging stations have received concessions in electricity tariffs from the government. The government has mandates under which banks are obliged to provide loans to the entrepreneurs who want to buy and operate safa tempos. Many entrepreneurs have benefited from this arrangement.

International institutions have also assisted in making the EV industry a commercially viable enterprise that helps combat worsening air pollution. USAID, through Global Resources Institute (GRI), played a key role in developing commercially feasible three-wheeler EV prototypes and demonstrating to the public the importance of EVs. Later, when commercial production and operation of EVs began, the Danish International Development Agency (DANIDA) got involved by making loans available for the purchase of safa tempos and setting up charging stations.

One of Kathmandu's 26 charging stations, which support 550 public EVs.

In a recent development, DANIDA has set aside an EV fund, through its Environment Sector Program Support (ESPS) project. It will initiate and support development of improved EV prototypes (three wheelers and four wheelers), studies to increase battery life, and local production of an EV chassis. The EV fund is also expected to provide training to mechanics, drivers, and owners, and environmental and technical upgrading of existing lead-acid battery recycling facilities within Nepal.

Diesel Vikram Tempo Ban

The decision to ban the operation of diesel-powered Vikram tempos because of their significant contribution to Kathmandu's worsening air pollution came as a boon for the EV industry in Nepal. (Vikram is a brand name for diesel and petrol-run three wheelers manufactured in India.) The demand for safa tempos soared after the ban, since more EVs were needed to fill the transportation gap. Within seven months after the ban, about 300 new safa tempos were brought to the market. At the end of April 2000, there were about 560 safa tempos on the streets of Kathmandu.

The decision to ban diesel tempos was hailed by environmentalists and the general public as a bold and progressive move. But there was criticism because the government chose microbuses (vans that seat 12–14 people) as a substitute for displaced tempos. As a concession, the government had decided to support displaced diesel tempo owners in importing microbuses (of Euro I standard) by providing concessions in import duty and VAT exemption.

Environmentalists felt that the government ought to have chosen the locally manufactured safa tempos as Vikram's substitutes rather than the microbuses. As it happened, the import of microbuses was delayed, and there was little competition to fill the gap. So more and more safa tempos came to the market.

Emerging Threats & Opportunities

The major technological constraint in operating safa tempos is the life of the batteries. Profit for safa tempo operators depends largely on this. In most cases, the batteries have survived for 450 cycles, which is quite low compared to what the manufacturer has claimed (754 cycles for the Trojan T-105). In a few cases, batteries could not run more than 300 cycles, which led to some operators going bankrupt. Also, the slow speed of the safa tempo has become an irritating factor to the traffic police in the Kathmandu valley.

The demand for safa tempos is gradually approaching the saturation point in Kathmandu. Unless new routes are opened up and opportunities for operating EVs in other cities of Nepal are explored, the demand for safa tempos is going to dwindle. There is also a need to explore and tap a market niche for four-wheeled EVs soon.

However, there is a light at the end of the tunnel. Manufacturers are gradually taking strides in promoting EVs outside the Kathmandu valley. Green Electric Vehicle (Pvt.) Limited has begun operation of safa tempos in the Lumbini area, the birthplace of the Lord Gautam Buddha, where diesel tempos are also banned. In Biratnagar, a city in eastern Nepal, one safa tempo has already been used to carry solid wastes for the municipality. Manufacturers are trying to introduce safa tempos for public transport there as well.

A working EV's daily ritual. Swapping in the second set of batteries at midday.

One emerging advantage of the EV industry is that it has become an opportunity for women to be employed as drivers. Already there are thirteen female safa tempo drivers, and many more are in the training process. Three institutes have been opened up to help women get driving training. Driving has traditionally been an occupation of men in Nepal. However, because EVs are a new technology, it has been easier for women to break social barriers and join the driving profession.

Industry Consolidation

The EV industry in Nepal is in the process of consolidation. It still requires support in the form of research and development, incentives, and infrastructure development and support. At a time when commercial operation of EVs is beyond imagination even in developed countries, it has become a relatively successful enterprise in Nepal. The case of safa tempos in Nepal shows that EVs need not necessarily be expensive. They can provide transportation at fares that even the poor can afford.

This has served as a good example of how economic growth and environmental protection can go hand in hand. The EV industry in Nepal has empowered women by generating employment in the driving sector while giving us great hope of combating air pollution. The industry has passed through a learning curve, and has begun to establish itself assertively in the market, providing employment as well as quality service to commuters.

Access

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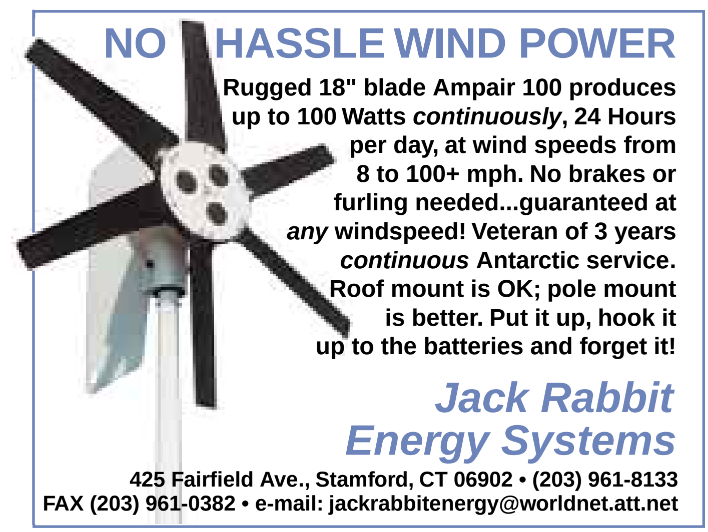

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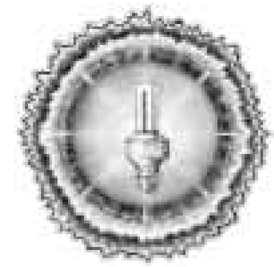

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TOP SECRET

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

PROFILE: 0011

DATE: August 9, 2000
LOCATION: Somewhere in the USA
INSTALLER NAME: Classified
OWNER NAME: Classified
INTERTIED UTILITY: Classified
SYSTEM SIZE: 3,840 watts of PV
PERCENT OF ANNUAL LOAD: 95%
TIME IN SERVICE: 9 months

Last year I asked my utility what it would take to convert to net metering. They responded, "The interconnection of residential renewable resource generation to our system is fairly new and uncommon, so we are in a learning process. I am working with the various departments that have a part in making this happen."

Since I did not wish to be a test case, I went guerrilla.

The system I use has the capacity to supply most of our needs. All lamps are compact fluorescents, purchased from our local utility at a very low cost. I bought a Sears high efficiency fridge, and use propane for our stove and dryer. The house is heated by wood, with oil as backup.

I have also found a unique way of dealing with some of the phantom loads around the house. I use inexpensive converters (24 to 12 V) connected to the battery bank to power devices such as the answering machine, intercom, and clocks. This works for all devices that require a transformer to convert AC to DC. Our electrical energy consumption is about 10 KWH per day.

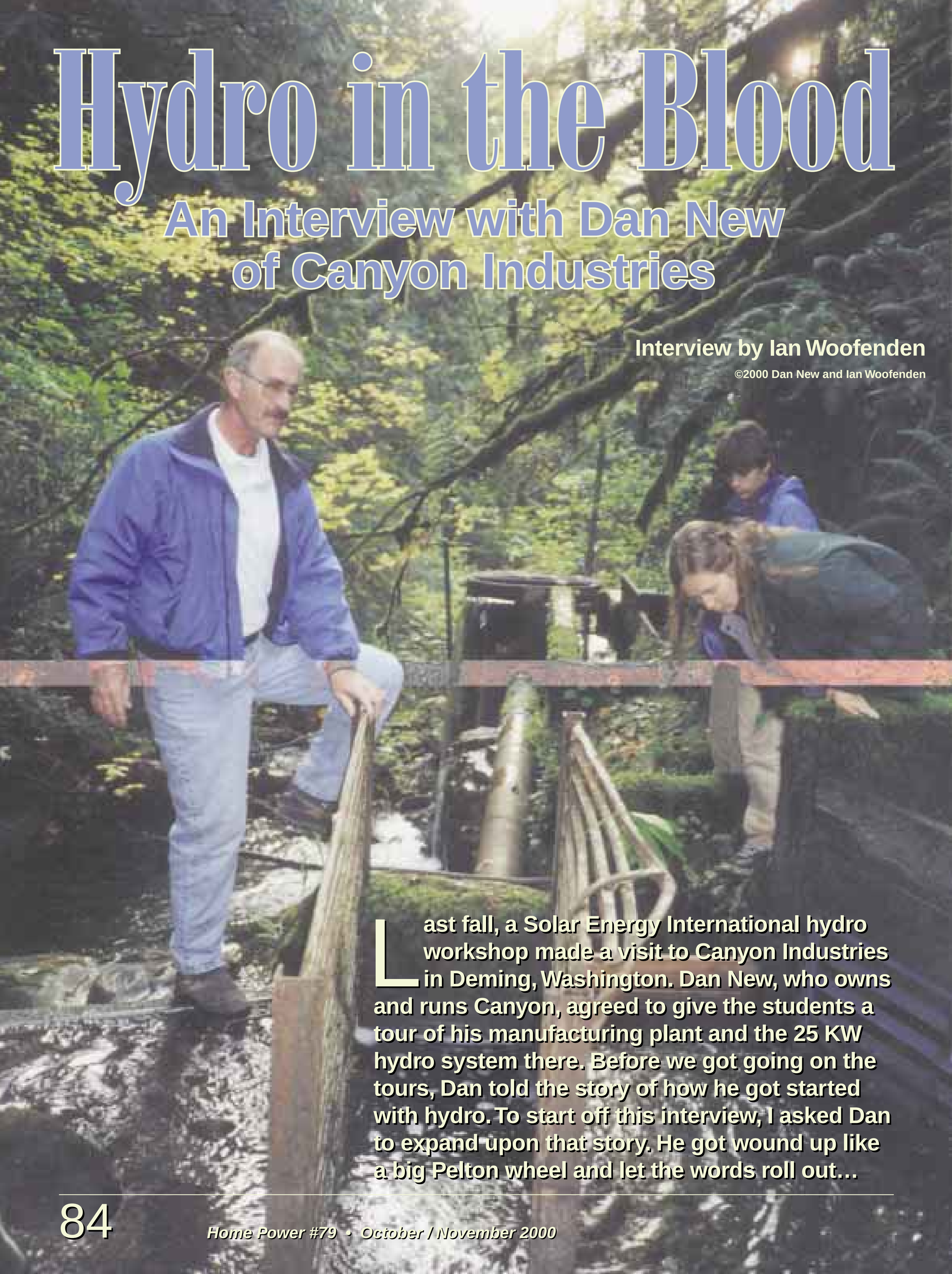
Our needs are met with thirty-two Kyocera KC-120s, which give us plenty of energy. I can often use the air conditioner at night, and still not use more kilowatt-hours than I put back into the grid. With this amount of solar energy, getting the energy from the arrays to the batteries was a challenge. I decided to use two pairs of 250 MCM cables and two fan-cooled Trace C-40 controllers running at a max of 55 amps each. I have one 24 volt 1,180 amp-hour Deka flooded battery, which supplies enough backup for three sunless days. The inverters are Trace SW4024s, one in use and one as a spare. I monitor my system with two C-40 displays and a TriMetric 2020.

With the Trace set for "sell," my meter spins backwards at a rate of 2 KWH on a good day. Combining solar energy with energy efficient appliances and lighting has reduced our average bill from $180–250 per month to about $20 per month.

Even though there is a net metering law in my state, my local utility is using a data collection system that makes it impossible to net meter. They use wireless communications with their meters, and the system cannot recognize which way the meter is spinning. The more I use the grid for my energy, the faster my meter spins to the right and the faster my bill goes up. The more energy I put back into the grid, the faster the meter spins to the left and—guess what?—the faster my bill goes up.

The counting device doesn't know which way the meter spins; all it knows is how many hash marks pass by. So I'm paying for any grid energy I use, AND for any solar energy I send back into the grid. Fortunately, I've reduced my consumption radically, and most of my usage is covered directly by my array.

For now I'm happy to have reduced my utility bills, and I enjoy the fact that I am utilizing natural pollution-free resources to generate my energy. When my utility company makes it easier to go through the process, I might go public with my RE system. In the meantime, I'm content to be a solar guerrilla.



Hydro in the Blood

An Interview with Dan New of Canyon Industries

Interview by Ian Woofenden

Last fall, a Solar Energy International hydro workshop made a visit to Canyon Industries in Deming, Washington. Dan New, who owns and runs Canyon, agreed to give the students a tour of his manufacturing plant and the 25 KW hydro system there. Before we got going on the tours, Dan told the story of how he got started with hydro. To start off this interview, I asked Dan to expand upon that story. He got wound up like a big Pelton wheel and let the words roll out…

Dan with his Dad's original turbine—in the powerhouse where Dan had his hydro conversion experience.

In the mid sixties, my father was working to install his own hydroelectric system. Engineers at Puget Power told him it was not possible, that he had no idea what was involved, and that it was far too complex for the private citizen to understand. At the time, I was in my early twenties, and lots smarter than I am now. I told him I just couldn't understand why he was spending so much time and money on this hydro project. I told him he could just spend $500, get Puget Power lines into the place, and then get all the power he wanted for $15 a month for the rest of his life. Like many fathers, he was just too stubborn to listen.

My uncle took me aside, and explained that my dad had searched Oregon, Idaho, and Washington before buying the homestead in 1939, simply because it was best suited for a little hydro plant. During the second world war, my dad built airplanes at Boeing, and used his spare time to work on water turbine parts. As his family grew, my father had to put childish things like little hydro plants behind him, and support all of us instead.

So I quit bothering him. I gave him a hand off and on, but it was his project. I had no love for the work, or for the concept. I watched or helped while he hand built a little diversion in the stream, laid over 2,000 feet of 8 inch steel pipe, built a powerhouse, and worked in his shop on a Pelton wheel. I wasn't even around when he fired up the plant for the first time, on a day he described in his journal as a "red letter day," even going to the trouble of finding a red pencil to make the entry. I had no interest in the project when I visited him, or when I listened to him describe the virtues of having an abundance of "free electricity."

During one of these visits, my dad said he needed to go down to the powerhouse to change nozzles. He explained that the stream flow was going down due to the recent dry spell, and that he needed to "nozzle down" to avoid taking too much water out of the stream. There were no restrictions to his licensed right to take 450 gpm from the creek, but he was always careful to keep a good flow going to "keep the fish cool."

It was dark as we walked the path down to the powerhouse, but the turbine was humming along, and the lights in the powerhouse were always on. My father slowly closed a big 8 inch gate valve, bringing the turbine to a stop, and putting us in the dim flashlight gloom. He quickly changed to a smaller nozzle, explaining things to me that I had no ear to hear. Once the new nozzle was in place, he said, "Start her up!"

A typical Canyon Pelton (75 KW) in a remote area of Papua New Guinea.

Dan and a Canyon employee with a Pelton wheel on the grinding and polishing stand.

Following his instruction, but with no enthusiasm, I slowly started to open the big gate valve. All the pressure on the penstock was against the closed valve, and I could feel this force as I began to open the valve. First there was the hiss of water, as the disc of the valve came off its seat. As the valve opened a little more, there was a louder sound, a "power" sound. Slowly the turbine shaft began to turn. I could hear the jet striking the buckets with a gentle flap flap sound.

I opened the valve a little more, and the speed increased. The jet was now a steady throb, and I added water until the throb became a buzz. The buzz quickly became a smooth hum, and the lights, like magic, returned to the powerhouse.

I've been hooked ever since. I loved hydro from that moment, and that affection has grown until I'm convinced that I have the best job possible.

What is it that keeps you excited about hydro?
Hydro is magic. I like the little teeny systems, and I'm excited by the kinda giant projects. I work with the neatest people, and hydro sites are always in the most beautiful parts of the world. The variables in sites, equipment design, and application are seemingly endless, and the good that hydro accomplishes is difficult to contest. What is it about the ocean, a lake, a river, or a creek that seems to draw the attention of all people? I don't know, but hydro holds the same fascination.

How did Canyon Industries get started?
After my father got his hydro going, people came asking him to build a very small turbine, just to charge batteries. He worked for years on a little turbine, setting up a test lab, and making design changes based on his tests.

The magazine *Popular Science* was doing an article on little water turbines, and interviewed my dad at his shop. My father died a month before the article came out, but the publicity generated by the story in *PS* in September of 1976 got Canyon Industries going. My son Richard and I now jointly run the business, which employs fifteen people.

A 15 KW Pelton turbine operating in Costa Rica.

What's your market?
We sell turbines throughout the world. Perhaps our biggest market is in Central and South America, but we have two larger turbines in the shop right now, one going to Ireland and one to Scotland. We have turbines in Papua New Guinea, Morocco, Zaire, Guatemala, and Colombia, just to name a few. North America accounts for the majority of the smaller micro turbine sales, but most of the larger turbines are shipped overseas.

Tell us about the turbines you make and sell.
We build two lines of turbines. Canyon has a number of turbines we call "standard" units. We use production practices to lower the costs of these standard units, and build several of each model at one time. These are the turbines in the size range of about 4 KW to 100 KW, and these are usually installed to provide electricity to remote homes, farms, ranches, retreats, or communities.

We also build larger units on a custom basis. These turbines, sized from about 100 KW to over 5,000 KW, are for remote communities, or for systems designed to tie into the national electric grid. Custom turbines are designed with highest efficiency in mind, and are built to be used at only one specific site.

A large (1,400 KW) Canyon Pelton turbine with two runners and four nozzles, operating near Idaho Falls, Idaho.

Do all of your turbines use Pelton wheels?
We build two types of turbines—the Pelton design, credited to the inventive engineer Lester Pelton, and the crossflow type, which is a design often referred to as the Banki or Mitchel turbine. The Pelton turbine is generally used at sites having something over 100 feet of head, but it may be used successfully at any head. Compared to other types of turbines, the Pelton uses quite small amounts of water, but can produce thousands of horsepower with very high heads. We currently have designs for Peltons up to 10,000 KW, but we build many Pelton turbines for projects generating under 10 KW.

The Canyon crossflow turbine is for projects that offer lower heads, say about 20 feet on up, but it can handle rather large amounts of water. By design, the crossflow is somewhat limited in power output. We build crossflow turbines for projects sized from 5 KW to 1,000 KW.

How are Canyon turbines manufactured? How much is done in-house?
We build every part of the turbine at Canyon, except for the foundry castings. All of the castings are made to our patterns and designs, but it takes a very good (and sometimes large) foundry to provide good castings. The Pelton turbine runners are all single piece castings, and we have patterns for over forty different designs.

The generators, controls, shafting, bearings, and other parts are all standard, but most other components of the turbines, such as housings, nozzles, seals, jet deflectors, and assembly bases, are fabricated in steel by artisans in our shop.

Our crossflow turbines are constructed entirely in our own shop, where we have lathes that will turn as large as 100 inches in diameter, computer numerically controlled (CNC) machine tools, shears, rolls, and a variety of welding machines.

What's the most challenging part of designing a quality turbine?
Boy, that's a tough question. The greatest challenge is to design a turbine that is the most efficient, most durable, and most affordable. With the standard turbines, we concentrate on building a rugged, compact unit, with reasonable efficiency. With the larger turbines, we have a bigger budget, which allows us to develop the highest possible efficiency. But even with the larger units, we must watch costs very closely, since we must compete on an international level.

As far as manufacturing, which part takes the most care and time?
With both Pelton and crossflow types, the most care goes into the design and manufacture of the wheel—what we call the runner. The runner is the heart of the turbine, and is the part of the machine that converts the energy of the water into the spinning of the turbine shaft. Of course, a good runner in a poorly constructed housing, perhaps with improperly built nozzles, will result in a mediocre turbine. They must all work together to get the most out of the water.

OK, so we have a pretty good view of why, who, and what you and Canyon Industries are. Let's talk more generally about small hydro power. What are the big hurdles for hydro power?
First off, we need to understand that not very many people can even consider a hydro project. Most people don't have a stream that's possible to develop with hydro. So the few people who are able to build a hydroelectric system are in a very small minority. Next in the line of hurdles is the need to maintain any stream so that it can continue to support flora and fauna.

After that comes the very difficult tasks of convincing the majority that the hydro system is a good idea, or at least permissible. The physical parts of a hydro project—diversion, pipe, turbine, and transmission line—are all easy to do, and offer a variety of choices.

For your average customer, are the politics more of a problem than the siting and equipment specification and installation?
Maybe "politics" is not the best word, but I know what you mean. You see, most streams are sort of public domain. So everyone has an interest in how that stream is used, maintained, and protected. That's a lot of interests, and there are few of us who are willing to see all sides. I'm a prime example. Show me a stream, and I automatically assess its hydro potential. Others see a stream, and feel it best that no one approach it for any reason.

Many others don't even know about the stream, but have strong opinions about how it may be used. So, with all these concerns, the "politics" of the project are often much more difficult to deal with than the actual work at the site.

What's to be done about that?
It may be that we need to teach people about electrical energy, and then let them decide where and how they want it generated. Despite the magic of hydro, there is truly no "free" electricity. A price must be paid for all forms of power generation: solar, hydro, wind, oil, coal, gas, or nuclear. What we seem to have, as we enter a new millennium, is a populace feeling that electricity is a basic human right, not to be denied anyone who regularly pays their power bill.

This same populace seems to be strongly opposed to any form of power production. I feel that education may assist all of us in making the best choices. Naturally, I feel that one of the best choices is hydro.

Let's talk about the small hydro industry a bit. How big an industry is it, and where does Canyon fit in?
Microhydro to small hydro is a very small industry. Remember, not many people have a stream in their back yards. Canyon probably provides 20 percent of all the micro to small turbines in the world, maybe 60 to 70 percent in the United States, and we're a very small company.

Is the market expanding, shrinking, or staying the same?
For Canyon, the U.S. market seems to be staying the same. The market in South and Central America is growing, as it is in parts of Europe, Australia, New Zealand, and Indonesia.

