HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #70

April / May 1999

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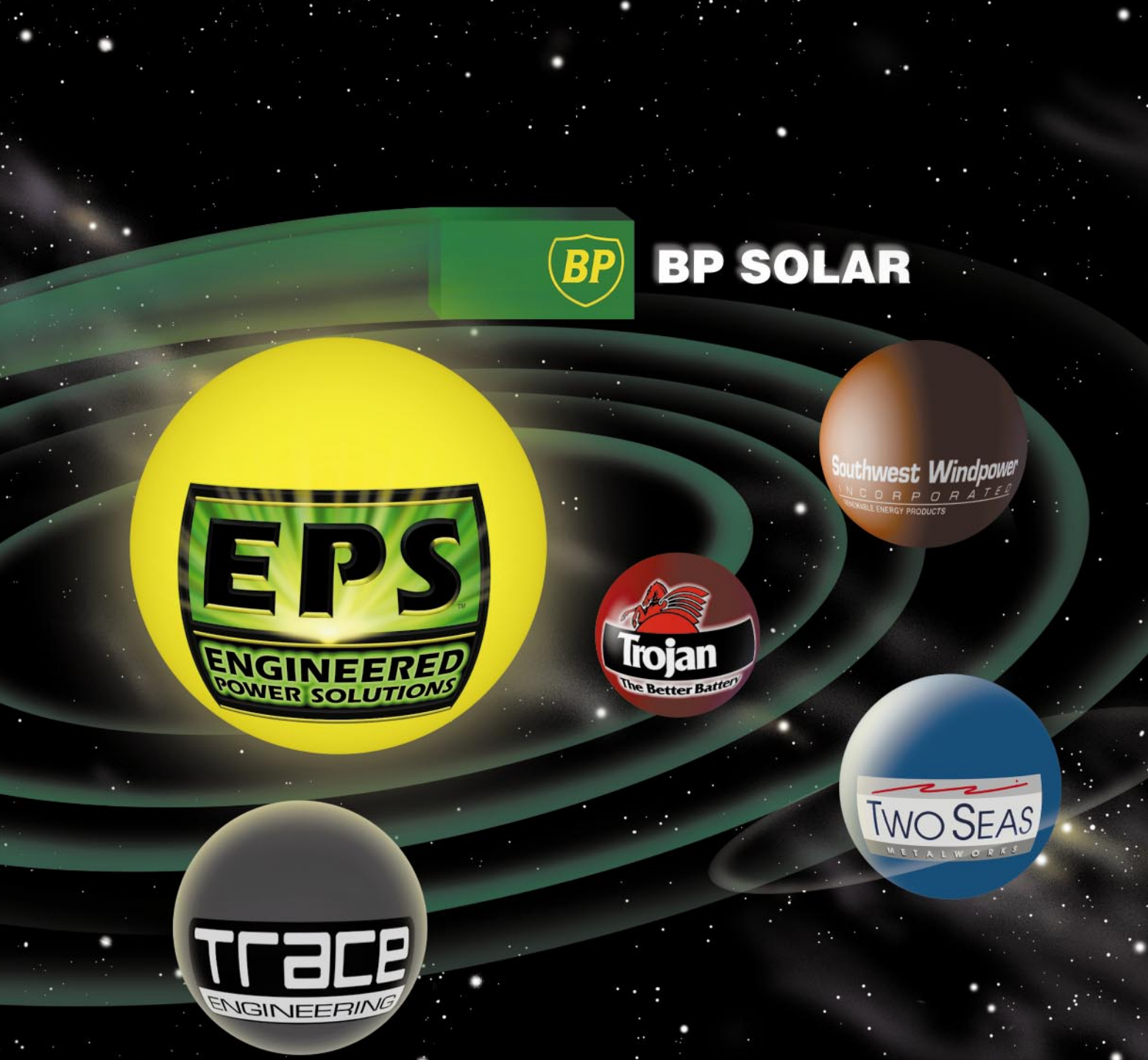

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Features

GoPower

More GoPower

Guerrilla Solar

Homebrew

Cover: Bill Lord's Maine home has photovoltaics integrated into the building design and intertied with the utility grid.

Things that Work!

More Features

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Regulars

Access and Info

Access Data

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April 1, 1999

Home Power
Dept. Responsible for Responsible Responses
P.O. Box 520
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Dear Editor,

I have noticed a disturbing trend with the increase in the use of so called "renewable energy" resources.

Wind power is the first major concern. Every time someone uses a wind generator, they "harvest" the wind. First the major power suppliers got in on the action, and now individuals are joining the bandwagon. What do you think happens to the wind they harvest? It's used up, of course, so there is less and less wind all the time for the rest of society! Many people blame automobile emissions as the big culprit in global warming, but I think that it's the RE people hogging all the wind.

Of course things will tend to warm up when you take away the wind. "Oh what a nice cool breeze," people used to say. As wind generators become more and more widely used, you will hear this lovely expression less and less. Soon all the wind will be used up, and our planet will be completely still. We need to lobby the government to set up restrictions on the amount of wind people may use for their generators, or there may not be any left for our children.

The next disturbing trend is the voluminous number of photovoltaic panels being used to produce electricity. Every year thousands of people put these contraptions on their rooftops. They are all UV resistant of course, sucking up all the good juice the sun has to offer, while leaving behind all that terrible UV light to burn our skin in the summertime. Have you noticed that the summertime warnings about high UV ratings began to occur at around the same time that PV panels made their way into the popular domain?

Yes, these are the culprits that are causing our skin to burn in twenty minutes or less. The government should put an end to all you "enviro-nuts" using up all our precious sunshine, and leaving only the poisonous UV rays for the rest of us.

Please help us in our attempt to save the environment. Grab a fan out of your basement and leave it running for a few days to increase the amount of wind on our planet, before the "RE" people have their way and use up all our precious resources.

Yours Truly,
A Concerned Citizen

Spring is here again—Hooray! The hours of sunlight increase, plants begin to grow, we run our generators less and less. Our minds open up, too. A bit of silliness here and there takes the edge off winter, off environmental concerns and political battles, off magazine deadline craziness. It's the humor like the letter above (we hope it's humor) that reminds us that what we are doing is not only important, but fun too. Promoting the use of renewable energy is not just the right thing to do—it's what we like doing.

—Ben Root for the *Home Power* crew

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Mike Bryce
Sam Coleman
Mark Fitzgerald
Lincoln J. Frost Sr.
Stephanie Harmon
Anita Jarmann
Bruce Johnson
Kathleen Jarschke-Schultze
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—Kathleen Jarschke-Schultze

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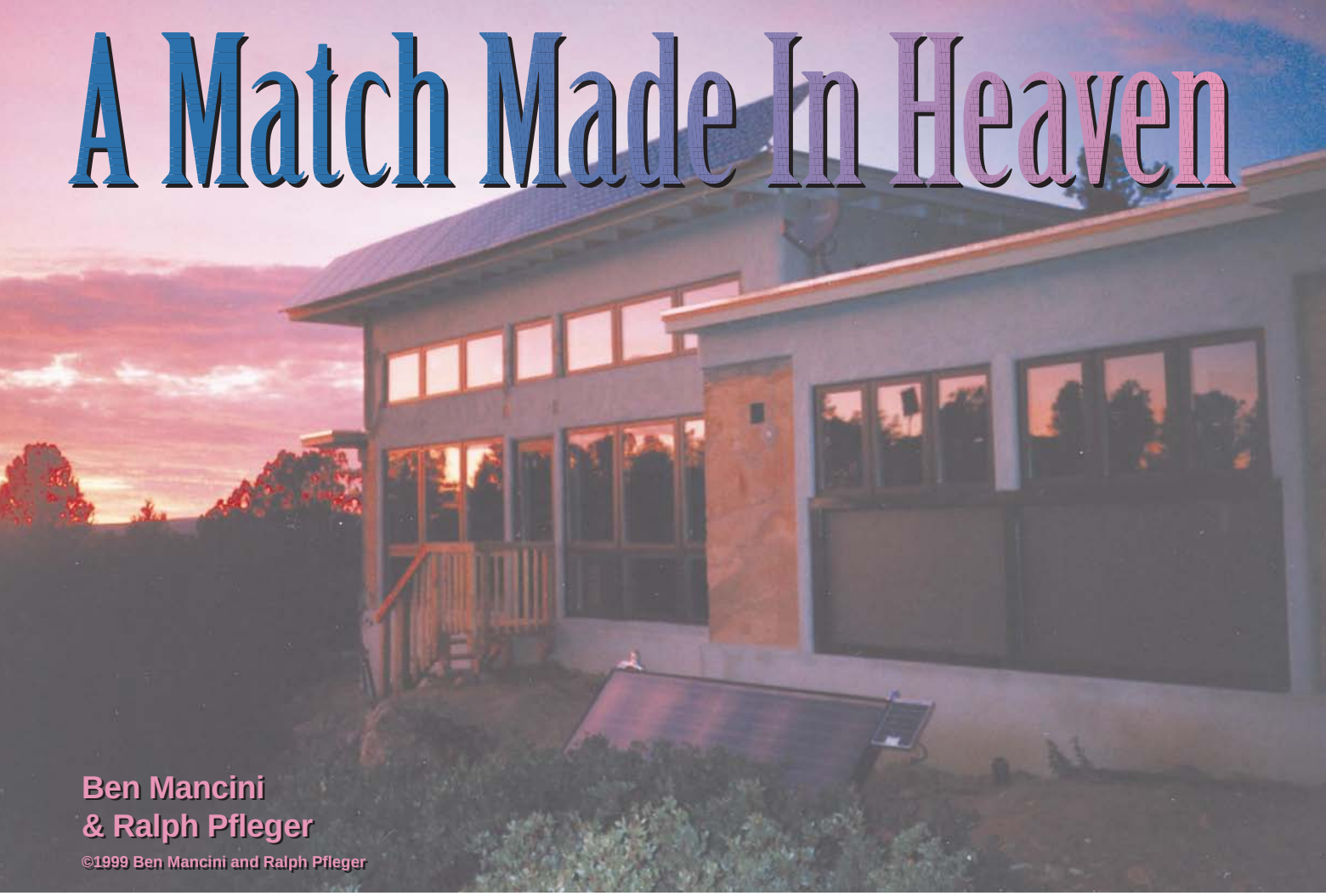


Ben Mancini
& Ralph Pfleger

Above: Eighteen PV panels run along the roof edge. A 4 by 12 foot hot water panel sits low in the foreground.

It isn't often that customers walk into our central Arizona store who not only want to purchase a solar electric system, but who also want to build a passive solar home. It's even more unusual if they already know how much power the home is going to require.

The combination of passive solar design and PV is a perfect match. A passive solar home requires less energy for heating and cooling than a conventionally built home. If it is well designed, no electric lighting is used in the daytime. These three energy loads often account for a high percentage of the energy used in a conventional home.

Pieces Fall into Place

It wasn't long after I met Kevin McKean and Jennifer Scott that the pieces started falling into place for their renewable energy home. The property that they found had a small solar-powered cabin on it, but the system wasn't quite large enough for their needs. Instead of upgrading that system, they decided to build a separate system for their new house. With the construction of the house, the old system has been dedicated to water pumping and pressurizing. It runs an AC submersible pump and an AC pressure pump.

As Kevin and Jennifer thought about the kind of house they wanted, it became apparent that their lifestyle was very well suited to living in an off-grid home. Their energy consumption was not large and they liked the aesthetics of passive solar homes. They contacted Michael Frerking, a local architect with extensive experience in passive solar home design using rammed earth and cast earth building materials.

Michael designed a home that was built with a new and innovative cast earth technology which uses concrete trucks to mix and deliver the material, and grout pumps to place it. The mixing and placing method can be up to eight times faster than traditional rammed earth building. The home design includes trombe walls, direct gain for the living room area, daylighting throughout the house, and thermal mass storage in walls and concrete slab. The northwest corner of the house is about three feet (1 m) below grade. The whole house has a very low profile from the road, and sits below the treetops.

Kevin & Jennifer's System Loads

Loads	*Watts*	*Hrs.*	*W-hrs/day*
TV and satellite receiver	120	3.5	420
Lights	105	4.5	473
Refrigerator	125	10	1250
Computer	175	5	875
Stereo	62	2	124
In-floor circ. pump (winter)	96	6	576
		Total	3,718

Commitment to Renewables

Kevin and Jennifer were committed to energy independence using a renewable source. Even though a utility hookup would have cost only $5,000, the $15,000 system cost was an acceptable alternative. The house is located at about 4,800 feet (1463 m) in elevation, in an area with mild winters, hot summers, and abundant sunshine. Their PV system gives them independent and reliable renewable energy.

The new house has several solar technologies at work: the passive solar design has direct gain and Trombe walls as the primary heating source, excellent day lighting, a solar thermal domestic hot water system, and PV for electricity. Because there is a 30° F (16.7° C) swing between daytime and nighttime outdoor temperatures, summer cooling can be achieved through high thermal mass that allows the storage of night time "coolth." A ceiling fan helps the comfort level as well.

Kevin & Jennifer's System Costs

Component	*Cost*
Trace 4024 sine wave inverter	$2,675
Trace DC disconnect	$231
2 Trace C-40 controllers	$294
18 Siemens SP-75 modules	$7,182
16 Trojan L-16 batteries	$2,880
Inverter cables & battery interconnects	$149
Liquidtight conduit and fittings	$165
Array combiner junction box and fuses	$373
Lightning arrestors	$87
E-Meter	$190
DC breakers, AC breakers, and boxes	$90
Aluminum array mounting frames	$366
PVC conduit and fittings	$40
Wire	$288
Labor	$1,400
Total	$16,410

Above: A view from the southwest.

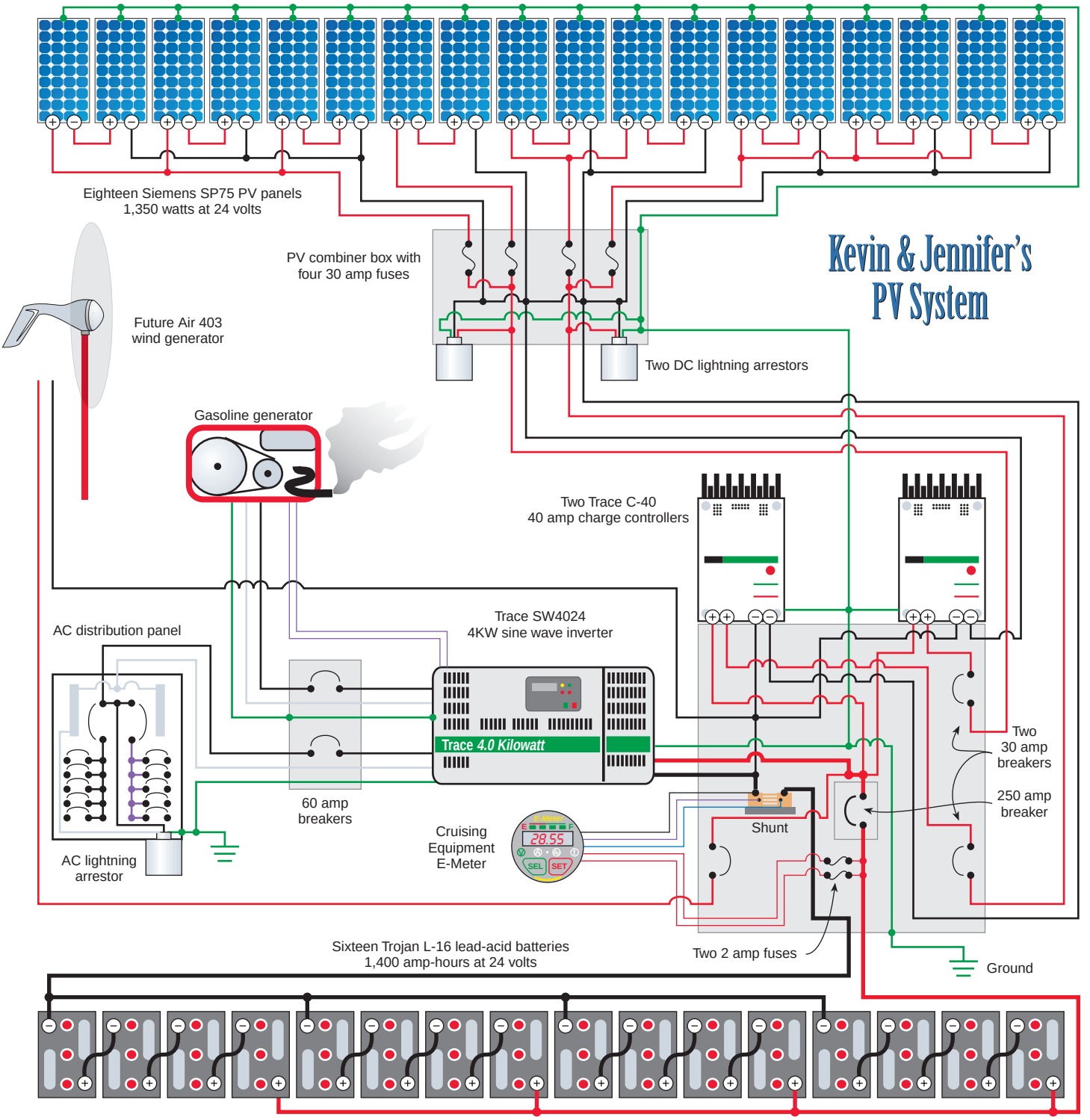
Efficiency is King

Since the house was conceived with PV in mind, every appliance was evaluated for its efficiency. For example, the backup space heating is an in-floor heating system, using a timer-controlled AC circulating pump to supply propane heated water to the floor loop. The DC pump on the domestic hot water system is powered by a 10 watt solar module.

The lights in the house are a combination of fluorescent and halogen. The refrigerator is an energy efficient 22 cubic foot (0.62 m^3) Whirlpool SERP model that uses less than 1500 watt-hours per day.

PV System

The PV system consists of eighteen Siemens SP-75 modules installed on three adjustable side-by-side roof mounts. These can be angled from 20° in the summer to 50° in the winter. Solar insolation ranges from about 5.4 peak hours in December to 7.7 peak hours in June. The PVs are configured as four subarrays at 24 VDC and are wired to a junction box on the roof. They are then combined into two independent wire runs to the battery room. The junction box has two DC lightning arrestors.



The batteries and controls are in a dedicated room on the north side of the house. Two Trace C-40 controllers are installed there, one controlling 20 amps, and the other 25 amps. These are attached to a Trace DC disconnect box, which houses the 250 amp main inverter disconnect breaker. The PV disconnects, the E-Meter shunt, and an additional breaker for a future Air 403 wind generator are also wired into the box. The inverter is a 4KW Trace SW4024 sine wave, and the E-Meter is attached just below the inverter conduit box. The battery room also houses the main AC breaker panel for the house, and an additional AC lightning arrestor.

Below the power board is a battery box, vented to the outside. The box contains sixteen Trojan L-16 batteries,

Above: Trace components control it all.

for a total capacity of 1400 amp-hours at 24 VDC. The temperature in the room stays at 65 to 68° F (18–20° C) year-round. Since the batteries are in a conditioned space with a stable temperature, their total capacity should be available throughout the year.

Power to Spare

So how well is the system working? Kevin and Jennifer moved into their new house at the end of October of '97, just in time to test the system during the winter minimum production period. The E-Meter shows an average consumption of 80 to 120 amp-hours per day. During the worst month (December), their array produced about 214 amp-hours per day. The batteries are topped off by 1 PM on most days. They should be able to go through most of the storms in this area without any need to run their backup generator. They have all the comforts of home, and power to spare!

Access

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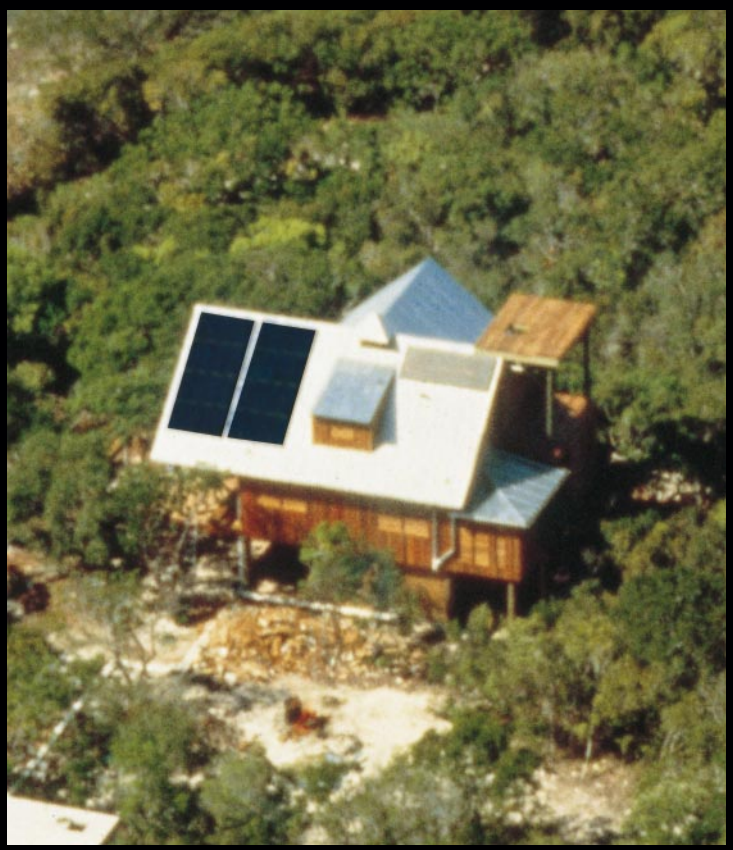

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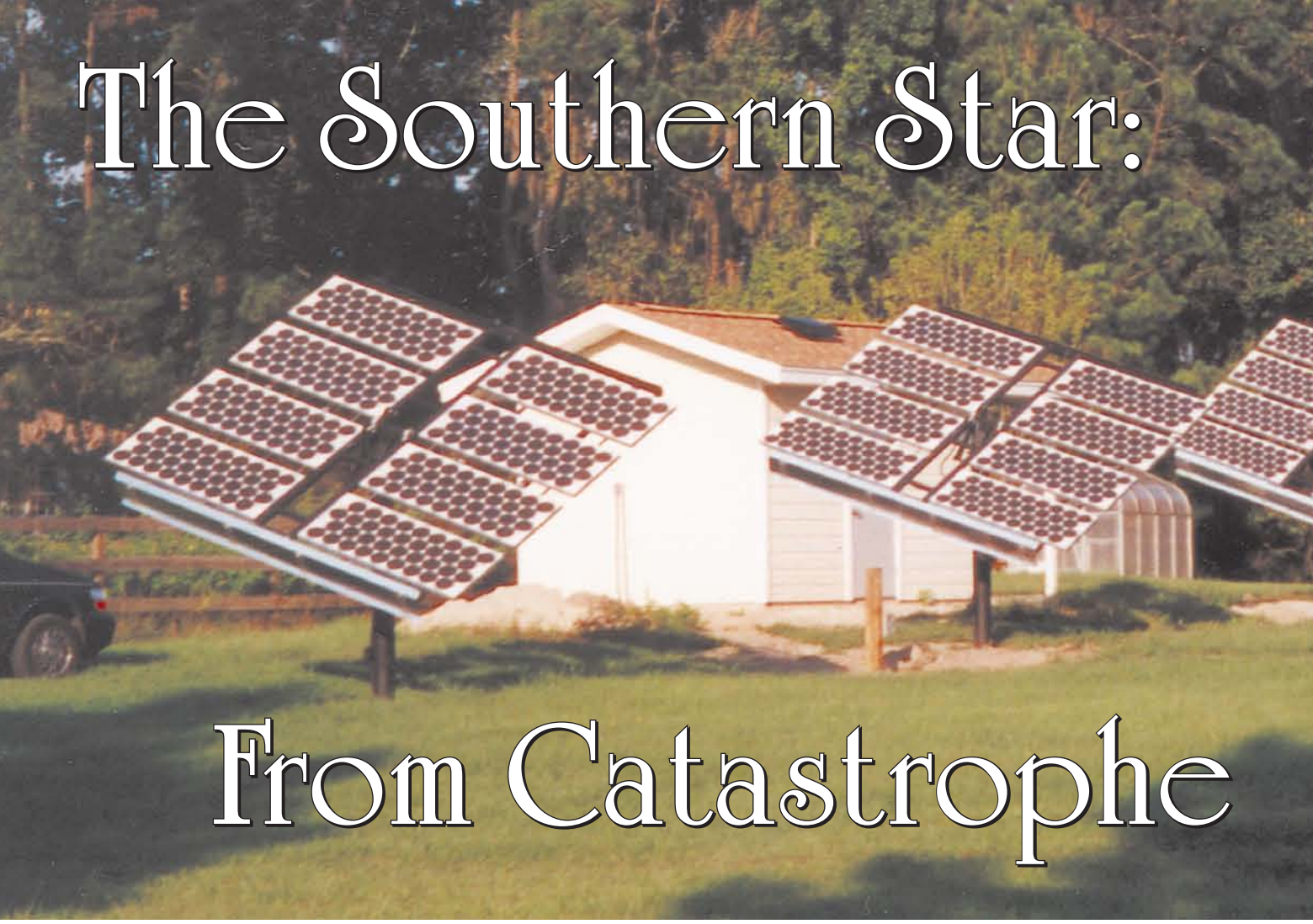
The Southern Star: From Catastrophe



Above: Six Zomeworks trackers hold eight 100 watt Siemens SR100 watt panels each for 4,800 watts at 48 volts.

After surviving the devastation of Hurricane Andrew, Al Ford moved his family from southern Florida to the rolling hills of northern Florida's Alachua County. Living through the aftermath of the hurricane—months of no running water, flush toilets, air conditioning, or fans during the heart of a tropical summer—Ford developed a clear awareness of the fragile nature of grid-connected power.

Because of his experience, Mr. Ford asked Energy Conservation Services of North Florida (ECS) to develop a solar power system to back up his new home's diesel generator. Mr. Ford wanted to develop a solar electric system not only for personal comfort and reliability, but also to inspire others. He wanted to show that solar technology is not only economically viable, but the best socially conscious power choice today.

Set an Example

Ford believes that environmental consciousness should motivate both decisions and actions. He wanted his system choice to set a sterling example of how southern shelters could be upgraded cost-effectively, while still protecting Florida's fragile environment.

The total cost of the system was $69,000, including the battery house and all controls. The system design was meant to encourage two groups of new homeowners to consider solar—affluent southern homeowners who often spend $25,000 to $100,000 to upgrade their bathrooms and kitchens, and a wider range of southerners who could afford to choose smaller, affordable, off-the-shelf solar backup systems.

The Al Ford solar electric system was given the name "Southern Star" because it was meant to be an example that any licensed solar contractor or electrician could easily duplicate. The design goal was long term reliability in the hot humid subtropical climate, with little in the way of homeowner maintenance and monitoring. Mr. Ford did not want to be technically involved with his power system any more than a typical homeowner wants to be involved with his HVAC system.

to Inspiration

Tom Lane and Linda Tozer

Space between panels and tie-down loops on the corners of the trackers provide protection from hurricanes.

Plug into the Sun

We hope this article will help readers realize how easy it can be to "plug into" the sun. After twenty-two years of solar contracting, we can easily appreciate the autonomy and design of Trace's new Power Panel. The grid-connected homeowner does not want to own a unique system that requires daily involvement. The typical off-grid system designed today for people in remote homes is not autonomous enough to meet the needs of most people. The future of our industry in the South, if solar is to become a part of the mainstream in grid-connected homes, is simplicity, reliability, and autonomy.

To overcome past design dilemmas and create a system that would have long-term reliability in a humid subtropical climate, we tried to design a uniformly balanced system that could be assembled quickly and checked easily for system malfunctions during and after installation. These design hurdles have been a stumbling block to local electrical contractors. They generally choose simple stand-alone generators over the environmentally and technically superior inverters with battery chargers and solar electric backup.

System Design

The Fords' solar electric system uses a Trace Power Panel that includes two SW4048 sine wave inverters, producing both 120 and 240 volt AC power. This Power Panel delivers 8 KW, with a surge capability of 18.7 KW, to power a 1.5 horsepower well pump and every electrical circuit in the home except the air conditioning circuits.

The system includes two 40 amp Trace C-40 charge controllers, each with digital meters and LCD displays. These meters allow all wire connections from the solar arrays to the power panel to be checked individually.

The photovoltaic array contains 48 SR100 Siemens modules. They were configured individually as 6 volt modules at 12 amps each. These 100 watt modules, mounted in eight panel arrays on six trackers, were then wired as eight panels in series to create 48 volt arrays at 12 amps. This wiring scheme is not advisable if shading is a problem, but these trackers are in full sun for more than eight hours a day. Wiring this way was greatly simplified—only one #8 (8.4 mm^2) flexible wire run exits each tracker.

Above: The Ford house has a solar hot water system with panels on the roof.

The two rows of three Zomeworks Universal Track Rack trackers were wired and fused as two parallel subarrays, each at 48 volts and 36 amps, in a lightning-protected combiner box. Every combiner has a separate wiring run of #2 (33.6 mm^2) wire to one of the two C-40 controllers. The digital voltage and amperage meters on each controller enabled ECS' technical crews to fine tune the trackers and the wire connectors, producing nearly identical amperage and voltage readings from each subset of three trackers. The Siemens SR100 modules consistently delivered higher than claimed amperage and voltage to the power panel.

Tracker Features

Several unique installation features for southern sites were incorporated into the installation of the Zomeworks trackers. Each tracker had four D-rings welded onto its corners. This will enable us to level out and strap down the corners to earth anchors within minutes if a hurricane approaches. The SR100 modules were spaced a few inches apart, moderating the dangerous sail effect of a solid, massive array in a hurricane.

The new universal Zomeworks tracker, which comes knocked down in pieces, made it easy to bring all six trackers to the site for assembly using one trailer. The universal tracker is a design breakthrough that costs only $175 more than a fixed pole mount rack. Trackers are definitely cost effective below 34° latitude if you ground mount more than 600 watts per array and get full sun for at least seven hours a day.

We used a special flat black, high temperature coating to weatherproof and rustproof the racks for the humid southern climate. For installation anywhere near the ocean in Florida, I don't recommend the painted mild steel typically used in manufactured racks. Only anodized aluminum, stainless steel, or pressure treated wood should be used in a mounting system that will be in the salt air of coastal environments.

We encountered wet, sticky, southern "gumbo clay" while digging the six holes for the tracker poles. Fortunately, we subcontracted to a local tree planting company whose power spades made quick work of digging the holes. Six inch (15 cm) schedule 40 black iron poles were heavily duct taped where they were surrounded by concrete in the ground and sprayed with an automotive rubberized black bumper coating above ground. A post hole digger was used to round out a one foot deep, six inch wide (30 by 15 cm) hole at each hole's center to drop the bare tracker pole into the earth below the pole's concrete collar. This helped to ground the pole to the earth for lightning protection.

Below: ECS crew members (from left) Jamie Dempsey, Shirley Lane, Tom Lane, and John Ault in the custom built power shed which houses the Trace Power Panel and thirty-two Trojan L-16 HCs.

Batteries

The battery bank consists of thirty-two high capacity 6 volt 395 amp-hour Trojan L-16 batteries. The L-16 HCs are a bargain in that they cost only $12 to $15 more per battery than the standard 350 amp-hour L-16s. These batteries, besides having an extra 45 amp-hours per battery, have dual positive and negative terminals. The extra stud terminal made it easy to make the fourteen connections between the eight batteries in series. Four strings of eight batteries resulted in a 1,580 amp-hour bank at 48 volts.