What does the future hold for small hydro?
The future is good for small hydro, worldwide. It makes sense, as it provides us with power at a comparatively low environmental cost.

What are your own personal hydro goals? Do you have designs, turbines, or systems that you hope to develop in the coming years?
For the last eight years, I've been studying the Francis turbine. Building a good, small Francis turbine is a personal goal, and I've infected just about everyone at Canyon with the idea. We expect to add this well-known design to our Pelton and crossflow types within the next two years, and I'm really excited about it.

What wise words do you have for people who want to use hydro and for people who want to work in the small hydro field?
Oh, Ian, you've saved the best question `til last. After getting me to ramble on and on, I can answer this one quickly and with enthusiasm—just do it!

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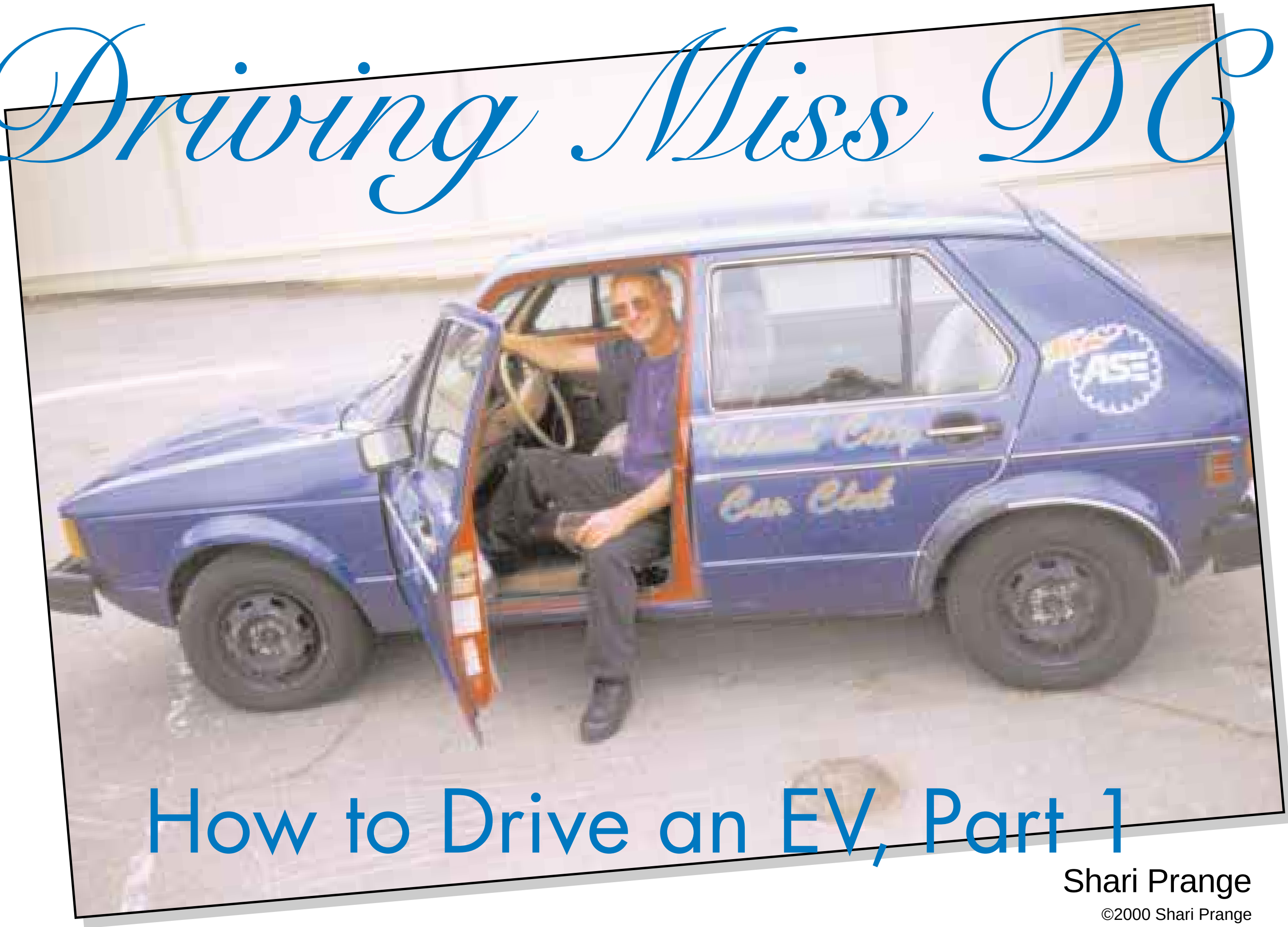
Driving Miss DC



How to Drive an EV, Part 1

Shari Prange

If you put two identical electric vehicles into service, one may get only a forty mile range, while the other gets eighty. Why?

Your EV's hardware controls its potential for performance. The combination of chassis, motor, controller, and batteries determines its maximum capabilities for speed, acceleration, and range. The last item—range—is actually the first priority for most EV drivers.

But what determines whether the EV actually reaches its potential in daily driving? The answer is the "wetware," which is you, the driver. There are simple techniques you can use to get the most out of your EV.

AC vs. DC

First, we need to make a distinction between manufactured EVs and conversions. Most manufactured EVs have several things in common that are different from most conversions. Manufactured EVs like the GM EV1 and the Honda EV Plus generally use AC drive systems set up so that the motor drives the wheels directly, drawing from a battery pack of about 300 volts. This means that there are no gears to shift.

These cars also have regenerative braking, which means that the motor creates drag to slow the car as soon as you take your foot off the throttle, just as a gas engine does. In the EV, the drag is used to generate a small amount of electricity, which is put back into the batteries.

The result is a car that drives very much like a gas car with an automatic transmission. Many of the tricks for optimizing performance are taken out of the driver's hands. This means that actual performance is more nearly uniform among manufactured EVs than among conversions.

Conversions, on the other hand, almost always use DC drive systems, manual transmissions, and battery systems in the 96 to 144 volt range. These systems are dramatically less expensive and more available to the hobbyist mechanic. Regenerative braking is also more difficult to achieve with a DC system than with an AC system, which is the reason it is not often found in conversions. This setup lends itself to some different driving techniques.

Since there are not many manufactured EVs on the roads yet, your experience is likely to be with a DC-powered conversion. So we'll concentrate on techniques for driving them.

Starting
When you turn the key on, nothing apparent happens—there is no sound. For this reason, many conversions have an "on" light on the dash. This is one of the car's original warning lights, usually the alternator warning light, which has been rewired to turn on whenever the key is on.

Do not put the clutch in and rev the motor. For one thing, it just won't make the same satisfying macho sound that a gas engine makes when you do this. For another thing, revving the electric motor with no load on it can overspeed and destroy it in the blink of an eye.

Unlike a gas car, you can start an EV from a stop without using the clutch. You can't "kill" the electric motor the same way you would a gas engine. However, this makes for an abrupt, jerky, and unpleasant start. In some EVs, you can take off in second or third gear if you are lazy and don't want to shift. This is not really a good idea though, because it draws a lot of current until you get up to the proper speed for that gear. This high current draw is hard on your components, and diminishes your range.

Your best bet is to start off just as you would in a gas car: engage the clutch, put the transmission into first gear, and release the clutch gently while depressing the throttle for a smooth, efficient takeoff.

Why Manual Transmissions & Clutches?
First, you need to understand that voltage equals speed. The higher the voltage to the motor, the faster it spins. AC motors can usually spin up to 12,000 rpm, or more, safely. It takes 300 volts to get them there, but it gives them a full range of road speeds from zero to freeway speeds without using a transmission.

The DC motors used in conversions top out at 5,000 or 6,000 rpm. They don't need as much voltage to reach their rpm limit, but they do need multiple gears to provide a full range of road speeds for the vehicle.

Automatic transmissions have various problems that make them unpopular for conversions. One of these problems is that the shift points are poorly matched to electric motors. We'll talk about this a little more later. If there is some reason you simply cannot operate a clutch, you can shift gears in a conversion without using it. However, it takes some practice to develop the right touch to do this smoothly, and it can be hard on the transmission. It's a much better idea to use the clutch, the same way you would in a gas car.

Shift Points
But when should you shift? A practiced EV driver can recognize the shift points from the pitch of the soft whine from the motor, but this is much quieter and subtler than the sound of a gas engine. A beginner will be baffled by the lack of auditory cues.

Watch your gauges—as volts go up, amps go down.

Fortunately, the "redline" on the electric motor is very similar to the redline on the gas engine of most economy cars used for conversions. This means that the shift points are very similar. (The redline is the rpm limit above which you will damage the engine or motor. Don't go there!)

For example, in a typical compact car conversion, first gear will be good up to about 25 mph (40 kph). Second gear extends to about 45 mph (72 kph), and covers the great majority of your driving needs. (If you cannot operate a clutch due to a physical problem, and you don't ever need to drive on the freeway, you could simply leave the car in second gear all the time.) Third gear is good to about 65 mph (105 kph). Fourth gear will probably take the car as fast as it is capable of moving. Fifth gear is pretty unnecessary.

There is a formula you can use to determine the exact shift point for each gear in your car, and you can then mark them on your speedometer. This formula is:

$$\text{mph} = (\text{rpm} \times r) \div (g_1 \times g_2 \times 168)$$

mph = maximum speed for the specific gear

rpm = rated motor rpm at pack voltage

r = rolling radius of the drive wheel tires in inches

g_1 = gear ratio for the specific gear

g_2 = gear ratio of the vehicle's differential (find it in your shop manual)

168 = constant value

This will give you the maximum speed you can safely drive in each gear. But that still doesn't exactly answer the question of when to shift.

We already established that voltage equals speed. As you depress the throttle, the voltage to the motor increases, and it spins faster. At the bottom of the speed range for each gear (say, 25 mph for second gear), the motor is spinning more slowly. At the top of the speed range (45 mph for second gear), the motor is spinning as fast as it safely can—it's at or near its redline.

You need to know that electric motors work in the opposite way from gas engines, as far as efficiency is concerned. Gas engines are more efficient at low rpm. Electric motors are most efficient just under their redline. This is one reason why automatic transmissions are not good in EV conversions. They are designed to keep a gas engine running in the most efficient part of its rpm band, which means low rpm. But in an EV, the automatic will have the motor running at its least efficient rpm.

You can cruise at a steady 45 mph (72 kph) in either second or third gear. However, you will be much more efficient in second gear. The best technique for efficiency (which means the most range) is to drive as close as possible to the top of the speed band for each gear.

Efficiency Gauge

Is this confusing? Well, there's a handy "efficiency gauge" in EVs to help you understand it. It's the ammeter. This shows you the amperage you are using at any given moment. The higher the amperage, the less efficient you are running, so you want to keep the ammeter needle as low as possible. If you watch your voltmeter and ammeter side by side, you will quickly see that there is a relationship between the two. As volts go up, amps go down, and vice versa. Running at a high rpm is more efficient, and keeps the amperage low.

You can experiment by holding a steady speed and shifting up to a higher gear. You will see voltage fall off and amperage increase. You're traveling at the same speed, but burning more juice to do it.

Here's an extra credit item for advanced students. You can maintain a smoother speed and better efficiency if you keep the throttle partially depressed while shifting gears instead of lifting your foot off it entirely. Old racers call this speed shifting, and it helps keep the motor revs from falling off during the shift. However, it must be done carefully. Don't put the throttle down too far, and don't leave it there too long between gears, or you could overspeed the motor. If you don't feel confident about doing this trick, play it safe and lift your foot off the throttle completely for a moment while you shift.

The Sweet Spot

Electric motors can have a favorite speed they "want" to run at for a particular gear. This is not just anthropomorphizing. It has to do with how electric motors work. On flat ground, there is a spot that balances on the fine line between efficiency and safety. The motor revs are high enough to be efficient, but still low enough not to stress the motor by overspeeding it. If you are sensitive to the car, you will notice that it seems to run particularly smoothly and effortlessly at that speed.

If you have a load on the motor, like a slight uphill climb, the motor can actually limit its own speed. It works like this: when electricity flows through a motor, it creates a magnetic field, and the natural attraction and repulsion of the poles of this field make the motor armature and shaft spin. However, every motor is also generating electricity. The two processes are opposite sides of the same coin.

On the one hand, applying electricity to a motor creates a magnetic field, which causes the armature to spin. On the other hand, the motion of the conductive armature through the magnetic field induces an electric current. This is usually called the "back emf." The tricky part is that the induced current works in opposition to the applied current. The faster the motor spins, the greater the induced current, until it balances the applied current. At that point, the motor tends to self-regulate and maintain the same speed.

This is the zen of electric motors. What it means in real life is that sometimes, no matter how much more throttle you give it, the car just doesn't move any faster. You can mash the pedal to the floor, but it's just wasted effort.

This usually happens while climbing hills. The natural tendency is to step on the throttle harder, which is totally ineffective. Instead, try backing off the throttle to the point where the car starts to respond to it again. You may find, paradoxically, that you move faster with less throttle instead of more. You may also find that you make better progress if you shift to a lower gear.

Tune In Next Time

So far, we've covered the basics of getting an electric conversion started, in motion, and up to speed. We'll pause here to let you digest this information. Next time, we'll talk about strategies for dealing with different driving conditions, and braking to a stop. So if you've been following along in your EV while reading this article, I guess you'll just have to keep driving until the next installment comes out!

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Battery Rack Design & Construction

Mike Brown

In the last issue, we talked about battery layout, and finding out how many batteries will go where. We determined how much space was needed for the batteries, the battery box, and the battery rack. Now we will take our two-dimensional length and width layout and add a third dimension—depth. We will pick the material to build the rack with, and determine how to fasten the rack to the car.

Suspension Racks

First let's look at the type of battery rack that is sunk into the floor of the trunk or hatch area, under the back seat of the car, or between the frame rails of a pickup truck under the bed. I call this type of rack a suspension rack because the weight of the batteries is suspended between the top of the rack, where it is attached to the car body by its flange, and the bottom of the rack, which is unsupported. This type of rack is shaped like a basket, with a flange around the top edge, and vertical supports extending down to the base.

The amount of depth to be added to this rack is limited by the amount of ground clearance needed to permit driving over all the various dips and bumps found on the streets. Another issue to consider is the pavement's angle of departure, or how abruptly it shifts from flat to uphill or downhill. How steep a driveway can the car be driven up before the bottom of the battery rack scrapes on the pavement?

The rule of thumb I use is that no part of the battery rack should be any lower than the lowest non-movable part of the rear suspension. This rule has worked well for me over the years. The rack won't bottom out, but it still carries most of the batteries' weight below the floor level of the car. This is a very important safety factor in case of a collision.

My material of choice for battery racks is 1/8 inch (3 mm) thick steel angle stock. Depending on which type of rack it is, the size (width of the arms) of the angle stock varies from one to two inches (25–50 mm) wide. The size of the angle stock is determined by where it is used in the rack.

For example, the base of our Voltsrabbit rear rack, which supports eight batteries and their box, is 1-1/2 inch (38 mm) angle stock. The top of the rack is 2 inch (50 mm) angle stock. This provides a wide flange where the rack meets the floor of the car and gives space for the 1-1/4 inch (32 mm) fender washers with the nuts and bolts to fasten the rack to the body.

The distance from the surface that will support the flange down to your needed ground clearance determines how deep the rack will be. The tops of the batteries and battery box may extend a few inches

A suspension rack installed in a hatchback.

above the flange at the top of the rack. The top and bottom of the rack are held together at the proper distance by four pieces of 2 inch (50 mm) angle stock at the corners of the rack.

The corners are butt-welded to the edges of the top and bottom angle stock. Additional strength is added by welding 1 by 1/8 inch (25 x 3 mm) flat stock straps to the outside of the angle stock from top to bottom at the center of each side of the rack. If the rack is a large one, the bottom can be reinforced with a piece of 1-1/4 inch (32 mm) square tubing running from side to side under the center of the rack.

It's necessary to have each battery in the pack supported on at least two edges by the rack, even if the batteries are in a box. It is very important to size the material of the rack top and bottom, the corner pieces that hold the top and bottom together, and any reinforcing straps used between the top and bottom to suit the weight the rack is supporting. Attention should also be given to the number and type of welds holding the rack together, and their weight-carrying ability.

If you are not an experienced fabricator and welder, it might be best to bring a professional welder in at the start of the rack design to help determine material size and design for ease of assembly. What you pay for design help will save you money when you start fabricating the rack, and will eliminate the possibility of failure due to a weak design.

Bridge Racks

Now let's look at the type of rack that would be found in the former engine compartment of a car or truck. I call this the bridge rack because it carries a load (batteries) over a gap (the space above or around the motor) and is attached to an abutment (the frame or body of the car). This is also the type of rack you would use in a VW bug if you were going to put batteries where the back seat was.

Instead of a basket shape, this type of rack is more of a tray with a lip around the edges. It needs to be paired with a matching hold-down frame that secures the tops of the batteries.

In my last column, we determined how many batteries we are supporting and where we are putting them. We proved that we can close the hood over them safely (the depth dimension again) by taking measurements and building mock-ups. Now we can proceed with the design of the rack.

The materials remain the same—angle stock in 1 or 1-1/2 inch (25 or 38 mm) widths. Which size to use depends on the number of batteries the rack is supporting and the distance it has to span without support. If any tube or angle stock is added to the underside of the rack for battery support, make sure it doesn't interfere with any other part of the car, like the motor or transmission.

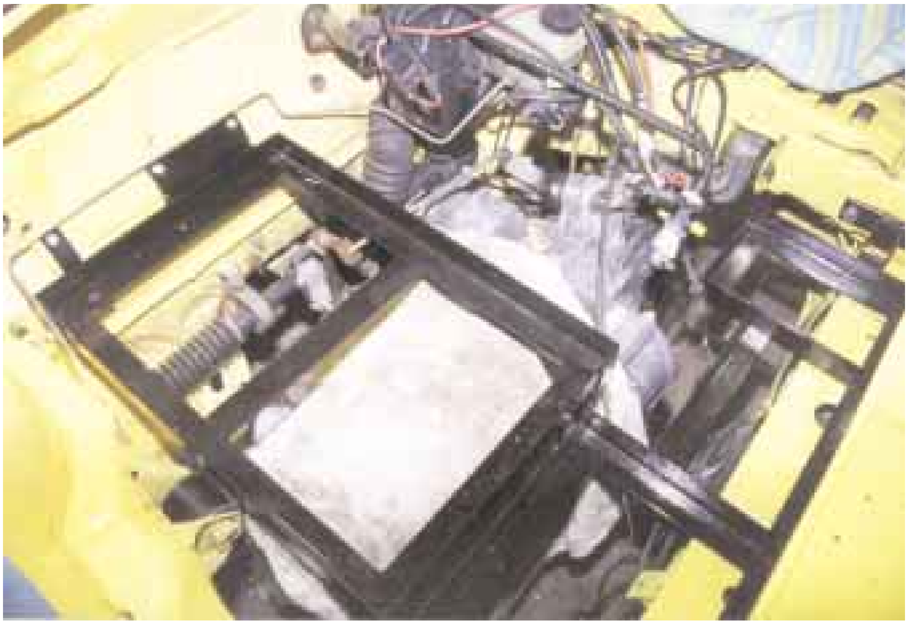
Most front engine/rear wheel drive cars and trucks have a large open space where the engine was. The boxes and racks that fill those spaces tend to be rectangles of varying sizes. The front engine/front wheel drive cars have a differently shaped space for batteries because the transaxle remains in the engine compartment after the engine is removed.

This results in a battery space that is L-shaped, and often the batteries in the base of the L are lower than the batteries in the upper part of the L. This split-level space situation can be handled with separate upper and lower racks, or a one-piece split-level rack. Which alternative to use depends mainly on the availability of places to mount the racks to the car. The bridge-type rack presents some choices, but the layout still comes down to rectangles of varying sizes.

Floor Racks

The third type of battery rack we are going to discuss is called the floor rack. This kind of rack is found in van-type vehicles, usually under or between the seats. It is also found in pickup trucks where the batteries are put

A split-level bridge rack supported on the right by the original bumper bracket bolts, and in the rear by the mount plate on the firewall.



in a box in the bed instead of boxes and racks under the bed. It could also be used in a hatchback-style car where sinking the rack is not possible. In short, this rack works anywhere there is a perfectly flat floor to set the rack on.

This type of rack is almost always a large rectangular tray with ten to twenty batteries in a box. Since the rack is fully supported by the floor of the vehicle, 1 inch (25 mm) angle stock is strong enough for the perimeter. Flat stock should be added to support the floor of the battery box where the edges of the batteries meet. Supporting the weight of the batteries is not as big a problem with this rack, but mounting the rack to the floor and securing the batteries and battery box to the rack is a challenge.

Attaching Suspension Racks to the Chassis

The primary job of the battery box and rack system is to keep the batteries secured in their place and isolated from the passengers. How the battery racks are attached to the car's chassis or body is a crucial part of the battery rack's design.

Attaching the suspension-type battery rack to the car's body is made a little easier by its position in the body. Because it is in a hole in the floor of the car's body that is only a little bigger than the outside dimension of the rack, it is well confined in the front-to-back and side-to-side directions. Since most of the battery pack's mass is below the level of the car's floor, in the event of a collision, the batteries will stay below the floor.

All of the good news mentioned above does not eliminate the need for fasteners. Our Voltsrabbit's sunken rear rack is held in place by twelve 1/4 inch (6 mm) bolts. The bolts go into holes in the rack, through holes in the body. Under the car, a 1-1/4 inch (32 mm) diameter fender washer is placed over the bolt and a 1/4 inch nylon locking nut is threaded onto the bolt.

This may seem like too few bolts of too small a diameter, but shear forces (forces that are trying to cut the bolt in two across the diameter) on the bolt are limited by the close fit of the rack to the hole in the body. In a collision, horizontal forces would not be carried by the bolts alone, but would be distributed along the entire angle stock flange where it meets the body.

Under tension (where the forces acting on the bolt are trying to pull it apart lengthwise), the tensile strength of the bolts combined with the amount of contact between the rack's flange, the car's body, and the fender washers keeps the loads within safe limits.

The practical proof of these statements is the fact that the rear of a Voltsrabbit can be lifted with a floor jack using the reinforcing bar on the bottom of the battery rack as a jack point. This is done without any distortion of the body around the rack or any damaged bolts. Since our car is torn down regularly for classes, we have been able to check for any damage or distortion from the forces encountered in long-term use. In nearly ten years, we have found none.

If your suspension-type rack is holding more than eight batteries, you could go to a 5/16 inch (8 mm) bolt. Always use as many bolts as you can place around the perimeter of the rack at 6 inch (15 cm) intervals and have body metal under them to fasten to. When you are ready to install the rack, place it in the hole, clamp it in place, and spot drill through the holes in the rack to locate where to drill the holes in the body. Use a felt pen to mark the outside edge of the rack's flange. Remove the rack, and finish drilling the holes.

You may have to drill through a thin sheet metal frame member on a unibody car to bolt the rack to the car. If so, run the bolt through a pipe spacer inside the frame member to prevent crushing the frame when you tighten the bolt. The spacer should be as long as the depth of the frame member it is going into, minus the thickness of the metal the frame member is made of. Try to get this dimension as close as possible. Too long a spacer will keep the rack from being tightly fastened to the frame member. Too short a spacer will result in the frame member being crushed. A little too short is better than too long; a little crush is all right.

To install the spacer, drill holes to fit the bolt size through both the top and bottom of the frame member. Next, drill the bottom hole to the size needed to allow the spacer to enter the frame member. When you are ready to do the final installation of the rack, apply a thick bead of silicone caulk to the top of the body between the edge of the hole and the felt pen mark you made earlier. Put the rack in the hole, and line up the bolt holes in the rack and the body. Install the bolts in their holes, using longer bolts where needed to go through the frame member.

From the underside of the car, install the fender washers and nylon locking nuts on the bolts, and tighten securely. When you get to one of the bolts that needs a spacer, put the spacer over the bolt, install the fender washer and nylon locking nut, and tighten as before.

When these steps are completed and the battery rack is securely attached to the car body, any chassis stiffness lost by cutting the hole in the car's floor is replaced by the battery rack. Installation of a suspension-type rack in a pickup is a similar process. The truck frame, however, is much thicker than a car's sheet metal floor, so the bolt hole spacing could go out to 8 inches (20 cm) apart, the bolt size could go up to 5/16 inch (8 mm), and there is no need for the fender washers.

Attaching Bridge Racks to the Chassis

How difficult it is to install a bridge-type battery rack depends on the number of mounting points available on the car's chassis. You need to find a place to make your attachment. Then design a welded extension to your rack to reach the attachment point. The first thing to look for is an existing bumper mount whose bolts could also be used for a battery rack mount.

Motor mount bolts can also be used, even if you are still using them to mount the electric motor. A non-moving part of the suspension, such as an upper shock absorber mount or suspension pivot mount, can be used. But it must be strong enough to take the load you are adding plus the existing load.

You will probably have to substitute longer bolts to make up for the thickness of the mount you are adding and still have the same amount of thread engagement as the original bolt did. When substituting bolts, be sure to get the same thread pitch, size (diameter), and class of hardness as the original bolt.

You may be asking yourself, "Now, what do I do? I've used the front bumper mount bolts to support the front of the rack, but at the rear there are no ready-made places to attach the rack to." In a unibody car, this can be a problem. If there is a welded sheet metal frame member that would support a rack mount, you could use the long bolt and spacer method described above.

If it looks like all that you have to attach the rack mount to is the vertical sheet metal firewall, it's time to make a sandwich. It's not edible, but it does give strength to a thin steel firewall by distributing the loads from the battery rack over a larger area of the firewall and stiffening the firewall at that point.

This type of mount consists of a flat steel plate 1/8 inch (3 mm) thick welded or bolted to the rack. This plate should be as big as it can be and still fit against a flat spot on the firewall. There are a number of 1/4 inch (6 mm) holes drilled in the plate. An identical steel plate, the same size and shape with the same number and location of holes, is fabricated at the same time. This plate is the backup plate, and it goes inside the car on the opposite side of the firewall from the mount plate.

Sometimes it can be difficult to hold the backup plate in place while threading a bolt through both plates and the firewall and tightening a nut on it. In this situation, I weld a nut to the backup plate, which gives me what is called a captive nut.

When the rack is installed and bolted to the other mount points, the mount plate is held in place against the firewall by the other mounts. Then the locations of the holes in the mount are transferred to the firewall by spot drilling through the holes in the mount. The rack is removed, and the holes are ready to be drilled the rest of the way through the firewall. Before you start drilling, it is wise to check to make sure that there are no vital components like heater cores, wire bundles, or electrical components where you are going to be making holes.

Install the rack for the final time, securing the other mounts loosely for now. Line up the holes in the sandwich mount with the holes in the firewall. Have an assistant inside the car hold the backup plate in place and line its holes up with the mount and firewall holes. Now insert the bolts through the three holes and secure with the nylon locking nut.

If the backup plate has captive nuts, I have found that it is easier if I line up one set of holes by inserting a small punch through all three pieces. Then I have an assistant move the plate until I can thread one of the bolts through one of the other holes and into one of the captive nuts. Thread the remaining bolts with lock washers into the backup plate captive nuts, and tighten them enough to hold the plate in place. Then remove the punch and install the final bolt and lock washer.

The small pickup trucks that are converted are of the body-on-frame type of construction, which offers its own set of challenges. There are few mounts or existing bolts to use to help mount the battery rack. There are, however, two heavy frame rails that could have rack mounts bolted or welded to them. The design of these mounts might be another place where a consultation with your welder would be helpful. One word of warning, however. If you weld the rack mounts to the frame, bolt—don't weld—the mounts to the rack. You might need to remove the racks to service the motor, and you don't want to have to cut them up to get them out.

Attaching Floor Racks to the Chassis

The floor-type battery rack could be mounted like the suspension-type rack with a bolt, flange, fender washer, and nylon locking nut system. However, since the loads on the mount come from above the flange, I don't think this system is strong enough. I have seen videos of accidents in EV races where a car went into a wall. When the rack sat on top of the floor and was attached by bolts, washers, and nuts, it tore loose because the washers pulled through the body metal.

The sandwich system, which spreads the load over a larger area, is preferable. The mount plates could be welded inside the perimeter of the rack to free up floor or bed space. In this case, the mounting bolt holes should be countersunk, and flat-headed bolts should be used to avoid interference with the bottom of the battery box. Mount plates should be placed at each corner of the rack and in the center of the long side of the rack. Be sure to check the underside of the vehicle for interference with the backup plates and nuts.

Both the bridge and floor-type racks have the battery box and batteries sitting on them. In some situations, this means that they should be built with a bottom, sides, and top like the suspension rack, but without the top mounting flange. The sides should be high enough to contain the majority of the batteries' mass like the suspension-style rack. I'll discuss this further next issue when we talk about battery box and battery box hold-down design, as well as protective coatings for the racks.

I have tried to write this with as much detail as space permits, but if I haven't been clear enough or you have more questions, please write, phone, or email me and we will talk about it.

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Word Power

Renewable Energy Terms

Watts = Volts x Amps Power Equation

Ian Woofenden

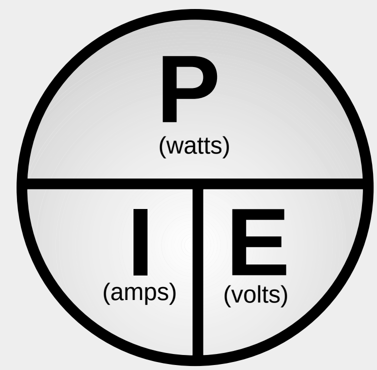
Derivation: The watt, volt, and amp are named after three well-known people in the history of energy—James Watt, Alessandro Volta, and Andre Ampere. This equation does not seem to have a formal name, so I'll just call it the "power equation."

To understand the power equation, you need to understand what power is. Power is the rate at which energy is generated or used. Though no analogy is perfect, energy is like miles traveled, while power is like the rate of travel—miles per hour.

Power is measured in watts. When we see a 50 watt lightbulb, we know it uses energy at a certain rate. Technically, a watt is equal to one joule per second. But the important thing is that a watt is a rate of energy use or generation, not an amount of energy used or generated. Instead of saying "a lot of power," we should say "high power" or "a large value of power," so it's clear that power is a rate, not a blob of stuff. We should never say that power "flows," since power itself is a rate of flow. Energy can flow, but power doesn't.

Two things go into the flow rate of electrical energy. One is the "pressure," and the other is the rate of charge flow. We call electrical "pressure" voltage—it's the push that makes charges flow. And we call the rate of charge flow amperage—an amp is a certain number of charges passing a point in one second.

You might remember from my column in *HP77* that there's a direct relationship between volts, amps, and ohms. Well, there's a similar relationship between watts, volts, and amps (in DC circuits and resistive AC circuits). Take a look at the power equation diagram. Cover the unit you want to solve for, and the remaining two units will give you the rest of the equation. If one is above the other, divide. If the remaining two are beside each other, multiply.



Power Law

So there are really three forms of the same equation:

Watts = Volts x Amps
Volts = Watts ÷ Amps
Amps = Watts ÷ Volts

We can use this equation to do lots of common electrical computations. For example, if a motor is drawing 20 amps at 12 volts, we know that it's using energy at the rate of 240 watts (watts = volts x amps). If a lightbulb is drawing 100 watts at 4 amps, we can conclude that the voltage is 25 volts (volts = watts ÷ amps). And if we have a 150 watt lightbulb running on 120 volts, we know that it is drawing 1.25 amps (amps = watts ÷ volts).

We can also play with the values within the equation. If you run a 100 watt lightbulb directly from your 12 volt battery bank, it will draw 8.3 amps (amps = watts ÷ volts). If you run another 100 watt lightbulb through your 120 volt inverter, it will only draw 0.83 amps (amps = watts ÷ volts). The same amount of energy flow results in both cases, but the higher voltage means that the amperage is proportionally lower.

This only scratches the surface of the usefulness of this formula, and I'm glossing over some technical distinctions and exceptions. I continue to find applications for the formula as I learn more about electricity and renewable energy systems, and I expect you will too.

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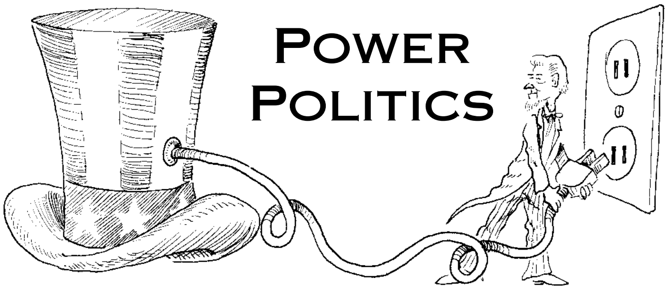


He's A Contender

Michael Welch

We are faced with a choice in this November's presidential election. We can vote for someone who is well ensconced in our corrupt political system, or we can vote for a third-party candidate who is not beholden to corporate political puppeteers.

We've had this choice in other elections, so what makes this one any different? There is no conservative third-party candidate that has a chance, but there is Green Party candidate Ralph Nader, who is poised to make inroads into our two-party "duopoly."

Nader is renewable energy's knight in shining armor. He is the only candidate who has dedicated his life to fighting for what is right for the citizenry, as opposed to giving away public rights to corporations. Coal, oil, gas, nuclear, and utility companies are some of the biggest abusers of our political system; Nader is prepared to take them all to task. Nader founded Public Citizen and its Critical Mass Energy and Environment Program to help promote RE, and to get rid of polluting and unsafe energy technologies. He would be RE's ideal President.

Lesser of Two Evils is Still Evil

Many readers fear that a vote for Nader will ultimately help elect the more conservative mainstream candidate, the worse of two evils. In the 1996 election, that did not matter too much. It was fairly easy to support RE by voting for Ralph Nader because for every vote Ralph sucked away from Bill Clinton, Ross Perot had taken away several others from Bob Dole. The danger of accidentally electing the less desirable candidate by accident was minimal.

Ralph Nader, Presidential candidate.

In 2000, a vote for Nader appears a bit more risky for those concerned about the lesser of two evils. In comparing Gore and Bush from the standpoint of RE, or from just about any other progressive point of view, the difference between the two is visible. Very few potential Nader supporters would come from the conservative Bush camp, whereas Nader's votes could be drawn away from the more liberal Gore. Theoretically, if too many Nader votes come from potential Gore voters, we might end up with Bush, an oil company man, as President.

I'd hate to see that happen, but I also believe that there is not enough difference between the two mainstream candidates' governing capabilities to merit much concern. Sure, there are significant philosophical differences. But when it comes right down to who has access to politicians after elections and who has the most influence, politicians follow the money, which flows from the corporations.

Corporate influence has been slowly homogenizing Democrats and Republicans into a single party of corporate supporters—they might as well be called Republocrats. Since the differences between the mainstream candidates have become seriously reduced, the risks associated with accidentally electing the worse of two evils are also reduced.

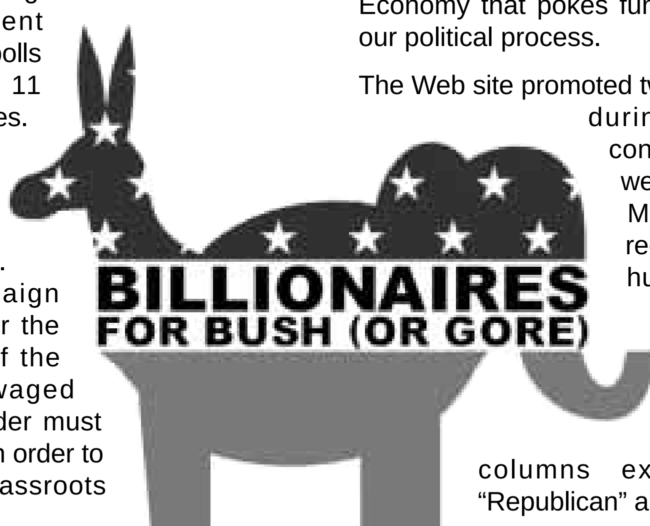
Vote With Conscience & Effect
Co-worker and Libertarian Ian Woofenden suggested another reason for voting for purer third-party candidates instead of the lesser of two evils. He firmly believes that our votes should be counted for what we believe in, rather than acquiescing to marginal differences in candidates. “You continue to get an evil,” he says, “and you don’t let anyone know what you really want or stand for.” This is a good point for sure, and one I agree with. Ian and I also agree that results are just as important as standing on principle. Something needs to change, and the sooner the better for the health of our planet. Nader does have a very slim chance of being elected this time around, but the possibility of strengthening him now for the 2004 election is what finalized my decision to support him.

Get Back the Non-Voters
The Nader campaign does not target Gore voters specifically, but is aimed at those who otherwise would not have voted. They intend to target a “get-out-the-vote” campaign at disenfranchised citizens who have given up voting because they think their voices have not been heard. The Nader campaigners hope for a response from these folks because they say their candidate is different—not a part of the group of politicians representing business as usual.

Once formerly disenfranchised voters start coming on board, it should show up pretty obviously in the polls. If, as a result, the polls and the media show that support for Nader is increasing significantly, many more voters will be willing to jump the Bush/Gore Republocrat ship for the clean candidate.

There was actually a surprising head start for Nader in the polls. A Fox News-Opinion Dynamics poll taken about a week before this writing showed that he had already received 8 percent nationally, and various state polls showed between 7 and 11 percent in their respective states.

But Nader is not assured to be on the ballot in every state—that is the campaign’s current push. According to Nader campaign literature, “The real battle for the hearts, minds, and votes of the American people will be waged locally.” That means that Nader must make the ballot in each state in order to garner the strength for a grassroots campaign.



The more states with Nader on the ballot, the more credible his candidacy appears to the media. The more credible the candidate, the more likely he will be able to participate in the debates, as Perot did during the last election. If Nader can get into the debates, the American public will have their eyes opened to the real political problems, and to the best candidate.

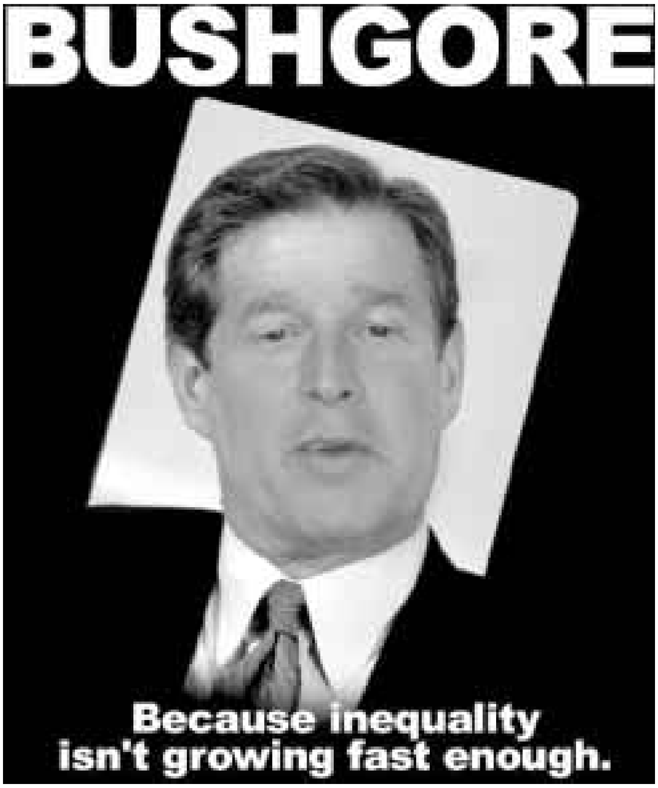
Solid Choice
I have decided to vote for Ralph Nader this time around. And I fully intend to send his campaign a check to help them sway disenfranchised voters to vote again. Nader is the right person for the job. He has proven over and over that he will watch out for non-corporate and non-Republocrat needs. And, unlike the last presidential election, Nader plans to actively and persistently run for President, rather than being a passive, reluctant Green Party draftee.

Ralph Nader is the only candidate who seems to understand the importance of RE. Combining that with his knowledge and wariness of corporate control makes him a natural to lead us toward a decentralized renewable energy future.

And even if voting for Nader gets Bush elected, I tend to agree with environmental leader David Brower of Earth Island Institute. He said, “It’s better to have a president who you know is an enemy than to have a president who you think is a friend and is not.”

Campaign Humor
There seem to be more and more organizations around using humor to make political points. It is refreshing to see the humor of the situation. Leaving behind the doom and gloom can be empowering. Check out the Web site “Billionaires for Bush (or Gore)”—www.billionairesforbushorgore.com. This is a satirical organization set up by United for a Fair Economy that pokes fun at big money’s corruption of our political process.

The Web site promoted two “Million Billionaire Marches” during the two Republocrat conventions last summer. These were spoofs of the Million Man & Million Mom marches that recently took place in D.C. Other humor on the site includes the Bush/Gore candidate comparison, in which both candidates look the same with check marks all the way down the comparison columns except in the categories “Republican” and “Democrat.”



Al Bush...or George Gore?

There is also a spot called "66 Smart Billionaires," which lists corporations that have donated at least US$50,000 to both Bush and Gore. That's right, both! When it comes right down to it, these companies do not care who gets elected, as long as they can get access when they need it.

This brings me to my favorite sad-but-true section of the Web site, which is called "Return on Investment." It states, "Attention Billionaires: If you're like most of us, you're always looking for higher returns on your investments. And while you may be familiar with stocks and bonds, currency speculation, IPOs, and all the rest, there's a new investment arena you really ought to be aware of: legislation."

It goes on to list several corporate campaign contributions and the resulting return on investment. The list starts with GlaxoWellcome, a huge international pharmaceutical firm that invested US$1.2 million in campaign contributions. In return, they received a legislated 19 month patent extension on Zantac, one of their products. This resulted in a US$1 billion payoff, or an 83,333 percent return on investment. Enough said.

More funny campaign stuff came across my desk in the form of a forwarded email. Filmmaker and comedian Michael Moore has decided to support the Nader campaign for the same reasons I have. But he takes it a couple of steps further. In his email titled, "Bush and Gore Make Me Wanna Ralph," he says the Democrats should be sending campaign contributions to Nader.

Why? Because when all those former voters hit the polls to vote for Nader, they will also be voting for Congressional candidates. They will most likely vote for Democratic candidates, which could restore the Democratic majority. Then he says, "Or, better yet, let's try to elect enough Greens to Congress—a dozen or so—and they'll hold the deciding votes because neither the Democrats nor the Republicans will have the majority. It'll be a friggin' Knesset!"

The guy is too much. Check out his Web sites listed below, and sign up for his email newsletter, *The Awful Truth.* And don't forget to send your campaign contribution to Ralph Nader. He is also going to need a ton of volunteer help to get his message out. To find out how to help Nader in your state, go to www.votenader.org/state/index.html, where you will find access info for Green Party organizations near you. If you don't have access to the Web, just give me a call, and I'll get that info for you.

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Don Loweburg

Y2K Again?

Are Y2K fears coming true? Well, not exactly, but lately we are getting Y2K in time-release doses. I'm referring to the eroding reliability of utility service in many parts of the country. Here on the west coast, power warnings go out every time we have a heat wave. Citizens are told to curtail electric consumption (sweating is good for you). In spite of voluntary reductions in consumption, utility customers are experiencing rolling blackouts.

I've read of similar events on the east coast too. Remember the promises we heard when the utility industry started going through restructuring in the late 1990s? Electric prices were supposed to go down! The exact opposite has occurred. In southern California, there are reports of electric bills doubling. One friend called to inform me that his electric bill had gone from $11 to $55.

Meanwhile, utility profits soar. A July 28, 2000 *San Diego Union-Tribune* headline read, "Sempra profits soar 34 percent in 2nd quarter." Sempra is the holding company that owns San Diego Gas and Electric. The situation is rudely ironic. Utilities scared voters into dumping California Proposition 9 with warnings of blackouts and high power bills. Prop 9 was a ballot initiative that would have rolled back the utility bailout part of California's electric restructuring law. The proposition failed, but we are having outages and escalating power bills anyway.