Our battery suppliers made installation easy by cutting the twenty-eight series and six parallel battery cables to exact lengths in red for positive and black for negative. The cables were crimped and heat shrunk to pre-measured specifications and delivered with the batteries, ready for installation. Positive and negative battery ends and four pairs of 3/0 (85 mm^2) welding cable for the two Trace inverters were also pre-manufactured, allowing rapid assembly upon arrival.

Above: An aerial view from the south makes the huge array seem small.

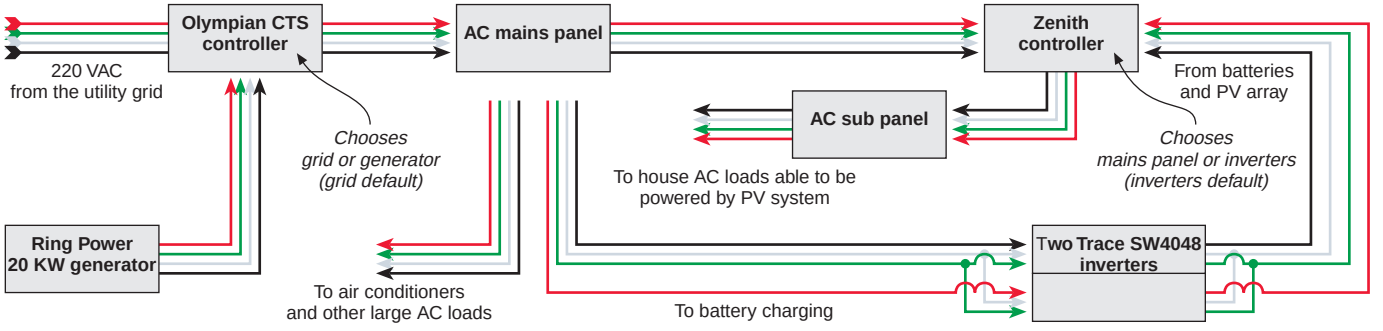
A battery box to contain the battery system was pre-built from marine grade plywood and pressure treated pine. This was fiberglassed, and then treated with rubberized bumper coating.

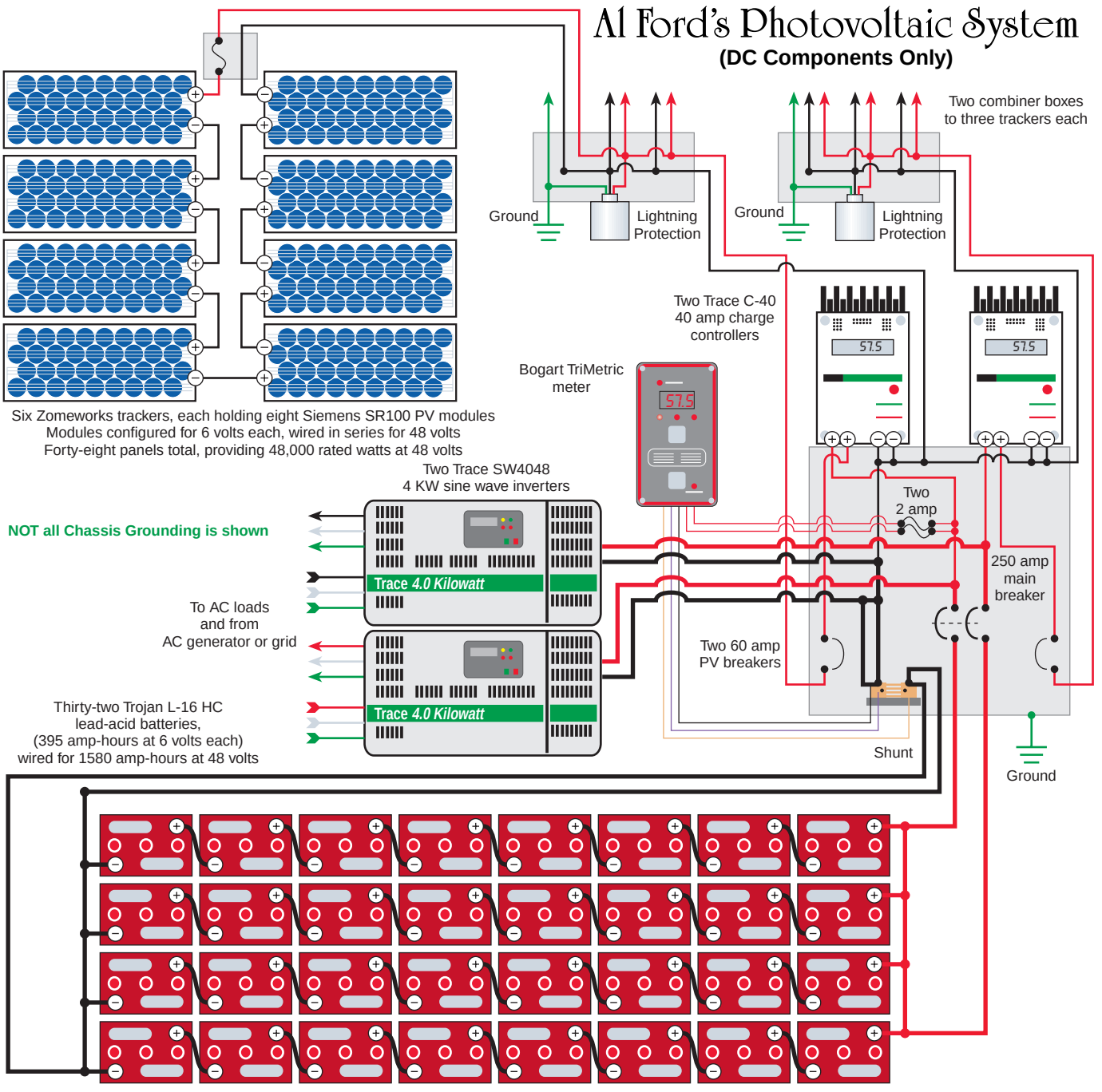
When the job permit was pulled, I asked the electrical inspector about using welding cable for battery connections. He advised me that the cables supplied by the authorized Trojan battery distributor would satisfy the National Electrical Code, and plain common sense. So, having the battery distributor manufacture the interconnect cables saved time and made it easy for the electrical inspector to approve the battery bank.

Power Room

The battery and system components room was built on a 10 by 14 foot (3 by 4.3 m) concrete slab. It was poured along with the tracker holes, saving time and money. Insulation and sheetrock were applied to the room walls, but the ceiling was left exposed. Then the ceiling, interior walls, and exterior metal door were sprayed with LO/MIT-1 radiant barrier coating. This radiant barrier paint's low emissivity and low absorptivity will help to keep the room cool in the summer and warm in the winter. The pure aluminum coating, often used in car firewalls, also provides a shield against electromagnetic pulse and other outside electronic interference. The paint's spectral reflectivity is 98 percent, helping to illuminate the room with minimal lighting.

AC System Flow





To help vent any hydrogen created by the battery bank, the roof has a continuous ridge vent combined with a direct PV-powered fan on the southern roof. Storage batteries were eventually capped with Water-miser safety vent caps. These extend watering intervals for a safer fume-free environment in the battery room. These caps will not melt down during equalization charges.

Automatic Operation

One unique aspect of this system is the automatic operation. The battery bank is protected and maintained by grid power if necessary, or by a backup diesel generator should the grid fail. The diesel generator is capable of supplying the home's entire load and has its own transfer switches which will automatically start and operate it at full speed within seconds. The inverter battery chargers were programmed to bring the battery bank to full charge with grid-connected power whenever the battery bank drops to 60 percent of its rated capacity. If the grid fails, then each inverter battery charger has generator power available for charging.

The solar input to the system passes through a Zenith automatic transfer switch connected to the sub-panel used for powering the 110 volt and some of the 240 volt loads in the Ford home. The transfer switch automatically transfers back to the grid or the generator if the solar electric system malfunctions. Upon grid failure, there is virtually seamless power generation. For the Ford's home to lose power, it would take a failure of all three systems—grid, generator, and solar.

The solar control center and battery room is locked and only accessible to ECS solar technicians and the electrical subcontractor. The Fords can monitor the battery banks, voltage, input from the solar array, and system contribution to the home's load each day by viewing the TriMetric battery monitor located on an outside wall of the battery room.

An annual maintenance contract will assure the Fords a trouble-free system. Within the next few months, we will create a modem connection to inverter ports so that the system can be monitored directly from the ECS office.

The 1.5 hp conventional well pump will be replaced by a three inch diameter Grundfos integrated variable frequency drive submersible pump which has no starting spike. This revolutionary and inexpensive AC submersible Jetsub well pump only operates on a sine wave inverter. Because it has a soft start, it makes extra inverter power capacity available.

Solar Water Heating Systems

The downstairs and upstairs water heaters in the Ford home were re-plumbed in series. Two 41 gallon (155 liter) PT-40 ProgressivTube passive batch solar water heaters were also plumbed in series with the electric water heaters. These preheat the water for both electric backup water heaters.

A small direct-drive DC pump wired to a 10 watt Siemens PV module circulates water from the bottom of the upstairs water heater through the solar water heaters to the bottom of the downstairs tank. Water then leaves the downstairs tank from the top water outlet and is delivered to the bottom of the upstairs tank. This strategy assures the homeowner of 162 gallons (613 liters) of heated water. The lower electric elements were disconnected to minimize power consumption from the grid. The backup upper elements only operate if water temperature drops below 120° F (49° C).

Future Sustainable Community

Al Ford plans to develop more than 200 acres in nearby Alachua into a sustainable solar-powered community. Part of his inspiration came from a visit to a Ford automotive manufacturing plant that uses a massive array of Siemens modules to help power the plant. The sustainable building strategy for the community is to incorporate natural earth-friendly recyclable building materials into the homes. Ivor Sparks, a local builder who specializes in sustainable building with natural materials is working with Mr. Ford on the community design.

Above: Tom Lane (left) and Al Ford celebrate the completion of the system.

Single family homes are planned around minimal automobile use. Traffic design will make it easy to walk or bicycle to community shopping, parks, and entertainment. Potential community homeowners will be able to choose from an array of earth-friendly home building materials. Solar electric system designs will use prepackaged, preassembled components, creating a more compact and less costly system than the Fords'. This will give the community homeowner access to affordable and easily installed and maintained systems.

This community design will help others realize that solar and other environmentally friendly technologies are viable today. They are, in fact, an integral part of any sustainable 21st century community seeking to renew rather than waste the planet's resources. Jobs for some of the people living in the new sustainable community may be provided by the University of Florida's high technology Progress Center in nearby Gainesville. The Center, as planned by the University of Florida, will serve as an incubator for research and to foster new high-technology jobs.

A Long Tradition

Pioneering new energy technologies is in Al Ford's blood. Mr. Ford's great-grandfather was Henry Ford of the Ford Motor Car Company. Henry Ford had his own home power electrical generator in Dearborn, Michigan, designed by his friend Thomas Edison. This independent home electrical system is thought to have been one of the first in the nation.

The original system included hydro-electric power, a steam-powered generator, and a large battery bank for backup. The hydro-electric system was recently restored by the University of Michigan and is still providing the home with electric power. It consists of two 55 KW DC generators coupled to Leffel turbines. The eight foot high dam and special venturi system give power equivalent to that of an eighteen foot high dam.

The battery bank was removed in 1925 and the system is now tied to the grid. The steam power equipment is still on site, but not operational because of safety concerns. The Ford home is a National Historic Landmark on the University of Michigan campus in Dearborn, and is open to the public.

The friendship between Henry Ford and Thomas Edison prompted them to build homes near each other in Fort Myers, Florida. These homes and Edison's lab are still standing and are open for public viewing.

Why Florida?

Florida is the home of the Florida Solar Energy Center, the Florida Solar Energy Research and Education Foundation, the Florida Solar Energy Industry Association, and the Florida Energy Office at the Department of Community Affairs. Recent accomplishments of these organizations include the elimination of state sales tax for solar equipment, a state law preventing homeowner associations from establishing covenants which prohibit solar collectors, and builder incentives for installing solar energy equipment.

These organizations also have been instrumental in opening up new Florida housing markets and in assisting Florida companies in the export of solar equipment throughout the Caribbean Basin, Mexico, and Central and South America. Florida solar electric sales climbed dramatically in 1998, a result of these groups' efforts, a series of southern climatic catastrophes, and in response to the Y2K issue. We also expect solar electric contractor jobs to spiral up dramatically over the next few years.

Our industry association is lobbying the State Legislature to introduce a "Solar Christmas Lights Bill." This bill, initiated by Tom Lane, Technical Director of FLASEIA, and Peter DeNapoli of Siemens Solar, would allow homeowners to plug up to 600 watts of solar electric power directly into their wall sockets—just like plugging in Christmas lights. They are already allowing this in Holland, with Trace Micro Sine Inverters on the back of solar electric panels. The proposed bill would allow the homeowner to do this without permits and without utility approval. People who support green energy could give their friends a 100 watt solar panel each Christmas or on our annual state "Sun Day."

Solar Future Today

The future of solar electric power is today. The Southern Star that Al Ford built can help others realize that this technology is affordable and readily available. It is ready for the builders, architects, and real estate and banking industries to offer to the public as a real "upgrade" to basic shelter. Solar technology can power the base electrical load with only a 10 to 20 percent budget increase for most homes. This is a minor investment for most homeowners; it will not lose its equity value, and it can be expanded in the future.

Al Ford's commitment to solar energy should be celebrated as a showpiece of environmentally responsive design that can be easily copied. His Southern Star is an example and a challenge to inspire others to make solar energy a part of their lives.

Access

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SIEMENS

By providing power to a remote canyon in northern New Mexico, Siemens is helping an ancient order of Benedictine monks thrive in the modern world. The Monastery of Christ in the Desert sought safe, reliable, affordable energy to build and run new facilities and pursue a high-tech livelihood—designing sites for the World Wide Web. Connecting to the nearest electric grid would have cost more than $1 million, but Siemens turned on the lights for a fraction of that. Mounted on trackers that follow the sun throughout the day, eight solar arrays produce enough energy to run everything from computers to kitchen appliances.

The monastery's building program—designed to use cost-efficient, environmentally friendly materials—has attracted global attention from those seeking to renew rather than waste the world's resources. Powered by Siemens technology, this religious community is a model of spiritual devotion and sustainable living.

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Camarillo, CA 93011
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Trace Engineering

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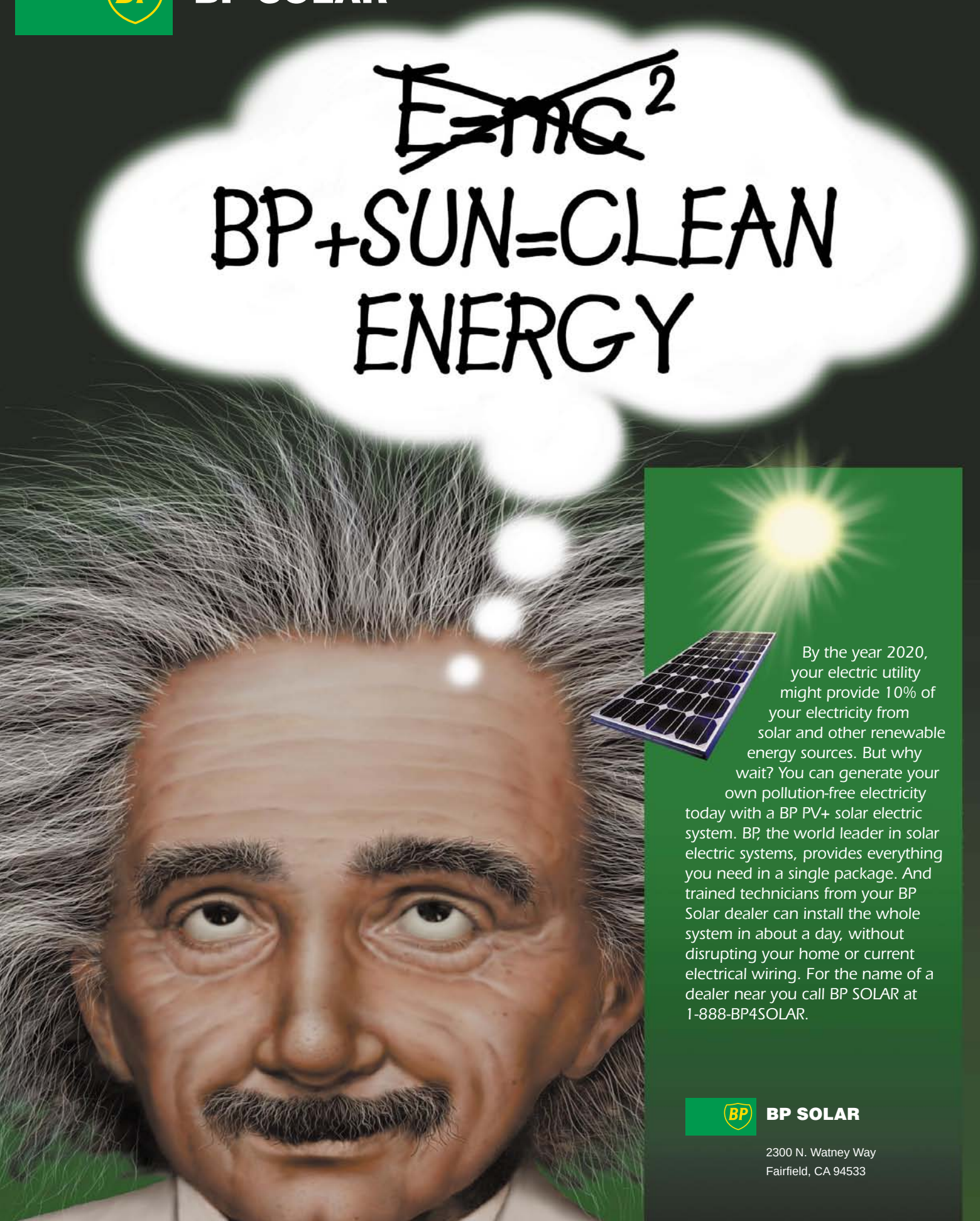
This is page 22

BP SOLAR



By the year 2020, your electric utility might provide 10% of your electricity from solar and other renewable energy sources. But why wait? You can generate your own pollution-free electricity today with a BP PV+ solar electric system. BP, the world leader in solar electric systems, provides everything you need in a single package. And trained technicians from your BP Solar dealer can install the whole system in about a day, without disrupting your home or current electrical wiring. For the name of a dealer near you call BP SOLAR at 1-888-BP4SOLAR.

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Retiring But Not Shy

Mark Fitzgerald

Above: The Lords' home with integrated PV and solar thermal panels. Below: The sunny living room. Photos by SDA.

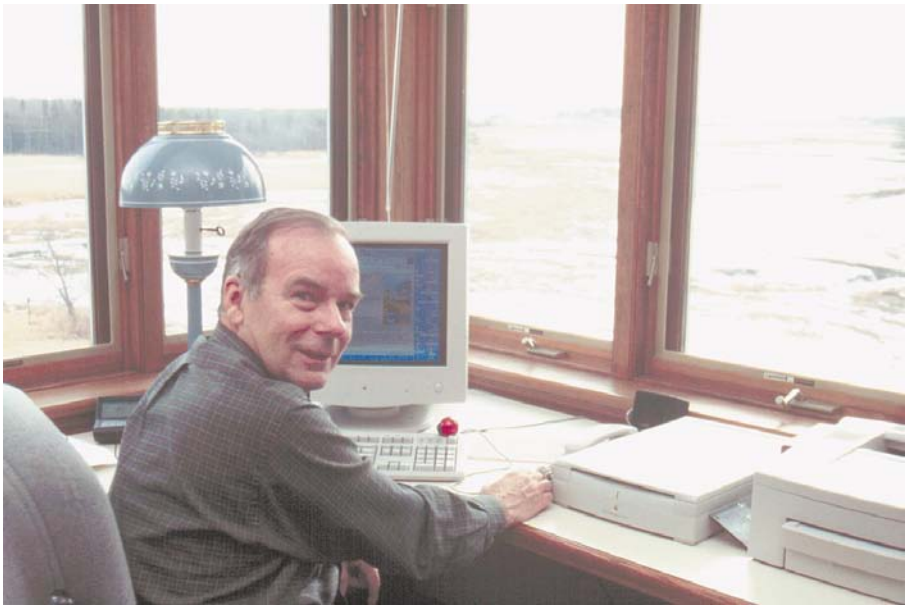
It's a Tuesday afternoon in July at the Lord home on the Maine coast, and the meters tell us that all is well: 74 amps at 43 volts into the inverter, and just over 13 amps at 230 volts out. The array operating temperature is 48° C (118° F). The system is on a pace to easily exceed four megawatt-hours again this year, as it has each year since it was turned on in March 1995.

If you already live in a sustainable, PV-powered home, you will readily appreciate what Bill Lord has to say about his home. If you are looking forward to the day when you become energy self sufficient, and you want to know more about what's in store, you can ask Bill yourself. Not just proud of his home, Bill has taken it upon himself to make sure that anyone who is interested in the systems he is using has access to his experience. He's a *Home Power* kind of guy. While not exactly an evangelist, this is a man who knows how to communicate.

Lighthouse

Bill and Debbi Lord have returned home to the rocky coast of Maine, where Bill grew up. Like the lighthouses that dot the coast, Bill uses his Web site to provide an important point of reference to those navigating the

world of sustainable energy technologies. The Web site is full of information on all aspects of his home's evolution, development, operating history, and status. Bill's passion for communication rivals his passion for sustainable technologies. He responds to dozens of email messages each month from students, industry professionals, and other interested people.



Above: Bill updates his renewable energy Web site.

Why did the Lords choose the path of renewables? Bill retired after 31 years as a producer with ABC News, and is currently a journalism professor at Boston University. After years of commuting to New York from Connecticut, the Lords wanted to retire to the coast of Maine, and had the means to live any way they wanted. Going back to their original plans of 20 years ago, they chose renewables. As Bill said, "I've wanted to do this since before it was called renewables or sustainable energy—when it was just *solar."* Originally, he wasn't as focused on the environmental aspects. His was a practical approach—use whatever is available and effective. The formal environmentalist philosophy came later.

Genesis

The path to this PV-powered home is measured in decades. But the series of events that led up to it really began eight years ago when Bill bought his first copy of *Home Power* magazine at a newsstand. In college, Bill wanted to be a physicist, so PV was a technology that he could really get his arms around.

About six years ago, the Lords got a Real Goods catalog in the mail. They decided to take the Tour of Solar Homes, which ranged from rustic to elegant. What struck Bill and Debbi both was that all the homeowners were making a common statement with their lifestyles, and they were "damn proud of what they were doing." These were kindred spirits.

About the same time, ABC News was reporting on a PV-powered exhibit at the Museum of Natural History in New York City. There, Bill met Steven Strong, of Solar Design Associates, the designer of the exhibit's power system. Bill had Steven's book, *The Solar Electric House,* and knew that this was the person to build his sustainable home.

Design Process

What followed was a two and a half year design and development process. Thorough communication between Solar Design Associates and the Lords made the project successful. It started with early idea meetings and continued with design sessions. Bill and Debbi even walked through their old house with a video camera, recording what they liked and didn't like.

What came through most strongly during the design meetings was that family and a sustainable future were most important to the Lords. While it was to be their retirement home, it had to comfortably accommodate regular visits from their children and grandchildren. The home also had to have minimal environmental impact.

It was a team effort. Solar Design visited the building sites the Lords were considering to assess the solar potential. "At the second site, Steven pulled out his compass...and blessed the property," said Bill. "We had begun the process." Another key was working with a local contractor, Tim Spang. His reputation for quality work and an enthusiastic, *can do* attitude, made Tim and his crew an obvious choice.

Integrated Systems

The 2,900 square foot (269 m^2) home was designed to be very organic—an integrated system of efficiency, energy, and sustainable technologies, each optimized to work as part of the whole. The systems include the PV and solar thermal systems; super-insulated walls and ceilings; radiant heating in the floors; low-consumption plumbing fixtures; high-efficiency lighting, with air-sealed, recessed fixtures; and heat-mirror, argon-filled windows, with R-8 ratings.

In a home with a tight envelope, indoor air quality is a concern. Solar Design included heat-recovery

Above: Bill's yearly excess could power an average U.S. home for a month.

ventilation, dedicated outside air for exhausting appliances and the wood stove, a central vacuum system, and a passive radon mitigation system under the basement slab.

All of these systems seem invisible to the Lords and their guests. All the systems, that is, except the roof-integrated thermal collectors and PV array. Those form a continuous, blue-gray south roof surface, replacing the traditional roofing materials. They are the only outward evidence that this home is more than just another pretty building.

Solar Thermal Systems

The solar thermal system, with its 480 square feet (45 m^2) of collectors, provides space heating and domestic hot water. Heat is distributed in the multi-zone radiant floor system of cross-linked polyethylene tubing in one and a half inch (38 mm) concrete floor slabs. The drain-back solar thermal system stores its harvest in two sequentially staged (series-connected) 500 gallon (1,893 liter) insulated storage tanks in the basement.

The radiant system is fed directly, while the domestic hot water is cycled through a heat exchanger in the tank. The system is backed up by a 34 gallon (129 liter) sealed-combustion, condensing propane boiler. The Lords also use propane for drying clothes and for cooking.

The radiant heating system in the floors works particularly well with solar thermal systems. The low delivery temperatures required by this type of heating strategy wring the most out of the BTUs harvested from the sun. For cooling, the house takes full advantage of the prevailing breezes to cool the interior, eliminating the need for mechanical air conditioning.

PV Array

The 4.2 KW, 384 square foot (36 m^2) PV array is made up of 16 high-voltage ASE Americas modules. They are passively cooled by means of a thermosiphon air flow from behind. The system includes a battery bank and two Trace inverters. A primary inverter is used for grid-intertied operation, and a secondary 2.5 KW mod sine wave inverter (Trace U2536SB), with twelve BP sealed batteries, comes online when the grid goes down.

Central Maine Power's net-metering policy made it feasible to go utility-interactive rather than stand-alone. (See Bill Lord's article in *HP65,* page 52.) On the Lords' home, there are two meters—one measures power purchased from the utility, and the other measures power sold to the utility. They are balanced one-to-one against each other on a monthly basis. If the Lords use more than they sell back, they pay the difference at the retail rate. If the Lords sell more than they consume, the utility must only pay them at its avoided cost, which is substantially lower than the retail rate.

While the Lords considered going stand-alone (they may still, one day), the availability of the grid and the simplicity of the connection made the initial choice quite easy. That, and it just tickles Bill to have Central Maine Power owe him money at the end of the month.

The original design did not include a battery backup system. However, after the severe ice storms of 1998 caused power outages across the state, the Lords decided to upgrade the system to provide backup power to critical loads. The backup system was

Below: Two 500 gallon insulated storage tanks.

designed and installed by Peter Talmage of Talmage Solar Engineering, a friend and neighbor.

The PV system went online March 3, 1995, officially marking the completion of the construction phase and the beginning of the sustainable living phase. The system has averaged a production level of about 400 KWH per month.

A Mind of Its Own

Now that he's lived in the home for more than three years, I asked Bill what strikes him most about living in a sustainable home. He said that it took a while to learn that the home has a "mind of its own." The house is monitored and tuned through a network of sensors, so things like temperature and air flow don't have to be adjusted. The thermal sensors in the rooms of the home are set to control the radiant zone heating system via a series of motorized zone valves.

The house has a heat-recovery ventilation system, which has its own control with a manual override. And as much as they love the atmosphere it provides, they don't often get to use the wood stove. The house is so well built that the added energy quickly overheats the home, even on cold Maine nights.

Bill said that he and Debbi feel that they are becoming creatures of the sun. They are more aware of the sun, they feel healthier, and they are more attuned to the weather. They also love watching the sea birds stalking in the marsh, or waking up to see a moose or a fox in the front yard. But most of all, they feel they are making a personal difference—for themselves, for their children and grandchildren, and for their community.

Upscale Renewables

Some people might think this type of house should be featured in *Architectural Digest,* leaving the pages of *Home Power* to those living a simpler life. Sometimes there seems to be a rift between people who choose PV as a component of a simpler life, and those who add PV to a more conventional or upscale home. The truth is that they have more in common than not.

The Lords believe that those who can afford to build a home like this should be willing to spend the additional five to ten percent of the cost of the home on sustainable energy technologies, ensuring that they are not a drain on the world's resources. The Lords have chosen to be an example, showing that responsible living is both practical and realistic. And, though they are in an area of high-priced homes, theirs is just one of four within a mile that uses renewables. Others include an architect living off-grid, a home with a wind generator, and one with a PV system on the guest house. Even their neighbors, George and Barbara Bush, have a solar thermal system on their home.

Above: Installing the high voltage ASE modules.

Not a Tough Choice

Bill has many reasons for wanting to live in a sustainable home. He will quickly tell you that he would prefer that the nearest nuclear plant be 93 million miles away. He's concerned that the Seabrook nuclear power plant is only 60 miles southwest of them and the Maine Yankee plant 60 miles to the northeast. Bill and his family want to do whatever they can to reduce the need for plants of this type. Another thing Bill said cuts to the most human reason of all: "There is no need to sacrifice lives for oil. The Middle East sells us oil. God gave us the sun for free. It shouldn't be such a tough choice."

Access

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Left: Bill and Debbi are happy with their renewable energy system and proud of the example they are setting.

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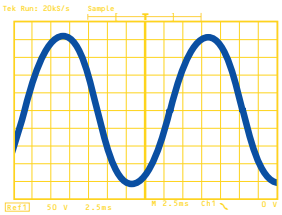
More than just Power



PROsine's True Sine Wave output: so smooth, it's usually better than local electric utility power.

The digital LCD panel on the PROsine 1000 & 1800 can be rotated in 90° increments to accomodate any inverter installation orientation

PROsine Interface panel: occupies the chassis cavity when the standard PROsine LCD panel is mounted remotely.

PROsine 2.5 True Sine Wave inverter•charger

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PROsine 1000 True Sine Wave inverter*

**Available with hard wire, GFCI, and transfer relay options.*

PROsine 1800 True Sine Wave inverter*

The new PROsine™ line of true sine wave products are truly a breed apart. With PROsine's true sine-wave output, all your equipment runs exactly as its supposed to without any unwelcome surprises. You get heavy-duty technology without all the bulk and weight of competitive units, allowing you more choices for installation and location. And speaking of installation, easy-to-understand manuals get you up and running quicker than ever. All models are CSA approved to UL standards for Solar Photovoltaic use.

Each PROsine model has its own easy-to-understand remote display panel. Use it to access information on battery and inverter status, and to monitor battery charging capacity at all times. The removable LCD panel on the PROsine 1000 and 1800 is also rotatable. Flip it around in any orientation, or mount it remotely anywhere you want.

The PROsine 2.5 and 3.0 know a lot of tricks too. Both offer smart 3-step battery charging with temperature compensation so your batteries never boil. Their high charger power factor allows you to draw up to 30% less generator current than many competitive inverter/chargers and still provide the same charging current. Combined with rated charging current down to 95V AC, you'll run your generator less and reduce your system operating costs.

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Read **Things That Work** article on the PROsine 2.5 in Home Power #69

Southwest Windpower

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Some Things Simply Thrive in the Sun.

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TOP SECRET

GUERRILLA SOLAR PROFILE: 0002

Date: April, 1999

Location: Somewhere in the USA

Installer Name: Classified

Owner Name: Classified

Intertied Utility: Classified

System Size: 1082 watts of photovoltaics; 900 watt wind generator.

Percent of Annual Load: 90%

Time in Service: 18 months +

Notes: Our system includes 18 PVs totaling 1082 peak watts, a Whisper 900-H 1 KW peak wind generator, 4 Trojan L-16s, a Cruising E-Meter, and a Trace 4024 inverter set on *sell!* We have safety disconnects and fusing as needed.