In my last column, I referred to a *San Francisco Chronicle* story on distributed generation (DG). The story reported that Secretary of Energy Bill Richardson felt that "utilities are hindering the use of small generators such as fuel cells, small-gas turbines, and solar cells that allow consumers to produce their own electricity." Richardson also went a step further, stating that blackouts "could otherwise be avoided if the barriers to distributed generation were removed."

Read the Full Story

The DOE study that prompted these statements is now available to the public (see *Access).* It is titled *Making Connections: Case Studies of Interconnection Barriers and their Impacts on Distributed Power Projects.* The study reiterates many of the points made in this column during the last few years regarding DG and utility practices that stifle DG interconnection. Twenty-six detailed case histories form the gist of the study. Of a total of sixty-five distributed generation projects surveyed, only seven experienced no problems.

The case histories stretch the imagination as to what the regulated and non-regulated utilities get away with. In five cases, utility obstruction resulted in projects being abandoned. In two other cases, the customers chose to disconnect completely from the utility, going off-grid rather than suffer further utility abuse. The authors also cite several occurrences of "pirate" or unauthorized interconnection.

Some Possible Remedies

The study, in addition to providing documented case histories of utility abuse, presents a list of findings and a "Ten Point Action Plan." *Home Power* readers will be familiar with many of the findings and recommended actions. Point number 10 of the action plan bears special mention. The authors refer to "a right to interconnect."

This is probably the most fundamental element in a fully functional distributed generation system. But this right does not exist now. Every customer-generator must deal from scratch with their particular utility. When compared to our transportation and communications systems, the present system of utility fiefdoms—each with its own policy and rules—is archaic. This structure itself is a major barrier to DG.

Computer Software for PV

I recently came across two software programs that may interest PV professionals and users. The first is called

WinVerter, and is published by RightHand Engineering. This software works in conjunction with the Trace communications adapter that is sold as an option for the SW and PS inverters. You must have the communication adapter to use this software.

The communications adapter allows SW and PS inverters to be remotely programmed with a laptop or other PC. WinVerter is a Windows-based program that replaces the DOS software shipped with the adapter. WinVerter provides a single screen on which all the inverter setup parameters are displayed simultaneously. I find it helpful to see all of the settings at once. To change a parameter or setting, you click on the appropriate box and enter the new value. When all the parameters have been entered, the changes are “written” to the inverter.

One very nice feature of WinVerter is that each setup can be named and saved as a file. This should make it much easier to recover from accidental loss of programming if the inverter’s DC power source is turned off. This feature should be especially attractive to dealers who support numerous Trace SW and PS series inverters in the field. Randy Richmond, author of WinVerter, plans to introduce other products, including remote inverter programming over a phone-modem connection, and a logging program to record metered values over time. WinVerter is reasonably priced, looks good, and is easy to use.

The second program, Solar Design Studio V4, by Maui Solar Software, consists of a suite of programs written for the Windows operating system. The suite includes PV DesignPro for stand-alone, grid-connected, and water pumping systems. Also included on the CD is a program for active thermal system design, and an IV Curve Tracer (characterizes PV module performance), plus U.S. and global weather data.

The IV Curve Tracer represents the latest modeling of PV performance based on extensive field testing at Sandia Labs by David King and his colleagues. PV DesignPro uses the Sandia model as the heart of the design algorithm. The Sandia model not only incorporates the latest mathematics, but also includes significant adjustments based on empirical values derived from field testing. By using the IV Curve Tracer, you can quickly analyze module performance under a wide variety of conditions.

One of the most significant benefits of the program is that it more correctly characterizes cell temperature based on ambient air temperature, wind speed, and insolation (the amount of sunlight). The manufacturers’ practice of basing a module’s power output rating using a 20°C (68°F) cell temperature (room temperature) verges on fraudulent. This remains the practice of module manufacturers, though systems are now beginning to be rated at normal operating cell temperature.

The difference between the methods is enormous. For example, using the IV Tracer program and entering an air temperature of 20°C results in a cell temperature of 50°C (122°F) with the module in full sun. At this cell temperature, the module produces only 80 percent of rated power. If one wished to obtain full manufacturer’s rated power, the ambient air temperature would need to be -9°C (16°F).

User Friendly

Using PV DesignPro is very easy. The program uses a graphical interface. System characterization is achieved by entering data in a sequence of windows. For example, click on an array icon and an array data window opens with entry boxes for module type, number of modules, etc. Then click on the next icon, opening the battery sizing window. Once all data entry is complete, the “calculate” icon is clicked, and after a few seconds the results are displayed. Since most of the displays are graphical, it’s easy to understand the results.

You can review the fraction of energy delivered on a monthly or yearly basis, or view the results on a daily basis. Ease of use and elegant graphical displays make this program satisfying and fun to use. Most of the outputs can be printed, providing very high quality documentation and presentation support if required.

I have used pencil and paper for years to size systems, and have developed a few empirical fudge factors that seem to work. As a check on my methods and the program, I ran the numbers from a few of my own successful systems through the program. The results from the program generally represented the real world systems and how they performed.

Besides being a very good design tool for the professional, DesignPro is also a great learning tool. “What if” scenarios can be set up and quickly run, providing invaluable lessons. For more information, contact Michael Pelosi at Maui Solar Software. Let him know you read about the program in *Home Power.* One caution: DesignPro is a very computation-intensive program. It makes hourly computations over a one year period—that’s over 8,700 complex computations. A fast, capable computer is required.

Photovoltaic Distributed Power Coalition

The California Public Utilities Commission is holding hearings (Order Instituting Rulemaking, OIR 99-10-025) about regulation changes for distributed generation.

The Photovoltaic Distributed Power Coalition (IPP, CalSEIA, Powerlight, AstroPower, Green Mountain Energy, and BP Solarex) represents the interests of the PV industry, and has presented testimony to the commission.

Phase I and Phase II testimony is now complete. The purpose of the testimony is to have the commission adopt regulatory policy favorable to the PV industry, PV system integrators, and PV system users. I've stated the goals of the coalition here in general terms in previous columns. Now that the testimony is public record, it is possible to detail the specific recommendations. The following five points are excerpted from the Phase II testimony of Tom Starrs on behalf of the coalition. Starrs is an RE advocate and attorney based in Washington state who helped formulate many of the net metering laws being implemented across the country.

- "Eliminate standby charges for on-site solar electric facilities up to 1 MW peak generating capacity." Customer-generators would not be charged any additional fees. No net metering would be required by utilities for excess capacity, but customer-generators might negotiate a power sales contract with an energy service provider.
- "Preserve existing usage-based rates that allow customers to use electricity generated on site to supply their own loads and therefore to offset bundled retail prices, including distribution charges and other restructuring-related charges, unless and until there is concrete evidence of net economic losses significantly affecting utility profitability or utility rates." Utilities are proposing to shift from the current usage-based rates to fixed rates. Fixed rates will reduce the value and economic incentives for on-site solar.
- "Consider the adoption of performance-based ratemaking approaches that make the utility indifferent to the amount of energy "throughput" on its system, such as revenue-cap regulation." This eliminates the utilities' incentive to discourage customer self-generation.
- "Consider the adoption of financial incentives, in the form of geographically de-averaged buyback rates, to reward the installation and operation of on-site solar applications in designated areas with high distribution costs." The installation of on-site solar generation in distribution impacted areas may eliminate the need for substation upgrades or distribution system expansion by the utility. Reward these "distribution benefits."
- "Develop appropriate schedules for distribution wheeling that fairly balance the interests of utilities and developers of on-site solar applications." Rates to wheel solar-generated power to other customers should reflect the incremental or actual cost to the utility when transporting excess solar energy from the generation site to a second customer's site within the same distribution system. (Wheeling is the transport of independently generated electricity to customers using utility owned wires.)

Readers interested in an electronic copy of the full testimony should contact IPP. Thanks to those who have supported this very important project. And, of course, there continues to be a great need for financial support. Checks should be made payable to IPP.

$$$$$

Financing PV systems has been a problem for years. Based on my experience to date, most residential PV customers still pay cash. There is some good news, though. Thanks to the hard work and persistence of Keith Rutledge at the Renewable Energy Development Institute (REDI), one company in northern California has been making solar loans now for over a year.

Terry Phenicie heads Valley Financial in Ukiah, California. Last year, one of my customers obtained financing through the company for an off-grid straw bale home with PV. I called Terry to get more information. Valley has set up a very streamlined process for qualifying loan applications. One option is a single page application, available to PV contractors.

When meeting with a serious customer who needs financing, the application can be made on the spot. Valley Financial promises a 48 hour turnaround. A second option is to make the loan application online at Valley's Web site. Valley Financial writes loans for projects throughout the country, not just in California.

Leaders & Followers

During the last ten years, I have repeatedly gone to local banks and lenders searching for financing. The loan officers were generally attentive and, in principle, supportive. However they always took the position that because there were no off-grid PV homes already financed in their local area, they would not risk making such a loan.

I've come to the conclusion that the financial community is made up of mostly followers. Valley Financial stands out, and should be rewarded for their leadership in PV financing. I suspect that by this time next year, many of the followers will wake up and see the opportunity. I prefer to work with companies like Valley Financial—companies with enough vision to take a risk and not be bound to the herd.

Access

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Making Connections: Case Studies of Interconnection Barriers and their Impacts on Distributed Power Projects, Available electronically at www.doe.gov/bridge • Paper copy for sale, U.S. Department of Commerce, NTIS, 5285 Port Royal Road, Springfield, VA 22161 • 800-553-6847 or 703-605-6000 • Fax: 703-605-6900 • orders@ntis.fedworld.gov
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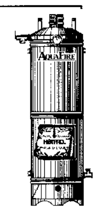

PV Modules, Conductors, & the Code

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center
Sandia National Laboratories

Photovoltaic (PV) modules produce electrical energy when exposed to light and connected to a load. Determining the necessary conductors to move this energy from the module to the load is frequently a confusing task.

I'll start by discussing the rating information listed on the back of the module, and how those ratings are determined. Next I'll cover the varying environmental conditions, and the requirements of the National Electrical Code *(NEC).* All of these factors will be used to establish the ampacity requirements of PV conductors.

Laboratory Ratings

PV modules are rated by the manufacturers in laboratories or on the assembly line under a set of test conditions called "standard test conditions" (STC). These conditions are: an irradiance of 1,000 watts per square meter (W/m^2), a PV cell temperature of 25°C (77°F), and some other less important (for our purposes) factors.

The actual measurements are made using a solar simulator that can produce a light of the correct intensity and spectrum. The room or test chamber is maintained at 25°C (77°F) to keep the module cells at this temperature. The duration of the light exposure is so short that there is no appreciable heating of the cells in the module. While the light is on, a specialized tester called an IV curve tester measures the open-circuit voltage, the short-circuit current, and the peak-power-point operating voltage and current. The tester can also record data for the complete current vs. voltage curve (IV curve) for the module.

Some manufacturers label each module with the test results of that particular module, while others print the average values for that model. Each manufacturer guarantees the power output of the modules in slightly different ways. In addition to the numbers mentioned above, the module label will also contain the maximum power output rating (at STC), the maximum open-circuit voltage (usually 600 volts or less), the maximum series fuse (to protect the module), and the National Fire Protection Association (NFPA) fire rating. The fire rating is used with local building codes when the PV module is to be mounted on a roof.

Field Operating Conditions

When PV modules are installed, they are no longer in benign, indoor laboratory conditions. They are exposed to long-duration sunlight, ambient air temperatures, winds, and other environmental conditions.

Ambient air temperatures in the United States may reach 50°C (122°F) in some locations, and can be lower than -40°C (-40°F) in other locations. The modules may be mounted where they are not exposed to cooling breezes, causing them to operate at higher temperatures. In other situations, the modules may be on open racks exposed to high steady winds, which can keep their operating temperatures at or very near ambient temperatures.

When sunlight falls on a module, the module is heated. The temperature rise of the module cells and the module junction box depends on the intensity of the sunlight and the amount of cooling the module experiences, either through natural convection and radiation or from cooling breezes. Modules may be exposed to sunlight that can range in intensity from 0 W/m^2 (night) to values as high as 1,500 W/m^2 under cloud-enhancement conditions. A sunlight intensity of 1,000 W/m^2 (the average over the surface of the earth at sea level) just happens to be the value used for rating modules. In many locations throughout the USA, the sunlight peaks at 1,100–1,200 W/m^2 for several hours each day.

With high winds, modules may operate in bright sunlight at the local ambient air temperature, which can be very cold in some locations. In other installations, high ambient air temperatures and no cooling winds can lead to very high operating temperatures for the modules.

Module manufacturers sometimes publish a "normal operating cell temperature" (NOCT) for their modules, which is measured with an irradiance of 850 or 1,000 W/m^2, an ambient temperature of 20°C (68°F), and a windspeed of 1 m/s (2.24 mph). The NOCT for crystalline silicon modules is in the 44–48°C (111–118°F) range. In the Southwest, with light or no wind, we typically see modules operating 25–35°C (77–95°F) above ambient air temperatures with module cell and junction box temperatures as high as 75°C (167°F)—considerably higher than the NOCT.

Crystalline PV modules lose power at about 0.5 percent per degree Celsius as their temperatures increase above the STC rating temperature of 25°C (77°F). With an NOCT of 47°C (117°F), the module is operating 22°C (72°F) above 25°C, and has lost 11 percent of its rated power. On hot summer days in many parts of the country, PV modules are frequently operating at 65°C (149°F), and have lost 20 percent of their rated power due to heating. The lost power is largely due to reductions in the peak-power operating voltage point of the module as temperatures increase. Further power losses may be experienced if the battery operating voltage pulls the module operating point off the already lowered peak-power point.

Module Operating Voltages

When a PV module operates at temperatures below 25°C (77°F) in low ambient air temperatures and/or high winds, the open-circuit voltage increases above the rated open-circuit voltage measured at 25°C. This varies slightly from manufacturer to manufacturer, and from crystalline silicon modules to thin-film technologies. The actual open-circuit voltage is the voltage that stresses the insulation on conductors and the insulation in circuit breakers, fuses, and switchgear. It also determines whether fuses and circuit breakers will function near the limits of their voltage ratings.

Since the module manufacturer and many installers do not know how low the temperatures may go in a particular installation, the instructions supplied with the module (as required by UL Standard 1703) currently state that the rated open-circuit voltage (Voc) of the module must be multiplied by 125 percent prior to determining the system operating voltage.

The *NEC* then requires that the system voltage be determined by multiplying the number of modules connected in series by this new open-circuit voltage (I call it the “design” voltage). This system voltage is then used to determine the voltage rating of conductors, switchgear, circuit breakers, and fuses. This ensures that under the worst case, cold temperature conditions, the PV array will not generate voltages that are in excess of the ratings of the components in the system.

A table was added to the 1999 *NEC* to acknowledge the fact that historical weather data may be used to determine the lowest temperature at many locations. A Web source for this data is referenced below. Instead of a straight multiplier of 125 percent, *NEC* Table 690-7 allows a variable, temperature-dependent multiplication factor to be used when the lowest temperature is above -40°C (-40°F).

These voltage correction factors are important in both high-voltage and low-voltage PV systems. In high-voltage systems, the older 125 percent (1.25) multiplication factor limited the rated open-circuit voltage to 480 volts DC. When multiplied by the 1.25 factor, this gave a system voltage of 600 volts—a significant limiting voltage in the code and on most modules. This represents about 22 PV modules (Voc of 21.8 volts) in series. Some high-voltage inverters really need 24 modules in series to function properly in high-temperature environments without added equipment. With a multiplication factor of say 1.10, 24 modules with a Voc of 22 volts could be connected in series and not exceed the 600 volt limit.

Voc Correction Factors for Temperature*

Lowest Ambient Temperature		
Centigrade	*Fahrenheit*	*Multiply Voc by:*
25 to 10°	77 to 50°	1.06
9 to 0°	49 to 32°	1.10
-1 to -10°	31 to 14°	1.13
-11 to -20°	13 to -4°	1.17
-21 to -40°	-5 to -40°	1.25

* From NEC Table 690-7

In low-voltage systems, many installers want to use the inexpensive Square D QO circuit breakers and load centers that are rated at 48 volts DC. In a nominal 24 volt system, using the 1.25 multiplier, the system voltage is about 55 volts (2 x 22 x 1.25 = 55), which exceeds the 48 volt rating of the circuit breaker. However, if it can be determined that ambient temperatures do not go below 0°C (32°F), Square D QO circuit breakers may be appropriate, since the system voltage would be 48 volts (2 x 22 x 1.10 = 48.4).

As the code mentions in Section 690-7, if you are using other than silicon-type PV modules (such as some of the newest thin-film modules), the manufacturer should be consulted for information on the maximum expected open-circuit voltages at the lowest temperatures in your location.

Eventually, the Underwriters Laboratories (UL) Standard 1703 will be revised to clarify the calculation of maximum voltage, and Section 690-7 of the *NEC* will establish and articulate the requirement. In the meantime, a good rule would to be ignore the 125 percent requirement in the instructions supplied with modules (based on UL 1703), and just apply Section 690 and Table 690 in the 1999 *NEC.* If the minimum temperature is unknown, a 125 percent multiplying factor should be used as shown in Table 690-7 for temperatures below -40°F (-40°C).

Module Operating Currents

Module currents are nearly a linear function of the intensity of the sunlight. The current does increase very slightly as temperature increases. But the voltage drop as temperature increases is much greater, and hence the module power decreases as temperature increases. The module is rated at STC with a short-circuit current and a peak-power current.

Since we want the PV modules to deliver power under all sunlight conditions, the current the wiring must handle must be carefully considered. In normal daily operation, the sunlight may be as high as 1,100–1,200 W/m^2 for several hours around solar noon. This is up to 120 percent of the 1,000 W/m^2 used to rate the modules at STC.

In some instances, clouds may gather so that reflections from the vertical cloud surfaces concentrate the sunlight on the module with irradiance values up to 1,500 W/m^2. This results in correspondingly high values of power and output. These cloud-enhancement conditions are not static, and rarely last more than a few minutes. So we need not worry about steady-state currents at these levels.

Another factor to consider is that some shunt-type PV charge controllers short circuit the PV module to control the battery charging process. That means that we want the module conductors and overcurrent devices to be able to handle the rated short-circuit current, and any normal currents that are above that value on a regular basis. Based on 30+ years of experience with terrestrial PV systems, the PV industry selected a factor of 125 percent for increasing the rated (at STC) module short-circuit current to determine a "design" current that would account for the higher current conditions. This design current is used to size the conductors and to determine the rating of overcurrent devices.

With a conductor ampacity of 125 percent of the STC-rated short-circuit current, the conductors are assured of being able to handle the normal and expected daily currents without overheating. Fuses and circuit breakers sized at this 125 percent value will not trip in normal operation. These overcurrent devices will, however, protect the module and array conductors from high fault currents originating from the batteries, parallel connected PV modules, or grid backfeed through utility-interactive inverters.

Of course, there may be some very unusual conditions where the ambient temperatures are very cold, the winds are high, there is reflective snow or water at just the right angle, or the clouds form a lens. In these very rare conditions, the overcurrent devices may trip. But the *NEC* and UL do not require us to overdesign for these conditions, just for those conditions that can be expected periodically in most systems.

We have now determined the normal, expected daily current output of a PV module. This multiplication of 125 percent will be found in both the UL-required instructions for the modules and in the 1999 *NEC* in Section 690-8,9. Again, UL Standard 1703 will be modified to clarify the current multiplier in the module instructions, and the 125 percent requirement for current correction will appear only in the code. Installers should not use both of these particular 125 percent factors, only one.

Note that the *NEC* has requirements established not only in Article 690, but in Article 240 and elsewhere throughout the code that prohibit overcurrent devices and conductors from being operated at more than 80 percent of rating. For example, a 15 amp AC branch circuit protected by a 15 amp circuit breaker may be loaded to no more than 12 amps (80 percent of 15) on a continuous basis. If we had a vacuum cleaner drawing 12 amps, it would have to be connected to a circuit rated for at least 15 amps (125% of 12 is 15). This 80 percent safety factor requirement is related to the long-term durability of components in tight, hot environments like load centers.

Conductor Ampacity Requirements

A second 125 percent multiplier (the reciprocal of the *NEC* 80 percent safety factor of 1/1.25 = 0.80) is used to determine the design current for the module. In the module and array wiring for PV systems, we must use both of the 125 percent factors (increased sunlight and 80 percent limit) to determine the ampacity of the conductors and the rating of the overcurrent devices. The combination of the two factors of 125 percent yields an overall multiplier of 156 percent (1.25 x 1.25 = 1.56).

The array wiring and overcurrent device calculations are based on the number of modules or strings of modules that are connected in parallel. A few circuit breakers are listed for operation at 100 percent of rating (consequently, one of the 125 percent factors is not required for these breakers). But these devices are usually only found in factory-assembled and listed components.

Summary

We now have a starting point for determining the ratings for PV array conductors and overcurrent devices. The voltage rating for conductors and overcurrent devices is based on a temperature-dependent factor from Table 690-7 of the *NEC.* This is used to multiply the STC-rated open-circuit voltage marked on the back of the crystalline silicon module. Thin-film module manufacturers provide this information in the module instructions. This module design voltage is then multiplied by the number of modules that are connected in series to determine the system voltage. All conductors and overcurrent devices should have a voltage rating at least this high.

The module rated short-circuit current (at STC) gives us a starting point for determining the required ampacity for conductors and overcurrent device ratings. First, we multiply the rated short-circuit current by 125 percent to allow for the normal expected daily variations in the current produced by the modules. Then, to meet the *NEC* requirements for not operating conductors or overcurrent devices at more than 80 percent of rating, the first product of 125 percent times the short-circuit current is again multiplied by a second 125 percent. The product of the two (125% x 125%) is 156 percent. This design current is the number used for overcurrent device ratings and the ampacity of conductors.

In the next *Code Corner,* I will present some examples of module and array wiring and overcurrent protection.