Why am I a solar guerrilla? Mainly because of laziness, I guess. I prefer not to be the local test case for legal electrical backfeeding. Jumping through the local utility's regulatory hoops (once they figure them out) is something I am not interested in. This system is safe and wired to code. It is far easier to just do this "under the table."

I choose to operate grid-interactive because this eliminates the need for a large battery bank and charge controller. I can also share clean, renewable energy with others, not to mention the great fun of watching the utility meter spin *backwards!* I have seen this system feed peaks of 1600 watts back into the grid on sunny, windy days. The system meets about 90 percent of my yearly electrical needs. I plan to add four more PVs soon to make this 100 percent.

I have consciously chosen to install and live with renewable energy because it is a very intelligent thing to do. Last year was the warmest year on record. How long can we continue to pump carbon into the atmosphere without reaping the "rewards?" There are higher values than the profit motivations that many (including utility management) sell their souls for. This system serves as an example for others that this technology is feasible and appropriate *now.*

Short term costs suggest that green energy is less economic than the brown stuff. The reality is that today's brown energy "profits" come at the cost of tomorrow's generations. Renewable energy remains the only choice for an intelligent species. I am proud to be a part of the inevitable energy choices of tomorrow, *today.*

This home in Massachusetts has been using a Solarex polycrystalline system for nearly twenty years!

Even skylights aren't an obstacle as demonstrated in this roof-integrated system using Solarex laminates.

Owners of this residence in Colorado chose a state-of-the-art 800 W Solarex Millennia™ system for their new home.

Your Place in the Sun

For over a quarter of a century, Solarex has been the leader in solar electric technology.

While most of the PV industry was content to use single crystal cells, a byproduct of the semiconductor industry, over twenty-five years ago Solarex invented polycrystalline silicon – a technology just for PV. Today, while other manufacturers are just 'discovering' the advantages of polycrystalline silicon, Solarex's technology has been performing successfully in real world conditions for nearly three decades.

Solarex offers choices: two technologies and the most comprehensive product line in the industry. Our Millennia™ module features advanced tandem-junction solar cells, which are a major development in thin film efficiency and stability. Our unique monolithic construction eliminates mechanical interconnection between cells giving the highest possible reliability. Our polycrystalline modules are efficient, attractive, and well proven in more than two decades of use.

Solarex makes products that fit your home. They're designed for easy installation and are architecturally compatible on a broad range of residential roofs. Both polycrystalline and Millennia products can be attached directly to the roof using Solarex's new patent-pending Integra™ frame. Electrical connections in the array are made quickly and reliably without tools, using the connectors integral to each module. Installing a Solarex roof array is easy and typically takes less than a day saving both time and money.

Solarex uses less energy to fabricate each module resulting in an earlier energy pay back as low as one year – far superior to competing technologies. With a Solarex polycrystalline or thin film system you'll be making a commitment to clean energy while reducing your monthly electric bill. Month after month, year after year, your system will be generating free electricity from sunlight.

Give your family solar energy security. Investing in a solar system for your home can offer you and your family freedom from unexpected power interruptions caused by storms, brownouts or other unforeseen circumstances. While others might sit home in the dark, you'll have the power you need.

Call us for more information and the authorized sales and service location nearest to you.

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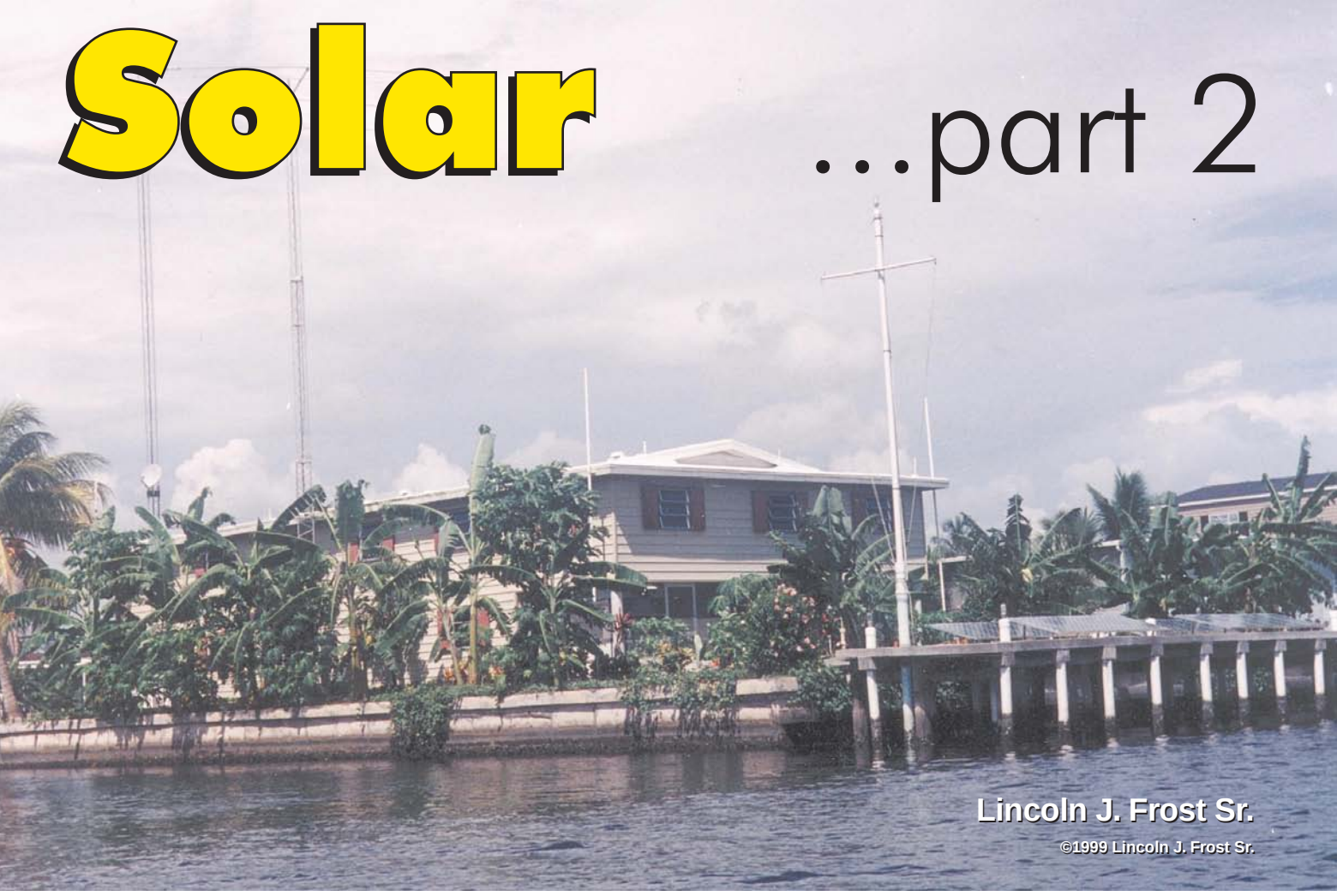
Solar ...part 2



Above: Lincoln Frost's house and dock-mounted PV array in the Florida Everglades. See the article in *HP55* for a detailed description of Mr. Frost's installation.

Have you ever wondered, "What happened to all those solar installations I've read about in *Home Power?* Did they just fade away into the sunset, or are they still working, and if so, how well? What were the 'bugs,' and what were the surprises?" Read on—here are some answers to your questions.

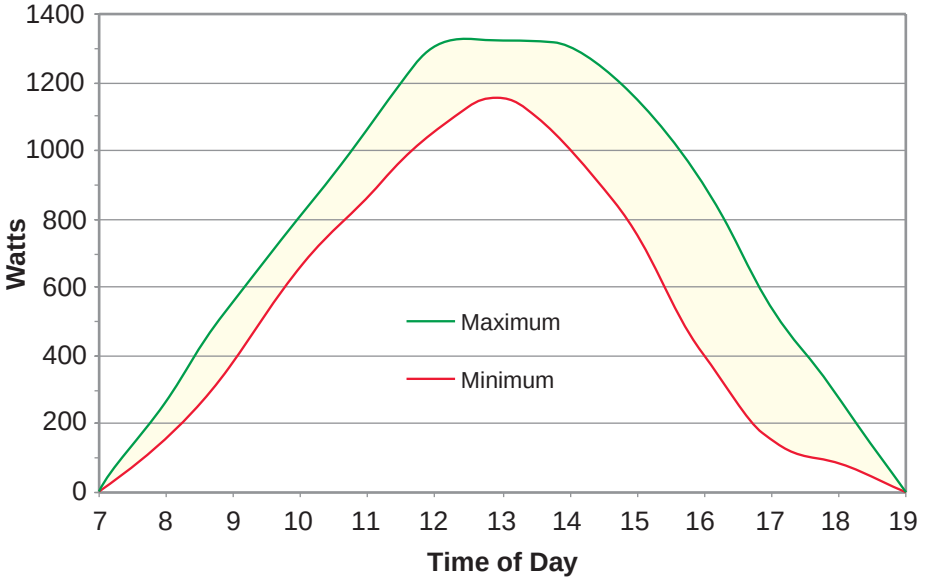
We're located in "Sunny Florida" about 35 miles south of Naples, within the boundary of the Everglades National Park. Our system was described in *HP55,* page 44. Our goal for solar was to supply about half of our 120 VAC requirement. The system included 24 Siemens PC4JF modules (now SP-75s), for a total of 1,800 rated watts; a Heliotrope PWN-CC-120E voltage regulator; and twelve Trojan L-16 batteries wired for 24 volts (1,050 amp-hours). These fed a Trace SW4024 inverter. The 120 VAC from the inverter was wired into a breaker box feeding our household circuits.

Our loads for 120 VAC appliances and tools consist of two computers, a printer, Shop Smith, ham radio (KD4IQC), copier, fax, tea kettle, frypan, toaster, hair dryer, TV, two 16 cubic foot (0.45 m^3) GE refrigerators, etc. *It all works—there are no bugs!*

Table 1: Daily Average Kilowatt-Hours

	1996		1997		1998	
Month	Solar	Grid	Solar	Grid	Solar	Grid
Jan		19.0		15.0	5.5	18.0
Feb		16.0		14.0	5.4	21.0
Mar		14.0	6.0	11.0	4.9	18.0
Apr		13.0		13.0	5.5	20.0
May		16.0		21.0	5.8	32.0
Jun		29.0	6.6	32.0	8.1	46.0
Jul		48.0	6.0	46.0	8.1	47.0
Aug		44.0	10.6	45.0	9.0	54.0
Sep		31.0	7.0	44.0	8.6	51.0
Oct		21.0	10.0	20.0	8.7	44.0
Nov	7.8	18.0	6.3	20.0		
Dec	5.4	16.0	5.1	18.0		
Solar Average					6.8 KWH/Day	

Graph 1: Minimum & Maximum Input Watts



Data

Now just how well does it work? See the graphs and table for some data after more than two years of operation.

Graph 1 shows power output from the PVs over the course of an average day. We get an average of 5.8 hours of sunlight per day here. Not much happens before 7 or 8 AM and after 4 or 5 PM. Cloudy days, misty mornings, and hazy afternoons cut into our electricity production. Our daily average solar input is 6.8 KWH.

Graph 2 shows the relationship between solar input and battery voltage. Most of our household activity occurs during the day, when the sun is shining. Conversely, the zero input occurs when usage is at its minimum.

Table 1 shows actual watt-hour meter readings at 120 VAC. Electricity leaves the Trace inverter and goes mostly to household usage. Occasionally, when more electricity is being made by the 24 Siemens modules than is being consumed by household usage, it goes to the grid. Yes, the meter occasionally runs backwards when the inverter is set on *sell.* Note that considerably more grid electricity is consumed from May through September. This is due to our 240 VAC air conditioning system, necessary in our warm, humid summer weather.

Equipment Performance

The Siemens PC4JF Modules have given us no trouble and are tilted manually March 21 and September 21 to more efficiently gather the sun's rays. The modules seem to produce about 70 percent of their rated capacity. This is total *system* output, including inverter inefficiency and system losses.

The Heliotrope PWN-CC-120E voltage regulator worked well, but needed considerable added heat sink capacity to dissipate heat. There should be a better way to conserve this wasted energy.

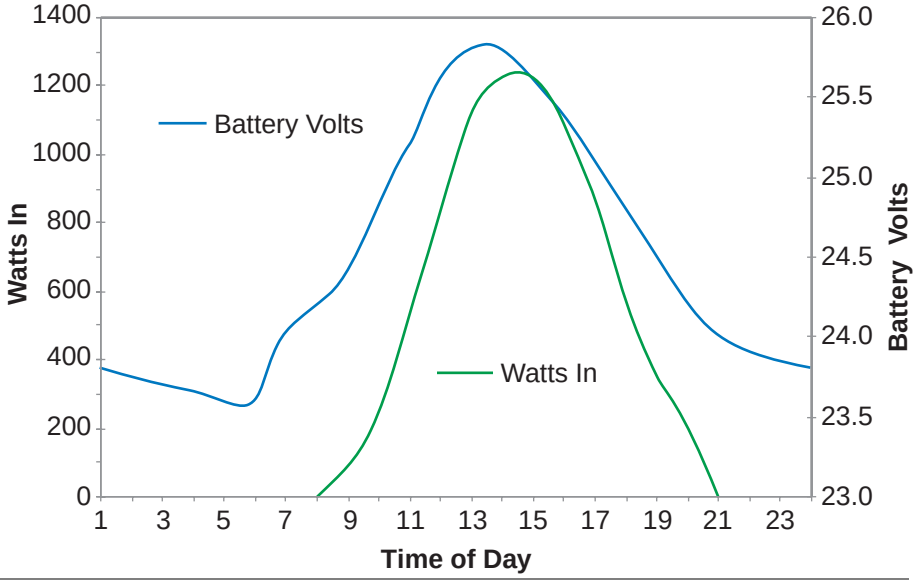
The Trace SW4024 inverter is a superb piece of hardware and has performed well. The instruction manual has been written for experts and those already well versed in the inverter's many capabilities, and not for novices.

The batteries, twelve Trojan L-16s, have been checked and serviced twice a year for specific gravity and liquid level. They are equipped with Hydrocaps and the twelve of them require about 1.5 gallons (5.7 liters) of distilled water twice a year. The batteries are kept clean and all terminals are coated lightly with petroleum jelly.

Success

All of the original criteria have been met. This installation was designed to operate as a grid intertie and to produce about half of our 120 VAC requirements. It does just about that and gives us uninterruptible power

Graph 2: Input Watts vs Battery Voltage



so that our electronic hardware does not fall out due to power interruption or failure.

We now look upon the grid as an unlimited, gigantic battery. Our twelve Trojans are a small battery capable of supplying power for short periods of time if efficiency measures are put into effect. If push came to shove, we could shut down the nonessential gadgets and stuff and at least limp along for several days without the grid! The neighbors used to phone when there was a power outage and inquire if we had power. They don't do it any more because we *always* have power.

I used to economize by getting rid of all the phantom loads, idiot lights, etc. But now I know that for the price of four solar modules—$1,000—I can just let the present appliances and gadget circuitry stay in place and get easily accessible, affordable and replaceable ones. Sometime in the near future, I will probably install four more 75 watt modules and bring the daily solar input close to 10 KWH.

Access
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Power Measurement For Home & Business

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The Brand Digital Power Meter measures and displays: 1 to 1850 watts, 1 watt-hour to 9999 kilowatt-hours and elapsed time in hours. After inputting your energy cost in cents per kilowatt-hour, it calculates the cost to run an appliance in both elapsed time mode and estimated monthly cost mode.

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4-1850 displays:

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20-1850 displays 4-1850 information plus:

peak watts	0 to 1850
amps	0 to 15.00
Volts	0 to 130.0
volt-amps	20 to 1850
VARs	20 to 1850
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Price: **4-1850:** **$149.95***
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Inquiries regarding PC interfacing, meters for DC and 240 VAC applications, international variations and customized instruments are welcomed. Please call for pricing and availability.

You can spend four times the purchase price of a Brand Digital Power Meter and not get the quality results you get with these meters.

Richard Perez, in his review of the 4-1850 Brand Digital Power Meter for *Home Power*, said, "This is the first time that I have wished for more than two thumbs, 'Both Thumbs Up!'"

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TOP SECRET

GUERRILLA SOLAR PROFILE: 0003

Date: April, 1999

Location: Somewhere in the USA

Installer Name: Classified

Owner Name: Classified

Intertied Utility: Classified

System Size: 1200 watts of photovoltaics; 300 watt wind generator.

Percent of Annual Load: Classified

Time in Service: Classified

Notes: Our system includes sixteen Siemens Pro J4s charging 40 Trojan T-105s. All of this is fed into a 555 Ananda Power Center, and then to a Trace SW4024 and UB2524.

I snapped for a different reason than most people, I think. I am an ocean tug boat operator, and I love music. Upon returning home from a three month adventure, I walked into my home and smelled smoke. I followed the smoke to my beloved stereo system which I like to leave on 24 hours a day. It was completely fried, thanks to the local power company fools. This was not the first loss.

I have been a "Wrench" since the 60s. Right then and there, I said "Never again!" That was 1990. My system has grown since then. My initial commitment was absolute—I installed all of the best and biggest equipment, as I could afford it.

I've never had a regret—I cannot count the number of times I have shown guests and visitors how "the meter runs backwards." We have enjoyed the benefits of our system numerous times. I look into the valley at night when all the lights in the city go off. Ours don't.

A few years back, we had a direct hit from a hurricane. This was the tenth hurricane we have experienced, I think, and the fourth or fifth direct hit that we have lived through. After the storm, there was no power on our hillside for over six weeks. That also meant no water, since there was no electricity to pump it. The interaction with the power crews when they finally showed up was quite interesting.

I actually demonstrated to these repair crews the impossibility of the SW4024 inverter backfeeding their line. All of them were assembled around the meter box and the stereo was playing in the background, with no grid power for miles and miles. I got two of my fingers wet by putting them in my mouth and immediately touched them to the exposed connections going to the meter. This was a convincing demonstration.

We didn't know we were guerrillas, but we would be very proud to be counted among the group.

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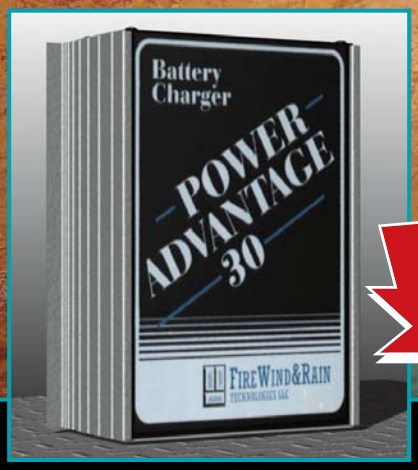

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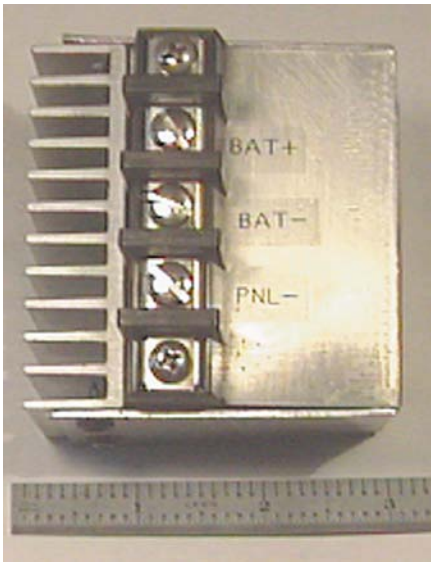
Low Cost PV Regulator

Tom Kirkgaard



Building solar panels or batteries is beyond the capabilities of the average person. Building a regulator for your PV system is not.

This regulator design is capable of handling up to 30 amps for a 12 volt or 24 volt system. To build it, you need to be able to read schematics and know basic construction techniques. If you've built small homebrew projects before, this should be no problem.

A regulator's job is to connect the solar panels to the battery when it needs charging, and to disconnect them when it doesn't. The regulator should also prevent battery power from being dissipated in the solar panels after the sun has gone down. The ideal regulator would not generate any heat while controlling your precious solar power. This regulator design achieves this with a minimal number of parts, at low cost.

Operation

The regulator connects or disconnects the panel dependent on the battery voltage. The user sets this voltage, so any type of battery can be accommodated. The switching portion of the regulator uses a field effect transistor, or FET (Q2). FETs are amazingly efficient. At 20 amps, I measured only 0.2 volts drop across the FET used in this regulator.

The brain of the regulator is a 555 IC. This part is usually used as an oscillator, but it contains the circuitry needed for an on/off regulator. Pin 5 in U1 sets the reference voltage for U1. The output of U1 pin 3 goes to 12 volts when the input to U1 pin 2 falls below one half of pin 5. The output of U1 pin 3 goes to 0 volts when the input to U1 pin 6 rises above pin 5.

The battery voltage is divided by potentiometers R2 and R3 and applied to U1 pins 6 and 2. Setting the on/off voltage limits with R2 and R3 allows a voltage range. Within this window of voltage, the regulator can be on or off depending on whether the battery voltage is rising or falling. Below the lower limit, the regulator is always on. Above the upper limit, the regulator is always off. In operation, when the regulator is on, the battery voltage rises to the upper limit, then shuts off. It will remain off until the battery voltage drops below the lower limit, then the regulator turns on.

Preventing discharge at night is easily accomplished with a diode. But unless you pick your diode carefully, it can be a source of power loss. Diodes have a small voltage drop in the forward direction. A standard power diode can have a drop of 0.6–1 volt. At 15 amps, this would translate into 9–15 watts of wasted power. In this project, we use a Schottky diode, which can reduce the voltage drop to 0.4–0.7 volts. At 15 amps, it wastes 6–10.5 watts of power. This may seem fussy, but you probably paid $5 a watt when you bought the panels.

Construction

There are 12 and 24 volt versions of this regulator. For the 12 V version, install all the J1 jumpers (denoted by connecting the two dots to the left and right of the J1 designator) and install all parts *except* the ones beginning with (2). For the 24 V version, install all the J2 jumpers and install all parts *except* the ones beginning with (1).

A good approach would be to install all the parts except D1 and Q2 on a perfboard. Layout isn't critical, but it would be wise to allow for a good common for all parts going to ground. When building, keep in mind that the regulator will most likely be connected to a large battery. Make sure there is no possibility of a short. A small aluminum box can serve as a protective enclosure and heat sink.

My prototype had a barrier terminal block with three screw terminals on the top and solder tabs on the bottom. This was used to make the solar panel and

battery connections. It was positioned so the drain lead (D) of Q2 could be soldered directly to the solder tab.

FET Mounting

The diode (D1) was not installed in the enclosure of the prototype. You may want to connect the source of Q2 to pins 1 and 3 of D1, then connect pin 2 to the terminal strip. Before installation, the FET (Q2) can be damaged with static electricity. Avoid touching the leads until required by installation. The diode (D1) and FET (Q2) require heat sinks. The mounting surface on the FET (Q2) is connected to the drain (D). The drain (D) is grounded on the FET so it can be mounted to the regulator enclosure. The diode will generate the most heat.

The diode (D1) mounting surface is connected to its cathode, which should not be grounded. Use a TO-247 isolation mounting kit for D1. The kit should consist of a very thin insulating material to go between D1 and the enclosure. An insulating washer goes between the mounting screw and the mounting hole of D1.

The diode actually operates with less voltage drop (which is good) at higher temperatures (max 115° C; 239° F). On the other hand, the FET has the lowest resistance when kept cool.

Adjustment and Testing

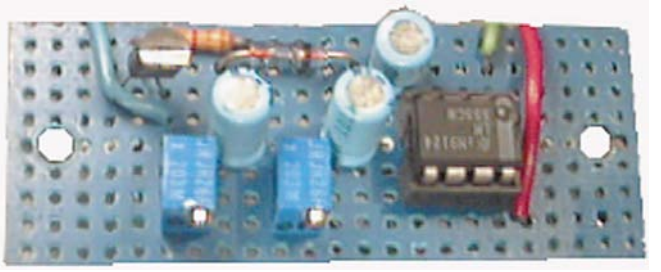
First verify the wiring accuracy of your board. Connect a 12 or 24 volt battery or a power supply to the battery terminals on the regulator. Measure the voltage at U1 pin 5. It should be 6.8 volts for the 12 V version, and 12.5 volts for the 24 V version, +/- 0.7 volts. Record this reading as V1. Measure the voltage at the battery terminals, and record this reading as V2. Calculate the R3 and R2 settings.

R3 Turn Off

Decide on the *off* voltage for the regulator. R3 voltage equals V1 times V2, divided by the *on* voltage. If you choose 14.0 volts as the *off* voltage, R3 is 6.8 x 12.0 / 14.0 (which equals 5.83). Adjust R3 (U1 pin 6) to 5.83 volts with respect to ground.

R2 Turn On

Decide on the *on* voltage for the regulator. R2 voltage equals V1 times V2 times 0.5, divided by the *off* voltage. If you choose 13.0 volts as the *on* voltage, R2 voltage is 6.8 x 12.0 x 0.5 / 13.0 (which equals 3.13). Adjust R2 (U1 pin 2) to 3.13 volts with respect to ground.



Above: The components laid out on perfboard.

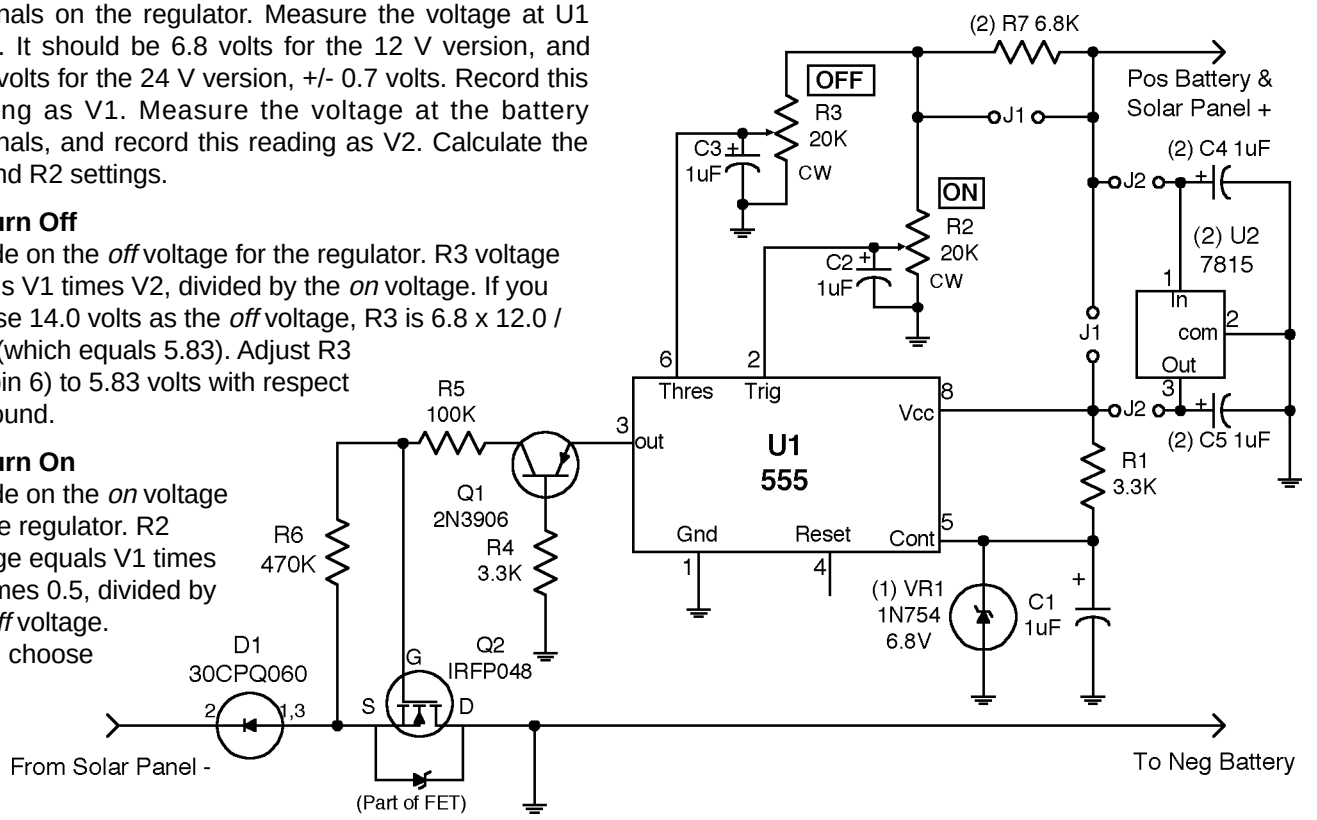
If you have a variable power supply connected to the battery terminals you can verify the adjustments. As you vary the supply above and below the *on* and *off* voltages, you should see U1 pin 3 change from 0 volts to approximately the same as the Vcc (supply voltage) of U1. Do not exceed 18 volts for the 12 V version, or 35 volts for the 24 V version.

Precautions

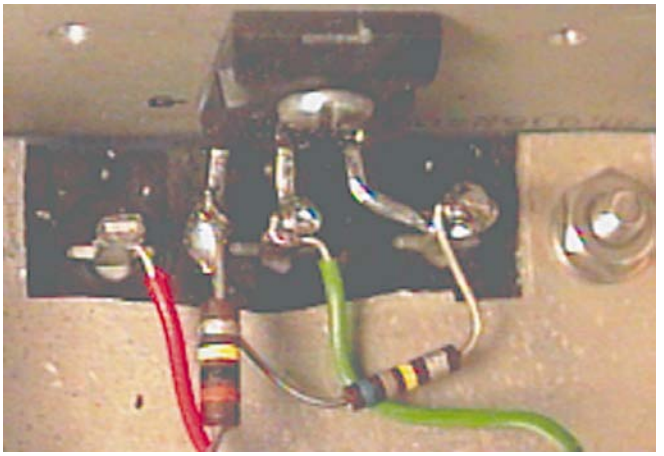
Do not connect anything to the negative terminal(s) of the solar panel(s) other than the regulator.

It is possible for the regulator to oscillate if the on and off voltages are too close. This is due to the resistance

PV Regulator Schematic



in the wiring from the regulator to the battery. If this occurs, increase the *on* to *off* voltage span and use larger wire from the regulator to the battery. See examples of systems in other *Home Power* articles for safe installation of regulators.

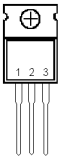


Above: The FET installed.

Parts List

Qty	*Code*	*Description*	*Cost*
1	Q1	2N3906 PNP transistor	$0.85
1	Q2	IRFP048 N channel HEXFET	$4.30
1	VR1	1N754 6.8 V 0.5W zener diode (1)	$0.50
3	C1-5	1µF 25 V electrolytic capacitors (1)	$0.59
5	C1-5	1µF 25 V electrolytic capacitors (2)	$0.59
2	R1,4	3.3K 0.25W 5%	$0.10
2	R2,3	20K ten-turn trimmer potentiometer	$1.49
1	R5	100K 0.25W 5%	$0.10
1	R6	470K 0.25W 5%	$0.10
1	R7	6.8K 0.25W 5% (2)	$0.10
1	D1	30CPQ060 30 amp Schottky diode	$3.50
1	U1	LM 555 timing circuit	$1.39
1		8 pin DIP IC socket	$0.25
1	U2	LM7805C or LM340T-15 15 V reg. (2)	$1.25
		Total	$15.11

Lead Assignments



	Q2		D1		U2
1	Gate	1	Anode	1	Input
2	Drain	2	Cathode	2	Common
3	Source	3	Anode	3	Output
Tab	Drain	Tab	Cathode	Tab	Common

Q2, D1, and U2 have similar style cases

Access

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takirkgaard@mail.hac.com

Sources for parts:

Radio Shack, 100 Throckmorton St., Fort Worth, TX 76102 • 800-843-7422 • 817-415-3011
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The Elec-Trak Rides Again

Reviving G.E.'s Electric Lawn Tractors

Mike Bryce

Above: General Electric's 20 horsepower Elec-Trak E20 on the left and the 10 horsepower E10 on the right.