Questions or Comments?
If you have questions about the *NEC* or the implementation of PV systems following 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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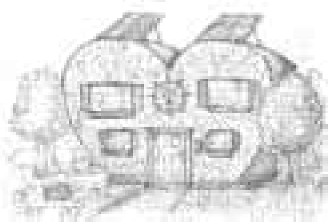
National Renewable Energy Laboratory solar radiation and weather database: http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum^2

Home & Heart



Kathleen Jarschke-Schultze

Not everyone who uses renewable energy lives in the boondocks. Every year, more people opt for grid-intertie systems. This column is not for them. It is for the families that are far from the nearest town, down the dirt road a ways.

Country Living

The least expensive land is usually beyond the grid. Solitude and space are out there. When your closest neighbor is a quarter mile or more away, you usually become good friends. If you can't see another house from your own, the view is always beautiful. The problem comes when the local authorities can't figure out why the heck anyone would go live way out there. Their usual conclusion is that if you aren't retired, you must be doing something illegal.

Over My Head

When I first came to live with Bob-O in the mountains, I had my first taste of *law vs. boondocker* discrimination. Every autumn, the local sheriff's office, in conjunction with the U.S. Forest Service, would fly the CAMP (Campaign Against Marijuana Planting) helicopter over the mountains and drainages looking for illegal plantations. In theory, that's okay. What is not okay is when that authority is overstepped, and the helicopter flies directly over dwellings at less than 500 feet, becoming illegal itself.

When this first happened to me, I really didn't understand why the helicopter seemed so interested in our cabin. I told my friend Sarah about it and she explained who they were and their excuse for being there. She also advised me, "Don't moon them, they'll just come back for a closer look."

Night Flight

Another friend was wakened in the wee hours of the morning by a cabin-shaking "thwock, thwock, thwock." She immediately recognized it as a helicopter. However, having one of the few meadows of flat land in the mountains, she thought it must be a medical emergency helicopter looking for a safe landing area.

She threw on a minimum of clothes and ran outside to turn on her truck headlights to help the pilot see to land. She figured that if the helicopter was flying at night, it must be a catastrophic emergency. To her immense relief followed by righteous rage, it turned out to be the C.A.M.P. helicopter hovering so close to her cabin that the windows rattled.

That night the helicopter buzzed quite a few local homes. Complaints were lodged. When the matter was investigated by the authorities, they admitted that the helicopter had flown that night. But they could find no record or log of who the crew was or who had authorized the night flight. The investigation of the whole episode was dropped.

Got Law?

Several years later, the helicopter used by CAMP was painted flat black, with no markings or identifying numbers on it. It came up one drainage and circled a home below the 500 foot legal limit. It then proceeded up the canyon to the next home and circled there, again below the limit. The first neighbor watched it circle the second home after it left his. The second homeowner called the local gendarmes while the helicopter circled.

He was first told that it wasn't their helicopter. He then got angry enough to make a big mistake. He verbally threatened the helicopter to the officer on the phone. After about ten minutes, the helicopter quit circling that home and could be seen continuing up the canyon circling the other homes there.

Six months later, sheriff's deputies arrived at the second home in bulletproof vests to handcuff and arrest the homeowner. The charge was "terrorist threats." The bail was $5,000. This guy was such a threat that it was half a year after the offense that the officials got around to arresting him. All that time there was a warrant out for his arrest, but he had no knowledge of it. He could have been arrested at any time, anywhere, without warning. They didn't even know what he did for a living. Some investigation. Some threat.

So began a series of appearances in court. First he had to appear to say he would hire his own lawyer. Then he had to appear, to hire that lawyer. In his next appearance, the D.A. had the charge lowered to "annoying phone call" (because "terrorist threats" would be very difficult to prove at this late date). He also had witnesses willing to testify on his behalf that the helicopter was too low. After four appearances in court, the defendant asked for his bail money back. He had lived in the county most of his life, worked there, and owned his own home.

The judge would return his bail money only if he opened his person, his vehicle, and his home to search at any time without probable cause. This was unacceptable to the defendant. The judge disregarded the fact that the whole incident took place because the defendant felt the helicopter crew overstepped their authority and violated his legal rights in the first place.

The upshot was that the defendant was offered a “court diversion.” After a year of not having any run-ins with the law (he had never had any before), the homeowner was granted an “unconditional dismissal” of the charges. After the court diversion was offered to and accepted by the defendant, the $5,000 was returned to his wife, who had bailed him out.

When asked about the the incident, the officer in the helicopter denied flying over the house, and said he flew off to the side of the house over a “suspected marijuana site.” This turned out to be the water run-off of a buried spring box, out in a meadow with no trees or brush around it. The runoff had caused the plant growth around the drain pipe to be green on an otherwise dry, yellow hillside.

What You Can Do

If this happens to you, grab a camera and walk far enough from your house to be able to get the helicopter and the house in the same picture. Also take pictures of just the helicopter. Zoom in with your camera to identify the helicopter and its occupants.

Record the date, time, and length of the incident. Do not call the authorities. Call your neighbors instead and ask them to take pictures and watch the progress of the helicopter, if possible. Will this get it stopped? No, but it’s best to be prepared if you decide to pursue the matter.

You could also contact the Civil Liberties Monitoring Project. This California organization keeps a record of helicopter abuses under the guise of law enforcement. While they focus on a three-county area in our neighborhood, they are very aware of the issues and may be able to refer you to other organizations.

This could just be a western phenomenon. I don’t know. Most remote home dwellers in the West have a helicopter story. The main thing is to remain calm and clear headed. Get pictorial evidence of the incident, date, times, etc. Seek legal advice if you are going to pursue it. As a friend once told Bob-O, “Don’t ever expect justice from the American justice system; the best you can hope for is an even-handed application of law.” And remember, don’t moon them.

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Reviewed by Michael Welch

R*eNew,* the fantastic quarterly magazine from Australia, has a lot in common with *Home Power*. It covers many of the same subject areas, with a "down under" bent, and with a little more emphasis on the non-energy aspects of sustainable living. The new CD of their back issues gets a solid thumbs up from me.

The early incarnation of *ReNew* was called *Soft Technology,* and was first published in 1980. The CD-ROM contains the complete first forty issues of the magazine in Adobe Acrobat format. There is an incredible amount of excellent information here. I've spent many hours perusing the CD, and still have barely scratched the surface. The CD and magazine are produced by Alternative Technology Association (ATA), a non-profit community organization that has used and promoted sustainable technologies since 1975. They've got their stuff together.

For an example of the caliber and level of technical information included, here is the CD's index listing for "Micro Hydro":

A homemade waterwheel 13-7
A low technology reaction water turbine 24-6
Cross-flow turbine design. 35-33, 37-16
Flood damage to small water turbines 32/33-48
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As you can see, the index is very tantalizing. I can assure you that the rest of the index entries and articles are just as good. The numbers after each index entry refer to the issue and page numbers of the article.

The CD is pretty much limited in scope to the back issues of the magazine—no extra lectures, video clips, data, etc. There is some background info on ATA and its programs, along with membership info, *ReNew* subscription info, contributors' guidelines, and advertising rates.

There is one drawback to the CD that deserves only minor mention (hey, nobody's perfect). There is no cross-document search capability. This is because the early years of the magazine were not available digitally, and therefore were scanned instead of being distilled from the original electronic page layouts. But the index appears complete and well thought out. The CD contains the freeware Acrobat Reader to view all the magazines on the disk.

I highly recommend this great resource. ATA promises a second edition late this year or early next year that will cover issue 41 and onwards. I can hardly wait.

Access

Reviewer: Michael Welch, c/o Redwood Alliance,
PO Box 293, Arcata, CA 95518 • 707-822-7884
michael.welch@homepower.com
www.igc.org/redwood

Soft ROM, A$39 (drawn on an Australian bank) postpaid from Alternative Technology Association, National Office, PO Box 2001, Lygon St. North, Brunswick East VIC 3057 Australia • +61 3 9388 9311
Fax: +61 3 9388 9322 • ata@ata.org.au
www.ata.org.au

ReNew subscriptions cost A$22 per year. Overseas subscriptions cost A$27 in NZ and PNG, A$35 elsewhere.

HAPPENINGS

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

CANADA
Oct. 15–18 '00. International EV Symposium: exhibition & drive. Race an EV on a Formula One track. EVS-17 650-365-2802 • Fax: 650-365-2687 ElectricEVent17@aol.com

Oct. 21–24, '00. Halifax, Nova Scotia. Rise and Shine 2000, Canada's 26th National Solar Energy Conference. Keith Robertson • 902-422-1557 www.chebucto.ns.ca/Technology/RS2000

Alberta Sustainable House: open house 3rd & 4th Saturdays, 1–4 PM. Cold-climate features/products regarding 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

CHINA
Nov. 23–26, '00. Beijing. Intl. Development & RE Conference. Info: CERE 2000 Secretariat, Yong ZHANG, No. 1 Sandaokie, Jianguomenwai, Beijing 100022, P.R. China
86-10-65157760
Fax: 86-10-65158442
cisc@midwest.com.cn
www.ciscexpo.orgcn.net

NICARAGUA
January 2001. Short course on solar energy in Nicaragua. An opportunity to offer your hands, heart, and a unique gift: Electricity! Introduction to PV for developing countries, course offers a combination of lectures, field experience, & tourism. In English, by Richard Komp & Susan Kinne. US$850, plus airfare. Barbara Atkinson, 215-942-0184 • lightstream@igc.org

NATIONAL U.S.
Pollution Prevention Video Series. Appalachia Science in the Public Interest offers 42 videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar Powered 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 & offers "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: recommended design practices, PV safety, balance-of-system 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: 202-9326-2502 • www.ftc.gov

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

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

ARIZONA
Glendale & Scottsdale, AZ. Living with the Sun: lecture series by AZ Solar Energy Assoc. How to save money & the environment. 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 Tuesday of every month at Scottsdale Redevelopment & Urban Design Studio. Jim Miller • 480-592-5416

Tax credits for solar in AZ. A technician certified by the AZ Department of Commerce must be on the job site. ARI SEIA 602-258-3422

ARKANSAS

Mt. Ida, AR. Sun Life Construction by Design: Seminars 3rd Sunday of each month on our passive solar earth-sheltered project. Hands-on seminars incl. ferro-cement, building dwellings for minimal materials expense. US$40 per day (includes construction manual). Loren Impson, 71 Holistic Hollow, Mt. Ida, AR 71957 • 870-867-4777 loren@ipa.net • www.Sun4Life.com

CALIFORNIA

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

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

Hopland, CA. Workshops through Oct. on RE, straw bale, ecological design, & sustainable living. Institute for Solar Living, PO Box 836, Hopland, CA 95449 • 707-744-2017 • isl@rgisl.org www.solarliving.org

COLORADO

Carbondale, CO. Solar Energy International: 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. Experienced instructors & industry reps. For owner-builders, industry technicians, business owners, career seekers, & international development workers. US$500/week. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 sei@solarenergy.org www.solarenergy.org

ILLINOIS

Oct. 14, ‘00. Macomb, IL. Alternative Resources For A Healthy Environment Expo 2000. Western Illinois University campus. Soy, cotton, kenaf, amaranth, & hemp products. Solar cars, solar ovens, bluegrass/folk music. 9–4 PM, US$2. Sponsored by Save Our Land & Environment, 309-837-3150 Fax: 309-833-1176 http://homepages.go.com/~earthprotect

IOWA

Prariewoods & Cedar Rapids, IA. Iowa Renewable Energy Association meets 2nd Sat. every month at 9 AM. All welcome. Call for schedule changes. IRENEW, PO Box 466, North Liberty, IA 52317 • 319-875-8772 irenew@irenew.org • www.irenew.org

KENTUCKY

Oct. 21, ‘00. Mt Vernon, KY. Solar Tour Day: Appalachia—Science in the Public Interest. Solar cookers, dryers, fans, space heating, water heating, automobile, greenhouses, PV systems, & more. ASPI, 50 Lair St., Mt Vernon, KY 40456 • 606-256-0077 aspi@kih.net • www.kih.net/aspi

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

MASSACHUSETTS

Greenfield Energy Park needs help preserving 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

MICHIGAN

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

MONTANA

Whitehall, MT. Sage Mountain Center: seminars & workshops, one day, 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 MEXICO

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

NEW YORK

Oct. 15–19, ‘00. Bioenergy 2000—Moving Technology into the Marketplace: the 9th Biennial Bioenergy Conference. NRBF, 202-624-8464 nrbp@sso.org

NORTH CAROLINA

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

OHIO

Perrysville, OH. RE Classes: 2nd Sat. of each month, 10–2 PM. Tech info, system design, NEC compliance, efficient appliances, hands-on straw bale post & beam building. US$70, or US$90 w/spouse, in advance. Solar Creations, 2189 SR 511 S., Perrysville, OH 44864 • 419-368-4252 www.bright.net/~solarcre

OREGON

John Day, OR. Oct. 21, ‘00. Spend an autumn morning finding out how to have warm windows for the whole winter, & all your winters! Help to install Window Quilts in the EORenew office. Ray Pokorny of Solar Interior Design will put up one quilt as a demo. Students will make & install the second quilt as hands-on training. 9 AM–noon. Tuition $25. SolWest/EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 solwest@highdesertnet.com

John Day, OR. EORenew Workshops. October 21, ‘00: Window Quilt Construction & Installation workshop ($25). Spring ‘01 (date TBD): Simple Solar Water Heater Installation (hands-on) by Anthony & Victoria Stoppiello. Mid-June ‘01: Hands-on installation, 1kW wind genny & 100-foot tilt-up tower, in a hybrid system at Morning Hill Forest Farm; followed by 1-day workshop, “Monitoring & Metering of RE Systems with Data logging.” Last week of July ‘01: SolWest pre-fair workshop, hands-on microhydro installation on hybrid system. EORenew, PO Box 485,

Canyon City, OR 97820 • 541-575-3633
info@solwest.org • www.solwest.org

TENNESSEE
Summertown, TN. Kids to the Country: a nature study program for at-risk urban Tennessee children. Sponsorships & volunteers welcome. 51 The Farm, Summertown, TN 38483
931-964-4391 • Fax: 931-964-4394
ktcfarm@usit.net

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

El Paso, TX. El Paso Solar Energy Association: meetings normally held 1st Thurs. of month. EPSEA, PO Box 26384, El Paso, TX 79926
915-772-solr • epsea@txses.org
www.epsea.org

Houston, TX. Houston Renewable Energy Group: meetings last Sunday of odd-numbered months at TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258
jferrill@ev1.net
www.txses.org/hreg/HREGhome.htm

WASHINGTON STATE
San Juan Islands, WA. SEI Workshops. Oct. 13–15, ‘00: Microhydro Power, US$250. Oct. 16–21, ‘00: Photovoltaic Design & Installation, US$500. Oct. 23–28, ‘00: Wind Power with Mick Sagrillo, US$500. Oct. 29, ‘00: Renewable Energy for the Northwest, US$75. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855
Fax: 970-963-8866
sei@solarenergy.org
www.solarenergy.org • Local contact: ian.woofenden@homepower.com

WISCONSIN
Amherst, WI. Midwest Renewable Energy Association (MREA) Workshops. See ad. Call for cost, locations, instructors, & further workshop descriptions. MREA membership & participation: all welcome. Significant others half price. MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166
Fax: 715-824-5399
mreainfo@wi-net.com

the Wizard speaks…

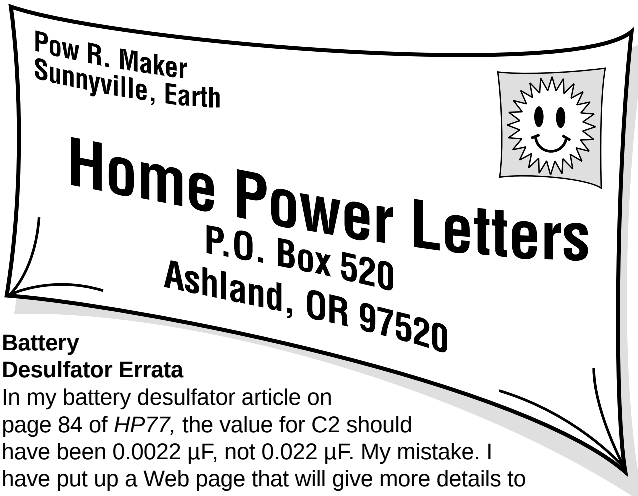
Methane Hydrates

Methane hydrates consist of molecules of methane gas trapped inside crystals of ice. They exist under the ocean bottom all over the world, and in permafrost in some locations. These hydrate deposits contain more than twice the carbon content of all the world's other fossil fuels combined. The natural release of methane from these hydrates may play a role in global warming. Methane is thirty times more powerful than carbon dioxide in its effect on global warming.

Massive and explosive releases of methane from methane hydrate deposits may have been responsible for rapid warming events in the past. As the supply of other fossil fuels becomes depleted, many will be tempted to try to mine these deposits. They will be more expensive than other carbon based sources, since they have to be specially mined.

Mining the deposits could lead to large releases of methane, and burning the methane would release more carbon into our atmosphere. This would increase the rate of global warming well above today's projections.

This potential addition to global warming makes it even more imperative to discontinue the use of fossil fuels as soon as possible. We need to replace them with renewable energy sources. This will help to stabilize global temperatures and help to prevent potential catastrophic climate change. This must be the wave of the now. We cannot wait for the future.



Battery Desulfator Errata
In my battery desulfator article on page 84 of *HP77,* the value for C2 should have been 0.0022 µF, not 0.022 µF. My mistake. I have put up a Web page that will give more details to help you build and use the desulfator circuit. I will place updates there, and will add a guestbook soon to allow comments and questions to be posted. I encourage a group effort in this, since I don't have all the answers. Thanks. Alastair Couper
kalepa@shaka.com
http://shaka.com/~kalepa/desulf.htm

Needed: Sustainable Homes in Illinois
Dear *Home Power,* Illinois Renew and ASES are teaming up for a better-than-ever tour of solar and sustainable homes this October 14th. We're only lacking one key ingredient: solar homes for the tour! If you have a home with significant sustainable design features and would be interested in having your home included in the tour, please contact me. We'd love to have you. Sincerely, Hans Detweiler • Hdetweiler@elpc.org • 312-795-3720

Needed: Real Energy Prices
The current outrage over skyrocketing electricity prices is understandable and forgivable. After all, prices in places like San Diego have doubled and tripled overnight (17¢ per KWH this week). But this should not lead to the reregulation of energy. Full deregulation and paying full market prices is essential for America's future as a competitive world player and responsible world citizen.

Unfortunately, this will not be simple or painless. As we have witnessed in industries in the former Soviet Union and water systems in England, deregulation of socialized industries is challenging and complex. Unless it is done carefully, it also places a high burden on those least able to pay for past mistakes. In England, for example, many water customers were found to be paying only 10 percent of the real cost (similar to some areas of the U.S.). When water bills suddenly began to increase rapidly, the impact on poor consumers was severe.

In San Diego those hardest hit by doubled energy bills have been the elderly on fixed incomes, where an additional $50–150 a month is critical. Institutions with limited flexibility in budgeting such as schools and universities are also hit hard. It is clear in San Diego that a special fund should have been established to protect the poorer "lifeline" and institutional customers for the next five to ten years. It was not their mistakes that led to their current predicament.

The historical root of this latest crisis has been our desire to have a free energy lunch. To simplify things a great deal, electric utilities in the past were given many subsidies and a fixed profit based on sales. This encouraged them to increase sales and power production, whether it made economic sense or not. If a builder oriented the lots in a subdivision so that most of the windows faced west, requiring a much bigger air conditioner for each house, this was a bonus to the utility company because it meant more power was needed.

This would enable them to justify more power production to the regulators, which led to increased sales and profits. It didn't matter to them, the utilities commissions, or the builder; but it did add thousands of dollars worth of unneeded generation capacity, expensive air conditioners, and a lifetime of air conditioning bills for the owner. These could often have been completely avoided for free by orienting the lots correctly, putting the windows in the right place, and providing proper overhangs on the windows to shade them in summer.

The utilities were never really asked to avoid environmental damage either. Our lust for more and more cheap power led to the damming and destruction of most of the rivers in the West, and air pollution and related ecosystem damage over millions of acres across the country. But "what the heck?"—electricity was cheap. The 1973 and 1979 energy crises revealed the flaws in the assumption that power would soon be too cheap to meter, but the lessons were not heeded for long.

Although the current shortages and price hikes have everyone fuming about the "greedy" utility companies, they should direct their anger at the builders who built their houses without consideration of solar orientation and natural cooling strategies. They also should be angry at their legislators and decision-makers who did little to encourage energy conservation in planning subdivision layout, house orientation and design, and commercial building design and construction. In the late 1970s, the California Energy Commission offered free advice to builders and developers to reduce energy demand and improve comfort (if true cost pricing was in place they would do it on their own).

Even earlier, I had helped the innovative design firm, Living Systems, develop climatically adapted local building codes. These were later voided by a state law that was much weaker and less effective for cooling. Since then, energy design skills and materials have gotten much better. For no increase in construction cost, it is often possible to reduce energy demand 50 percent. For an additional 10 percent increase in construction cost, it is often possible to reduce heating and cooling energy demand 90 percent.

This is nothing new. The Greeks built excellent solar homes and buildings 2,000 years ago, and even developed extensive solar developments in many cities, including Olynthus. Sadly, no one has been thinking about solar design or building energy efficient homes recently, because energy has been "cheap."

We are now thinking about these things again, but sadly, more effort is being put on placing blame than on accepting the truth—we are all guilty of wanting a free lunch. We must press on to free energy markets and true cost pricing, because if we do not complete the transition to free market prices, we will continue to build inefficient homes and buildings that are uncomfortable, unhealthful, expensive to operate, and very vulnerable to energy supply interruptions.

If we do not make this transition to a free market, we will also be left behind by other countries that do. France, for example, has had a free market in water supply since the 1850s, and it is no coincidence that French water companies are now supplying efficient and low cost water services to many countries in the world, including a growing number of people in the U.S. It is also no surprise that arguably the best bus system in the world, in Curitiba, Brazil, is run by private bus companies.

However, we should learn from the experiences in England and the Soviet Union. We need to develop a deregulation process that protects the innocent rather than just the utilities. While San Diego Gas & Electric deserves credit for moving so quickly to free market pricing (that is what they were asked to do), the California legislature should properly be rebuked for implementing such a poorly developed strategy for such an important and commendable goal. We also need to factor in full environmental costs, something the Soviet Union also neglected, leading to catastrophic pollution.

If our courage falters and we retreat to socialized energy again, we will pay much more for power in the long run. We will also face more energy shortages in the future, and continue to be at great risk for disruption, brownouts, blackouts, and discomfort. We are in our current energy bind because developers have not stepped up to build new facilities, fearing that deregulation won't last. We need to prove them wrong, and we must put their minds at ease so that they will invest now! We also need to develop ways for energy conservation to compete against new power production, because negawatts usually cost only a fraction of new watts.

It is time to rethink the transition process without losing sight of the goal—a free market with full cost pricing. David Bainbridge, Environmental Studies Coordinator, GLS Department, United States International University, 10455 Pomerado Rd., San Diego, CA 92131 • 858-635-4616 • Fax: 858-635-4730 bainbrid@usiu.edu • www.usiu.edu

Hello David, Great letter. You darn near wrote my next column for me. Now I have to find something else to write about. You are correct in finding fault in California's legislature. Dereg here was set up to fail on nearly all levels. Too much attention was paid to profits for the utilities, and not enough to safeguards for consumers. Through loopholes in the methods for bidding for power and for making it available to the bidders, the energy providers (who are not necessarily the utilities) have been able to jack up the price of power. It is not the actual cost of production that drives the prices, but rather the timing during which it is made available to bidders. Some of these producers have been able to more than triple what it costs them to make the power.

While I am all for free enterprise (maybe some day some country will actually try it), this is ridiculous. And now that California's governor and the PUC have decided that the problem is lack of supply, they want to put the approval of new generation facilities on the fast track. That pretty much means fossil fuel-powered turbines. Bummer… Some careful thought and planning could have made renewables an important part of California's upcoming generation boom. Michael Welch

Hello David, I think yours is one of the most important letters that Home Power *has run in a long time. I agree with you completely that our present energy predicament is largely due to the lack of reality in energy pricing. As advocates for renewable energy, we are repeatedly faced with people who say it is "too expensive." But they are only comparing renewables to the unreal price that our skewed system has put on non-renewable energy.*

The true cost of non-renewables includes the many direct and indirect subsidies that we pay through our tax dollars. It also includes environmental degradation, health costs due to pollution, military costs to defend "our" oil, and many other unseen costs.

The phrase "free market" is a bit loaded for many people with an environmental conscience, and I certainly don't agree with all the connotations that have been put on the phrase. But I do agree strongly with you that we need energy pricing to be real. *It is the dishonest, politically-based instead of reality-based pricing that has been largely responsible for getting us into the mess we're in.*

This system has given a few companies enormous power over what energy we use, by granting them monopolies, subsidies, and protection. It has removed much of their responsibility by legislating liability limits and not holding them responsible for their actions. It has diluted the economic "vote" of individuals by moving many energy decisions into the political realm, where large companies have much more clout than individuals.

I applaud you for your clear call for a free market in energy, and your wisdom in calling for a compassionate and intelligent transition. Renewable energy will shine and prosper when the price tag on non-renewables reflects reality. And the true cost—including environmental and social costs—will undoubtedly be lower. I also urge you to consider writing more on this vital subject for Home Power. *Ian Woofenden*

"Green" Power?!?

Here I sit in my solar and wind powered home looking at a post card from a company with a Web site listed as www.green-e.org, telling me that my local utility (which I don't use) is going to be offering me "green power" from renewable sources. They have a chart on this card which shows where electricity comes from. Here is the breakdown:

Large hydro	10%
Other renewables	2%
Gas	8%
Nuclear	18%
Coal	52%
Other Fossil	8%
Oil	2%

Now according to the latest figures from the U.S. Dept. of Energy (government agency), this is wrong. But my point is not about how they play with the numbers, but about how they play on our basic impulse to do good while distorting the truth. Here is the truth:

There are over 20 coal-fired plants in the U.S. with a capacity of 100 megawatts each or larger, operating at peak capacity at any one time. 100 megawatts is 100,000,000 watts. This is a small portion of our generating capacity. According to figures we have all seen in the news lately, we are in the midst of an energy crunch.

Let's say, for arguments sake, that the utilities decided to replace one 100 megawatt block of power with a real renewable source (not hydro) using solar panels. Say they got a deal to purchase these modules at a US$3 per watt installed cost. This would be a US$300,000,000 investment. This is more than the bid cost of the last nuclear plant constructed in the late '70s. Have you heard of any such massive public work?

A 100 megawatt solar installation would still only provide power during the day. What about the night? Just start up the coal-fired plant for the night? *Wrong*—it takes about 12 to 15 hours to start up a large coal-fired steam turbine system from dead cold. The racking gear alone to spin the hundred-ton machine uses the power of one 500 KW diesel generator. So the figure bandied about, where a 1,000 acre portion or so of Arizona or New Mexico could be covered in solar panels and power the U.S., would cost someone about US$12,000,000,000. Think this will happen soon? I don't.

The present day electrical consumption of the USA is nothing less than astronomical when expressed in watts. There are so many varied loads it is hard to imagine the complexity of the system and service provided by the electrical grid. Further complicating the scenario where the USA is serviced by a renewable-powered grid is the fact that, in general, most transmission lines have losses near 75%. All in all, a very daunting task to supply even 1 or 2% of the electrical demand from these sources. And since renewables are only 1 or 2% of the total, my question is this: Where are they getting this green power to sell to all those folks on the grid?

Here is the point where it gets really sticky and I offend some folks. Remember "The Emperor's New Clothes"? Well, your green power doesn't exist. Just like suddenly Philip Morris is all community conscious and willing to do the right thing, so are your local utilities. Except they are not getting addicts off nicotine, they want more addicts hooked up to your local power injection. Without the cash kiddies, they don't exist. Sure, they would like to supply green power, buth they can't afford it either, not after satisfying the investors. The bottom line would not allow for this type of monumental cash outlay, no matter if it is to save the planet. No matter how many grid-connected homes may appear, it's not nearly enough.

So it really is up to you, me, and the guy with the 5 acres who can't afford the power line, to provide our own power and take ever so much more load away from the ineffective and relentless power grids. The more we as individuals, as well as businesses and industries, make our own power and conserve, the less power they have to make, and in doing so, plant after smelly plant will eventually shut down. This is my hope. Wm. von Brethorst, Planetary Systems • brethors@3rivers.net

Hi Bill. There's a couple of things I might add. First, green-e is not a power company, but rather a non-profit that certifies companies that meet their qualifications as sellers of green energy. Unfortunately, their qualifications bite because they lead people to think their power purchase decisions are actually doing some good, when it usually does not. See my Power Politics *columns in* HP64 & 65, *and the letter to editor and response in* HP67 *for more info.*

It is true that coal plants and other water-boiling plants take a long time to ramp up their power production from cold start. Nuclear takes the longest to shut down and restart. But you will find that most modern plants being built are natural gas turbines which can ramp up production relatively quickly. You will be seeing a lot of these plants being built in the next few years.

I pretty much agree with your comments, but you use the high cost of utility-scale renewable energy to justify getting off the grid as an alternative. When you think about it, home-scale RE costs significantly more than utility-scale RE, making it even more unlikely that the millions of households that want green power will be able to pull it off. Definitely it is the best way to go, but still unlikely to happen.

With regard to the reality of folks using utility-scale green energy, the only way it can truly happen is by going with a company that is building new RE sources. While not perfect, the energy program that powers the Redwood Alliance office is as green as any other I have seen. We are using Green Mountain's Wind for the Future program (See HP63 Power Politics*). They also have a Solar for the Future program which has been building on-grid PV systems in California and Pennsylvania.*

Watch out, though, many companies are calling large-scale hydro a green resource, which is not OK by me. Also, at least one of the major green energy players in CA is promising to develop new "RE sources" using geothermal geyser power. To do that, they want to develop a particular site which is unspoiled wilderness and sacred to several northern California Native American tribes. That is also unacceptable to most in the environmental movement.

The sad fact is that in this country we need to vote with our pocketbook—the politicians sure aren't going to take care of it. Until each of us gets off-grid, if we write that check to the companies that are building more RE sources, our votes will begin counting and finally begin adding up. Yours for an RE future for everyone, Michael Welch.

What to Do?

Hello *Home Power,* We live in a condominium complex and can't even store firewood in our carport. What would some options be for us to consider regarding renewable energy? We'll probably have to submit to the homeowners association, but at least we can ask. Thanks for any advice. Joe & Merci Schuessler, PO Box 806, Aptos, CA 95001 • mercedina@webtv.net

Hello Joe & Merci, Well, the best place to start is with your appliances. Are you using incandescent lighting? If so, consider compact fluorescents. How about your TV, VCR, stereo, and microwave? Are they on plug strips, or are they phantom loads, sucking up energy 24 hours a day?

The essence of using renewable energy is effective use of electricity. Making your home as efficient as possible makes RE more practical, and gives you an immediate reduction in your utility bills.

Next, consider installing a MicroSine PV system. This consists of two PV modules (about 1 meter square area) and a MicroSine inverter. This setup will put about 400 to 500 watt-hours of solar electricity onto the utility grid each day. It can spin your utility meter backwards and reduce your power bill.

The two PV modules can be placed on a patio or on a balcony, or even mounted over the edge of the balcony or window. All that is necessary is that they see as much sun as possible. This is a battery-less system, so there are no hassles with batteries. Cost is about US$1,000, and the PVs carry a 20 to 25 year warranty, so they'll continue to make solar-electric power for quite a while.

I don't know what's wrong with some homeowners' associations. Karen's mom just moved into a new house and the local homeowners' association will not allow her to use one of the greatest energy savers ever—a clothesline in the back yard. Enough is enough! No wonder this country has energy and environmental problems! Richard Perez

Hostile Skies

Hello Richard, You've probably gotten a million of these messages by now but… To get from Milwaukee to England, it took us 48 hours, five airports, two bus rides, a night in a motel, and $500 for "extra" airfare. And the conditions on the plane violated Geneva Convention rules for treatment of prisoners. I've had really good luck with Amtrak, east of the Mississippi. John R. Surber, Milwaukee, WI • surber@csd.uwm.edu

Hello John, My Ozonal Notes *piece on air travel seems to have hit a nerve among many* Home Power *readers. I've received many air travel horror stories. I'm with you—let's stick with ground travel! Richard Perez*

The Not So Friendly Skies
Richard, Just got the Aug/Sept issue of *HP,* and as always, I enjoyed reading it. However, your unfortunate "hosing" events during your trip to MREF in Madison hit a bit close to home.

As your youngest brother, and having worked in the airline industry for over fifteen years, I can tell you that the traveling public never sees half of the FUBAR situations that really occur. I am sure that your delays were attributed to such factors as Betty Sue the flight attendant calling in sick because she had a hangnail, or maybe that Avionics part just seemed to have gotten lost by the overnight delivery company. It also could have even been as seemingly inconsequential as someone forgetting to sign off on a piece of paper. You would be surprised as to the actual reasons that cause schedules to crater.

One of the biggest problems is that the airlines—and this goes for the majors all the way down to little bitty charter guys—schedule their equipment too tightly. All it takes is one small, unexpected event, and all hell breaks loose! I have personally seen this many times, and have spent many sleepless nights trying to rectify those situations. The only time I have been afforded any possible relief for this tight utilization of resources was with a small charter outfit that I worked for back in the late '80s. These guys were visionaries, and actually kept a spare aircraft and two hot crews set up at all times for just such occurrences. Needless to say, they were eventually squashed out of existence by the major carriers. But I will say that they had guts, and went down, so to speak, fighting.

Another kicker is the airlines "spoke and hub" flight routes. That flight to Chicago to get to Madison was a perfect example. It does not make much sense, even to a seasoned veteran of the industry, why you have to fly from Dallas *through* Chicago to get to Orlando!

When United arranged for the 747 to do the short hop from Denver to San Fran, I can guarantee you that there was a manager who got the butt chewing of his life in a morning operations meeting! I am sure United lost their shirt on that run!

The agents in customer service who are on the front lines during these battles have to have the patience of our mother. They take the brunt of the frustration of the weary traveler, and only get further insulted when their paycheck arrives.

One saving grace is the airport concessions, although I hate to say how many all-beef quarter-pound gut bombs I may have consumed in my time. It is still amazing how they complicate your frustrations by not allowing the indulgence of a smoke during such trying times. If you do find that one establishment that allows you to light up, you usually don't have to because just breathing in the secondhand smoke of the umpteen other smokers suffices. You were truly lucky to find that place in Denver that allowed you to smoke. In Atlanta's Hartsfield airport, they have the grace to provide actual smoking lounges on three of the five concourses, but this is not the norm. Maybe they provide such places in Atlanta because Delta has the worst record of flight delays out of Hartsfield, their home base. I guess it must keep the riots to a minimum.

I think you summed up air traveling experience in the next to the last paragraph of your piece, "fly early, expect delays, believe nothing, and carry a flask of strong drink." The only thing I would add is to carry along a blow-up pillow for the long sitting sessions that seem to accompany most air traveling experiences nowadays.

Having been in the industry and seen the behind-the-scenes shenanigans as well as having actually been "hosed" by United Airlines in the past more than once, also in Denver, I too am grounding myself whenever possible! Craig Perez valkyman@bellsouth.net

Hello Craig, and yes, for the benefit of our readers, he really is my youngest brother. Thanks for the explanation of why things get hostile in the friendly skies. While air travel is so seductive, promising us the opportunity to travel very long distances in short periods of time, I think this promise is largely unfulfilled. I liken the situation to installing a supercharger on a car with a clutch that slips. I'm with you, let's stay grounded! Richard Perez

Howdy John & Craig, Just as the Supreme Court offers minority opinions in response to their majority rulings, I'd like to get a couple of cents worth in here. Personally, I have not had as many problems with my flights over the years. One of the jokes around here is that we should try to avoid flying with Karen & Richard, because something usually screws up their itineraries. It has nothing to do with them, really. Karen books everyone's flights, even mine. It seems to be a matter of luck and coincidence.

What is difficult for me and some others on the crew is that ground transportation makes us spend many days on the road when we travel to far-away places. It is nearly impossible to do any of our work while traveling in a motorhome. Traffic and weather problems and differences in driving styles stress us out. Safety and rest are always concerns. Several days driving with a monolithic can full of bodies can be trying and tiring. And just like any other family, squabbles pop up that add into the mix, although as a group, we get along very well.

When you add up the time spent and the tiredness of the crew, and compare it to the trials and tribulations of flying, I vote for the airlines.

If we cannot fly, we should try using the rails supplemented by van rentals from the nearest point of disembarkation. While not taking less time than RV driving, it would allow us to arrive safe, rested, and possibly even get a little work done on the way. And if any of us need space from the others, there's always the other end of the train. I may end up in the caboose after submitting my minority opinion, though… Michael Welch

Microhydro and Fish
Hi guys, I was re-reading *HP77* the other day and realized that our email discussion regarding microhydro structures in fish-bearing waters had made it into print. We're gratified to see that the subject is being taken seriously. After all, *HP* is about making power. It's not a nature magazine fer cryin' out loud, and we realize that worrying about a handful of fishies is somewhat of a distraction.

Having said that, I've gotta share some knowledge Patti and I have gained since this discussion started, since it bears on comments made by *HP* staff. In the last couple of months, we've been thrashing about in the infamous western Washington brush, ground-truthing DNR base maps for the tributaries near our residence. DNR base maps show all rivers down to the tiniest tributaries, and are marked as to whether the waterways are fish-bearing or not. Ground-truthing refers to the process of actually looking in the streams for fish, and checking the accuracy of the base maps, which are often in need of correction.

We've found salmonids (coho and cutthroat) hanging out in ridiculously small waterways. In one tributary, we found fish two hundred feet below the point where water first appeared at the surface. Other tributaries were not exploited as far, but in all cases we were surprised at the persistence of the fish. Fisheries biologists have since told us that our findings were pretty typical. You couldn't spin a toy pinwheel in these flows, much less a real impeller. Bob-O's comment that most microhydros go in small creeks with no resident fish population concerns me. From what we've seen, it's the other way around—microhydro becomes infeasible long before the creek stops supporting fish.

There's another thing I have to respond to. It was pointed out that adults would have no difficulty getting past the small dam under discussion. This is probably accurate. However, juvenile passage was never mentioned. We're in the process of replacing a culvert on our property with the help of grant money from USFWS. The culvert impedes but doesn't stop adult passage. It does stop juveniles from moving freely up and down the stream in search of food and shelter. This is a critical measure of juvenile survivability. The fact that we're getting funding when adults can get past the barrier is an indication of the importance placed on this part of salmon recovery.

OK, I'm done. Thanks for listening. I'm sorry for trying your patience. I don't want to dilute the energy that all of you dedicate so effectively with tangential issues, but this fish stuff has become really important to us and we had to throw our two cents in. Bill & Patti Barmettler, PO Box 1462, Chehalis, WA 98532
360-748-8265 • bpbar@juno.com

Dear Bill & Patti, Great letter. I can't—and won't—challenge your findings. I must, therefore, agree with them! My experience is with creeks far to the south of you. When the water gets as low as you describe, it also gets too warm to support most fish, especially salmonids. Also, it rarely *rains here between June and October (unlike your neck of the woods where folks grow webs between their fingers and toes!), so there is little if any recharge or cooling of the puddles. I can see that from Washington up the Pacific coast, it's a fish of a different color. Clearly folks up your way have to be extra careful to provide passage. My concern about your letter is this:*

While nearly all the fish in creeks in your area are salmonid, in most other areas, it just ain't so. Not that other fish don't deserve our respect and attention, but they generally aren't as endangered as salmon and steelhead. Most folks couldn't tell a salmon fry from a french fry, and they aren't very likely to catch and kill one to find out.

I'd hate for folks to get gun shy about a little microhydro plant and stay on fossil fuels, nukes, or burning salmon from BDH (big damn hydro) just because they need to create a very small impoundment (often the best protection for little fish), which might or might not impede feeding. When it comes time for the fish to run downstream to the sea, I don't see the problem.

The hard truth is this. While it's our absolute moral, God-given duty *to tread lightly on the earth, tread we must or perish. It's a question of doing the best we can with what we've got to work with this time around. Ya know? Thanks again for your letter. Best, Bob-O Schultze*

Old Fridge—New Fridge

Dear Eric, Richard, and Larry, I read your exchange *(HP76,* page 148) about old refrigerators with great interest, and want to share a bit of my own experience with these appliances, which parallels Eric's findings to some degree.

I became interested in old refrigerators a few years back, just as the electric utility campaigns to get them replaced were getting underway. Three years ago, my wife and I moved to Berkeley, California and found a studio apartment. We were settling in, trying to make sense of the unfortunate layout of the kitchen, when it occurred to us that substituting a smaller fridge would let us use the available space more efficiently. Determined to find the most energy efficient model available, I researched the matter carefully. Exact size, method of defrosting, country of origin—I was willing to consider most any combination. Real Goods provided specs on the Sun Frost models, and the Association of Home Appliance Manufacturers (AHAM) gave us an overview of much of the rest.

I even got a whiff of the curious world of Energy Guide labels. When the neighbors' fridge died in the middle of my search, we gladly donated our (and their) landlord's 19 cubic foot mustard-yellow behemoth, hefting it down and then up narrow flights of stairs. Without a fridge in our flat, the pace of my search quickened. I selected a 9.5 cubic foot manual defrost Sanyo (built in Southern California, incidentally) with a single exterior door and a smallish freezer compartment.

Somewhere along the way, I picked up the requisite pieces to assemble a meter just like the one Eric built. After two and a half years of metering and a bit of tinkering to get the freezer to properly freeze ice cream, I can say I have been very pleased with the purchase. The fridge consumes 167 KWH/year, for an average daily rate of 456 WH. I concede that with a skimpy 1-3/4 inches of PU insulation, a Sun Frost in sheep's clothing I have not (quite). But as a graduate student with a less than stable source of income, the payback (energy costs saved/purchase price of fridge) has been most rewarding. At northern California electricity prices (10.4¢ per KWH plus 2.1¢ per KWH premium for deregulated wind energy), the fridge has already paid for itself. The old yellow one had been gobbling up roughly 3.3 KWH per day.

But, I have veered from Eric's insight about the old model in his kitchen. Having done a bit of metering on my grandmother's 1946 Leonard fridge, I finally was able to purchase a 1947 Frigidaire a year ago (5.8 cubic feet). No, it's not in my kitchen—there's no room and I wouldn't know what to do with the extra fridge space. I lent it to a lab at UC Berkeley where the research folk keep their sandwiches and beer cold. With another homebuilt 120 VAC analog meter, I've been tracking its consumption as well. 240 KWH per year or 660 WH per day. Not a lot of deterioration in performance over 53 years! This one cost me a mere US$70, the meter US$7. The miserliness with which both models consume electricity is proof enough for me that the industry and households could do better producing and choosing less hefty appliances. As Eric pointed out, nearly all the fridges found in your local appliance dealer's showroom (and all the Energy Star models) don't come close to either one.

In conclusion, I want to comment on Eric's enthusiasm for reducing loads to scale back the design of a renewable energy system. While 130 KWH per month is impressive, why stop there? I'd like to see someone organize a competition for the lowest household energy bills and how they were achieved. For the U.S. as a whole, average per capita residential electricity consumption currently works out to about 11.5 KWH per day or 350 KWH per month. With a bit of tinkering and some slight changes in behavior, we've managed to drop below the average by a factor of 30, and we're not ready to stop just yet. Reuben Deumling, deumling@socrates.berkeley.edu

Hello Ruben. Great work and that's the attitude! Every watt-hour saved is a watt-hour that doesn't need to be generated, transmitted, and, if you are off-grid, stored. I've seen families of two who are content and happy with just two PV modules.