The '70s sure were exciting. We saw the end of the Vietnam war, Nixon and his Watergate, the Arab oil embargo, Three Mile Island, and the General Electric "Elec-Trak" riding lawn tractors.

The Elec-Trak is a battery-operated lawn tractor. It was produced by General Electric in the early '70s. The power of these tractors ranged from the small 8 hp E8 to the 20 hp E20, with several models in between. Each tractor operated on a 36 volt DC system, supplied by lead-acid batteries. The battery pack consisted of six 6 volt golf cart batteries, or in the case of the smaller E8, three 12 volt batteries.

On the E8 and E10 tractors, the 36 inch (91 cm) mower deck was suspended below the belly of the tractor. Two 36 volt mower motors each turned an 18 inch (46 cm) mower blade. There were two blades and two mower motors on each deck. Most of the larger models had the mower deck out in front of the tractor, though some were longer in order to hold the mower deck under the tractor's belly. In either case, the cut width was increased to 42 inches (107 cm), using three motors driving three cutting blades.

Along with increases in horsepower, the larger models grew in complexity. Many of them had an electric lift motor to raise or lower the front-mounted mower deck. This lift motor could also raise and lower the snow blower. Why, the E20 even came with cruise control!

Attachments

The entire line of Elec-Traks ran on 36 volts DC. You could purchase many attachments for the tractors, including a chain saw and a DC to AC rotary inverter. There was a snow blower and a tiller that would plug

Below: This beat-up E10 still works like a charm.

into the PTO (power take-off) that the mower deck normally used. With such foresight, many people in the '70s said the Elec-Trak was 20 years ahead of its time!

With one of these electric tractors, you could mow your yard and then trim the hedges without using a drop of gasoline. There was no oil to change or dirty oil to discard. When you were done, you plugged in the on-board charger and set the timer. Recharging a depleted battery bank required about twelve to eighteen hours.

A Rose by Any Other Name

General Electric sold the rights to build their tractors to several different companies. Wheelhorse and New Idea produced the Elec-Trak under their own labels. Wheelhorse models were red, and used a completely different model-naming scheme. A Wheelhorse C145 is the same as a General Electric E15. New Idea changed the color scheme to orange and cream. Under the New Idea brand, the tractors were called EGT or Electric Garden Tractors. Although the basic tractor remained the same, each supplier made various changes in the circuitry and mechanics of the machines.

Elec-Trak E10

Because of the sheer numbers of E10s produced, you are more likely to run into one of these than any other Elec-Trak. Also, of all the different models, the E10 is by far the easiest to get back into working condition. Plan to pay from nothing to about $200 for a used E10. Prices will vary of course, depending on the condition of the basic tractor and battery bank.

The E10 can be broken down into four main components: battery charger, main drive motor, PTO, and mechanical subassemblies. If you find an E10, it's a good bet that the battery bank is kaput! The batteries in my E10 were fourteen years old. Remove a few battery caps and check for water. If the cells are empty or below the plates, don't add water. Instead, remove and replace the batteries. There are three 6 volt golf cart batteries in the front and three under the seat. I replace worn out batteries with Trojan T-105s.

Also, while you're working on the batteries, check the battery cables for cracked ends and burnt wires. The original E10 came with 6 gauge (13 mm^2) wire. I replaced mine with 4 gauge (21 mm^2) stranded wire. Mark the cables so you know what went where. It's best not to install the new set of batteries just yet, as you may need to repair the charger.

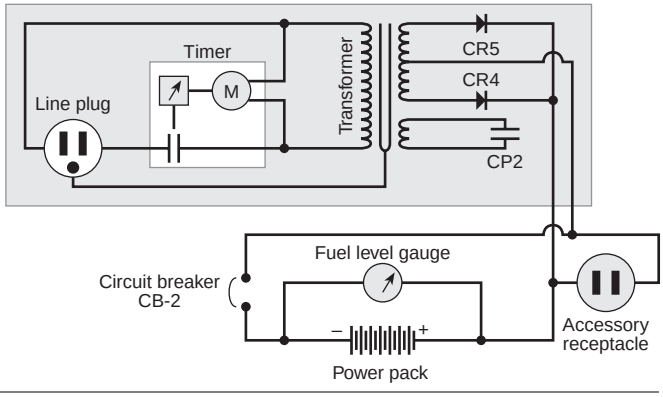
On-board Charger

All Elec-Trak tractors use the same charger. The only differences between models are the physical shape of the mounting plate and the location of the charger. In our E10, the charger is under the steering column. The charger's schematic is shown in Figure 1.

Above: Donna's hedge trimmer plugs directly into this E15 Elec-Trak.

All Elec-Trak chargers work the same. The heart of the charger is the specially wound ferro-resonant transformer. The output of the transformer is routed to two large diodes mounted on a heat sink. The transformer, along with a capacitor, regulates the current flow into the battery bank. To prevent overcharging the batteries, a motor-driven timer switches the charger off. No electronics are used to control the charging current to the battery bank.

Figure 1: E10 Charger Circuit



Above: The three motors on the out-front mower deck of an E20.

By using a clamp-on DC amp probe and a Fluke 73 meter, I measured over 21 amps of charging current flowing into the batteries after a mowing job. After ten hours or so, the charging rate drops to about 10 amps. The finished charge current levels off at 6 amps. The bank of six batteries are wired in series for a 36 volt system with 220 amp-hours of storage. A complete sixteen-hour charge would be equal to about 10 KWH.

Testing the On-board Charger

You can test the charger without removing it from its hiding spot. With the batteries removed, connect your voltmeter to the positive and negative battery cables. Plug in the charger and move the timer knob past the "start" position. You should hear a loud hum from the transformer and read at least 39 volts on your meter. If you do, then the charger is working correctly.

However, if your meter reads 20 volts or so, then one of the diodes has opened. If the meter reads about 30 volts, the capacitor is defective. On two different occasions, I've found one of the wires leading to the capacitor had fallen off. Since these tractors take such a beating, look for loose wires before digging too deep.

If the transformer growls loudly, and the voltmeter reads zero, quickly unplug the charger. One or both of the diodes may be shorted, or there might be a rare short circuit on the battery side of the charger. There are no breakers or fuses on the AC input side of the charger. A 50 amp circuit breaker on the battery side is supposed to protect the charger in case of a short circuit between the charger and the batteries. If this circuit breaker trips when the charger is unplugged, but with batteries in the circuit, then both diodes are shorted or there is a external short between the batteries and the charger.

No hum from the transformer and no output usually means a defective timer switch or connector. It's also possible to have an open primary winding on the transformer, but that's rare. Pay attention to the wires leading to and from the timer switch. These tend to fall off, shutting down the charger. Also, the wires coming out of the transformer will be brittle due to heat and old age. Use care when handling them.

Fixing the Charger

If one or more of the above tests indicates a faulty charger, the charger must be removed from the tractor for repair. The only way to get to the charger is by removing the front two batteries. If the battery compartment is badly corroded, then all three batteries must be removed to make extra room for the hammers and pry bars you'll need! There is a plastic tray on the bottom of the front compartment. Remove this tray by pulling it out. Be mindful of flying crud. Eye protection is a must!

With the plastic tray out, you'll need to remove three bolts on each side of the tractor. These bolts hold the charger mounting plate to the tractor's body. The bottom two bolts will probably be too corroded to be used again. Replace the hardware with stainless steel bolts and nuts when you reassemble the unit. With all

Below: The timer control knob is clearly visible on the E20 charger. The PTO socket is at lower left.

six bolts removed, tilt the top of the charger plate toward the front of the tractor. With the top of the charger exposed, the capacitor can be seen on the charger mounting plate, beside the transformer.

There should be two wires coming from the capacitor. Make sure they are both connected securely. If the wires have become disconnected from the capacitor, connect them and retest the charger before removing it from the tractor. This could save you a lot of time and effort.

To make removal of the charger easier, I like to remove the deck plate under the transmission shift lever. To do this, unscrew the ball from the shift lever. Remove the bolts holding the deck plate. Lift the plate up over the shift lever. This exposes the main drive motor and the back side of the charger. Now it's easier to access the wiring harness leading to the charger.

If you need to remove the charger from the tractor, unplug the nylon connector leading from the timer motor. You will also need to remove the negative lead from the post on the charger and the positive lead connected to the heat sink. With these wires removed, you can take the charger out of the tractor. This sounds easy enough, but there may be enough corrosion from the battery acid to make it a struggle.

Testing for Bad Diodes on the Charger

One or both of the diodes on the heat sink may be no good. There are two wires coming from the transformer to the diodes, one wire to each diode. Unsolder both wires. Use your VOM (volt-ohm meter) to find the defective diode. With your VOM set to measure resistance, a shorted diode will read about zero ohms from cathode to anode, and zero ohms from anode to cathode too. Since a diode is like a one-way valve, you'll need to reverse the test probes while checking diodes. An open diode will show infinite ohms between cathode and anode. A good diode will show about 500 ohms in one direction and about 25 ohms in the other.

According to an old General Electric service manual, a defective diode means replacing the entire heat sink assembly. However, these assemblies are no longer being made. The diodes are pressed into the heat sink. You don't want to punch out the diodes and replace them, even if you can find replacement diodes. I leave both diodes alone, although one or both may be defective, and install two new 35 amp diodes. Drill a new hole for the replacement diodes on the heat sink, and use 1N1188A diodes. To help transfer heat from the diodes to the metal heat sink, use silicone heat sink compound, available at Radio Shack or through Hosfelt Electronics.

Above: The E20 charger removed from the tractor, showing the heat sink with two diodes, capacitor, and transformer.

Of all the Elec-Traks I've repaired, I've found only one with a cooked transformer. This one died because one of the diodes had shorted and the user kept on trying to charge the batteries. When I find a dead charger, nearly 80 percent of the time the problem is a defective diode on the heat sink.

To test the repaired charger, plug the connector from the timer motor into the charger. Apply power to the charger, and turn on the timer. Take your reading from the heat sink (positive) to the center tap of the transformer (negative). The center tap is fastened to the large stud near the heat sink. You should see 39 to 41

Below: The opened access panel on an E10. The larger relay on the right is the PTO contactor.

volts if everything is working correctly. Before you install the charger, clean out any crud you see.

Main Drive Motor

The E10 uses a very simple drive motor and control circuit. The drive motor is a permanent magnet motor about the size of a large thermos. There are no special circuits used to reverse the drive motor or to change its speed. That's all done by the Peerless transmission. We only need to apply power to the drive motor to get it spinning. The motor start circuit for the E10 is shown in Figure 2.

Start Circuit

Three things must happen to allow the main contactor ("L" in the schematic) to pull in. First, the key switch must be on. Then the operator must be on the seat, closing the seat switch. Finally, the clutch/brake pedal must be depressed, operating the clutch switch. With the clutch pedal depressed, the drive belt is prevented from transferring power from the motor to the transmission. This allows you to start the tractor without being thrown off the seat!

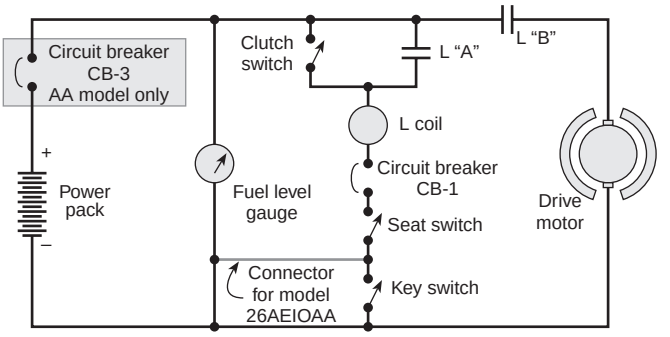
Once the contactor pulls in, a separate set of contacts seals the contactor in. You can then remove your foot from the clutch and drive off. Turning the key switch off or getting off the seat will unseal the contactor, stopping the drive motor. To restart the tractor, you must depress the clutch and reset the key switch to seal the contactor again. The operator, of course, has to be in the seat!

Some Quick Tests for the Drive Motor

If you have removed the plate under the shift lever, the drive motor will be fully exposed. On the rear of the motor, you'll find the two armature terminals. One is connected to the negative battery lead. The other one runs back up to the main contactor located behind the steering column. To access this contactor, remove the two screws holding the cover panel in place. There is enough wire slack to allow the cover panel to lie flat. Place a piece of cardboard on top of the batteries if they are installed. This will prevent the cover panel from shorting out the battery terminals.

First either put the transmission in neutral, remove the drive belt from the pulleys, or jack up the rear end so the wheels are off the ground and block them. To verify that the drive motor works, check it with a 12 volt battery. Connect the tractor's negative battery cable to the negative post of the battery. Connect a heavy-duty clip lead to the positive battery post. Then briefly touch the other end of the lead to the contactor ("L") cable that goes to the main drive motor. If there are no problems with the drive motor, it will start spinning. This simple test shows whether the drive motor is working or not.

Figure 2: E10 Start Circuit



If you tested the drive motor with the external power source and the motor runs, the problem is in one of the control switches. In rare cases, you may have an open contactor coil. All electrical connections must be tight. Check for tightness at the main contactors and PTO contactors. These tractors shake and rattle, so loose wires are common.

The seat switch is the first one that ends up being defeated by the user, so look under the seat for a switch. It should be mounted on the cross member holding the small seat spring. If the switch is there, but you see no wires coming from the seat, look for them taped together somewhere in the battery compartment. Battery acid and water may have eaten away at the wires, preventing the motor from starting.

Check the clutch switch as well. It's located on the right side of the tractor under the transmission. With the clutch, seat, and key switches on, you should measure 36 volts across the contactor's coil. If you do get 36 volts but the contactor does not pull in, the coil is bad and needs to be replaced.

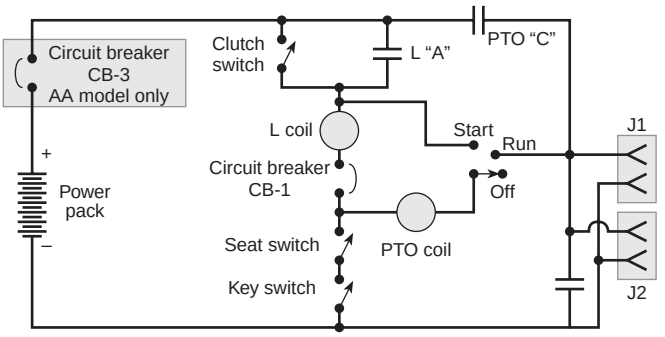
PTO Circuit

On the E10, the PTO circuit works almost exactly the same way as the motor drive circuit, minus the clutch and seat switches. When the PTO start switch is moved to the start position, it seals in the PTO coil. This allows the spring-loaded switch to move to the run position. The mower motors are permanent magnet motors. When the PTO switch is turned off, the PTO contactor shorts out the mower motors, dynamically stopping the motors.

Mechanical Subassemblies

All of the mechanical subassemblies are very basic and straightforward. It's beyond the scope of this article to cover all the details. A good dose of common sense will be your best guide. If it looks like it needs oil, then oil it. If you see a grease fitting, grease it. Check for wear and tighten loose fasteners. A few of the more common problems are discussed here, with suggestions on how to deal with them.

Figure 3: E10 PTO Circuit



Don't Know Where You're Going?

Stripped-out steering columns are a very common problem in these tractors. What happens is that the steering shaft and pinion gear wear down the gear and sector assembly. If the wear is not excessive, you can add some shim washers to take up the slack. This job is messy and labor intensive. If you have all the batteries out of the tractor, I suggest you tilt the tractor over on its side. This will allow you to work on the steering components without standing on your head.

Remove the cotter pin from the gear and sector assembly. Pull the steering shaft and pinion gear away. Add your shim washer and reassemble. Try the fit. If you have too much slop, add more shim washers. If you can't get the assembly together, remove one shim at a time until the steering pinion and sector assembly are nice and tight. Replace the cotter pin with a roll pin and finish up with a nice glob of grease on both gear surfaces.

Whoa! I Can't Stop!

Don't flip the tractor over just yet. Did you check to see if your brakes work? Now is the best time to work on them since the tractor is on its side. There are two basic brake designs used on the Elec-Trak, the die-cast caliper brake and the steel caliper brake.

Die-cast Caliper Brake

On the transmission, you'll see the brake disk. If you have the die-cast caliper, there will be a small nut and cotter pin assembly. This nut is the brake adjustment. However, before you do anything, I suggest you watch the brake assembly while you operate the brake by hand. If nothing moves, you have lots of work to do. Plan on using plenty of WD-40! Adjust the brake by removing the cotter pin and turning the adjustment screw until it's finger tight. Back off the adjustment counterclockwise until a very slight drag is felt when rotating the brake disk by hand. Replace the cotter pin.

Steel Caliper Brake

First jack the rear wheels off the ground and block the front wheels. Then remove the rear wheel on the brake side of the transaxle. Remove the cotter pin from the brake clevis pin, then remove the clevis pin. Rotate the brake clevis to shorten the brake linkage until the brake drags, then back off one-half turn. The clevis and clevis pin must be reinstalled temporarily to check brake drag. Reinstall the clevis, clevis pin, and cotter pin on the brake actuating lever. Then reinstall the wheel and test brake function. You should now be able to go in the direction you want to go, and stop once you get there!

Main Drive Belt

The E10 has a single drive belt. It runs from the drive motor to the transmission. A single idler pulley is controlled by the clutch pedal. There are no adjustments to take up any slack from a worn belt. If the main drive belt slips, then the belt must be replaced.

Finding Parts and Supplies

I have had no contact with General Electric, and they no longer supply parts for the Elec-Trak. A local tractor dealer here has been very helpful. They used to sell these tractors, but don't have the time to deal with inquiries.

The diodes are available from Hosfelt Electronics or Mouser Electronics, among others. Any local golf cart supply house will sell you coils and relays. The belts are common Gates products, which any mower shop will be able to replace. I would be more than happy to help readers find sources for parts, and assist with any Elec-Trak problems.

Life with an Elec-Trak

The first thing everyone asks is, "How long will it run on a charge?" That's a question that is hard to answer! There are so many variables one must take into account. How tall is the grass? Are the blades sharp? How fast will your forward speed be? What kind of grass will you be cutting?

Generally speaking, I can cut about three acres of grass on one charge, provided I keep the blades sharp and cut when the grass is dry. During the spring, when the grass is thicker, I have to reduce my forward speed to cut the grass cleanly. Going too fast through high grass will cause excessive current to be pulled, shortening run time. During late summer, when the grass grows slowly, I can really increase the forward speed of the tractor. In other words, your mileage may vary!

On my E20 tractor, with a mower motor idling, a single motor draws 7 amps. With three mower motors sitting there running, that's a hair over 20 amps. Drive motor current varies, depending on what gear you're in and if you're going up or down a grade. When you start putting a load on the mower motors, the current will increase. It would be interesting to know just what these

machines draw under load. But I decided that it would be unsafe to try measuring motor current while mowing the back forty!

All Elec-Trak tractors come with an analog voltmeter that serves as a "fuel gauge." I have found huge differences in meter accuracy. The higher end models also come with a "load meter" that monitors current draw from the battery bank. It's fun to watch the load meter increase as the tractor heads uphill!

What Happened to the Elec-Trak?

Why did the Elec-Trak die out? I really don't know. Perhaps it was the expense of replacing the battery pack every several years. A life span of three to five seasons is about all you can expect from the batteries. To replace the battery pack, it cost up to $450. And of course, you can't mow twenty acres on one charge, either.

With an increased dependence on imported oil, the Elec-Trak may be making a comeback. New laws governing emissions from small IC engines may also spark renewed interest in the Elec-Trak. If you can find one, put an Elec-Trak back to work. There's nothing quite like mowing your yard while listening to the birds singing in the trees. That's something you can't do unless you're riding on a General Electric Elec-Trak!

Access

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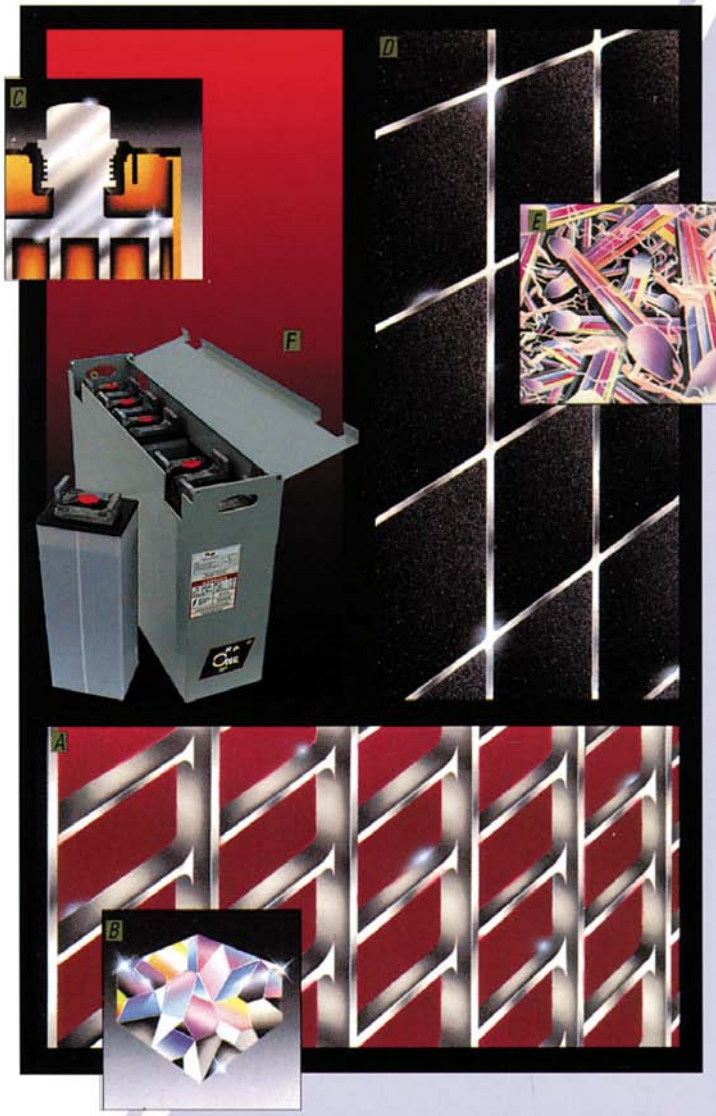

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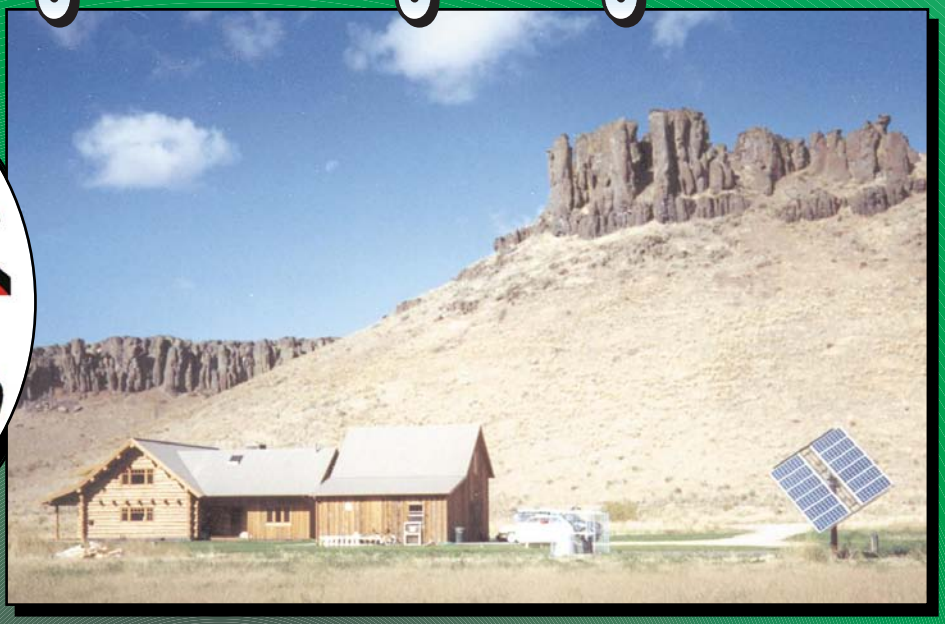

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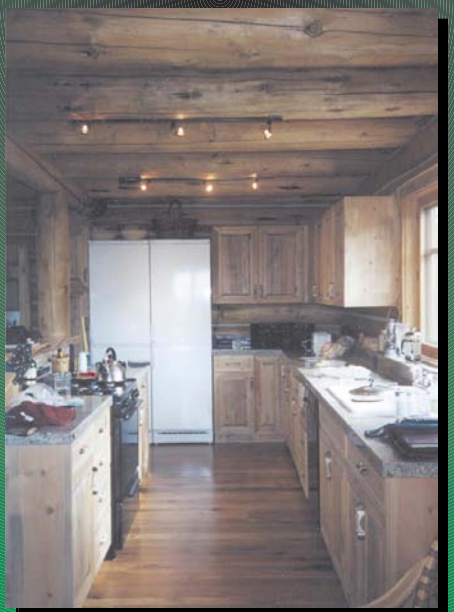

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Doin' It with DC

Bruce Johnson

Above: This old DeWalt radial arm saw has a 12 volt DC motor tucked inside the case of the original 220 volt AC motor.

When we began using wind power to provide electricity for our home twenty years ago, the inverters that are available today were not even dreamed of. If something couldn't be made to run on DC, then we simply didn't have it.

We get our power from a Whisper H900 wind generator and an assortment of PVs. The total PV output is about 300 watts. Our area of Oklahoma is excellent for solar and wind power. We're a middle aged couple without kids and we do fine without any generator backup.

System Loads and Equipment

Our loads include an RF12 Sun Frost refrigerator, basic lighting and electronics, a washing machine, and the tools described in this article, among others. We use an EnerMaxer controller, which dumps surplus power to a water heating element. Our metering is very basic—we've got a voltmeter built from plans in *HP2* and an ammeter with a homemade shunt built from plans in *HP6.* Our modest battery banks include a pair of L-16s, a pair of T-105s, and some used standby batteries we recently acquired. Our water is pumped into a storage tank by a seventy-year-old Aermotor windmill and is gravity fed into the house.

Our home and all the outbuildings on our little homestead are built from recycled lumber. Having DC powered tools to cut and shape lumber has been very helpful. Going DC has saved us the expense of a large inverter. The increased efficiency of DC motors is an added benefit. In this article I will describe how I've converted a number of tools to run on DC. I'll start with some general discussion of things to consider and then describe each tool individually.

Not for Everyone

One of the wonderful things about home power systems is that each system can be built to suit the needs, skills, and finances of the owner. A system that would serve the needs of a poet might not work well for a welder.

Converting power tools to run on DC is not for everyone. If your system already includes a big inverter, then the extra trouble and expense of converting each tool to DC is probably not worth it. But if you are getting along fine using mostly DC and perhaps a small

inverter, you might like the luxury of some stationary power tools. Converting them to DC could work for you, as it has for us.

Basics First

When I began collecting my assortment of used and homemade tools, I was careful to consider only those that were belt driven, with motors that were easy to remove. Tools that have the motor mounted internally are not good candidates for easy conversion. The conversion process boils down to two basic problems—finding the DC motor that will efficiently do the job, and then figuring out how to mount the motor on your tool.

Motor Selection

There are four basic types of DC motors to consider—series, shunt, compound, and permanent magnet. Each of these motors is defined by the way the magnetic field is wired and produced. (*HP34* has an excellent article on electric motors.)

In a series wound motor, the field is wired in series with the armature. Series motors have lots of starting torque. They are less efficient at high speeds and if not connected to a load, they can even rev up to the point of self destruction.

In a shunt motor, the field is wired parallel to the armature. Shunt motors don't have a lot of starting torque, but will maintain a constant speed, independent of load.

The compound motor is a combination of series and shunt. One field coil is in series with the armature and the other in parallel. Compound motors sort of average the best characteristics of both types.

The permanent magnet (PM) motor uses permanent magnets instead of an electromagnet to create the field magnetism. PM motors have the obvious advantage of not consuming any power to create the field. They also have good starting torque, though not quite as much as a series motor. A PM motor runs at a constant speed (whatever the designer wants), and that speed is proportional to voltage.

Second Life for Old Motors

The motors used on my tools all started out life doing something else. They've been obtained from surplus houses, flea markets, and salvage yards. Yes, you *can* buy a brand new low voltage DC motor, and many of the RE catalogues have them. I've never had to be in a hurry to convert any tool. This has made it easier to wait for the right motor to show up at a bargain price. Sometimes I've found the motor first and then decided what to do with it later.

It is important to know what the specifications in a catalogue or on the side plate of a motor mean so you can predict whether or not the motor will do the job you have in mind. The information should include the type of motor (series, shunt, compound, or PM), voltage, amperage, rpm, horsepower, duty rating, size and length of shaft, direction of rotation, and perhaps what type of mount.

Right: This six inch grinder runs on 12 volts DC.

I've found the PM motors to be the most useful, though I use some of the other types too. Usually, series motors are very high speed and not rated for continuous duty, so I use this type the least.

Voltage

The voltage of the motor should be compatible with your system. Generally, the voltage of a series, shunt, or compound motor should be the same as your system voltage. For example, if you have a 12 volt system, you

Below: Rear view of the grinder: The motor is an old generator from a Ford automobile.

Above: This twelve inch band saw is powered by a 12 volt Delco automotive generator.

should stick to motors rated for 12 volts. With PM motors, there is a little more latitude. You may use a PM motor rated for a higher voltage than your system as long as you don't let the motor draw more current than it is rated for. The speed and power will be proportionally less. For example, take a 24 volt, 40 amp, 2,000 rpm, 1 hp motor. It could be safely and efficiently used at 12 volts, 40 amps, 1,000 rpm, 1/2 hp.

Amperage

Do *not* exceed the amperage rating of the motor. That is what the brushes and commutator are designed for. If the motor specifications are not available, the gauge of the wires to the brushes can give you an idea of how much current the motor was designed for. All motors will draw more current when starting. It's the current that the motor draws when the machine is up to speed and doing work that is important. For a 12 volt PM motor you can figure 20 amps per 1/4 hp, and for 24 volts it will be 10 amps per 1/4 hp.

Motors with wound fields will consume slightly more. After each conversion, I always connect the tool to an ammeter and check what it draws. If the motor draws more current than it was designed for, it will overheat and be damaged. It is also very important that you use wire of adequate gauge for the volt and amp rating of your motor. Voltage drop caused by inadequate wire will kill an otherwise good conversion. Switches and circuit breakers must also be properly sized.

Duty Cycle

The duty cycle is closely related to the amp rating of the motor. If the motor is rated for continuous duty, then it should be able to run indefinitely at the rated current and not overheat. If it is rated at a 50 percent duty cycle, it will have to be off one minute to cool for each minute that it is on, and there will be a limit to how long it can be on. It's best to stick to motors that are continuous duty rated, if possible. When using a tool that has a motor that is not continuous duty rated, I'm in the habit of putting my hand on the motor periodically. If it's hot to the touch, I turn it off.

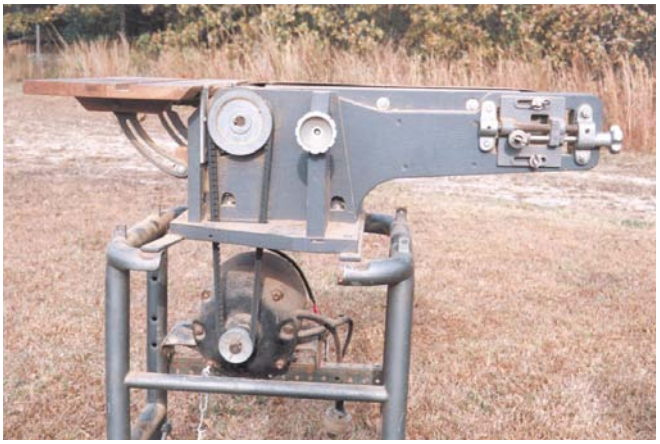
Speed, Direction, and Size

The speed that the shaft rotates is also an important consideration. If the tool you are converting is belt driven, there will be some latitude here because you will be able to adjust the speed of the tool with different pulley sizes. Most of the AC motors that you will be replacing will be 1,725 or 3,450 rpm, so DC motors in this speed range are the easiest to work with. It's difficult to make good conversions with high speed motors (over 4,000 rpm), so I avoid these.

The direction that the shaft rotates is also something to consider. A table saw running backwards won't make you the envy of your RE neighborhood. The good news is that most motors can be reversed quite easily. On a PM motor, it's as simple as reversing the polarity of the power. On series, shunt, and

Left: A 12 volt 1/2 hp 1,725 rpm Delco motor found at a flea market powers this belt sander.

Right: Another view of the belt sander showing the simple V-belt drive.



compound motors it involves reversing the polarity of the field coils in relation to the armature. Or, just by rotating the motor 180° on its mount, the shaft will be turning the opposite direction in relation to the pulley on the tool. On a few motors, the brushes are mounted at a slant rather than perpendicular to the commutator. This indicates that they were designed to operate in just one direction.

It's nice when the shaft size is something common like 5/8 or 3/4 inch (16 or 19 mm), but any size is usually adaptable. It is also good when the motor has a standard mounting bracket, but again, if that's not the case, it can be overcome with a little creativity. Sometimes the motors with oddball shafts and no mount are the best bargains. As I discuss individual tools, I'll give some examples of how to solve some of these problems.

Putting Words Into Action

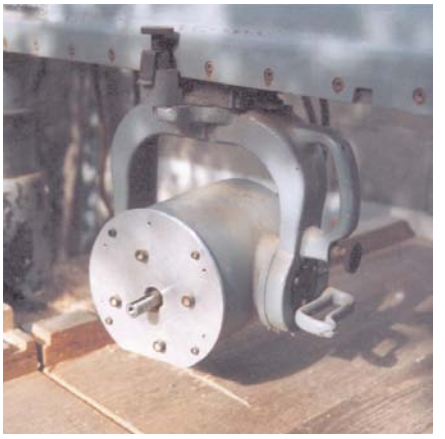
Well, that's basic DC motor ground school. Now we'll head out and see how these things fly. With each tool (and a few non-tool items), I'll describe the DC conversion. While I will try to give as much detail as space permits, I think the *process* of conversion is probably more important than the details. Since we are dealing with used equipment, the treasures that you find will probably be slightly different than the ones I've found.

Many of the motors described here are from Surplus Center. The bad news is that none are listed in the current catalogue. So, the success of your project will depend on your own careful creativity. Remember to be patient. What I describe here represents twenty years of enjoyable tinkering.

Drill Press

An old drill press was one of the first tools I converted. I used an old automotive generator for the motor. Until about 1962, cars used generators rather than alternators. The construction of the generator is identical to a shunt wound motor. When it is used as a generator, the field circuit is completed by the voltage regulator. To use it as a motor, just complete the field circuit with a wire.

For some generators this will mean grounding the field terminal, and for others it means connecting the field terminal to the armature terminal. To distinguish one from the other, check where the other end of the field is connected (you will have to disassemble the generator to do this). If the other end is grounded, then the one that comes out through the case will have to be connected to the armature. If the internal connection is to the armature lead, then the field terminal will need to be grounded.



Right: The radial arm saw with the blade and blade guard removed, showing the newly fabricated aluminum plate that holds the 12 volt motor.

In *HP40* I described how I use one of these automotive generators to run our washing machine. Twenty years ago, old generators were cheap and easy to find. They are harder to find now, but they are still around and make a pretty good 1/4 hp 1,000 rpm motor. The rest of the drill press conversion simply involved making some angle brackets for the mounting. I used the V-belt pulley that was already on the generator.

Grinder and Band Saw

A six inch (15 cm) grinder and a twelve inch (30 cm) band saw also use old generators for motors. For the grinder, I wanted to increase the speed, so I used a six inch (15 cm) pulley on the motor and a two inch (5 cm) pulley on the grinder. The generators have an odd shaft size between 5/8 and 3/4 inch (16–19 mm). My six inch (15 cm) pulley had a 3/4 inch (19 mm) bore; so I used a piece of 3/4 inch (19 mm) copper tubing to make a shim for the pulley to fit snugly on the motor shaft.

On the band saw, I used the stock generator pulley and a seven inch (18 cm) pulley on the saw shaft. This runs the saw at a good speed for wood cutting. For metal cutting, I wanted to slow it down. The two inch (5 cm) pulley I had on hand had a 5/8 inch (16 mm) bore. The

Right: The rear of the eight inch table saw, showing the 1 hp 12 volt DC motor and power relay.

Left: This twelve inch planer is powered by a 24 volt 1 hp DC motor.

motor shaft was easily turned down to size just by running it and holding a file to the shaft. I mostly end up cutting aluminum, but when I need to cut wood, I swap the pulley back to get the higher speed. Angle brackets were used to mount the motor and a spring holds it in tension with the belt.

Cement Mixer

An old generator also makes a great motor for our three cubic foot (0.08 m^3) cement mixer. Again I just use the stock pulley. It draws about 15 amps when churning up a batch of concrete. It will run all day long and be barely warm to the touch, and is easily powered by two golf cart batteries. Since the mixer is not used very often, the motor is made to be easily removed so it is available for other seldom used tools.

Belt Sander

The six inch (15 cm) belt sander is powered by a 1/2 hp 1,725 rpm shunt wound motor I found at a flea market. I don't know what this motor came out of, but I considered it to be a good find for $15. It has the Delco name on it and weighs 50 pounds (23 kg). A few years later, I found another one that looked identical but was a 3/4 hp compound wound motor. Whenever I spot a motor at a flea market or salvage yard, I always look at the size of the wires coming out of it. If they appear to be #8 (8.4 mm^2) or larger, I take a closer look.

Radial Arm Saw

A few years ago I departed from the belt-drive only rule and tackled the conversion of a radial arm saw. The cosmic forces of the universe must have been in proper alignment or something, because this project came together nicely. I started with a sturdy old DeWalt saw that had a 3 phase 220 volt motor. As I was contemplating the project, the yearly Surplus Center catalogue arrived and in it was a 12 volt 1 hp 3,600 rpm PM motor with a 5/8 inch (16 mm) shaft. The price of $97 was a little steeper than I was used to, but the specifications were exactly what I wanted.

I began the conversion by disassembling the DeWalt motor and removing the field coil assembly from the case. Then I made a new end plate of 3/16 inch (5 mm) aluminum with a hole in it for the shaft of the new motor. The PM motor had a mounting bracket welded to the case which I cut off with a hacksaw. It also had tapped holes in the end plate, so I bolted it to the new end plate I had made for the motor housing. It was fortunate that the diameter of the PM motor was just slightly smaller than the case of the old motor so it could just slip inside.

The radial arm saw requires a left hand threaded bolt to hold the blade tight. I bought a 5/16 inch (8 mm) tap and cut threads in a 1/4 inch (6 mm) hole I drilled in the end of the motor shaft. I couldn't find a left hand threaded bolt anywhere, so I bought a left hand threaded die and made my own bolt.

The saw originally had a twelve inch (30 cm) blade, but I thought a ten inch (25 cm) blade would be more appropriate for the 1 hp PM motor. I made a new blade guard from aluminum plate. For ripping, I use a purchased hold down and anti-kickback system that is attached to the fence. I also mounted a heavy duty knife switch to turn the power on and off.

Table Saw

For the table saw, I used a PM motor. For several years I used a 1/2 hp motor I got from Surplus Center. This was fine for one inch (2.5 cm) lumber, but underpowered for two inch (5 cm) stock. I now use a 1

Below: When one motor isn't enough, try two. A second motor added to the walking tractor gives it enough power to pull a plow.

hp motor identical to the one on the radial arm saw. The extra power is especially nice when ripping. Thin kerf, carbide tipped blades help the saw run more efficiently. This motor came with a mounting bracket welded onto the case, and had a 5/8 inch (16 mm) shaft, so the conversion was very easy.

The table saw shares its motor with the electric rotary tiller for a short time in the spring. It doesn't make sense for a valuable motor to sit unused most of the time. So when I'm done tilling in the cover crop, the motor goes right back to the table saw. Designing mounts that allow a motor to be easily moved from one tool to another is a good money saving idea.

Planer

Several years ago we salvaged the lumber from a 100-year-old house. That gave birth to the desire for a planer in order to make the best use of this high grade material. We took a deep breath and purchased a new twelve inch (30 cm) planer from R.B. Industries. We purchased this machine without the AC motor. I already had a 24 volt 1 hp PM motor I found at a salvage yard. This motor had come out of a battery powered floor scrubber and at $5 it was about my best motor bargain ever. Mounting the motor was a simple bolt-up job. To provide the 24 volt power for the planer, I park my 12 volt tractor (see *HP53*) next to the planer shed and connect it in series with the 12 volt system in the shop.

This planer normally has a 3 hp AC motor, so the 1 hp DC motor might seem a little small. I don't know why, but a DC motor seems to have more power than an AC motor of the same rating. I don't think this is true of the 3 phase induction motors found in industry. But the single phase induction motors found in home appliances and shop tools gobble more power for the amount of work they do. As I use the planer, I check the ammeter so it doesn't draw more than the 42 amps it is rated for. If it does, I simply decrease the depth of the cut and do the job in two passes.

Two Become One

Another strategy to consider is to use two motors if you don't have one that is strong enough to do the job alone. This wouldn't make much sense if you were buying new equipment, but the rules are a little different for the tinkerer.

I couldn't find a more powerful motor for the walking tractor, so I simply added a second motor identical to the one on the machine. It has the same size pulley and drives the same V-belt. A three inch (7.6 cm) o.d. sealed ball bearing is mounted as an idler so the belt gets a good wrap around both pulleys. The second motor is easily removed, so when the extra power isn't needed I take it off and run with just one.

Right: This hammermill-type compost shredder is powered by a 24 volt aircraft starter motor run on 12 volts.

Air Compressor and Compost Shredder

Quite some time ago I ran across two surplus 24 volt aircraft starter motors. I run these on 12 volts and they have lots of power, though they are not nearly as efficient as the PM motors. On 12 volts they run a useful length of time before they get hot. A 12 volt starter motor would draw too much current and heat up too fast to be useful as a tool motor.

One of these motors powers an air compressor and the other a compost shredder. In both these applications, the high starting torque of the series wound motor is a real benefit. These motors had no mounting brackets or holes, so I made some big U-bolts out of threaded rod to fasten them onto angle iron mounting brackets.

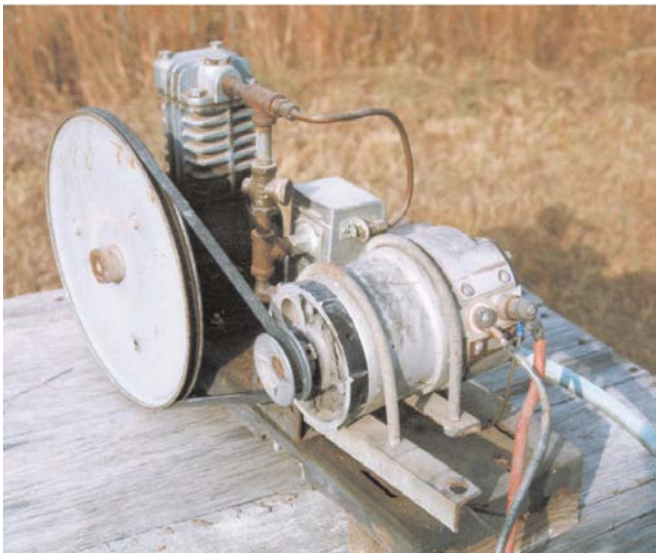
Water Pump

We live in an area where brush fires are a threat during winter and spring dry spells. When we retired our '68 Datsun pickup from road service, we mounted two 60 gallon (227 liter) plastic drums on it for water. I rigged a DC centrifugal pump, and it became our homestead fire truck. The motor is a PM 1/2 hp at 2,800 rpm.

The DC pump that I converted had the impeller mounted on a shaft separate from its AC motor, and was fastened with a set screw. To mount the DC motor, I made a plate (like the one for the radial arm saw) and bolted it to the pump frame. The pump delivers about five gallons per minute (19 lpm) at 25 psi, and I'm happy to say that we haven't had to use it yet.

Ceiling Fan

One hot summer a number of years ago we were really longing for a good ceiling fan. I knew from a little experimenting that top speed for a 54 inch (1.4 m) fan should be no more than about 200 rpm. About that time the trusty Surplus Center catalogue arrived and it listed

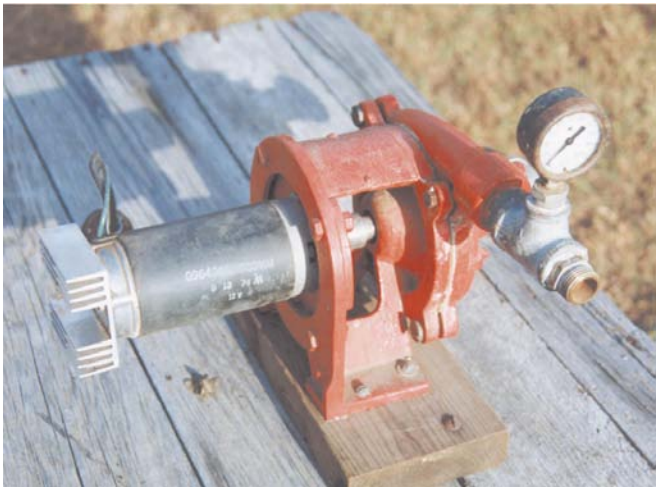


Above: A 24 volt aircraft starter motor run at 12 volts powering this air compressor.

a motor rated at 48 volts, 2 amps, 800 rpm continuous duty. Knowing that speed is proportional to voltage made me think that it was just what I was looking for. Sure enough, it checked out at 200 rpm at 12 volts and draws 2 amps when going full speed. We usually run our fans at lower speeds using a speed controller and they produce a pleasant, quiet breeze and consume only about 10 watts.

When I saw how well it worked, I ordered four more motors (at $15 each) to make fans for every room and for the shop, too. This is another rule I try to follow: If I find a bargain, I stock up. Most of the time these things show up in the catalogue or flea market once and they never show up again.

Below: This surplus 12 volt DC motor made a neat conversion for a centrifugal pump.



A Little AC, Too

Our system has grown over the years and now includes a Trace UX1100 inverter. This gives us all the AC power we will ever need for home appliances and portable shop tools. One portable tool that most do-it-yourselfers use is the circular saw. Most of these draw 10 to 13 amps at 120 volts AC, which is pushing the capability of the inverter. I found the 5 1/2 inch (14 cm) Skil model HD5510 circular saw to be a very good tool. It draws 6.5 amps and works great on the inverter. I recently built a room addition using this saw and it breezed through hard, 100-year-old two by fours. I couldn't find a source for this tool locally, so I ordered it from Tool Crib of the North. Sears also sells an identical saw with the Craftsman label.

Still Crazy After All These Years

I hesitated some before writing this article, thinking that the new generation of inverters has made this information obsolete. But then I realized that if I were starting today knowing what I've learned from the last twenty years, I would probably still do things pretty much as I have. I hope this information will be useful to others. I'd be happy to answer any questions that you might have.

Doing it with DC has enabled us to do a lot on our small energy and dollar budget. All of our electricity comes from a modest wind and solar system. We have been off-grid for twenty years and have never owned or needed a backup generator.

Access

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Motors and power relays: Surplus Center, PO Box 82209, Lincoln, NB 68501 • 800-488-3407 402-474-4055 • Fax: 402-474-5198

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R.B. Industries, Inc., PO Box 369, Harrisonville, MO 64701 • 800-487-2623 • 816-884-3534 Fax: 816-884-2463 • info@rbiwoodtools.com www.rbiwoodtools.com

Skil model HD5510 circular saw: Tool Crib of the North, PO Box 14930, Grand Forks, ND 52808 800-358-3096 • 701-787-3400 • Fax: 800-343-4205 www.toolcribofthenorth.com

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The Future of Transportation

Joshua Tickell

With gasoline prices as low as 88 cents a gallon in some parts of the United States, it seems like our supply of oil may never end. The U.S. military recently showed its ability to defend fossil oil deposits in the Persian Gulf by hurling missiles into a Bagdad neighborhood and "removing strategic targets" inside the borders of Iraq. At the gas pump it looks like oil is cheap, and on the television it's obvious that we're in control. But, the politics and economics of oil will change during the next five years.

How Much Oil is Left?

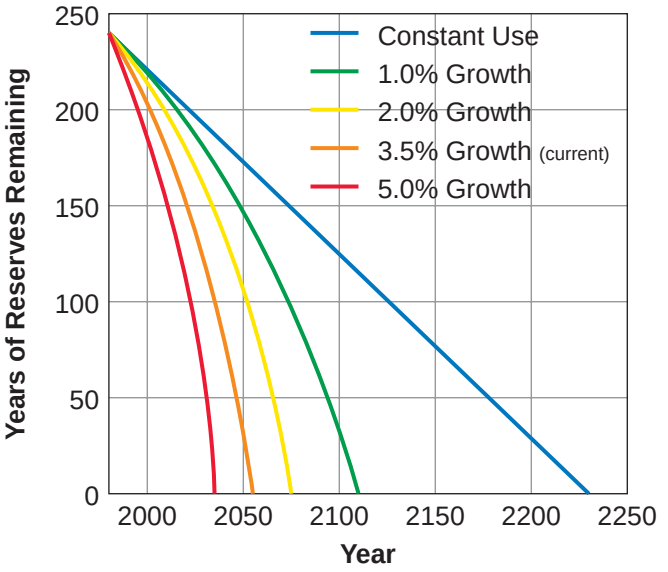
At some moment during the next five years, we will have consumed more than one half of the total usable fossil oil on Planet Earth. To date, we have extracted 807 billion barrels of crude oil. Only an estimated 995 billion barrels remain that can be extracted at current production costs.

If the worldwide rate of oil consumption remained a constant 24 billion barrels of oil per year, we would run out of oil in 2040. But consumption is not static—it is increasing by about 2 percent per year. Even our rate of increase is accelerating. Demand for oil will overshoot supply well before 2040. At some point between 2010 and 2025, all fuel from fossil oil will be too expensive for the average U.S. consumer to afford. Exactly when that point comes will depend largely on the actions of Middle Eastern countries.

Natural Gas Supplies Limited

In 1970, worldwide annual consumption of natural gas was 30 trillion cubic feet. Today, annual consumption is over 70 trillion cubic feet and is increasing at 3.5 percent per year. A 3.5 percent annual increase in consumption will deplete natural gas reserves by 2050. However, the increase in consumption of natural gas is accelerating at an astonishing rate. Cheap supplies of natural gas will be depleted by 2040.

Depletion of the World's Natural Gas Reserves at Different Rates of Growth in Consumption



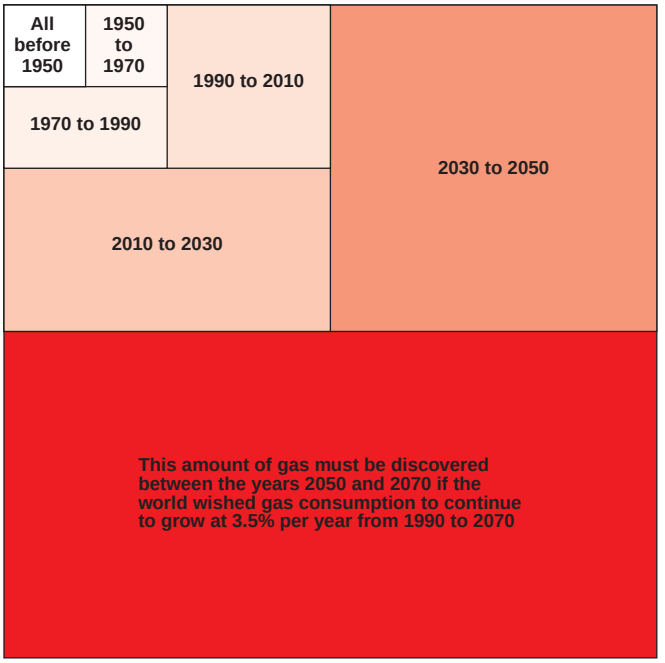
Power companies are building new natural gas power stations to give customers in their area cheaper electricity. New natural gas power facilities will soon supply up to 40,000 megawatts in the Northeast, Texas, and California. Experts believe that by 2010, the supply of electricity from new natural gas power facilities will jump to 100,000 megawatts. Natural gas power plants are attractive to investors. They have an average six year investment turnaround and can produce electricity for a cheap rate of two to three cents per kilowatt-hour.

As city smog laws become more stringent, natural gas cars will be on the rise. The demand for natural gas fuel will increase. Due to the rapid increase in consumption of natural gas for power generation and transportation, we cannot rely on natural gas supplies to provide fuel for our transport infrastructure in the near future.

Scramble for Oil

The United States scrambled to realign itself with OPEC as long lines of cars snaked out of service stations during the '70s. Arab Nations made a concerted effort to fix oil prices—resulting in mayhem. Iran, Iraq, Kuwait, Saudi Arabia, and the United Arab Emirates gained approximately 36 percent of the world's share of oil production during the early 1970s. A number of factors contributed to this, including simultaneous worldwide demand increase and

Necessary Natural Gas Discoveries to Maintain a 3.5% per Year Growth Rate



production decrease. Acting together, these countries increased the world price of oil to over $56 a barrel, pushing the U.S. into economic shock.

Realizing its vulnerability, the U.S. turned to other sources of oil. Alaska, the North Sea, and other locations began supplying more oil than ever before. By 1986, the Middle Eastern share of oil had fallen to 16 percent and the price of oil had dropped to $6 a barrel. During the next 20 years, the oil business in the U.S. went from boom to bust as the richly endowed fields ran dry and foreign oil again became an attractive source.

If you thought the 1970s were bad, wait until 2010. By then, Arab Nations will have the power to reenact the oil crisis and the United States will have no backup sources of cheap oil.

Impending Oil Shock

The capacity of the U.S. to produce inexpensive oil has continued to fall since the 1980s. By 2010, the DOE estimates that 62 percent of U.S. oil will be imported. The U.S. is relying heavily on the Middle Eastern nations to provide it with liquid fuel. In 1996, the five Arab Nations held 27 percent of the world's share of oil production. By 2000, they will again hold 30 percent. By 2010, the Middle Eastern share of world oil production will creep to 40 percent. By 2025, as worldwide production dwindles, the Middle Eastern share of oil production will rise to 50 percent.

Oil in the Middle East is not running low, and as the U.S. exerts its military prowess with less discretion, neither are grievances. Although we may offset the Middle Eastern control of the world oil economy by a few years through extracting recently discovered endowments and by using high cost extraction methods, we must eventually face the reality that 50 percent of the remaining oil in the world lies in the Middle East.

Buying time will not save the United States from a permanent oil shock. At some point in the near future, demand will overshoot supply, production will outpace discovery, and the Middle Eastern nations will take full control of their own energy resources. The supply of oil will not stop, but the supply of cheap liquid petroleum fuel that is affordable to consumers will stop.

Emerging Alternatives

Consumers in the U.S. have been begging automakers and politicians since the 1970s for alternatively fueled automobiles. When the subject arises, the finger of blame is invariably pointed at the low price of gasoline. When asked by *Newsweek* if the SUV (sport utility vehicle) is an environmental problem, Jack Smith, CEO of General Motors Corp. said, "...gasoline is too cheap in this country. It's selling for 85 cents a gallon in Atlanta...In the rest of the world it costs close to $5 a gallon. When you ask 'Do we need regulations?' [The answer is] no. We just need higher gas prices. That will change what people do." Jack Smith is giving us a good hint.

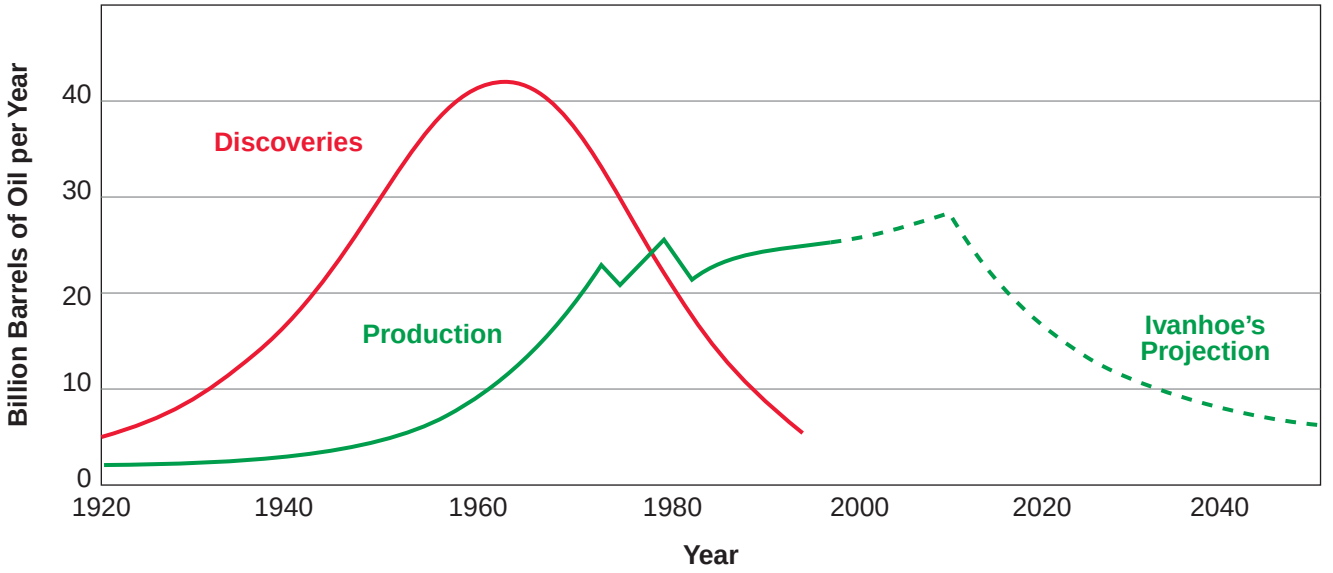
As engineers behind the scenes at GM race to have their hybrid vehicle prototype ready for the 2000 Detroit Auto Show, Jack Smith and his fellow CEOs at Ford and DaimlerChrysler are banking on having alternatives ready for sale to customers sometime during the first ten years of the new century. Unlike the oil shocks of the 70s, when GM, Ford, and Chrysler had nothing to offer the lines of stranded drivers, they will be waiting in the wings with alternative automobiles for the oil shocks of 2010 and beyond.

Emerging alternative vehicles offer increases in efficiency, decreases in weight, and other design improvements. While some promising technologies in personal transport are afoot, corporations, researchers, and politicians are giving little if any attention to true transportation alternatives such as biking, public transport, solar-charged electric vehicles, and agriculturally generated fuels.

Super Efficient Diesel and Gasoline Engines

While the Big Three race to create future alternative vehicles, other manufacturers and entrepreneurs are concentrating their efforts on providing consumers with high efficiency alternatives today. In 1996, Greenpeace of Germany introduced their Smile car (a converted

World Oil Supply



The two areas (Discoveries and Production) must ultimately be equal, since one cannot produce more oil than has been discovered.

Sources: Discoveries Curve adapted from USGS/Masters, 1994. Production Curve extrapolated by author to match Discoveries volume (area under Discoveries curve). Used with permission.

Renault Twigo). Its 250 cubic centimeter gasoline engine produces minimal emissions, accelerates to normal highway speeds, and gets 100 miles per gallon.

Although most people brushed the Smile off as a hoax rather than the two year engineering feat that it was, the efforts of Greenpeace had obvious impacts. Only three years after the Smile hit the German media, Volkswagen of Germany is releasing its 80 mile per gallon Lupo car this April. The Lupo has an aluminum body with a twelve year rustproof warranty, a small diesel engine, and a computer controlled manual transmission.

Honda pioneered the stratified combustion engine in the early 1970s and had a 50 mile per gallon Civic on the market during the oil crisis. Now they've upped the stakes. Their new engine produces one tenth of the emissions of California's Ultra-Low Emissions Standard. They call it the ZLEV (zero level emissions vehicle) because the air from its tailpipe is actually cleaner than the air most people breathe. The ZLEV will be available in the Honda Accord next year. Soon thereafter, Honda will introduce its new breed of ZLEV 70 mile per gallon Civics.

Keeping automobiles simple, light, and efficient will do more for the environment than future automobile technologies are likely to accomplish. As cars become more complex, they require more materials for production, have more systems to maintain, and inevitably, tax the consumer and the environment more.

Despite the advent of super efficient diesel and gasoline engines, automakers continue to focus on complex hybrid vehicles and expensive, inefficient fuel cell vehicles.

Hybrid Vehicles

Hybrid vehicles operate on the principle that two power sources are better than one. Hybrids have both an electric motor and an engine, which can be diesel or gasoline. By combining these features, the vehicles will double fuel efficiency with no net loss of power, style, or comfort. The manufacture of hybrids will use currently available technologies, will be much more efficient than current automobiles, and will make use of current fuel stations and pumps.

During the next five years, the first hybrids will roll onto showroom floors in the United States. Toyota will offer the Pirus to U.S. customers next year. Toyota's gasoline electric car gets a reported 66 miles per gallon and handles similarly to the Corolla. Although the car costs around $40,000 to build, it carries an estimated sticker price of $17,000. Toyota is making an investment in the future of hybrid vehicles, knowing that production costs will decrease as the number of cars produced each year increases.

While the Pirus uses a gasoline electric combination, most of the hybrid vehicle prototypes have a new breed of cleaner diesel engines coupled with their electric motors. These cars will get between 70 and 80 miles per gallon and will roll into showrooms in the next five

years. But not everyone is happy with the upcoming models. In a recent interview with *Newsweek,* Amory Lovins of the Rocky Mountain Institute said, "You can indeed make a diesel much quieter and cleaner...but fuel cells will beat them, hands down."

Fuel cells sound good, but their expense and experimental nature points us toward more practical technologies for increasing vehicle efficiency. Super efficient diesels and diesel electric hybrids provide two realistic means of achieving vehicle efficiency and are a practical application of currently available technology. For now, the combined efficiency of a diesel engine and an electric motor remains unmatched.

How a Fuel Cell Works

Electrolysis is the electrification of a liquid. We use a device called an electrolyzer to split molecules of water into hydrogen and oxygen. A fuel cell is essentially an electrolyzer running in reverse. Instead of putting electricity into water and getting hydrogen and oxygen out, we put hydrogen and oxygen into the fuel cell and get electricity and water out. This explanation is simplified, but just imagine hydrogen and oxygen piped into this thing and two wires feeding electricity out. That's basically how a fuel cell works.

Although fuel cells can be a practical solution for stationary power generation, vehicles with on-board fuel cells cost ten times more to build than conventional vehicles, they are comparatively inefficient, and still very experimental.