On the subject of refrigerators, I think that this industry is finally waking up. When Karen's mom moved into her new on-grid house, we bought her a new refrigerator/freezer. This 18 cubic foot Maytag has all the conveniences, such as easy to move shelves and auto defrost. It consumes about 1,180 watt-hours per day, and the cost was US$799. I applaud the refrigeration industry for finally putting their products on an energy diet. Richard Perez

Right Livelihood

Dear Editor, Ben Root's "right livelihood" piece *(HP78,* page 8) really struck a chord. Although it's been a while since I was saving lives as a Coast Guard radioman, my search for the perfect "socially responsible" job continues. In his editorial, Ben laid out a clear and understandable blueprint for choosing the right path. Such writing inspires not only those of us in the renewable crowd, but acts as a catalyst for positive change throughout the general populace as well—keep up the great work! Roger J. Wendell WB0JNR, Aurora, Colorado

Thanks Roger! The daily grind is worth it when we have a positive effect. Ben Root

Budget Surplus to Solar Power

I am a subscriber to *Home Power,* and I must say that I look forward to its arrival like those in the "old days" looked forward to the arrival of their Sears catalog during those long, cold, dark wintry nights. It's funny, more and more over time I've noticed that I'm becoming significantly more hard core environmentally proactive. I was listening to NPR the other day and they were talking about how to spend the budget surplus. I thought that it would be a real boost to our country, economy, and environment to offer every homeowner an opportunity to draw down a percentage of this money to spend on producing their own home, apartment, or living area power.

This "subsidy" would cut into the constant quest for the acquisition and consumption of energy that fuels the huge imbalance that we are suffering from societally. The money saved would help the grid, "energize" the economy by encouraging industry to produce in a constructive cooperative way, decrease our dependence on foreign energy, and radically reduce military spending, which is linked to protecting our interests in this area. Last but not least, it would go a long way towards beginning the healing process of our world by engaging us in raising our consciousness, by learning how to use our energy wisely through good stewardship and cooperation. Does this sound too good to be true, or have I made too many left turns lately? Best, Ben Macri • benmacri@home.com

Hello Ben. I must have taken the same left turns because this sounds like a great idea to me too. For example, consider a small PV system consisting of 100 watts of PV and a MicroSine inverter. Such a system exists today and costs about US$1,000. If each of the USA's some 93 million homes were to install such a system, we would have a generating capacity of 9.3 trillion watts of electric power, and produce over 30 trillion watt-hours of energy daily. Each of those PV installations would eliminate about 2 metric tons (4,400 pounds) of CO_2 *released into the atmosphere yearly. Sounds like a plan to me… Richard Perez*

Ecofan

Hello Kathleen, We read your article about the Ecofan and thought it sounded like a good idea. Caframo told us that we had a distributor not 25 miles away, but they have yet to negotiate prices and shipping costs. After some trans-Atlantic phone calls, we had an Ecofan shipped over to Stocksbridge, South Yorkshire, England, via an uncle who lives in Ontario.

We had to wait a week for a suitably cool day to warrant having a fire, which we lit at about 6:30 PM. What a difference this little fan makes! I know we are not in the depths of winter, but—my word—the room was warm within minutes of the fire being lit. In fact, it got so hot that my partner had to go outside for some fresh air. It wasn't really that cold, but we wanted to see this fan in action. We have a smaller stove in the other room and will be purchasing another fan soon. Could you let us know what a cord of wood is, like a fathom is six feet. We realise that a cord must be a measure of an amount of wood, but what?

We have a Air 404 wind genny, and a couple of photovoltaic panels that charge a small battery bank to power our household lights. We've just bought *From the Fryer to the Fuel Tank* with a view to manufacturing our own fuel to run a large generator to meet our household needs. The costs are nowhere as economical as your methanol—75 cents a litre, while ours is £5 a gallon—but we can try!

Costs for RE products are generally double when bought through distributors over here. We paid about £55 for the Ecofan via our relative in Ontario. The chap 25 miles away wants to sell the fan for about £85. Ripped off or what!

We moved to this semi-rural location two years ago, and are trying in our own way to be green/self sufficient/money saving and get out of the rat race. Anyway, thank you for a cracking magazine, and keep up the good work. Regards, Lyn & Richard Jarvis, Wellhouse Farm, Hunshelf Bank, Stocksbridge, Sheffield, South Yorkshire S36 2BS England • Lyn.Jarvis@btinternet.com

Hi Lyn and Richard, Bob-O and I are having a booth at our local county fair next week. I figured out how to set the Ecofan on a small solar cooker and make it turn without cooking it. It looks pretty cool. We gave a couple of Ecofans away as Christmas gifts last year to friends with wood stoves. They all really liked them. One guy's wife was telling us that her husband kept moving it around on the stove to find exactly the most efficient position for the fan. It certainly makes me feel good to know that people like you are getting some good out of my column. A cord of wood is 8 ft. long by 4 ft. wide by 4 ft. high (2.44 x 1.22 x 1.22 m), or 128 cubic feet (3.63 m^2*), cut, split, and stacked. Kathleen Jarschke-Schultze*

Energy Efficient Appliances

Dear Kathleen, Thanks for the info about energy efficient appliances you provided in your most recent *Home & Heart (HP78).* My wife and I both enjoy your column. I have found that the ACEEE Guide to Energy Efficient Appliances is very good for comparing models. I purchase a new guide almost every year just to keep tabs on energy efficiency trends, even though I am not currently in the market for any major appliances. However, the best source of this information that I have ever found is the Canadian government's department of Natural Resources Web site: (http://energuide.nrcan.gc.ca).

Along with all the standard basic educational info, this site lists the actual energy use in watts for each appliance. It also provides a calculator to determine the actual lifetime cost of the appliance (sticker price plus energy cost over the expected life of the appliance). This allows a consumer to make truly informed purchases.

The closest our US Environmental Protection Agency comes is its Energy Star program, which is something of a joke in my opinion. For many appliances, the vast majority of models are awarded the "Energy Star" label even though they may differ greatly in energy demand. I believe this is the result of the pervasive influence of corporate lobbying on our political system. In order to get the major industries to grudgingly acquiesce to the system, the DOE sets the standards at a very liberal level to make everyone happy. The result is that industry does not have to really strive to improve the energy efficiency of its products.

Even a cursory review of the range of energy use among different models and manufacturers (available at the Canadian Natural Resources Web site) of a given appliance reveals that the vast majority of appliances could be much more efficient simply by applying current technology! I believe the Energy Star label should be reserved for the single most efficient model in each size and style category. This would make it a truly special designation and manufacturers would have much more incentive to innovate in order to achieve it.

Another flawed source of info in the U.S. marketing system is the Energuide labels on major appliances. Although better than no labels at all, they are sometimes (intentionally?) misleading. The case of washing machines provides a perfect example. The Energuide labels for traditional top-loading machines do not include the energy use of very efficient front loaders such as the Maytag Neptune. Energy efficient front loaders (actually horizontal axis machines, including the Staber) are only compared among themselves on the Energuide labels.

When consumers are reading these labels (if they are reading them), they are trying to compare the energy use of different washing machines, not one style versus another. People could be easily misled into believing they are buying a very efficient unit that actually uses three times as much energy as the most efficient model available! These are a few of the pitfalls I have learned about in my quest to outfit my off-grid home with the most energy efficient appliances available.

Despite these problems, we have been able to outfit our home with all the modern name-brand appliances from mainstream retailers simply by taking the time to learn what to look for, and doing so. I hope more and more people will do the same, and this is what will really motivate manufacturers to increase energy efficiency. Thanks again for your informative article and thanks especially to our Canadian friends! Joe Schiller, 2951 Chapel Hill Rd., Clarksville, TN 37040 • schillerjoseph@netscape.net

EV Update
Michael, I thought I would write you and give you an update on my EV situation. In my article in *HP77,* page 92, I decided that although an EV definitely made sense, I needed too much range to be able to use an EV right now, and I couldn't afford to build one that had the needed range. I received a lot of email from folks who were encouraged to look at EVs more seriously because of my article, and because of that, I consider it a success. Mostly it was them who encouraged me to post this follow-up letter.

Shortly after that issue came out, my employer said I could charge up at work if I wanted to. This cut the range I needed down to about 30 miles, which was easily doable. They even reserved a parking place by a 110 VAC receptacle. Towards the end of July, I purchased a used 1986 Ford Escort conversion through the EV tradin' post (see photo).

When it arrived, I discovered that the charger was broken due to several years worth of road grime building up inside and corroding the circuit boards and wires. (A note to all BC-20 owners: seal up your circuit boards with some sort of insulating brush-on material, because the fan blows everything right over the board.) I ordered a backup offboard charger, and I've been driving the EV for running errands around town. Yesterday I received my repaired BC-20 back from K & W. They were very helpful. I hope to start using the EV for my commute in the next couple of weeks. Then I can take at least a small bite out of that haze that seems to plague Tulsa during the summer. David Brandt • davidbr@nordam.com

Solar Sustainability Challenge
I am thrilled to announce the Solar Sustainability Challenge, a solar "un-race" to take place at a time and place yet to be decided. The purpose of this event is to conduct a real world simulation of daily living, with solar transportation and sustainability in mind. This will not be just a race, but a group of events going from sustainable community to community, using solar cars as a sole means of transportation. Isn't that what we do every day in our gasoline-powered world?

I see no better way to spread the use of solar knowledge and know-how, and to accelerate and promote the introduction of sustainable and renewable technologies in communities around the country. This un-race could go anywhere around the U.S., Canada, or Mexico. The idea is to move—using solar energy only—from one community to another. Once in a community, participants would rest, maybe do some part-time work related to sustainability and solar energy, eat organic food and/or help in its production, get the solar car ready, and move to another community.

The winners will be the teams that can show the smallest human footprint, according to the premises set forward by Dr. Wackernagel from the University of British Columbia. Prizes will be a shining silver trophy… No, not really—how unimaginative! I would love to give the winners a new set of organic hemp or organic cotton clothes from Patagonia, or FoxFire, or a years' organic food supply from Whole Foods, or a new set of solar panels from Uni-Solar.

Home Power has graciously offered to publicize the Solar Sustainability Challenge in its pages. The biggest unanswered question is how to put the solar cars safely on the existing infrastructure—roads that are entirely designed for 4,000+ pound gas-guzzler SUVs and 80,000 pound tractor trailers—without having the need for a fleet of gasoline-powered vehicles behind and in front of the solar cars during the un-race. That really defeats the purpose of solar transportation. It is also the biggest challenge. Another challenge is solar tires that are inexpensive and will reliably last for a couple thousand miles. How about that, Michelin, Dunlop, Goodyear?

Our society is totally unsustainable now. Just to give you an example, imagine giving everyone in the world the same number of cars per capita as we have here in the U.S. We would need the iron, steel, rubber, and oil to produce and run these cars. We would also need lots of water—it takes about 40,000 gallons to make one car, and this is the same H_2O we drink. Then there's the air—the exact same brand we breathe. Looking at the whole picture, it would take the resources of not one, not two, but about six planets to do this. And in the end, we would no doubt leave them all as polluted and wrecked as we are leaving this one. Wow!

Let's make a solar and sustainable future for ourselves. A place where we can work, live, drink clean water, breathe clean air, and still leave a free and viable future for our children's children and all the living creatures that share the planet with us and make life possible here.

Please contact me as soon as possible if you would like to participate, help organize, sponsor, or contribute suggestions or resources for the race, or if you can get your community, organization, university, college or company involved and organized. We will soon be writing a set of preliminary rules, which will be published in *Home Power.* America is the one place in the entire world where revolutions not only are still possible, but happen. Tony Pereira, 1501 E. Carson St. #15, Carson, CA 90745 • 310-549-3077 • bk931@lafn.org

Net Metering in Iowa
Richard, I recently sent you a copy of an op-ed I had written for the Cedar Rapids Gazette concerning net metering in Iowa. Your response to me was that maybe this would cause some mild reaction. Well, I never have been so excited (or nervous) since 1992 when the first IRENEW Energy Expo was first established. The response was more than I expected.

The premise of my op-ed was twofold. First, net metering is legal in Iowa, but is constantly being stonewalled, mostly by MidAmerican Energy. Second, a school district in Iowa is being kept from net metering their 750,000 watt wind turbine by Alliant Energy (give all your electricity to us—the utility—first, and we sell back to you what you need!). My op-ed was printed on Wednesday before our Energy Expo, and by that Friday, fur had started to fly.

The Iowa Utility Board (IUB) issues "rules," not laws. What this means very simply is the utilities can keep (and have kept) alternative energy rules tied up in court forever. So when people assume that Iowa is one of over thirty states in our country to have legal net metering, forget it. The IUB will not enforce their rules until the legal process finds in their favor. This means net metering in Iowa is in limbo (not legal and not illegal). This legally delays the net metering process to infinity.

After my op-ed, the IUB received so many calls that I thought they were going to personally rip my throat out. Instead, by that Friday (two days later), my op-ed had caused a legal procedure to start to rewrite the rules so there could be no misunderstanding. Alliant has received a waiver so the school district can net meter. No one has told me why the energy company gets the waiver for something that it is required to do in the net metering rule.

What my letter did in two days (evidently) was to cause a legal rewrite of the rule so there could be no misunderstanding by the utilities and the public of where the IUB stands on this subject: "The intent of the original rule written by the IUB was not to exclude alternative energy producers." Here's a shortened version of the letter:

> **Letter to the Cedar Rapids Gazette**
> The tremendous rise and minor fall of gasoline prices this spring and summer is a major reason to get involved in energy issues. A second reason to become involved is the prediction that the cost of heating with natural gas will go up this fall and winter. The third reason to become involved in energy issues is because the two biggest electric utilities in Iowa are stonewalling "net metering."
>
> Net metering is an easy, legal way to reduce your electric bill. It is an arrangement between an electric utility and a customer who wants to produce some (or all) of his or her own electricity (usually using solar or wind energy). The cost of electricity from the utility is offset, in whole or in part, by the value of electricity produced by the consumer.
>
> This is an issue entirely different from electric deregulation, which will again show its ugly head this year. The utilities' unreasonable and unfair behavior concerning net metering has been going on for seventeen years, but most recently concerns the Eldora-New Providence school district.
>
> Iowa is one of over 30 states with laws and/or regulations making this production and exchange of electricity legal. One method of net metering can be a direct exchange between the customer and the utility, where the electric meter can run in either direction. MidAmerican Energy is so predictable about this subject that it has asked the federal government (again) to rule on this arrangement. MidAmerican has been keeping this in court since 1983. Last winter, the company even asked the Iowa Supreme Court for a ruling. Now here is the arrogant and unfair part: It is legal to net meter in Iowa, but the utilities are just saying no.
>
> Iowa's net metering bill specifies that the metering arrangement is up to the customer. Not in this case. This would fit the old saying about having your cake and eating it, too. The utilities want you to buy the oven, make your own electricity, bake the cake, and then charge you to eat your own cake. You put up the 750,000 watt (big) wind generator, give us the electricity and then we will sell it back to you. To have to sell all your electricity to the utility first is unfair, unreasonable, and not a legal requirement for net metering in Iowa.
>
> According to Paul Gipe (a national wind expert from California), the electric utilities across the United States are "obstructing wind and other alternative energy interconnections by unreasonable and unfair requirements." In the case of MidAmerican and Alliant, it also appears that "might makes right."

One thing you and I can do is to call the Iowa Utilities Board and explain how unfair and unreasonable MidAmerican and Alliant are in regard to net metering (specifically with Eldora-New Providence schools). Otherwise, net metering will never survive, even though it is legal in Iowa. Tom Snyder, IRENEW Board Member, Dyersville, Iowa • studegh@earthlink.net

Eco-Laundromat

Hi Folks! Part of a dream is coming true for me—a dream of an inner city community centre for poverty-ridden areas, a human-powered, solar-assisted, wetland remediated, water-recycling, heat-recovering laundromat. A small group of volunteers will be gathering this summer at Earthaven Ecovillage to create prototypes linking salvaged exercise equipment with laundry equipment.

I'm sure that some of you have experimented with hand-cranked, pedal powered, pulleyed, and other non-electrical devices to perform needed work. Some of you may even have read Alan Weisman's book, *Gaviotas,* in which he describes that community's use of children's playground equipment to pump deep groundwater up for fully supplying their community centre's water needs.

I know the ingenuity of *HP* readers, and I'll bet the thought of expending effort just to exercise might generate some amusement. I want to generate something else: community spirit, healthy bodies, and free laundry facilities where they're most needed (but don't lose that sense of humour). Several pedal-powered washing machines have already been designed in different parts of the world. What about hooking up a rowing machine to a laundry spinner, or pumping units of water instead of lifting weights? How efficient would a solar kiln be at "finishing" spun laundry? Could a children's rocking toy run a heat exchanger?

If you have design ideas, time for home tinkering, or a sudden urge to volunteer a week of your creative time at Earthaven, we'd be delighted. If you have a windfall, maybe you'd consider getting a fund together to donate some new high-end, energy efficient equipment for reconfiguring and comparing with the salvaged contraptions.

Earthaven intends to use their laundromat as a showpiece, linked with greywater cleaning ponds also filled from their café wastes. Their high profile, many visitors, and membership in the Global Ecovillage Network could help this idea move. Would any of you like to help, too? Jackie McMillan, 70 Cornell Ave., #8, Kitchener, ON N2G 3E4 Canada • Message phone: 828-669-8879 Earthaven phone: 828-669-6760 • jaiem@look.ca

What a great idea, Jackie! I hope our readers will support you with ideas, money, and time. And I hope we'll all be able to read about your success in a future issue of Home Power! *Ian Woofenden*

CO_2

I just finished reading Don Loweburg's column in *HP77.* As usual, his text is provocative and timely. However, I would like to balance his blanket statement that all CO_2 is bad CO_2.

There should be no question that CO_2 is a major pollutant in the United States and abroad. But elimination or mitigation of CO_2 production is not likely to be accomplished by blind promotion of wholesale conversion to solar generation of electricity and heat—not at today's cost per unit of solar capacity, and at the current fickleness of solar availability in most parts of the world.

There are three issues that govern how we should look at CO_2 and the practical need for energy in a typical residence in a developed area of the world. These issues are the relative CO_2 production per unit of heat released by various commercial fuels, the relative economics of renewable capacity versus traditional sources of power, and the practicality of best technology integration to obtain the best features of combined technologies.

It is important to note that not all fuels are created equal when it comes to CO_2 production. For example, combustion of 1 pound of carbon and 2.66 pounds of oxygen forms 3.66 pounds of CO_2. This process releases about 14,600 btu of heat. On the other hand, combustion of 1 pound of hydrogen with 8 pounds of oxygen forms 9 pounds of water. This process releases about 62,000 btu of heat. The hydrocarbon makeup of the fuel determines how bad the fuel really is when CO_2 production is the preferred unit of measure.

Coal, which is the dominant fuel for centralized utilities, is a demonstrated bad CO_2 actor because a typical bituminous coal will contain about 80 percent carbon by weight and only around 6 percent hydrogen. This means that coal will favor the first combustion process described above, and will produce huge quantities of CO_2, regardless of how "perfect" the combustion process might be.

Natural gas is on the other end of the spectrum. Composed of approximately 80 percent methane (CH_4), natural gas combustion produces a combination of CO_2 and H_2O, or water. If we burn 1 pound of methane with 4 pounds of oxygen, the result is 2.75 pounds of CO_2 and 2.25 pounds of water. The heat liberated is about 23,850 btu.

If we look at the dominant 80 percent carbon content of coal and the dominant 80 percent methane content of natural gas, we have a fair basis for comparison. The carbon produces 3.66 pounds of CO_2 while liberating 14,600 btu of heat. The methane produces 2.25 pounds of CO_2 while liberating 23,850 btu of heat. Therefore, the methane produces 94.33 pounds of CO_2 for every 1,000,000 btu of heat generated. The carbon produces 250.68 pounds of CO_2 for every 1,000,000 btu of heat generated. This means natural gas combustion will generally produce about 38 percent as much CO_2 as coal combustion per 1,000,000 btu of heat released. A similar ratio will be developed by propane (C_3H_8), a preferred fuel among renewable energy users.

It is not hard to see that a complete conversion from coal combustion to natural gas combustion would instantly cut U.S. CO_2 production in half. Furthermore, natural gas combustion is relatively "cool" and NO_x pollution would be dramatically reduced as well. This is why natural gas is increasingly popular in most areas of the U.S., so much so, in fact, that natural gas supplies nationwide shifted from surplus to demand during last winter in the East.

The point of this simplified view of the combustion world is that there are many sources of CO_2 production, both man-made and natural. Remember, utilities burn a lot of coal. Transportation burns a lot of gasoline and diesel fuel. All of these fuels are carbon rich. Mitigation of man-made CO_2 sources by eliminating coal combustion and the use of other high carbon content fuels is a good thing. Outright elimination by political fiat or grassroots agitation is not only virtually impossible, it is probably not practical while maintaining anything close to our current standard of living. I think Don's viewpoint is somewhat skewed and gives *Home Power* readers a distorted look at how they might view the specification of their PV systems and their place in the overall energy picture.

If we shift our scrutiny to economics and take another look at solar thermal and solar electricity versus traditional sources, we will find that the power production world is not full of idiots. Where money is the principal means of trade, the dollar will naturally seek out the low cost opportunity. In the case of electricity generation, the traditional, centralized utility can give us grid power for a capacity cost of around US$0.0001 per watt. Comparable solar capacity costs around US$4 per watt just for the solar panels.

On the thermal side of the game, thermal energy at about 80 percent conversion efficiency is so cheap (about US$6–10 per million btu) that the energy savings generated by solar thermal capacity will take virtually forever to pay out its first cost. (Don's life cycle costs statement has been noted. Does he or anyone else have any figures that support it across the whole spectrum of residential applications?)

It is mostly wishful thinking to assume that you can substantially replace an enormous, stodgey infrastructure with alternative technologies that have orders of magnitude higher costs than the old technologies they replace. The fact that most 1970s solar hot water companies went out of business when publicly funded incentives ended is confirmation of this fact. The economic burden of a forced changeover would crush most little guys and send them back into the dark ages.

It is my opinion that the high cost of solar capacity and the intermittent availability of solar power will always limit pure solar applications to a very narrow range of usefulness. A more balanced view will recognize this and attempt to find combined technologies that can bring out the maximum benefit from each technology's advantages. My whole thrust for the past forty years has been to find a mix of appropriate technologies that enhances independence, and to evolve a practical role for decentralized (distributed) energy generation in the home and in industry. From 1890s steam engines to the latest fuel cell systems, I have seen them all. There is no question in my mind that careful integration of combustion technologies is a key part of any workable renewable strategy.

I have evolved in my own mind how to best combine combustion technologies with renewables to obtain a renewable/combustion hybrid power plant that will give a homeowner seamless, unattended electrical and thermal energy, cost less than the current assemblies being specified, and produce the smallest possible environmental impact—both locally and globally.

First, all isolated, off-grid power plants must start with an inventory of loads. Conservation and careful planning of loads is the key to economical power plants. There are many off-the-shelf components now available that make load reduction easy while maintaining a "mainstream lifestyle." Don's remarks on efficiency are central to this part of the process.

Second, matching a battery/inverter system to the loads, including overall kilowatt-hours, peak capacity, and surge capacity is the critical "power management" part of the scheme. Undersizing inverters and oversizing battery banks are the common mistakes that result from ignoring this phase of the specification.

Third, determination of the dominant available sources of heat and electricity generation is the final exercise that determines the primary direction of investment in renewable sources, engine generators, propane-fired thermal converters (hot water tanks, boilers, etc.), or all of the above.

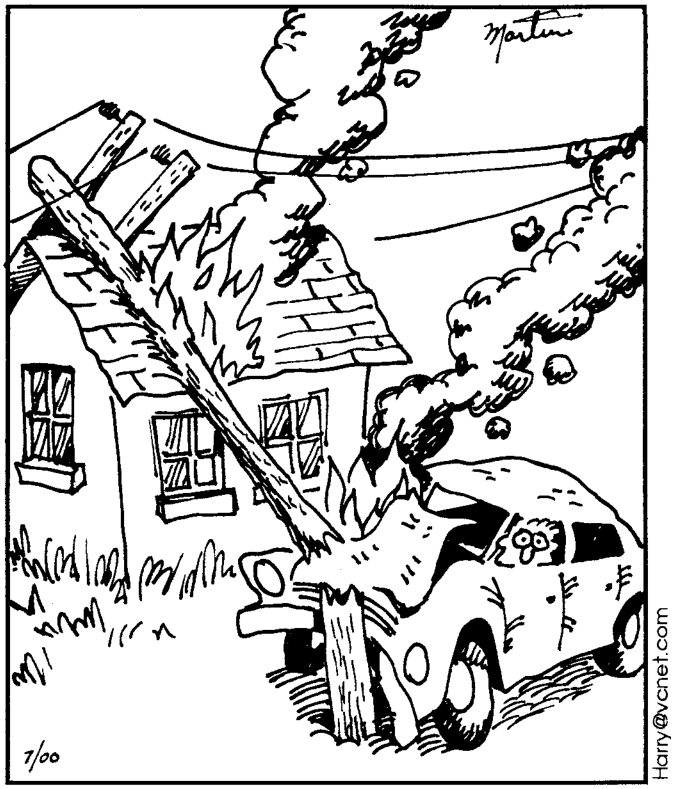
While the above comments may run counter to some of the more extreme renewable viewpoints, taking renewables to the mainstream will require balanced views that include everybody. If this can be accomplished, we all have a better chance to retire all the CO_2-belching dinosaurs that really do need to go. Thanks for the forum. William L. Petitjean, P.E., President, E-MultiSource, Inc. • petitinc@nwlink.com

Thanks, Bill, for a definitive analysis of the CO_2 issue. I agree with your main point that we must focus on the big offenders first. That makes sense, and yes, in the real world we must be aware that economics will shape our choices. I, in a sense, was addressing the issue with a sledge hammer while you went at it with a scalpel. Hyperbole may be of value at times, but if it's my brain being worked on, I vote for the guy with the scalpel. Kind regards, Don Loweburg

Hi William, I feel that you are missing certain key issues by focusing on the economic variables in the equation. Your analysis is only true if one considers initial off-grid costs, disregarding fuel, maintenance and sustainability. On-grid, your analysis disregards our environment.

The prices we pay for carbon power are artificially low, subsidized like solar in the '70s, and not the real costs of that energy. If we paid these full costs out of pocket, renewables would fare better in the comparison. The utility-scale solar and wind plants I visited recently in California were both producing clean energy at costs equivalent to that of carbon power.

My understanding is that the payback time of solar thermal is short enough to make it highly economically feasible, without subsidies, in most parts of the U.S. Ben Root



Those who live by the grid, die by the grid.

Tales from the Net Metering Trenches

Richard Perez

It never ceases to amaze me. After passage of net metering laws in thirty states, America's utilities still don't have a clue about what's going down. In states with net metering laws, utilities are still doing their best to keep our RE off of "their" grid. In states without net metering laws, the situation is far more simple—we just go guerrilla and they hardly know we are there. Not yet, anyway.

What is Net Metering?

Net metering means that utility customers can sell their excess renewable energy to the local utility at the local retail rate. Most state net metering laws have a provision that limits the amount of RE that the customer can sell to the grid. Most net metering laws state that, on a yearly basis, the customer can sell no more energy to the utility than the customer consumes from the utility. The end result is that a utility customer could have a zero electric bill from their utility. Net metering laws are designed to aid households in reducing their electric bills and the pollution associated with electric power generation.

A Strategic View of the Battle Front

In every state, the net metering legislation was passed over the objections of the utilities operating in that state. Some net metering laws go back over nineteen years, while others were passed just last year. In every case, utilities have done their best to see that net metering legislation either doesn't pass at all, or that if it does pass, it is ineffective. America's utilities are trying to hold on to their century-long, publicly-granted monopoly of electric power production. After all, electric power is a very big business—over 230 billion dollars annually in the USA alone.

People who are trying to install net metered RE systems are finding it difficult to impossible. Even in states with net metering laws, we are discovering that utilities are still not cooperating—they are defying the law. In these instances and in states without net metering laws, people are placing their excess RE on the grid without utility permission—guerrilla solar.

The main feature of this battle front is money. The utilities want to hold on to their monopoly, and feel challenged by homeowners placing RE on the grid. Allowing us to become producers of grid electricity sets a precedent that weakens their monopoly. From the homeowners' perspective, money is not the issue. These on-grid RE systems are lucky to break even over a twenty to thirty year period. No one—not with official net metered systems or guerrilla systems—is doing this to make a buck. It's just plain cheaper to buy the government-subsidized utility power.

Folks are doing RE on the grid for three reasons—an uninterruptible supply of electricity, a higher quality supply of electricity, and to help clean up our environment. Saving money or chiseling a few bucks out of a utility is not the motive. RE on-grid is simply more expensive than using grid power exclusively.

Tales from the Trenches—Connecticut

I recently spoke with a man who attempted to net meter his large (over 3 KW) PV system in the state of Connecticut. His local utility replied that they had yet to formulate their net metering policies and requirements. Connecticut has had a net metering law since 1998, and this utility still hadn't done its homework. They told this customer to call back in six months or so and maybe they'd have the necessary rules and regs ready. Then they could discuss net metering this person's system. This is from a utility in a state that has had a net metering law in place for two years now!

The person said "fine," went out to the power shed, and pushed the sell button on his inverter—he became a solar guerrilla. This guerrilla has a large system, and he was shocked to find his next power bill far higher than it was before he started putting his unauthorized RE on the grid. It turns out that this guerrilla has one of the new remote reading meters. It counts energy moving in either direction as a purchase from the utility. This guerrilla is actually paying the utility retail rate for each KWH of solar electricity he places on the grid. Such is the egotism of utilities that they build electric meters that consider all electric flow, regardless of direction, to be a sale from the utility.

I asked him if he was going to stop putting his RE on the grid because it was costing him money to do it. He replied, "No." He said that the reason he was doing this wasn't related to money, but to our environment. He wasn't concerned that the utility was charging him to share his RE with his neighbors, stating that it was a small price to pay for allowing his neighbors to use his surplus clean power. Such is the spirit of solar guerrillas.

Tales from the Trenches—Oregon
I was recently involved with the installation of a grid intertied PV system in John Day, Oregon (see the editorial on page 8 of this issue). We worked with the local utility, Oregon Trails Electric Coop (OTEC). OTEC originally told us that the metering setup at the Grant County Fairgrounds would not support net metering since it was a three-phase unidirectional configuration. OTEC installed a separate connection into their grid for this system, and to their credit, they did this for free.

About a week before the system was to be installed, OTEC contacted Jennifer Barker, who dreamed up this system. They told her that there would be a $15 per month fee to read the meters on this new RE system. We hit the roof. Technically, this is not a net metered system since there is absolutely no electric power consumption from the grid. All this system does is put solar electricity onto the grid. We are essentially donating about $7 worth of electricity to OTEC monthly, and they wanted to charge us $15 to read the meter showing how much electricity we had donated!

You can bet that we complained loudly. OTEC backed off, saying that it would make this particular system an exception, but that they would charge extra to read the meters of all other net metered systems in their operating area. Oregon's net metering law prohibits extra charges by utilities on net metered RE systems.

Such are the tales from the trenches. First we work for years to get a net metering bill passed. Then we have to fight each utility, system by system, to get this law implemented in their operating area. It's no wonder that folks go guerrilla, or go off-grid entirely.

The Positives of Net Metering for Utilities
I am truly amazed that utilities are fighting RE net metering so hard. Aside from setting a precedent against their monopolistic stranglehold on electricity, there is no real downside for them. Many of the technological advances that utilities crave are embodied in RE net metering.

Distributed Generation
For years utilities have been extolling the benefits of distributed generation. The concept here is that instead of building huge power plants and shipping the energy for miles over power lines, we can build many small power plants and have the energy consumed more locally. This is a sound concept. It increases grid reliability while decreasing transmission line costs. Net metering does exactly this—it gives us many small generating sources located very near to where the energy is consumed. An added benefit is that solar energy is produced during peak consumption hours.

Capital Investment
Net metered systems are paid for and maintained by homeowners, not by the utility. Here we have the situation where the finest and most expensive form of power is sold to a utility without the utility having to invest one cent of their capital in the generation sources.

Green Power to Sell
If enough net metered systems can be accumulated, the utility can sell this RE to non-net metered customers as "green" energy. Utilities currently consider PV-produced energy to be too expensive—they are not putting up PV power plants, we are. We're installing these PV systems with our own money and offering our surplus solar energy to utilities at less than it costs us to produce it.

Green energy commands a higher price than brown energy because it doesn't damage our environment. For utilities currently offering green power options, consumer demand has far surpassed their ability to generate green power. Net metered RE systems have the potential to fill utility coffers with "green" dollars while not costing them one cent in capital expenditures.

Power Reliability
Net metered RE systems offer greater reliability to the grid. Having thousands of small distributed power generators means that the failure of one large power plant doesn't have a great effect on the grid as a whole. Having thousands of distributed sources means that the energy is consumed close to where it is produced. This lessens the cost, loading, and dependence on expensive long distance power lines.

Power Quality
As the grid becomes more overloaded, power quality suffers. Brownouts, high harmonic distortion, and even blackouts are becoming regular occurrences. Once again, the distributed generating capabilities of net metered RE systems can aid the grid in maintaining its power quality and constancy.

The Negatives of Net Metering for Utilities
I searched long and hard for any legitimate or substantial negative impacts of net metered RE systems to the grid. I can find only one—net metering establishes a precedent that utilities do not have a

monopoly on power production. Under the latest round of utility deregulation, this monopoly is already being challenged, and on a far larger scale than net metering would for many decades to come.

Technology has already changed electricity from a rare commodity produced only in large utility power plants, to something that can be produced on anyone's roof. Like it or not, the days of utilities having a monopoly on electricity production are numbered.

A Dinosaur Mentality

Utilities have grown fat and slow under their hundred-year monopoly. They have forgotten that the public (that's us—you and me) have granted them this monopoly. They have used their profits to ensure their survival in spite of the environmental damages they cause. I can think of no sadder major industry in the USA than our utilities.

In a recent survey of utility employees conducted by KPMG LLP, a professional services firm, the following interesting facts came to light:

"Of the 197 utility employees surveyed nationally by KPMG, 78 percent responded that they had observed violations of the law or company standards in the previous 12 months."

"46 percent of all utility employees trust their company and its management, which is 13 percent lower than the national average."

"56 percent of utility employees feel that their customers would recommend the company to others, a full 14 percentage points lower than the national average."

This last quote is the most telling since if you don't like the local utility, you can't purchase electricity from a competitor. In almost all states, utilities have a monopoly within their service area.

What Can We Do?

Go Solar! The clearest and best resource for change in the morass of utility greed and pollution is to stand up and fend for oneself. The installation of a renewable energy system offers you reliable, high quality, clean power. If you have excess RE, put it on the grid, authorized or not. Share the benefits of clean energy with your neighbors.

Access

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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 twelve 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

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Q&A

Aluminium Wire
Just received *HP78*—another stellar performance by the crew at Funky Mtn. Institute! Maybe I should get a life, but not much brightens my day more than receiving the latest issue of *Home Power*. It's been fun watching the system transitions at *HP* Central over the years, and using your upgrades as a guide.

Booster battery—now there's a concept! (After reading the latest *Home Power,* Al, bowing and scraping, approaches his wife. "Susan, honey, dear, can't we free up a few bucks for just one more tiny improvement to our system? Oh, I know last month was the new RV Power Products charge controller, but we really need a couple more batteries to make a booster battery. Oh, yes, it will definitely improve our quality of life by leaps and bounds, and I'll never ask for another component, at least not until the next *Home Power* comes out…")

In the past, *HP* articles have recommended copper wire for all runs. Recently I've noticed the use of aluminum (aluminium to some) wire for long runs. What a relief! Several years ago, I moved my panels and batteries out of the house to an outbuilding 100 feet away. Daunted by the cost of copper wire for that 100 foot run, I looked into aluminum. It worked out that #2/0 aluminum would be adequate, much cheaper than a size smaller copper.

Then to my surprise, I found that 100 feet of URD aluminum cable (two #4/0 wires and one #2/0 wire wrapped together) was cheaper than 200 feet of #2/0 AL alone—some weird economy of scale thing. So I used the two #4/0 cables to make the run (separated the #2/0 out and am still trying to find a use for it!).

So, it seems that an article on the proper sizing, connections (and maintenance of those connections), and use of aluminum wire is in order and would be of interest to your readers. I understand that there are some rules of thumb for making connections with AL wire, especially making the transition from AL to CU. I hope I did it right… Before you say "Good idea, why don't you write it, Al"… Even though I've used AL cable, it doesn't mean I really know anything about it, and I'm sure there are many nuances and techniques unknown to me.

Your comments about air travel were interesting. I'm old enough to remember when air travel was fun! It sure isn't anymore. Nothing like being stranded in an airport for hours or days with kids—it would almost be easier to spend days with them in a car… I'm certainly looking forward to the time when they move transporter technology out of Star Trek and into our world. Anyway, keep up the great work—we all appreciate it more than we let on. Al Latham • thinkedg@olypen.com

Hello Al, We used aluminium wire on some 117 VAC circuits, and we have also used it on a 50 volt DC wind generator power line, and on some high current, 24 VDC PV power lines (from array to power room).

The reason we do this is cost. For the same resistance, aluminium cable is less than 1/3 the cost of copper. There are indeed some tricks to using aluminium cable. Here's what we've learned:

1. Don't make connections on aluminium where it will be out in the weather. All the connections should be made inside a building, or inside a weatherproof box.

2. Polish the wire strands even if the cable is brand new. We use a Makita drill and a small wire wheel to do this.

3. Liberally butter the polished bare wire strands, and the connector, with an oxide-resisting compound such as NoOx.

4. Only use connectors rated for copper and aluminium mating.

5. Tighten the hell out of the connections, and tape or shrink tube them well.

6. Since aluminium wire has higher resistance than copper, aluminium wire should be oversized by two AWG sizes compared to copper.

Aluminium oxidizes rapidly when exposed to moisture. It's essential that mechanical connections be bright, tight, and sealed against oxidation.

As far as the extra #2/0 conductor, you could use it for a smaller (less current) or shorter run. Or it could easily be paralleled in with either the negative or positive of the main run (I prefer negative because in some systems the negative current handling conductor is grounded, but it really makes no difference). This in effect gives you a 250 MCM wire gauge. But since #4/0 is pretty big already, I suspect you don't need even lower resistance.

Tell Susan I'm sorry to aid in continually picking your pockets. An RE system is almost organic and always seems to grow and change. Look on the very bright side—what are you going to be able to do with all that new electric power? Richard Perez

Homemade Battery Connectors
I just wanted to thank you for an article you wrote long ago on making your own battery connectors. I had

taken the easy way out and bought ready-made connectors. They seemed very flimsy when out of the package and were no better when soldered. I remembered reading your method on the CD I had purchased some time ago. I redid the connectors using soft tubing as you suggested. The first one was the worst of the lot, but still usable. They took a while to make, but were well worth the effort. I suppose the lesson is twofold:

1. No easy way out

2. Read *Home Power*

Also for something constructive to do at our camp at night, I will be putting together the battery desulfator project from the *Home Power* Web site, using one of the best little gifts my wife ever gave me, one of those soldering irons that run on butane. The project parts I ordered off the net arrived while I was at the camp installing two Kyocera 80 watt panels. Thanks again, Peter Millington • sinistr@ns.sympatico.ca

Hello Peter. Those handmade battery/inverter connectors are bulletproof. They are the only connector I know of that has less resistance than the cable to which they are soldered. Their mechanical strength is sufficient that you can pick up a very heavy battery with them (but we don't recommend that because most battery cases are not designed to allow lifting by the posts). The original article appeared in HP7, *page 36. Although that issue is out of print, the whole issue is on our* Solar2 *CD-ROM. We are still using handmade cables here. Some are over 25 years old and have outlived four different batteries. Thanks for the flowers! Richard Perez*

Battery Questions
Hello Richard, I hope you can enlighten me with answers to a couple of questions I have regarding batteries.

1. I have often heard it said that lead-acid batteries like to "grow up" together—that keeping them matched up is proper. I believe that adding a new battery to a group after 15 percent of their lifespan is over is not good, and that the new battery will only charge up to the level of the weakest battery/cell in the group. I'm looking for an explanation of how and why this is so. Do you have a simple symbolic/practical example as well as a scientific one that basic learners can comprehend?

2. I have a 24 V 2.2 amp charger for a small electric scooter and a 24 V 12 AH battery. According to my calculations, the charger puts out 52.8 watts, and it will take approximately 5.5 hours to bring the battery up to 100 percent charge, totaling 288 watt-hours. If I pay 10 cents per KWH, does it in fact cost 2 cents to charge up the battery at that rate? Of course all things being equal, there is power lost through resistance and charger inefficiency as well. Thanks for your assistance! Ben Macri • benmacri@home.com

Hello Ben. Yes, what you have heard is roughly correct. If you maintain your batteries properly, and completely recharge them routinely, you can add new batteries to the battery pack for about two years. If the batteries are abused by not recharging them fully or by not doing equalization charges, this period will be much shorter—on the order of a year or less.

One analogy is an iron chain exposed to salt water. As the links rust, their ability to handle a load decreases. If a single link fails, we might replace it, but the entire chain will not be as strong as it was when it was new—it will be limited by the strength of the weakest rusty link.

It would take someone who knows more about electrochemistry than I do to tell you the specific electrochemical mechanisms that cause aging and eventual failure in lead-acid cells.

I would double that cost figure on that scooter charge to about 4 cents. Most battery chargers are between 50 and 70 percent efficient, so you are actually having to put almost double the energy into the charger as you are getting out of it. Also, the battery itself is not 100 percent efficient, but more like 80 to 85 percent efficient, and possibly lower than that if the battery is being deep cycled, as would be the case with your scooter. I would expect that charger, if it actually puts out 2.2 amps constantly, to require about 6.5 hours to totally recharge that battery if it was fully depleted. Overall it's probably costing you a nickel to recharge that scooter. Richard Perez

What Does It Cost?
Hello, I have enjoyed your site on the Net for some time, and enjoy your articles. My wife and I have been considering building an RE home. I have been trying to educate myself as to what is needed. How much is enough and what is too much? That has been a tough question to answer, to say the least, and I get a real headache after a while.

We would like to install a hybrid system when we build. We live in southeastern Idaho, near Idaho Falls. I understand interest rates are going up after the first of the year (who knows for sure?) and would like to get financing locked in before then. We presently own a home and need to get it sold. The last article by the Bells was great, but the price of their system was more than I spent to buy my present home!

I do understand that you need to spend some money for quality items, but that is way out of my price range. We feel good about building an RE home. There is so much that you can't have an impact on these days. I feel that if RE was put into large-scale practice, this country and world would be much better off. But my income tends to say how much I can do… Thanks, Norm & Brenda Tew, Shelley, Idaho spdzrus@mail.ida.net

Hello Norm and Brenda. The cost of an RE system is entirely dependant on how much electricity you need. Steve Bell's system is cycling over 25 kilowatt-hours per day—that's a lot of electricity! I know of homes that consume between 2 and 4 kilowatt-hours per day, and the folks have all they need—refrigerator, computer, lights, TV, VCR, washing machine, microwave oven, toaster, well pump, and other appliances. These systems cost between US$6,000 and $12,000 if they are PV based, and far less than that if you have wind power or microhydro power resources available.

If you don't need some of the appliances listed above, or if you can conserve in other ways, the cost will be lower still. The point is that you determine how much the system costs by your electric power consumption. Less consumption means fewer system components and a lower price tag. I know of cabin systems that cost less than US$2,000, and supply enough power for lights and communication electronics (TV/VCR, radio, stereo).

The key to an inexpensive system is conservation. Examine what you really need electricity for; then buy the most efficient appliances and use them wisely. Every dollar you spend on efficient appliances will save you three dollars in system components.

The best way to begin is to analyze your electric power needs. There is information and software to aid you in this posted on Home Power's *Web site at www.homepower.com. Be ruthless with your appliances and eliminate energy wastrels such as incandescent lamps and phantom loads. I think you will find that if you are realistic with your energy habits, you will be able to afford a system that will meet your needs. Richard Perez*

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