Experimental and Expensive

Researchers, technology enthusiasts, and automakers are heralding fuel cell vehicles as the ultimate solution to our transportation dilemma. GM plans to unveil its fuel cell prototype automobile in 2005 or maybe sooner. Experimental, costly fuel cell vehicles have existed since the 1960s. Today's fuel cell vehicles are still just that—experimental and expensive.

Like batteries, fuel cells are not *sources* of electricity. Fuel cells are YSTE devices (You Supply The Energy). Fuel cells convert hydrogen, which must be produced, into electricity. This crucial point is often glossed over in all of the hype that surrounds fuel cells. Fuel cells allow us to use hydrogen as a storage medium, in the same way we use batteries. But fuel cells are *not* a source of energy and the hydrogen they use is *not* a source of energy, either.

Energy Balance Ratio

The most important measure of any fuel or energy carrier is its energy balance ratio. Simply stated, this is how much energy is expended to produce the fuel versus how much energy the fuel contains. If more energy is expended to produce a fuel than the fuel contains, energy has been lost in the production process. Such a fuel is said to have a negative energy balance ratio.

Hydrogen is an example of a fuel with a severely negative energy balance ratio. When hydrogen is produced by electrolysis, the energy balance ratio is 2 to 1 (2 units of energy in for every 1 unit out). By putting hydrogen into a fuel cell vehicle, we lose even more energy.

Fuel Cell Vehicles or *Fool* Cell Vehicles?

If we put 1 KWH of electricity into an electrolyzer, it produces hydrogen gas containing about 0.5 KWH of energy. If we pump that hydrogen gas into a fuel cell vehicle, the fuel cell will produce less than 0.25 KWH. Due to further energy losses, the electric motor of the fuel cell vehicle will receive less than 0.20 KWH of electricity. In this system, 80 percent of our original 1 KWH has been lost.

The proposed gasoline, methanol, and natural gas fuel cell vehicles are just as inefficient. Compared to the 50 percent efficiency achieved by super-efficient diesels and diesel electric hybrids, 20 percent efficient fuel cell vehicles lose, hands down.

Instead of extending the life of our limited energy resources, the widespread use of fuel cell vehicles would further increase the rate of energy consumption. Hydrogen for fuel cell vehicles would be produced from grid electricity. Most electricity in the U.S. comes from coal. Alternatively, large amounts of natural gas could be used to produce hydrogen. Since hydrogen production will increase fossil fuel consumption, fuel cell vehicles offer no relief from the shortage of fossil energy.

If you think fuel cells sound like a job creation program for desperate automakers, you're not alone. Daniel Becker of the Sierra Club says fuel cells are "...a scam

Practical Solutions to the Upcoming Crisis

- Conservation of liquid fuel through the use of public transport and the redesigning of neighborhoods and cities for optimum efficiency in transport.
- The widespread use of bicycles and the availability of bicycle lanes and bicycle racks.
- The use of electric vehicles charged by PV, wind, or microhydro systems.
- The limited use of biodiesel, ethanol, and methanol as liquid fuel substitutes.

designed to fend off regulations." Ralph Nader says, "Until they are on the showroom floor, it's nothing more than razzle-dazzle, R&D flimflam."

President Clinton's multi-million dollar Partnership for a New Generation of Vehicles program is giving huge handouts to the Big Three automakers to "develop" their hypercars. But not much federal money is being put into the construction of bike lanes, the public transportation system, or the efficient design of cities and neighborhoods. Fuel cell vehicles may be a breakthrough in design, but they alone will do nothing to aid the establishment of a sustainable transport system.

Real Solutions—Solar Fuels and Conservation

Fuel cell vehicles are less than 25 percent efficient and their cost is prohibitive. Hybrid vehicles are based on practical technologies but are currently expensive. Super efficient diesels and gasoline cars are being marketed in hopes of prolonging fuel supplies.

No matter what new vehicle technologies emerge, human civilization must soon face the fact that cheap liquid fossil fuel is running out. Due to the inescapable end of cheap oil, the days of the personal combustion engine automobile are numbered. The time has come to increase transportation efficiency, create fuels from solar energy, and conserve every possible BTU and calorie.

Fuel from Agriculture

Fuels made from agriculture—such as ethanol, methanol, methane, and vegetable oil—will soon be the only affordable liquid energy carriers. Methanol can be produced from biomass with an energy balance ratio of 2 to 1. Ethanol can be produced from grains and biomass with an energy balance ratio of 1 to 1. That's a pretty square deal in the fuel industry. Biodiesel can be produced from new or used vegetable oil with a minimal energy balance ratio of 1 to 3 and a maximum of 1 to 10. That's right—with biodiesel, only 1 unit of energy goes in for every 3-10 units produced.

Biodiesel is a fuel made from vegetable oil. It can be used in an unmodified diesel engine. The emissions of an engine running on biodiesel are drastically reduced. Although the manufacture of biodiesel requires a small percentage of methanol or ethanol, the fuel comes primarily from an oil-yielding crop such as sunflowers, canola, or soybeans. Both biodiesel and petroleum products are hydrocarbons.

Biodiesel has an advantage over all other alternative fuels—it can be used in existing engines without any vehicle modification. Biodiesel can also be made from used cooking oil, three billion gallons of which are produced in the U.S. each year. Biodiesel will allow upcoming diesel-electric hybrids to be renewably fueled and will help to reduce emissions.

The advantage of plant-based fuels is that plants are the cleanest, most efficient converters of solar energy to chemical energy. Plants are basically solar-powered refineries. Powered by sunlight, they take in water and carbon dioxide. Plants release breathable oxygen and build plant tissue and oils. With regards to the cost, energy, and level of technology, growing plants commercially is more efficient than discovering, procuring, and refining petroleum products.

Ag Fuels vs Petroleum

As we move into the new millennium, overall costs and energy needed to refine petroleum will increase while the inputs necessary for the production and refinement of agricultural fuels will decrease. Within the next ten years, agriculturally based fuels will be cheaper than petroleum. The cost of fuel in the United States in 2010 will likely be similar to the current cost of fuel in Europe plus inflation. If you include possible price controls enforced by the Middle East, a retail gallon of fuel could easily run up to $20. Price alone will be motivation for most consumers to conserve fuel.

In Germany, where gasoline and diesel fuel can cost as much as $8 a gallon, biodiesel fuel is sold at 1,000 service stations around the country. Biodiesel fuel often costs less than its petroleum competitors and is gaining in popularity as consumers become familiar with its benefits and automobile manufacturers endorse its use. The fuel is not taxed, because it is a carbon-neutral fuel. This means that all of the carbon that is emitted from vehicles running on the fuel is re-circulated into the next batch of crops grown to make the fuel.

In Germany, government, industry, environmental organizations, and universities are working together to provide consumers with alternatives before it's absolutely necessary. Towns are organized for maximum efficiency in transportation. Public transport is widely available, and bicycle lanes exist almost everywhere there are roads.

Home Power Solutions for Personal Transport

I believe that each individual can change society by rolling up his or her sleeves and doing the job. If enough people choose sustainable transportation, mainstream society will catch on.

We have three simple, low-cost, low-tech, and relatively sustainable methods for personal transport—the bicycle, the Electric Vehicle (EV), and the Biodiesel Vehicle (BV). The practical distance each can travel is very different. By combining these three forms of transport, we can sustainably travel any distance over

land. These transport mediums can receive their energy from the sun via food, PV, or vegetable oil.

Bicycles are the most sustainable, energy efficient personal transport devices created to date. EVs are second choice with highly efficient motors (up to 90 percent efficient), and efficient energy storage via batteries. Audi estimates that EVs could serve for 85 percent of all trips taken in personal vehicles.

As with any technology, EVs have limits. When you want to go 100 miles (161 km) or more, a biodiesel or straight vegetable oil-powered vehicle can be a wonderful thing. Most small diesel vehicles take very little fuel to go great distances, averaging 50 miles per gallon. In fact, one acre of soy, canola, or sunflowers can provide about 50 gallons (190 liters) of fuel (which can be stored in a common 55 gallon drum) and will power a small BV for about 2,500 miles (4,000 km).

The 1980s water-cooled Volkswagens such as the Golf, Jetta, Rabbit, Passat, Fox, Cabriolet, Pickup, and Vanagon are good candidates for becoming EVs and BVs. The gasoline models are easily converted to "Voltsrabbits" using the book *Convert It* and associated kits by Michael Brown and Shari Prange of Electro Automotive. Their Voltsrabbits are clean, quiet, simple to drive, and can be charged from a PV system.

The 1980s diesel watercooled Volkswagens have a 1.6 liter indirect injection motor. These engines run very well on heavy fuels such as straight vegetable oil mixes. I have received mail from people running their Volksie diesels on beef lard, palm kernel oil, used restaurant grease, pure soy oil, and more. Some have modified their cars, some have used biodiesel, and others have just poured the fuel in.

I encourage you to get a copy of *Convert It* and talk to Mike and Shari about getting a Voltsrabbit of your own. If you are interested in biodiesel, I encourage you to make the plunge and begin your own experiments and research with vegetable oil propulsion. It is a relatively simple, safe, and economical means of travel. And if you have an acre or two of farmable land, you can grow your own fuel. In my next article, I will be going into some of the technical aspects of making biodiesel fuel, using biodiesel and straight vegetable oil in diesel engines, and growing an oil-yielding crop.

Practical Solutions

Cheap supplies of fossil oil will soon come to an end. Due to the huge quantities of oil the world currently consumes, oil shocks are inevitable. Automakers and researchers will offer the hybrid vehicle and the fuel cell vehicle as solutions to the upcoming transportation crisis. Hybrid vehicles offer an increase in efficiency using practical technology. Fuel cell vehicles are not practical and will not become a practical solution.

Since agricultural production of fuels will yield only limited quantities and fossil fuel will be all but unavailable, the responsible and limited use of liquid fuel is inevitable.

As we near the end of cheap oil, citizens should be wary of any large corporation or institution heralding a new and expensive technology as a fix to the transportation problem. In the words of Alfred P. Sloan, President of General Motors Corporation from 1923 to 1937, "Many wonder why the automobile industry brings out a new model every year. The reason is simple.... We want to make you dissatisfied with your current car so you will buy a new one."

The objectives of the automobile industry have not changed, nor will they change in the future. But the day is quickly approaching when the inflexible dinosaur giants of the automobile world will make way for start-up companies, garage geniuses, and small dedicated groups of engineers. Just as backyard pioneers have created an entire industry around photovoltaic technology that was once considered "impractical," they will also build the basic blocks of an alternative transport industry. By showing that there are elegant, efficient, and low-tech solutions to the transportation problem, dedicated individuals will be the driving force toward the sustainable transportation systems of the near future.

Access

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For a more in-depth look at worldwide oil consumption and production patterns: www.oilcrisis.com

The Coming Oil Crisis, 1998. Campbell, C.J., Multi-Science Publishing Company and Petroconsultants S.A., Essex, England

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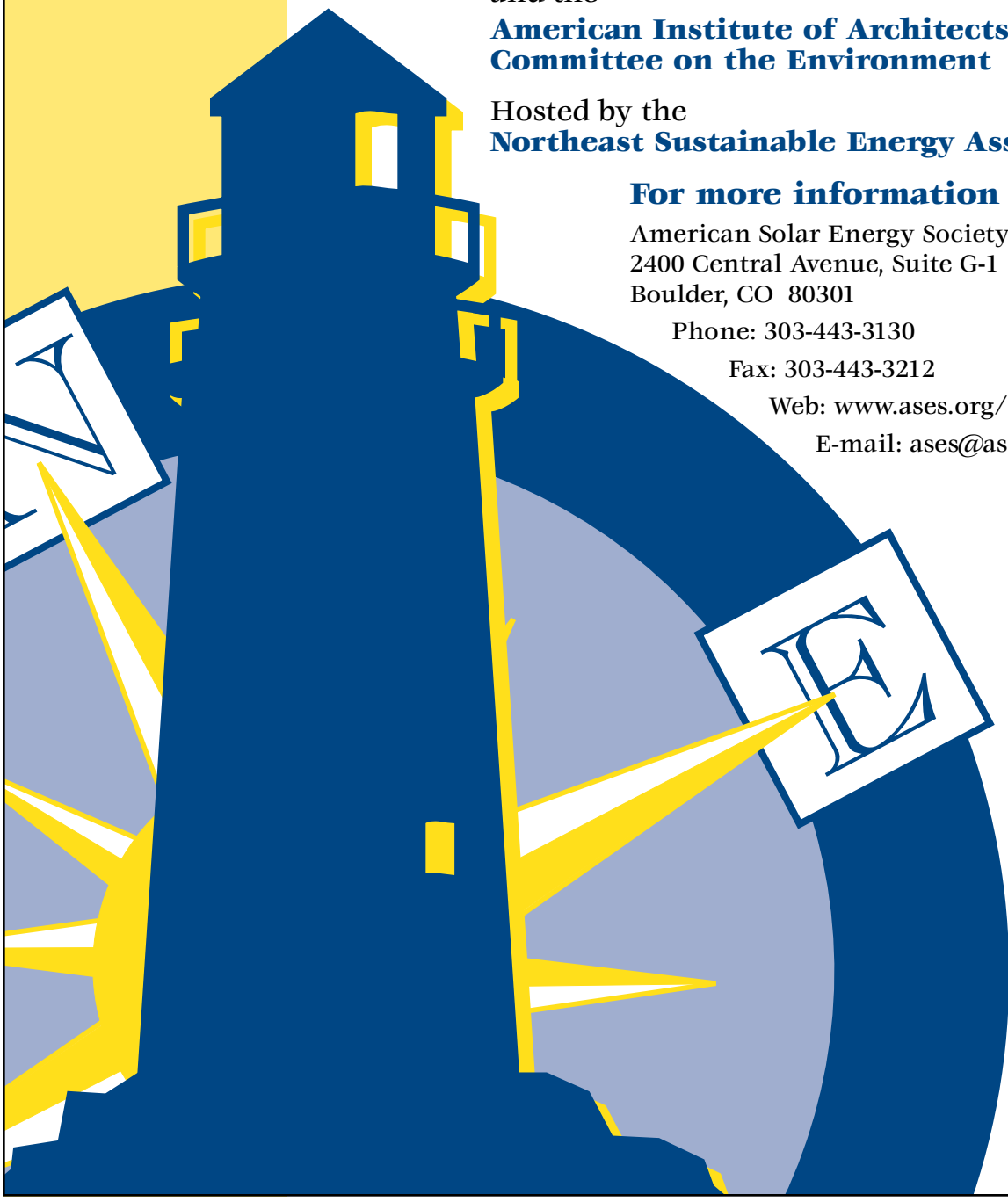

Things that Work!
tested by *Home Power*

Holly Solar's **LED Flashlight**

Tested by Richard Perez

I can think of no tool more essential than a flashlight. Over the past twenty-nine years of living in the country, I've worn out at least a dozen flashlights. They came in all sizes and weights, and they all had the same problems—dead batteries, a dead bulb, or a dead switch. This LED flashlight from Holly Solar is mechanically durable, gives long lasting light, and best of all, it's inexpensive.

What is an LED?

LED stands for Light Emitting Diode. These little light producers are really semiconductor junctions—diodes. The LED is designed so that the energy lost across its diode junction radiates as visible light. When it comes down to making light from electricity, the LED is three to seven times more efficient than fluorescent and incandescent lighting technologies. LEDs make more light using less power.

LEDs are low voltage DC devices. Like all diodes, they are polarized; they have a positive end (anode) and a negative end (cathode). The voltage drop across an operating LED junction can vary from 1.8 VDC (for a green LED) to over 3.1 VDC (for a white, high-intensity LED). This makes them naturals for operation on low voltage DC power sources such as flashlight batteries. LEDs don't draw very much—between 10 and 25 milliamps. Again, this makes them a natural for battery power.

When it comes to durability, the LEDs really shine. Typically, the LED junction has an *operating* life of over 100,000 hours—over eleven years. By comparison, incandescent bulbs used in conventional flashlights have lifetimes under 100 hours. LEDs are mechanically very rugged and will easily survive falls that would kill an incandescent filament.

Above: The LED flashlight.

LED Flashlight

Of all the applications using LEDs, the flashlight is the best. Longer lamp life, lower energy consumption, and higher mechanical reliability make LEDs ideal for flashlights. The only problem has been developing LEDs with high-intensity white light, and that's been solved within the last three years.

This Holly Solar PLW-3 flashlight uses three of the new high-intensity white LEDs for its lamp. The flashlight's body is made from black ABS plastic and is thick enough to survive being stepped on by a moose. Holly's literature says it's even waterproof to approximately 50 feet (15 m), though I haven't tried scuba diving with it yet.

The flashlight's transparent head is made of thick Lexan plastic and is sealed to the body using two rubber O-rings. The flashlight is 1.25 inches in diameter by 7.5 inches long (3.2 by 19 cm). It's light enough to be held between the teeth, freeing both hands for work. The unit is very compact and durable.

Below: All the parts.

Using the Holly Solar LED Flashlight
This flashlight is easy to use—just screw the head clockwise about a quarter turn until it lights. To turn it off, just screw the head counterclockwise. This very simple and reliable switch method is now used in the most durable flashlight designs.

To change the batteries, spin the head counter-clockwise and remove it. The three AA batteries slip out of the ABS plastic body for recharging (Yay!) or replacement (Boo!). This flashlight will accept any AA cells.

I used my Fluke 87 multimeter to measure the power consumption of the three LED lamps. They consumed 40.2 milliamperes at 3.3 VDC. I used three Golden Power 700 milliampere-hour, NiCd AA cells. In use, this flashlight had over 15 hours of operating time. If you use the new nickel-metal hydride (NiMH) cells, this operating time could easily be doubled to 30 hours. Compare this with a conventional incandescent flashlight lamp, which has less than 2 hours of operating time.

While the Holly Solar LED Flashlight is not as bright as conventional incandescent flashlights, this doesn't bother me. It puts out enough light to navigate around the house, walk around outside, and view objects up to 40 feet (12 m) from the light. On close jobs, such as changing a fuse or refueling the generator, the Holly flashlight is more than bright enough. The quality of the white light is good enough to easily distinguish colors, even though the light has a slightly blue cast to it.

The light comes with a strap that binds it to your wrist while you are working. You might find it to be a handy addition, but I'll probably never use it—I'm a flashlight-in-the-mouth person. I like to have both hands free while I direct the light with my head movement. Having it on a wrist strap tends to tie up one hand, though not as much as holding it without the strap.

No Warts, No Sweat
Warts? I looked hard for something wrong or even something that could be improved. I couldn't find anything. This flashlight is very well designed, from basic function down to little things like a rim on the face of the Lexan head to prevent scratching the lens.

This flashlight is virtually indestructible. It came in a plastic shipping tube via regular mail. It survived. There were no docs enclosed. If there had been, it would have been a waste of paper. If you can open a bottle of soda pop, then you can operate and maintain this flashlight.

Use It!
This is the flashlight to use. It's got everything we ever needed in a flashlight, except a belt holster. I will make one, which shows you how much I really like this product. It has a retail price of US$29.95 and its durable mechanical construction and design make it very long lasting. Holly Solar has sold over 25,000 of these flashlights to customers all over the world.

Right: The LED lamp assembly.

If you think that Holly Solar's LED lighting program only includes this one flashlight—think again. There are two other flashlights in their line, and that's just the beginning. Bill Hollibaugh, owner of Holly Solar, says that a variety of other LED projects have been spinoffs from the LED flashlight.

They now make LED streetlights for use in Japan, park lighting for Nicaragua, lighting for ATMs in Europe, and ski lodge lighting for resorts in Colorado. They even make lighting for the video cameras on NASA's space shuttle. Their Web pages are full of LED lighting products that can save folks off-grid and on-grid alike many kilowatt-hours of energy.

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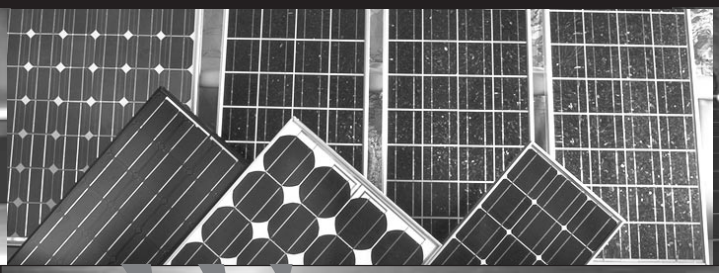

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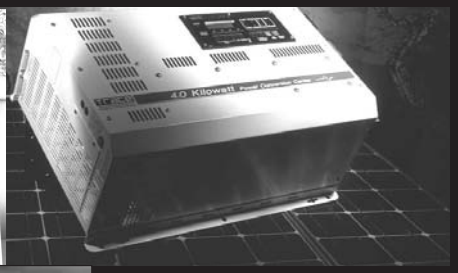

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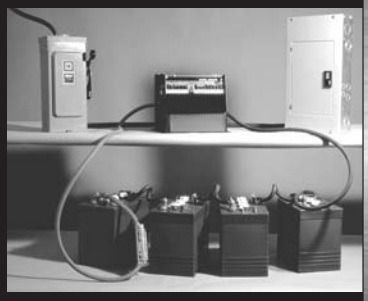

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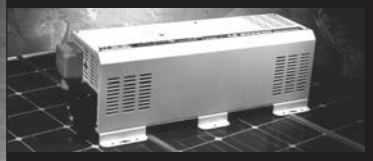

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GMAC Mortgage Offers Financing for Solar

Stephanie Harmon

Are you thinking about energy-efficient options you'd like to include with your new home? Trying to decide what to exclude in order to afford solar components? Considering putting some PVs on your roof? How do you plan to finance the modifications?

Until recently, many consumers had to use their savings, credit cards, or high interest home equity loans to finance energy-efficient improvements or solar electric systems. There is a better option. Through GMAC Mortgage Corporation, a Pennsylvania based full service mortgage lender, consumers can now finance solar installations or energy-efficient features with their first mortgage or home equity loan.

GMAC Mortgage is an indirect wholly-owned subsidiary of General Motors Acceptance Corporation. It is one of the nation's leading mortgage bankers. It services mortgage loans for more than 1.5 million customers and has more than 280 offices nationwide. GMAC Mortgage closed more than $777 million in energy-efficient residential loans last year.

PV Financing

GMAC Mortgage now finances PV and other renewable energy systems, passive solar design, and other energy-efficient improvements that consumers may want to add to their homes. Systems are not financed alone, but as part of a home mortgage.

Gale Prososki-Marsland of SolarBuilt in Tucson, Arizona is excited about the new programs. GMAC Mortgage has offered her company a builder's line of credit to construct solar homes in Civano, formerly the Tucson Solar Village. Civano is a model sustainable community on the southeast side of Tucson. It will incorporate passive and active solar, water conservation, pedestrian-friendly layout, waste reduction goals, and the use of "green" building materials.

SolarBuilt also has several clients who are financing PV systems with GMAC Mortgage in southeastern Arizona. "This is a big step forward for the solar industry," Gale said. "We need mainstream financing. I'd like to see it be like buying a car—financing is easy and you can almost buy on impulse."

Scott Sklar, Executive Director of the Solar Energy Industries Association (SEIA) is also very upbeat about the new program. "This is the first time a nationally recognized mortgage company has selected PV as a part of an energy-efficient mortgage program. This will accelerate lending for PV as no other lender has ever done. GMAC Mortgage is publicizing this new lending effort with literature, press releases, and advertising. They're saying, 'We're here for you if you want to add a PV system to your home financing.' This can be nothing but good for the industry."

Sklar says that perhaps the most exciting project that GMAC Mortgage has been involved in is right in downtown Philadelphia. Don Bradley, a local solar builder, is building eighteen townhouses using PV, passive solar design, and solar hot water systems. These are being built specifically for low to middle income families. The GMAC Mortgage financing is making solar affordable. "This project has generated lots of phone calls to SEIA," Sklar said. "People now think it's a real possibility for their own homes and communities."

Lower Energy Bills—More Buying Power

Special underwriting consideration is given to borrowers with energy-efficient homes or homes undergoing energy related improvements. When energy efficiency is included in a home design, higher monthly housing expense and debt payment ratios can be justified because of the potential for lower monthly energy expenses.

To show how lower energy bills mean more income for a mortgage, let's look at an example. Assume that a borrower qualifies for a mortgage of $90,000. We'll assume a mortgage rate of 7.5 percent for a term of 30 years.

Under standard guidelines, based on our borrower's income of $2,500 per month, the maximum monthly payment accepted would be $700 per month. (The principle and interest payment would be $630, leaving $70 per month for real estate taxes and insurance.)

An energy-efficient home can increase the borrower's maximum allowable payment to $750 per month. The borrower has the added buying power of $7,150, or 6.5 percent, for a mortgage of $96,500.

As far as solar goes, let's assume the home is new construction and solar components are added during construction. The home energy rating may boost the monthly savings figure even further. For example, if the energy savings were $100 per month, the maximum allowable payment would be $800. The borrower has added buying power of $14,353, or 13.75 percent, for a mortgage of $104,400. In many cases, this increase will be enough to add the solar system the buyer desires.

What Qualifies as Energy-Efficient?
GMAC Mortgage offers new features to an industry-recognized program known as Energy-Efficient Mortgage (EEM). Designed for new homes, it includes solar energy improvements integrated into the construction of the home. The quantifiable savings due to solar energy improvements can be deducted from the monthly principal, interest, taxes, and insurance when borrowers are considered for loan qualification.

An EEM includes homes with passive or active solar design or energy-efficient upgrades. Typically, the home must contain one or more features from each of the following three categories to receive a "high" energy rating:

1. Insulation and infiltration: insulation with high R-values or infiltration barriers included in ceilings, roofs, caulking, or weather stripping; sealing of sole plates; dampers for exhaust fans and penetrations of the exterior shell.

2. Windows and doors: double or triple pane windows or storm windows, storm doors or insulated doors.

3. Heating and cooling systems: new efficient heating and cooling systems or appropriate modifications to existing systems.

Helping a Nationwide Initiative
In 1997, the White House announced a Million Solar Roofs Initiative, calling for installation of solar energy systems on one million roofs by the year 2010. At that time, GMAC Mortgage committed to be a major part of this partnership between the government and the solar industry.

Since then, an agreement has been signed by GMAC Mortgage and the Solar Energy Industries Association (SEIA), a national industry organization for U.S. commercial enterprises involved in solar energy. GMAC Mortgage is committed to making mortgage loan products and related financial services available to eligible consumers who are working with builders and solar professionals on new or existing homes.

Recently, relationships have been forged with other solar industry organizations in an effort to increase public awareness of available loan products and services. Throughout the country, GMAC Mortgage is looking to build partnerships with utility providers, manufacturers, distributors, builders, and communities that want to decrease their burden on the environment.

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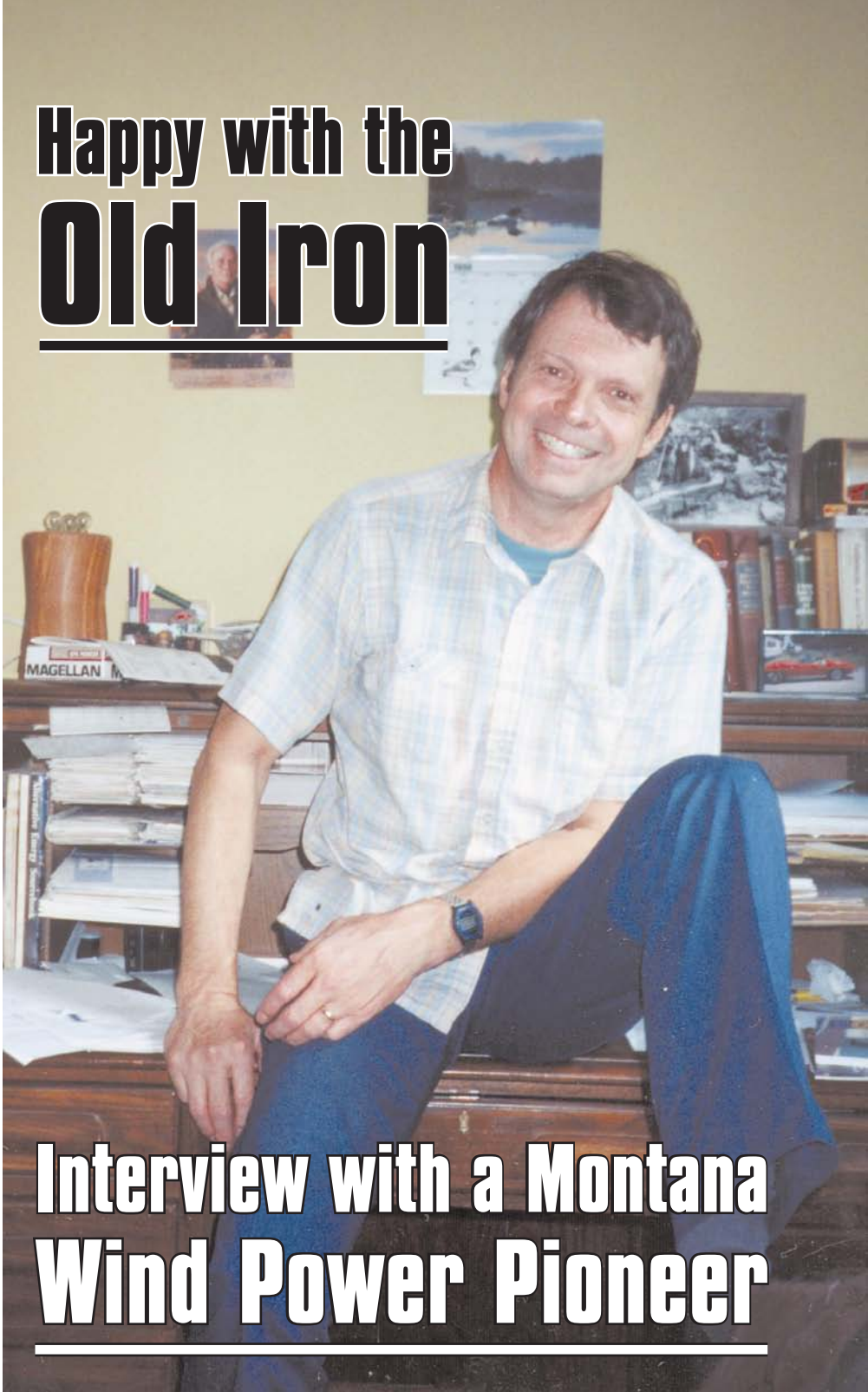
Happy with the Old Iron

Interview with a Montana Wind Power Pioneer



Above: Wind pioneer Steve Hicks lives near Livingston, Montana.

On my way through Montana last summer, I stopped to visit Steve Hicks of Mountain Pass Wind Company. Steve has been selling, installing, and tinkering with small wind generators since 1980. He's one of the pioneers of the recent wind power renaissance. In the basement office of his home located on a hill overlooking Livingston, he answered questions about his past, present, and future in wind power.

What was your first contact with wind power?

I used to be a pilot in Alaska. Energy was very expensive there in the interior of the state. I had time on my hands, I liked to tinker around, and figured, "I can build machines." I actually got a grant from the state of Alaska to build one out of old car parts. There was an old junkyard nearby. I used the differential from an old Vega, made my own props, and used a car generator. It was belt drive, with terrible siting. I never made an amp of power in Alaska. But I finished my booklet (*Home Built Wind Energy,* still available from Steve for $3.50 postpaid).

When I came down to Montana and refined the machine, it actually did put out some power, because of the high winds—I had better siting. I started out with a variable pitch governor, which I finally perfected. I moved to Livingston in 1981. I'm a geologist, and there's mining activity here, and I wanted to do the wind power business as a sideline. We have about a 16 mph average wind speed here, and it runs over 20 mph in the winter. It funnels down the Yellowstone River valley and we also get down slope winds off the mountains.

Did you have contact with other wind people at that time?

They almost didn't exist. Michael Hackleman and Jim Davis were around. There was one guy in the area who had made a home-built machine with a car generator. It wasn't as robust as what I was building. I did get some ideas from Hackleman's book, but overall there wasn't much activity. Before I started, Jim Davis had a lot of

gear-driven machines up. He liked the Winchargers, one of the earliest U.S. made wind generators. We've done some trading in the past. I also visited Kansas Wind Power years ago and got some 32 volt Winchargers from him. I've done some trading with Mick Sagrillo. And there's a guy in his eighties in Helena—Henry Bushnell—who did this for a living in the 30s, 40s, and 50s. He's got three gear-drive Winchargers right inside the city limits of Helena, and they've been up forever. He has some tales to tell. He worked between Helena and Great Falls, servicing wind machines.

Above: Steve's poorly-sited Wincharger overlooking Livingston and surrounding mountains. Soon this machine may be located at Steve's new site 70 miles north of Livingston.

Was there wind power here when you arrived?
No, I was the first one, but there were some shortly after I arrived. About that time Jacobs was reintroducing their machine, the 10 KW gear-driven model with the blade-activated governor. There was one of those machines that went up in the early 80s. And there were some Jay Carter 25 KW machines, but they had problems with those. As soon as they were out of warranty and stopped getting maintenance, the Livingston winds just ate 'em up.

Was there wind power in the state before the Rural Electrification Administration?
There's a guy up in the valley 30 miles from me; he put in a Jacobs in 1935. It's been ten years since I've been up there, but he was still using 50 year old Edison cell batteries and the same machine was running. He had it turned off a fair amount because he had a good wind site. East of us there are plenty of good wind sites, and many of the areas in eastern Montana didn't get utility power until about the mid 50s. I've picked up a few machines here and there, mostly east of here, but they are getting hard to find now.

I think it was late '81 or '82 that I saw my first gear-drive Wincharger. I got kinda excited about that. Hackleman had been hunting down old wind machines, but he was more of a wheeler and dealer than I was. I guess he was buying a whole truckload for $50 or something. I think I paid $150 for my first machine—a 1,000 watt, 2 blade, gear drive Wincharger. It was complete, sitting up in a barn. The blade was kind of weathered, but it was serviceable. I had it running, and then I ended up selling it to a guy in Idaho, Tom Simko (see *HP36,* page 18).

So when did you actually go into business?
I drove to Minnesota and got a Wincharger dealership in 1981. Back then, they were only building the small 200 watt Wincharger. But within four years, Winco was manufacturing a 450 watt machine and had reintroduced the big gear-driven four-blade 1,200, 1,500, and 2,500 watt wind generators. I started off buying two or three little 200 watt machines.

I've sold information and machines to people as far away as Australia, but I'm mostly dealing with customers within a five or six county area—about a 120 mile radius. Most of my customers are people new to the state who have remote property without utility power. I have yet to sell to a customer with utility power. I have sold a few solar panels, but mostly it's wind. I tend to pick up some of the solar people when they are hurting in the winter time—sell them a wind generator.

And I take real good care of people. My long time customers come back to me to buy new batteries or upgrade to a newer bigger machine or something. I don't have too many new customers; it's a part-time business. I spend a lot of time with my customers. I like working one on one with the owners. I work with some very independent-type owners—real good people. I like to work *with* people.

I'm working hand in hand with my customers. They know what's going on, and they know their systems. That's my strong point, I educate these people, and I'm working with them. They understand how to baby batteries, they understand what's happening when the inverter trips out for high voltage or this or that. I like the hands-on customer. I don't care to work with a guy who turns you loose to do the whole job, and I don't run into a lot of that anyway. My customers are a lot more knowledgeable when I'm done with them. And they're happy—they have good systems.

Above: Steve's good ol' Wincharger.

Here's a story for you. In Great Falls I picked up a wind generator customer. He was strictly solar, and was kinda hurting for power in the winter time. He had about a 13 mph average wind speed. I sold him a Whisper 1000 machine and he had more power than he knew what to do with. He had to dump all the surplus; he was very happy with it.

He was in an area where a subdivision grew up around him, and after a while everyone else had utility power except for him. So whenever there were new meter readers, they couldn't find the meter. He'd delight in watching them circling the house, looking for the meter. Then they'd knock on the door and ask, "Sir, is your meter inside?" And he'd say, "Sure, it is. C'mon downstairs, I'll show it to you." And he'd show them the metering system on his solar panels and wind generator....

What types and sizes of machines have you've worked with?

I've helped install some 65 KW machines in Iowa and Montana, but that's the exception. I've done some maintenance on these big machines too, but I really don't care for it and I'm not doing it anymore. I like the small DC machines. I've worked on machines from the 200 watt Winchargers up to 3 KW Jacobs and Whisper machines. I'm selling Whisper because I think they are the best buy for the money. I know Bergey is a fine machine, but there are others that have high failure rates.

I've had good luck with Whispers. I had one early problem when they came out with the three-blade 1,000 watt machine that was not governing soon enough. I put it in a high wind area and it burned up generators. They didn't have a test site comparable to where I was running this machine, so they were surprised. The company backed me a hundred percent; they were real good.

I repaired an old Windseeker one time. It was poorly sited and the local winds tore it up. I've heard secondhand stories about Air 303s, but haven't used them. My attitude is that if you're going to go to that much trouble, at least get a 600 watt Whisper, put it up in the air where it belongs and get some power out of it. I think some of these people are using these little Air 303s as if it's another solar panel, but the installations often aren't proper for a wind generator. I have no interest in selling those. I expect the Windseekers have improved; the one I dealt with was over ten years old.

I've had good luck with the old Winchargers. They have some limitations with the old air brake governor. You have to shut it down if there are high winds—it won't take the wind that these new machines will. But my customers are educated and they know that ahead of time.

What do you see as the future of wind power?

It seems pretty stable to me. I think I'll continue to get the same type of customers. Montana is a kind of romantic-type state and people want to be out west. I'll still be dealing with people who don't have a lot of money and want to make their own power. My typical customers are real do-it-yourself type people. They'll do their own car maintenance and fix most anything. And that's what I like.

I don't see things changing a lot for me. I'm still going to be specializing in the remote wind installations—it's a good complement to solar. But if solar prices come down much, it's going to hurt the wind business. Right now they really complement each other. Montana's a good wind state, and in the winter, wind generators produce power so much more cheaply than solar.

But I tell people the truth—wind's got headaches. They are not foolproof machines. These people know this going in. And I scare people off, too. But if they're willing

to work hard and put a tower and machine up, the power can be much cheaper than solar. Sometimes they do get scared off and they'll spend $20,000 to bring in utility power. But the do-it-yourself type people, if they do it right and get their hands dirty doing it, they're generally happy with their systems.

What would be your dream wind machine, if you could have anything?
Well, right now I'm in town. I've got a zoning restriction—the top of my blade can't be higher than 27 feet. It stinks! This is one of the first things I say to potential customers—this is not the way to do it. The only thing saving me here is that I'm in such a high wind area.

Dream machine? If I was to move to another little town... I've got a 50 foot, three legged, self-supporting Wincharger tower. I'd probably put up a nice 1,500 watt four-blade Wincharger. I can work on it and keep it going, I've got extra parts, and they're proven machines. They have some limitations; I wouldn't want to run them in 100 mph winds, though a friend in California has put his through 100 mph winds. It's a pretty tough machine. That's a good governor, a good machine, and I'd be pretty happy with that. Some people might want something bigger or newer, but I like the old machines.

This past winter, Steve did *move out of Livingston and found a new home 70 miles north. Soon we may be hearing about an old Wincharger running in a small town in Montana...*

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Solar Energy International

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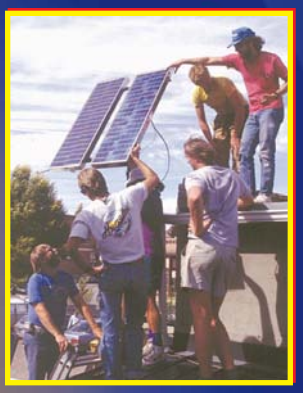
Solar Home Design	May 10–14
Natural House Building	May 17–21
PV Design & Installation	Jun. 1–11
Advanced Photovoltaics	Jun. 14–25
RE for the Developing World	Jun. 28–Jul. 2
Micro-Hydro Power	Jul. 5–9
Wind Power	Jul. 12–23
PV Design & Installation	Jul. 26–Aug. 6
Advanced Photovoltaics	Aug. 9–20
Successful Solar Businesses	Aug . 7–8



Workshops Outside Colorado

PV Design & Install, TX	Apr. 12–17
Renewables for the Northwest, WA	Oct. 3
PV Design & Install, WA	Oct. 4–9
Micro Hydro Power, WA	Oct. 11–15
Women's PV Design & Install, ME	Jun. 7–12

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Clean Water on Home Power!

Home Water Purification

Loren Amelang

Most Americans have grown up thinking pure, fresh water comes out of the wall at the turn of a tap. Many of us who live with home power systems are also providing and maintaining our own water supply. We become our own electric company, and water treatment company as well!

The simplest conventional private water system starts with an electric pump large enough to directly supply the maximum water flow rate required. Conventional pumps draw a lot of power, so you must have a large battery bank and inverter, even if the pump is only on for short periods of time. This system also needs a small pressure tank with a "drawdown" of about twenty gallons (76 liters) to prevent the pump from cycling on and off excessively. The water in the pressure tank is typically replaced several times a day so there is effectively no storage of water.

Off-Grid Water Systems

My first off-grid water system did not store much water. The old-fashioned windmill style pump was fitted with a small electric motor driven by PV panels. It filled up a fifty gallon (189 liter) barrel next to the well. A small DC pump lifted this water up to another fifty gallon barrel wedged into a huge oak tree. All of the water was used and replaced almost every day. I could use the fifty gallons by gravity flow as rapidly as I wanted to, but then I had to wait for it to be refilled.

When I became impatient enough to add more storage capacity to the water system, I began learning about water treatment. If the same water sits in a tank for days, biological contaminants that were insignificant in the incoming water have time to multiply and become a problem. The sediment filter cartridges required to protect the DC pressure pump grew algae until they were blocking the flow and causing the pump to cavitate noisily. Enough people reported vague "digestive upsets" that I began filtering all drinking water through my Katadyn filter.

Above: The author's ozone filter just pulled from the tank for cleaning. The filter is white when clean.

My real water treatment education was forced on me by a new property with a *real* water problem—iron. The plumbing fixtures were all bright orange, and the water looked like tea and smelled foul, right out of the well. If this water was allowed to stand, it grew iron bacteria. One slowly oozing outdoor faucet had a two inch (5 cm)

layer of what looked like butterscotch pudding coating its pipe!

Water Treatment Categories

Some systems must try to make "good" water from whatever "bad" water is available. The water may be unacceptable because of sediment (mechanically removable particles), dissolved minerals (hardness), chemical contaminants (from off flavors to toxic poisons), or biological hazards (giardia, non-fecal coliform, fecal coliform, or specific infectious agents).

Some of these problems require their own unique solutions. You might also have several problems combined in your water source. If you suspect you are starting with "bad" water, be sure to have it tested for a broad spectrum of various contaminants. A local government agency may be able to provide some kinds of testing, but you will probably need to have additional tests done by a commercial laboratory.

If you have good water, just keep it clean and fresh through storage and distribution. If the water in all of your tanks, pipes, and water heaters is not used up and replaced each day, you probably need to provide some type of preventive water treatment. The simplest, cheapest, and most common is chlorination, either by adding solid tablets which slowly dissolve in a storage tank, or by injecting liquid chlorine into the plumbing through a specialized metering pump. Unfortunately, chlorinated water is one of the things many of us left the cities to avoid….

Three Principles

I'm not a water treatment expert, just a wary consumer who has searched diligently for reasonable solutions to several water problems. My experience is a bit different from what you may have read in articles geared towards people served by public water systems. That's because all of my water systems have been individual and private. I've come up with three principles which any proposed water treatment solution must deal with.

1. The Medium is Messy

Most common water filters use some kind of mechanical barrier. The common pleated paper "sediment" cartridge has 20 micron openings and will keep your faucet screens from clogging up with debris, but does nothing about smaller contaminants. Likewise, large system "sand" filters trap only large, visible particles. The "backpacking filters," designed to make a biologically safe drink from whatever water you can find, have openings of 2 microns or less, and can catch bacteria and other infectious particles.

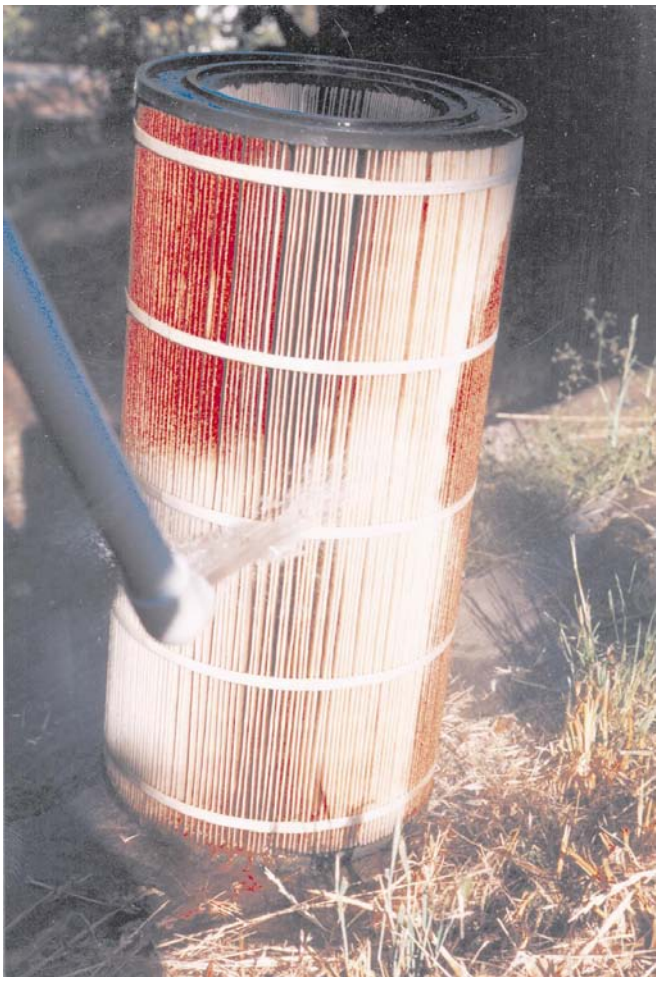
Reverse osmosis filters use a mechanical barrier which prevents biological contaminants and even dissolved minerals from passing through. Carbon granule or block filters rely on chemical attraction (adsorption) of contaminants to the filter medium rather than physically blocking their passage.

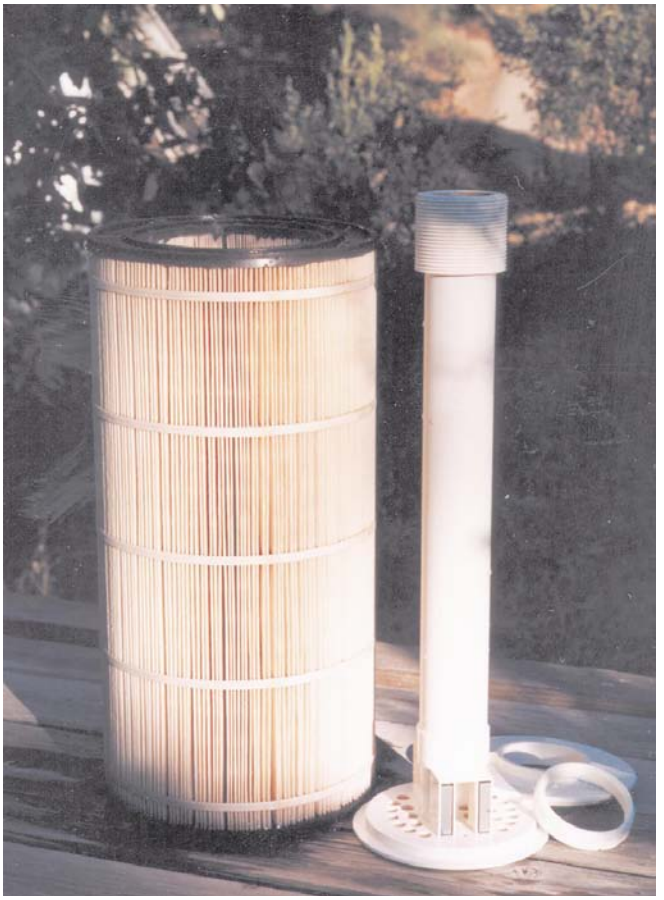
All of these devices provide a marvelous home for living things. Carbon filters attract biological contaminants along with their food supply. The sediment cartridges required by my close tolerance Slowpump clog with living algae long before they ever fill with mineral crud. If you have iron bacteria, they will not only live in the sediment cartridge, they will eat it. When you replace it, the pleated paper will simply be gone.

Many households use barrier or adsorption filters without obvious problems. This is because most shared water systems use chlorination to kill anything living in the water.

The filters with barriers under 2 microns, designed for unchlorinated water, are almost always used intermittently for treating small batches. They are allowed to dry out between uses. If they were to be used in a permanent installation where they were

Below: Spraying the filter clean.
Keep spraying until the runoff is clear.





Above: Water goes through the filter to the opening at the bottom of the center pipe, then rises with the ozone.

continuously wet, bacteria which could not pass through in their full grown size would eventually grow through the barrier during cell division. Some brands of this type of filter have chemical additives that inhibit bacterial growth.

Carbon filter cartridges work well when they are new, attracting a high percentage of all types of contaminants and hanging on tight. Unfortunately, an infestation of living things can quickly cover the whole surface, rendering the filter totally useless. Even without a biological infestation, there is no way for you to know when the cartridge has reached its limit for attracting contaminants, and has become a source of contamination rather than a solution.

Reverse osmosis filters trap practically all biological, chemical, and mineral contaminants, even the large quantities of dissolved minerals which make water "hard." Unfortunately, these filters must be flushed of their refuse with pressurized water. There is a lot of waste in this process—up to ten gallons for every gallon of purified water. This brings us to the second principle...

2. The Refuse Must Go Somewhere

In most installations, this slightly contaminated waste stream from typical reverse osmosis filters goes right down the drain. Since few people can afford a reverse osmosis system big enough to filter more than their personal drinking water, this waste of 10 to 40 gallons (38–151 liters) every day is generally tolerated.

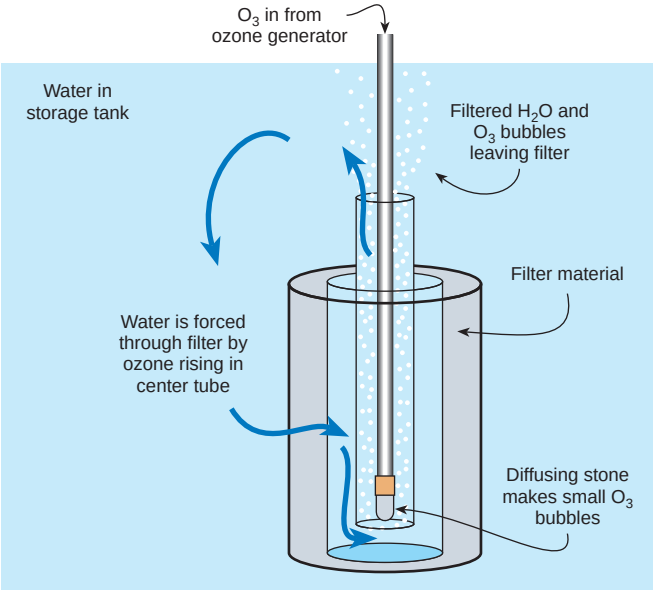
Small barrier style batch filters must occasionally be cleaned, generally by scrubbing the contaminants loose by hand and flushing them down the drain with potable water. Again, their limited size makes the impact of this problem tolerable.

Disposable filter cartridges, such as pleated paper sediment cartridges and carbon granule or block cartridges, are thrown in the domestic trash and probably eventually into a landfill. Along with the contaminants goes an inseparable maze of paper, plastic, carbon, and various other materials.

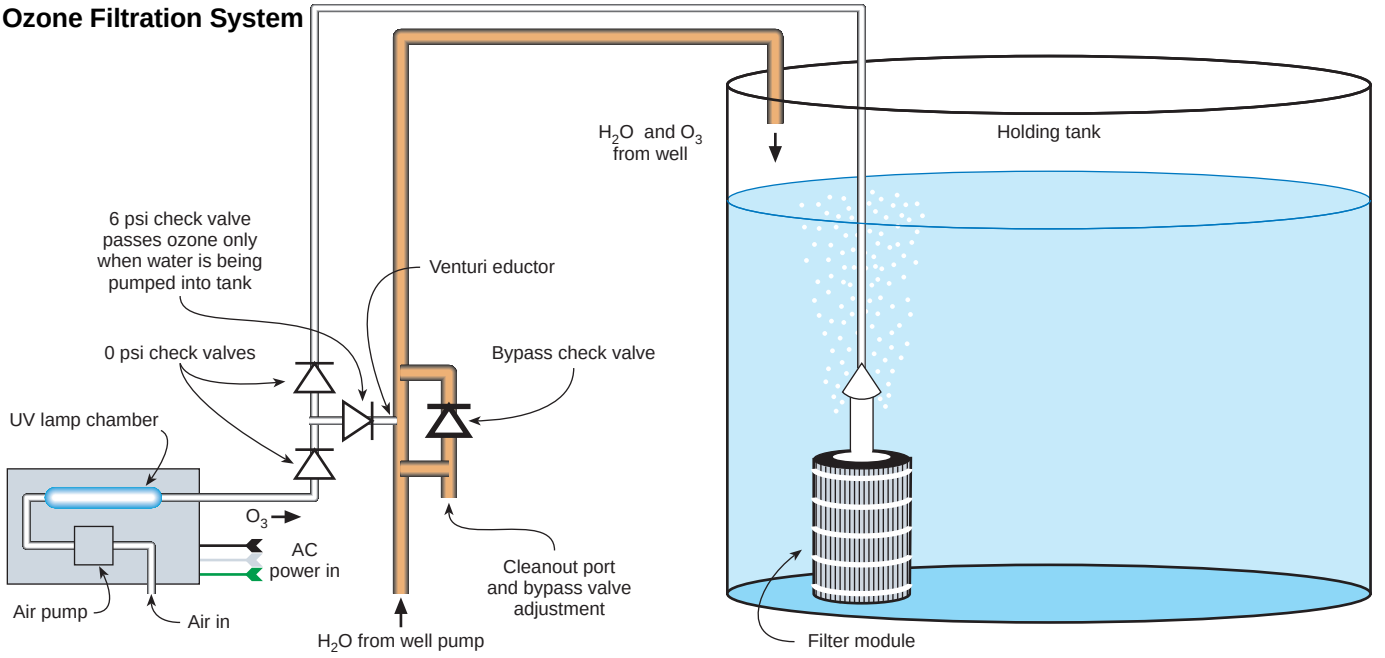
Obviously none of these systems are attractive when scaled up large enough to treat all of the water used in a home or homestead. When you talk to a water treatment company about handling more than your personal drinking water, you will probably hear about one of two different systems—backwashable media or ozone.

Backwashable media systems use common sand, or some other granular mineral, inside a tank. The tank is plumbed into the water line much like a cartridge filter. Conventional water softeners are backwashable media systems, using a special ion-exchange medium which can be regenerated using common salt. Different water problems require different media, and sometimes

Filter Operation Cutaway View



Ozone Filtration System



require a series of different tanks with different media. Backwashable media systems share the biological problems of the smaller barrier filters. Because of this, you will probably be sold a continuous chlorination system to go in front of your filter setup.

The advantage of backwashable media is that you do not have to physically remove and clean a cartridge to get rid of the refuse. The system generally includes programmable timers which control the backwashing process while you sleep. This convenience is costly, requiring a high volume pump and a lot of potable water to backwash the refuse out of the tank and medium.

You will also need to put this large volume of contaminated refuse somewhere. The control systems typically assume full time AC power is available to run the timers and high volume pumps. If you do not want the chlorine residual in your kitchen and shower, you will need a third system to remove it at the point of use.

Backwashable media systems rely on a combination of chemical reactions between their media and your contaminants, and mechanical trapping of particulates and precipitates in the water. Ozone systems could be described with the same words, except the granular "media" is replaced by ozone gas.

Ozone is a highly unstable molecule consisting of three oxygen atoms, formed by electrostatic discharge (such as lightning) or by exposure of air to strong ultraviolet light. It desperately wants to come apart into normal oxygen (two atoms of oxygen in a relatively stable molecule) and free oxygen ions which are ready to combine with dissolved minerals or biological contaminants. If it can't find anything else to combine with, most of the free dissolved oxygen will combine with itself into stable molecular oxygen within minutes of the ozone being released into the water.

Many dissolved mineral contaminants will react with the free oxygen to form solid oxides, which can then be trapped by a mechanical filter. Ozone is particularly effective at oxidizing iron (turning it to rust particles). In addition to reacting with minerals, ozone kills and destroys bacteria and viruses. Chlorine, which must be added to backwashable media filters, is considered a strong oxidizing agent, but pure free oxygen atoms are far more effective against simple biological molecules. Free oxygen atoms also leave no chlorine residue. In fact, the dissolved oxygen left after ozone treatment is beneficial to plants and animals.

In case you are worried, the ecological nightmare connected to ozone does not apply to ozone water treatment systems. Ozone is destroyed far up in the stratosphere by the breakdown of chlorofluorocarbon compounds, creating "ozone holes." Ozone which escapes into the air at ground level is oxidized to pure oxygen within hours, and cannot migrate nearly high enough to affect ozone holes one way or another.

Ozone water treatment systems come in many types and sizes, from those that fit in the plastic housing of a common sediment cartridge filter, to giant systems for whole cities. The ones I have experience with are designed to treat one domestic water system, cost under $2,000 (not including the required storage tank), and use a pleated paper cartridge filter which is similar to (but not interchangeable with) a swimming pool filter

Above: The ozone diffusing stone clogged with impurities.

cartridge. Ozone water treatment systems are often sold by direct mail. Unfortunately, they have a bit of an aura of "snake oil" about them, even though the big plumbing wholesalers now carry essentially the same units.

If your water system already uses an unpressurized storage tank of 1,500 gallons (5,678 liters) or more, just hang the filter cartridge in your tank, plumb the injector unit into the pipe from your water source to the tank, and hook up the wiring and ozone tubing. If you don't have the storage tank, you will need to add one and an additional pressure pump and controls.

The glaring disadvantage of these ozone systems, which the salespeople will not describe as vividly as I do here, is that *the refuse must go somewhere.* Depending on what is in your water and how much you use, you will need to remove and hand wash the filter cartridge between once a week and once a month.

To do this, climb up on top of your storage tank, remove the lid, and pull this ten inch diameter by twenty inch high (25 by 50 cm) filter cartridge up by its chain. It will be full of water and coated all over with up to one eighth inch (3 mm) of slime, which will fall back into your drinking water supply unless you lift the filter smoothly and at just the right speed.

Once you have it out and on the ground, you will probably spend half an hour spraying the goop out of the pleats in the filter. A gas or electric powered pressure washer (like the ones sold for washing cars) would make short work of this job and use much less water. Clean the ozone "diffusing stone" by soaking it in concentrated Muriatic Acid for a couple of minutes, and place the cartridge back into the tank.

The advantages of ozone make this ritual quite tolerable to me. For the new property, a comparable granular media iron removal system would have been much more expensive and more complex to install. It would have required a larger, freeze-protected pump house, and would have involved complex automation controls that the residents of the property might not have understood. We also would have needed a new drainage system for the high flow rate of the backwashing process, and a chlorine injection system to prevent the filter from becoming a bacterial colony.

For my own off-grid home, the issues were non-fecal coliform, algae, and preserving freshness in my new 3,000 gallon (11,356 liter) storage tank. While I could have taken care of these problems cheaply with chlorine injection, I was not willing to ruin my delicious water and fresh air with chlorine and its byproducts. While the ozone system

Above: The ozone diffusing stone after cleaning with Muriatic Acid.

is not particularly effective against the calcium hardness of my water, it has eliminated all of the black manganese stains from the plumbing fixtures.

I make double use of the ozone generator by diverting the ozone to my outdoor hot tub when its filter is running. This has eliminated the tissue algae problem that nothing else would touch. I have also cut the chlorine feed to the tub to one fourth of the previous amount. And the ozone does seem to make the chlorine residual less offensive.

The ozone filter unit is cleverly designed. The ozone gas, released inside the filter cartridge, causes the water in the storage tank to circulate around the tank and through the filter, trapping particles on the outside of the cartridge as it enters. No chlorine is required, because the ozone gas is continually circulating

through the tank and the filter medium. This destroys all biological contaminants in the water and prevents any problem of biological colonization of the filter itself.

Ozone also causes the majority of mineral contaminants to precipitate out of solution and become trapped in the filter cartridge. While the end product is not as "soft" as water from a dedicated water softener, we noticed a dramatic reduction in the amount of soap required for bathing and laundry after the ozone unit went in.

The ozone treatment system uses a small compressor, forcing air past the ultraviolet lamp ozone generator. From there, the compressor pumps the ozone into the filter unit. The compressor and lamp use about 50 watts of power. They are intended to run continuously. The lucky thing for those of us using home power systems is that the amount of ozone treatment required depends upon how much water you are using—really upon how much untreated water you add to the storage tank.

Definitely let the ozone run while you are pumping untreated water into the tank. In fact, most of these systems automatically divert all of the ozone into the incoming water line while your pump is running. Run the ozone long enough to mechanically filter out all of the particulates that will precipitate out of the incoming water.

Since ozone has a residual life measured in minutes, be sure that the ozone runs at least daily and preferably several times a day to prevent biological regrowth. This is true even if you are not adding untreated water to the tank. Keep in mind that the unit does not have to run continuously if you don't have the power available. In fact, it's a natural diversion load for solar electric systems, since most of us use and pump more water when there is more sun.

3. You Will Never Catch Them All

If your water has a biological problem, or if your usage is slow or intermittent so that water sits stagnant in your pipes and filter systems, face the fact that you will never kill every last contaminant. You must consider how your system deals with regrowth or recontamination past the point of purification. The vast majority of water systems deal with this by creating a chlorine residual in the filtered water.

Residual chlorine is free chlorine that remains after all of the oxidizable biological material in the water has been "burned out." Residual chlorine is what you are measuring when you use a pool test kit with the yellow "OTO" indicator. As in a swimming pool, you want that part or so of active chlorine remaining per million parts of water, even in the most remote parts of the plumbing, at all times. When this active chlorine finds some new

Inverter Users: Beware the Power Factor of Ozone Generators

When I first received my ozone generating unit, my techie curiosity couldn't resist plugging it into one of the computer UPS systems from my workplace to see what the measurements would look like. The Best Fortress UPS will report an amazing list of power related data to your computer's serial port.

Expecting to see a power consumption of around 50 watts for the ozone generator, I was shocked to see the UPS report that it was taking 127.4 DC watts from its batteries, producing 108 AC volt-amperes, but only delivering 22 real AC watts to the ozone system!

I knew the combination of ultraviolet lamp and ballast in the ozone unit was likely to be an inductive load, but using two and one half times the expected power from my batteries was definitely not what I had planned. Thus began a quick education in the effects of power factor.

Power Factor Defined

If you apply voltage to a resistive load, like an incandescent light bulb or a heater, current flows in direct proportion to the amount of voltage, and stops flowing instantly when the voltage is removed. We say current is "in phase" with voltage, and that the power factor is unity.

If you apply voltage to an inductor, like a motor or the spark coil in your car, it takes some time before full current is able to flow. During this time you are generating a magnetic field around the coil of wire. If you remove the applied voltage, the magnetic field remains momentarily. While it is dying away, it generates its own voltage across the inductor. (The spark coil of your car redirects this inductively generated voltage to fire your spark plugs.) We say that the phase of the current in the inductor "lags" behind the voltage we observe at its terminals, or that the power factor is lagging.

Alternating current, the 60 Hz AC stuff our inverters make from the direct current supplied by our batteries, involves the voltage going through zero and switching direction 120 times every second. The current this creates in a motor or in the ballast coil of the ozone unit is continually lagging behind the applied voltage.

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Beware the Power Factor, continued from page 93

Here's the point—every time the applied voltage increases, extra current flows into the coil to create the magnetic field around it. Every time the voltage goes back to zero, the magnetic field dies away and tries to return this extra current to the source.

The Cost of Power Factor

If you are buying power to run a big motor in a factory, the power company will measure your power factor and charge you more per kilowatt-hour if it is not unity. Even though they theoretically get the extra power back after each voltage reversal, they have to provide you with extra large wire and a larger transformer in order to pass the extra current back and forth, and more power is wasted in their transmission system due to the increased current.

The term "volt-amperes" or "VA" is similar to watts, but includes the extra current passed back and forth to the inductive load. The total VA is called "apparent power." "Watts" includes only the "real" power which gets sent to the load and is consumed there.

Big motors in factories usually have matching banks of "power factor compensation" capacitors. Capacitors are the electrical opposite of inductors—their current is highest when the applied voltage is changing most rapidly, and is actually zero when the applied voltage reaches its maximum just before beginning to decline again! The right size capacitor will exactly absorb the "extra" inductive current that the motor wants to return to the power source, and toss it back to the motor when it is needed to rebuild the magnetic field again. The power company no longer has to carry this extra current back and forth to their generator, so they don't charge the power factor penalty.

To get back to our ozone generator, the report from the Best UPS was that 108 VA of combined real power and extra power were being shuttled back and forth between its inverter and the ozone system. Only 22 watts of real power were being used to generate ozone, but 127.4 real watts were being taken from the batteries. If these measurements are accurate, over 100 watts were being wasted as heat inside the UPS! Obviously this unit was not designed to run motors or other heavy inductive loads.

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biological material to "burn," you get that characteristic chlorine odor.

I have no experience with chlorinating already purified water. The reports say that the unpleasant smell and the supposedly carcinogenic THMs do not occur when there is nothing left in the water to be oxidized. Chlorine advocates claim that it's possible to create a chlorine residual sufficient to prevent any biological regrowth problems, no matter how long the water sits stagnant, with none of the undesired effects. To try this, you will need an expensive metering pump, and you will have to feed it power and concentrated chlorine.

With four people living 500 feet (152 m) of pipe away from our ozonated tank, and someone here all the time, we have never noticed significant biological regrowth even without any chlorine residual. But another 100 feet (30 m) beyond, there is another home served by the water system. This house is occasionally unoccupied for up to a month at a time, and there we definitely see problems.

The old filter housings grow algae, and the water heater tank (which was thoroughly contaminated with iron bacteria before the ozone system went in) grows the "butterscotch pudding" iron bacteria. This system has been flushed and shock treated with chlorine many times, but *you will never catch them all,* and given the chance, the biological problems will come back. We have learned to run freshly ozonated water through all the pipes occasionally when the second house is vacant.

Things That Work

If your water comes from a shared system providing a chlorine residual, and you don't suspect toxic chemical contamination, you can choose a treatment system based on aesthetics. The chlorine should take care of enough of the incoming biological contaminants. If you like the taste of the water when you're using a particular filter, go for it. But if you are using a filter which removes the chlorine, do not store the filtered water! If your under-counter unit removes chlorine and then stores a gallon (3.8 liters) of filtered water, use it regularly to keep it fresh. Flush it completely before drinking any if it has gone unused for a few days.

If you provide your own water, and especially if you know it has or occasionally might have a biological contamination problem, your choices are much more limited. The simplest source of biologically safe drinking water is the "backpacking filter" used on small batches of water. Drink the water before the inevitable missed contaminants multiply, and clean and dry the filter element between uses. I prefer the Katadyn brand which has been proven in use for over fifty years.

Although it's impregnated with silver to retard bacterial growth, the filter does nothing about mineral or chemical contaminants.

If you have the required water pressure and can live with the continuous waste, a small reverse osmosis unit will provide biologically safe drinking water, and will remove mineral and chemical hazards too. I don't have firsthand experience with this, but I suspect that it would have problems treating the iron bacteria-laden water which is now handled by our ozone system. But it would make an ideal "finishing filter" after an ozone system, because there is continuous flow through the unit and only the microbiologically pure water is stored.

If you have lots of power to spare, a distillation unit will handle bacterial and mineral problems in your drinking water. It will boil the water into steam and recondense the vapor. There are reports that chemical contaminants with boiling points similar to water may sneak through the distillation process. If your water is hard or has lots of particulates, you will definitely have a cleaning problem.

For treating your whole water supply, especially on a low power budget, ozone is probably the best compromise. If you suspect a chemical contamination problem, or if your usage is too low to keep a dependable ozone residual in your household plumbing, you may also want to use one of the other filters.

Things That May Not Work

Assuming you might have a biological problem and that you are not providing a chlorine residual, all of the common carbon-based countertop, under-counter, and carafe filters are suspect. They should not be used even as "finishing filters" after an ozone system because *you will never catch them all.* They provide a reservoir of stagnant water which is not protected by the short residual of ozone.

There are some cute "ultraviolet" or "ozone" systems which fit in the space format of the common sediment filter cartridge, and are often sold in combination with matching sediment and carbon cartridges. They even come in 12 volt DC versions. Unfortunately, they miss the mark on all three of my principles.

The ultraviolet or ozone treatment happens only as the water flows through the tiny cartridge chamber, and the lamp is far too small to kill all the contaminants in one quick pass. There is no continuous circulation of ozone through the sediment or carbon cartridges, leaving them unprotected from biological "messiness." And if the treatment causes biological or mineral precipitation, there is nowhere for it to go but into the carbon filter

Beware the Power Factor, continued from page 94

Testing the Trace

Next I inserted the UPS as a measuring device between the ozone generator and my big Trace SW4024 inverter, which has over 100 pounds (45 kg) of transformer iron and is designed to be able to run nasty inductive loads like motors. The report was that 107 VA were being passed back and forth, and 28 watts used to generate ozone. But when I independently measured the power the Trace was taking from its batteries, it was only using 40 real watts. It was able to receive the extra power returned from the ozone generator and toss it back out again.

Then I arranged a power factor compensation capacitor for the ozone system. With the capacitor in place, and running on the Best inverter, the report was 35 AC VA of apparent power, 37 watts of real power into the load, and 41.5 DC watts taken from its batteries. The capacitor made a huge improvement in efficiency for this particular inverter running the ozone generator!

When running on Trace power, the capacitor made a similar reduction in the apparent VA sloshing back and forth between the inverter and the ozone system. There was a similar increase in the measurement of real power delivered to the load. Essentially, there was no difference in the amount of power taken from the batteries, which remained at 40 real watts—almost exactly the same amount that the Best unit used when tested with the capacitor.

So what have we learned? My interpretation is that a big, heavy sine wave inverter with a relatively low switching frequency will run the ozone unit quite efficiently, whether or not you add a power factor compensation capacitor. A small, physically lightweight, relatively high switching frequency sine wave inverter may be extremely inefficient, and may overheat when running an ozone generator unless you provide power factor compensation. With proper compensation it may do a perfectly fine job of running the same ozone system.

I have not tried it, but I would just about guarantee that a modified sine wave or PWM square wave inverter would run inefficiently, make a lot of buzzing noise, and generate significantly less ozone than either type of sine wave inverter. Beware!

until it's saturated. From there, the precipitation will contaminate your supposedly filtered water.

Your Mileage May Vary

For a single system, ozone seems to handle many water treatment needs quite well, but water problems are as individual as home power users, and ozone might not solve yours. It can't remove sodium, chlorides, fluoride, nitrates (fertilizer contamination), or sulfates (but it does remove hydrogen sulfide).

The goal of my research was to find a generally recognized and relatively ready-made water treatment solution, able to handle all of the water used on a rural property with a minimum of user intervention. I already have plenty of homemade energy systems to maintain, and I was not anxious to risk the health of people who had not chosen to be part of an experiment.

Your balance of water problems versus creativity, time, money, and personal energy is undoubtedly different than mine. When you consider buying an existing solution or creating your own unique system, ask yourself how it deals with the three major issues I have pointed out.

As an example, you could power a distillation unit with sunshine, but *the medium is messy*—how will you keep your distiller from becoming an algae farm as it cools down in the evening? *The refuse must go somewhere*—how will you clean the accumulated minerals and crud out of the heating area? And *you will never catch them all*—will you provide a chlorine residual so you can store the water for use when there is no sun?

I realize I have not provided you with ready-made answers to your water treatment problems. Only you know what you want fixed about your water, and what resources are available to accomplish that task. The marketplace is full of dealers who will try to convince you that the particular technology they happen to sell is best. I believe I have armed you with three critical questions that will help you to zero in on the system that will work best for you.

Access

Loren Amelang lives and works in a solar powered ridgetop home, with solar DHW backed up by wood, and a solar greenhouse which provides year-round space heat if the sun is out. But he has blown his "wireless" purity by adding an ISDN connection to the internet.

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For a reprint of *Should You Use A Water Filter?* Consumer Reports, July 1997, send $3 and request report #RO162. CU/Reprints, 101 Truman Ave., Yonkers, NY 10703-1057

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Amp-hour—Quantity of Charge

Ian Woofenden

In my last column I defined an amp as a *rate* of electron flow. It's not a quantity—it's a certain number of electrons passing a point in a given time.

There are lots of rates used in scientific descriptions, and some that are fairly common in our everyday speech. Miles per hour (MPH), revolutions per minute (RPM), gallons per minute (GPM), and cycles per second (Hz) come to mind.

What if I told you I had seen a car going 100 miles per hour *per hour?* You'd think I was a bit confused, and you'd be right, because it doesn't make much sense. In the same way, saying "amps per hour" does not make sense. An amp is a rate; miles per hour is a rate. There is no such thing as amps per hour!

When we want to describe an amount of "charge" that has gone through a circuit, we use another term—*amp-hour.* If I turn on a light that draws 2 amps and leave it on for an hour, the battery will pump 2 amp-hours of charge through the circuit. If I leave it on for four hours, the total charge will be 8 amp-hours.

Deep cycle batteries are rated in amp-hours. Theoretically, we can say that a 220 amp-hour battery will deliver charge at a rate of 220 amps for one hour, or at a rate of 1 amp for 220 hours. This is not actually accurate because we are ignoring efficiency and the rate of discharge, among other things. But I hope it gives you a feel for what an amp-hour is.

When we say amps, we're talking about charge flow *rate.* When we say amp-hours, we're talking about the amount of charge that has passed through a circuit, or the amount of charge that's pumped by a battery before its energy is depleted.

But an amp-hour is not the final and full measure of energy use. It doesn't include one factor—voltage. When we talk about how many amp-hours a device uses in a given time, or the size of our battery bank, we also have to specify voltage to give the whole picture. Forty amp-hours at 12 volts is not the same as forty amp-hours at 120 volts.

To bring voltage into the equation, we have to talk about *watts,* which will be my topic for next time.

Access

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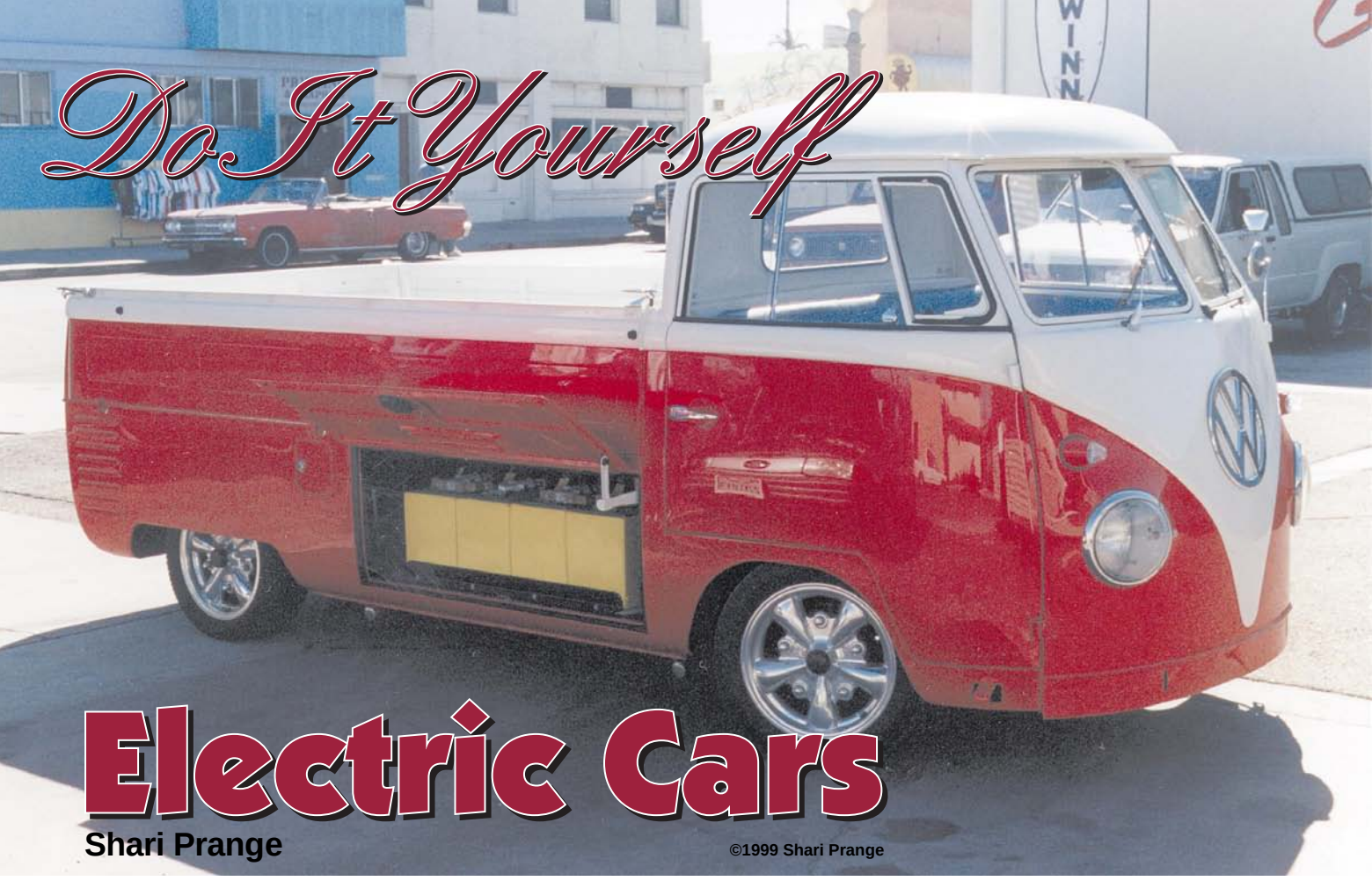

Do It Yourself

Electric Cars

Shari Prange

Above: A chassis that is perfect for one person will be all wrong for another—choose wisely.

There are many reasons people choose to build their own electric vehicles. Some people can't afford to buy a turnkey car. Others can't find what they want for sale. Some are particularly attached to a certain chassis, or want to do something a little different from the usual conversion. And some people really enjoy the challenge and sense of accomplishment of building an EV with their own hands.

Half the Fun is Getting There

For some people, the journey is more important than the destination. They may spend months or years building and lovingly refining their electric car. Then, when they just can't think of any other way to improve it, they sell it and start building a different one.

The disadvantage of building your own car is, of course, all the effort and time it requires. However, if you find the process itself to be fun, then that becomes a positive aspect instead of a negative one.

One obvious advantage is that you can save a lot of money by doing it yourself. Another is that you make every design decision, so you can get exactly what you want. If, after driving the car a while, you find that something about it is inconvenient or irritating, you can re-design and change it.

A final advantage is the intimate knowledge you will have of the finished product. You will thoroughly understand how your car is put together, because you screwed in every bolt yourself. If you need to troubleshoot a problem someday, at least you'll know where to look.

Choosing a Model

If you don't already own the car you want to convert, you will have to find one. This is true whether you are building the conversion yourself, or having it built for you by a mechanic. You should spend some time talking with someone knowledgeable about EVs in order to choose a model suitable for your needs.

Last time we talked about examining your priorities for the car. Speed, range, and passenger capacity are some things to consider. Some models will be fine for one person and completely wrong for another, because their priorities differ. If you start out with the wrong chassis for your purposes, nothing you can do in the conversion process will make it right.

As we mentioned in the last issue, there are two general types of conversion kits available: the bolt-in custom kit and the more generic universal kit. Just as the type of kit might sway a mechanic to take on the project (or not), it might also affect your choice of chassis. If you or your mechanic want the easier prefabricated custom kit, you should do some advance research. Find out which models have these kits available, then you won't waste time looking at the wrong cars.

Finding A Donor Car

Ideally, you want a car with a good body but dead engine. You can peruse the classified ads, of course, but you can also be more aggressive in your search. Look for local independent garages and parts stores that specialize in the make you want. Some of them may have bulletin boards with cars for sale, and you could put a "Car Wanted" notice there. Often, these places will know of a customer with such a car that isn't listed in the newspaper. Or, if they know what you want, they can keep an eye open for you.

Used car dealers have special access to private auto auctions. Perhaps one would be willing to shop for you if you give your requirements and pay for the help. Towing companies also sometimes have cars on their lots that will be lien-saled. These have been abandoned by their owners. Salvage yards get cars to strip and crush, and might be happy to sell you one whole.

Salvage Yard Savvy

If you get your chassis from a salvage yard, do not let them "do you the favor" of stripping out the engine and internal combustion parts. These guys aren't into finesse. Wires will be hacked off wherever it's easy to do so. You may spend quite a bit of time with a factory manual's wiring diagram, trying to identify the amputated stumps and locate the ones you need to use.

They will throw away hardware that you need, like the flywheel bolts, which are special order items available only through the dealer at high cost. They will also discard all kinds of brackets and little bits that you might have been able to adapt to another use. Without them, you will be designing and fabricating all your component mounts from scratch, when you could have had a head start by re-using original parts.

Be careful that things like trim pieces and door handles have not been cannibalized. This happens in salvage yards. It's not a catastrophe, but if you have to chase too many of these little things, the cost can add up, and it's really irritating.

Straight And Sound

Make sure that your donor chassis does not have any structural rust, especially in less than obvious places where it will come as a rude surprise later. Go over it (or have a mechanic go over it) with a fine toothed comb.

Above: A custom kit will have all the parts you need, but will only fit in a specific model of chassis.

You do not want a car that has been in a collision, either, even if it has been "straightened" and looks fine. A very subtle misalignment, not apparent to the eye, can cause fit problems with your components. One of our customers built a nice battery box with true square corners to fit in the bed of a pickup truck. When she tried to install it, it wouldn't fit. She discovered that the truck bed was twisted just slightly out of square, and had to spend some time and effort shaving the corners of her battery box to make it fit.

A chassis that is out of true can also increase the rolling resistance as it goes down the road, which will cause it to have less range than it should. There are a few clues that will give away a car that has been hit and repaired. Look for slightly mismatched paint on different panels of the car, or seams for hoods or doors that don't line up right. Is one bumper shiny and the other dull? If you get

Below: A typical generic conversion kit using modern commercially produced components.

Above: Building your own car can be satisfying and educational, as this high school boy discovered.

underneath the car, you may see fresh undercoating, or undercoating that is wrinkled or cracked or has been chipped away from a seam, or hardware that looks new or non-factory.

Documentation

There are a few pieces of paper you should pay serious attention to. One important document is the title of the car. If the car has already been "salvaged," you will need to go to some extra effort to get it re-titled as a streetworthy car. This will probably include some inspections, such as brakes and lights. This isn't a major obstacle, but it is an extra bit of hassle and expense. This is most likely to happen if you buy your car from a salvage yard.

The second piece of paper to look at is the registration. If the car has a dead engine and has been sitting for some time, the registration may have been allowed to expire. To get current license plate stickers might entail some substantial fees.

For example, it used to be a simple matter to revive a dead car with expired tags in California. You simply signed a form asserting that the car had been out of service on private property for such-and-such a span of time. However, the law was very quietly changed. Now, when the dead car comes due for renewal, you are required to send in $5 and a form stating that the car will be out of service. If you don't do this by the due date, then full registration costs (and late penalties) apply, even if the car isn't running.

Many people put cars out of service before the law changed, and were unaware of the change. When the car was sold, and the new owners attempted to get current tags, they found themselves stuck with several hundred dollars of back registration and penalties to pay.

The third type of documentation you need to address is your own conversion notes. One of the advantages of building your own car is the intimate understanding of it you will acquire. However, this only applies if you document your work. Make wiring diagrams. Keep a conversion diary. Take pictures or videos. Someday years from now, when you are staring at a handful of wires that disappear into the dash, you can look at your notes and identify just the one you need. You will thank yourself.

Kits

Next, you need to find the parts you will use for the conversion. If you are going with a custom bolt-in kit, you have probably already settled this issue. If not, you will be doing some comparison shopping.

Talk to suppliers and get their recommendations for a parts package for your project. Have they had customers convert this model before? They may recommend different motors, controllers, system voltage, and battery types, depending on your particular needs. Get an idea of what to expect as far as range and speed from the recommended package.

Ask for a complete list of what the kit or package includes, and the price. If you are comparing kits from different dealers, be sure you are comparing apples to apples. Does one kit include parts that the other doesn't have? Do the components have different ratings? Is there a difference in finish and quality? This last situation is most likely to apply to the motor/transmission adaptor. You might ask to buy the installation instructions separately in advance. Looking these over for completeness and clarity could affect your decision.

Overall, you want a group of parts that will do the job for you, fit your budget, and come with clear instructions. Choose a supplier willing to spend some time giving you advice and assistance before the sale, during installation, and after the car is running.

Paint By Number Or Freehand?

If you buy a custom bolt-in kit, you will have everything you need in one package, and you won't need to make any decisions or locate sources for other parts. This is the "insert tab A into slot B" type of kit. With a little close attention to directions, you can't go far wrong.

If you are using a more universal kit, you will have to do some design, fabrication, and part finding yourself. You can expect to design the overall component layout, with attention to weight distribution. You will need to design and fabricate mounts for various components, as well as racks and boxes for the batteries. You will also design and install all the wiring, and make necessary modifications to the suspension.

Your supplier may be able to assist you with some of this. At the very least, you should receive a generic wiring diagram to follow. However, you will need to exercise more care with this type of kit. Weight distribution, battery containment, wiring, and suspension and handling are all critical safety issues. If you are at all unsure of your skills or knowledge base, consult an expert.

In general, it is more economical to buy your components as a kit, since there is usually a package discount built into the kit price. Another advantage to a kit from a single supplier is the assurance that all the parts are compatible with each other.

Cheap But Still Good

Sometimes a person really wants an electric car, and has a very limited budget. There are alternatives, but they require some serious homework in advance. You need to study the different types of motors, controllers, chargers, batteries, etc. You need to learn which are compatible with each other, which are good deals, and which are disasters.

For example, there were some motors used in the early days of conversions that were very inefficient or fragile. In those days, there weren't many choices available. Today, there is no reason to use one of these when there are better options. If someone offers you an aircraft starter/generator or a Baldor motor, thank them kindly and say no. On the other hand, a used Prestolite is a very suitable bargain.

Use a parts list from a good quality kit as your checklist. This will tell you what components you need for a good working EV. Then you can substitute a good quality earlier generation motor or controller (or whatever) for the current production models in the kit.

One way to get components cheaply is to buy a dead used EV for its parts. If you can get a good motor, controller, and charger out of it, you've got the three most expensive components of a conversion. Then you can afford to buy some of the small pieces new to fill in the blanks.

If you are buying used parts, you may get some good quality pieces that are now out of production, with no factory support. If you are buying from private parties, you also won't have dealer support. It's very important to do some research about the parts before you purchase them. You are trading low price for lack of technical support, so you need to become your own technical support base. You may also find one or more experienced EV owners in clubs or on the internet who can help guide you along.

Building Components

Sometimes people want to build their own components, especially chargers and speed controllers. This is not really cost effective. Unless you are an electrical or electronics engineer, what you save in money you will sacrifice in performance and safety. These parts are so critical to the success and safety of the vehicle that it's poor economy to build them yourself.

The only reason to build your own components is to have an educational experience. If you really want to understand how a speed control system works at the schematic level, you can do this. However, you should be prepared to spend a lot of time on the project, and you probably won't match the performance of even older model production components. Also, when amateurs design and build components that will be carrying high current, the risk of shock or fire goes up.

A Car Is Born

So there you have it. As I mentioned last time, there is a pretty consistent inverse relationship between the amount of money you spend to get an EV, and the amount of your own time and effort you invest in it. On one end of the spectrum, you can walk into a dealership and lease a production car from a major manufacturer. On the other end, for a lot less money but more time and effort, you can build your car with your own hands. Choices in the middle of this spectrum include buying a used electric car, and having a mechanic build one for you.

If your driving patterns fit the capabilities of an EV, then one of these techniques can put one in your garage. Where there's a will, there's a way. What are you waiting for?

Access

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Mike Brown

As I said at the beginning of an earlier column, "In the EV world no matter where the conversation starts, sooner or later it comes back to batteries." It's been a while since we talked about batteries, but three recent contacts brought up questions we haven't discussed before, so now it's battery time again.

"My EV is supposed to have a range of 80 to 100 miles (130 to 160 km), but in my usual driving pattern, the most I can get before performance falls off is 40 miles (65 km). What is wrong with the batteries?"

An EV's maximum range is often based on calculations, with a dash of fervent hope or wishful thinking thrown in. In the case of an EV from a major manufacturer, it is the result of tests on a chassis dynamometer programmed to run a Federal Urban Driving Cycle (FUDS, a test procedure designed by the EPA to simulate typical urban driving). For both the home-built EV and those from small manufacturers, maximum range is based on actually driving the EV on a set route under real life conditions, either by itself or as a participant in an EV rally.

However the "maximum" range is determined, it is only a benchmark and loses importance as soon as the EV is put into real life service. As soon as the EV reaches the end user, it experiences the route it was bought to drive. This includes the road and weather conditions, and the driving style of the owner. Only then does the real or practical range become known.

At this point, the question is "Can the EV do its job and still feel strong at the end of its usual trip?" Many EVs use only a small percentage of their potential range, and only a few regularly go right to their limit. If the EV has been correctly matched to its task, then the only indications of possible trouble are poor performance at the end of the trip, or a lower than usual reading on the state-of-charge gauge. Actually "running out of juice" completely is very rare.

In this case, a ride with the EV owner on the longest of his usual trips told the story. From home to office there was a short length of freeway at 60 to 65 mph (97 to 105 kph), followed by about ten minutes of heavy stop-and-go traffic. It was all stop-and-go from the office to where he played golf. Then we drove ten miles on the freeway at 70 to 75 mph (113 to 121 kph), then for two miles (3.2 km) up a steep hill in stop-and-go traffic. The trip home got a little help from the downhill, but the freeway portion was the same. By the time we got it home, the EV was close to the limit of its practical range. We discussed the differences between calculated optimum range and real-life practical range, including his driving conditions and style. He agreed that the EV does what he needs it to do. The problem, which was one of perception rather than reality, was solved.

"I have a ten mile (16 km) round trip commute, and my EV has a sixty mile (97 km) range. By the time I get home, the state-of-charge gauge has barely moved. Do I have to charge every day, or can I wait until I have gone 40 or 50 miles (65 or 80 km)?"

The answer is yes, you should charge after every use even if it is only a few miles. We had this proven to us with one of our own cars that was being driven by an associate. His daily trip was about ten miles (16 km). Since the car had a proven sixty mile (97 km) range, he decided not to charge until the the state-of-charge gauge had fallen to the 50 percent mark.

The first time he tried this charging method, he got the expected three trips before hitting the 50 percent mark. The second time, the first two days of driving were just fine. On the third day, the state-of-charge fell off rapidly, and he had to crawl home with an almost fully discharged pack.

When he called me to complain of decreasing range and told me of his charging scheme, I told him to go back to charging every time he used the car. I told him to wait a couple of days, then take a thirty mile (48 km) run to see how the batteries held up. He did this, and sure enough the car performed well. It also came back with the state-of-charge gauge reading 55 percent, and still felt strong.

What caused the range to fall off? While flooded lead-acid batteries like to be discharged every day, even if it's only a small amount, they don't like to be left sitting partially discharged for even one day. Although the voltage will come back up a little while sitting, the batteries' amp-hour capacity remains the same, and being left for several days lowers it.

We have found that letting our EV sit for a day after it has been run and charged leads to a lower state-of-charge reading at the end of its next trip. One theory I have is that the heat generated in the batteries by driving and charging daily keeps them close to the 80° F (27° C) prefered operating temperature. This seems to be proven by the observation that the effects of sitting are greater when the weather is colder.

The other benefit of charging after every use is that you will have the full potential range of the EV available every day if, for some reason, you need to make more than your usual trip.

All of this is based on using a good quality modern charger that senses the condition of the batteries and tapers the charging rate accordingly. A crude charger that only tapers based on a timer or manual adjustments may overcharge and damage the batteries.

"I have been driving my new EV for two months now. It works fine, but how do I get more range out of it?"

The answer is patience. Since the EV is only two months old, the batteries may have only thirty to sixty charge/discharge cycles on them. The battery manufacturers tell me that it takes fifty to one hundred cycles before the batteries are at full capacity. The driver will note a gradual gain in range until the batteries hit that point.

The motor brushes take about thirty hours of running time before they are fully seated. The gain in range from this is not as obvious.

The third thing that needs to be broken in is the owner. Since he drove this car before he converted it, he is probably still driving it like a gas car. As soon as he learns how to drive it like an EV, his range will improve. Another factor is the weather. It's been cold, by our California standards, for the last two months. Even at 50° F (10° C), battery capacity is reduced by 15 percent.

So by the time the batteries, brushes, and his "seat of the pants" driving style are broken in, the weather will be warmer and his range will have increased. He will also be more comfortable with the difference between the maximum range he thinks he needs and the practical range he really needs.

I hope these comments make those of you who are presently EV owners more comfortable with your EVs, and give those of you contemplating an EV some things to consider.

Access

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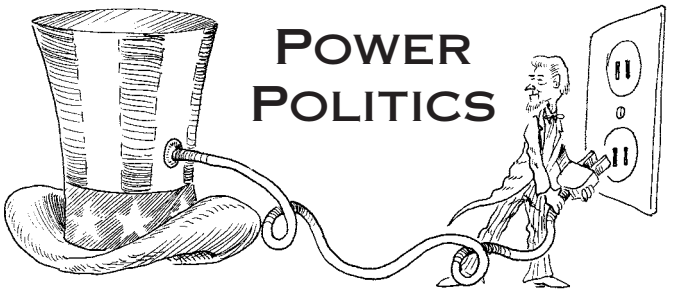

Nuclear Y2K

Michael Welch

How worried should we be when our dates change from the 1900s to the 2000s? There is an incredibly wide range of opinion on this question. I am concerned with what will happen at nuclear power and weapons plants throughout the world—NY2K.

Some believe that there will be only a brief power outage on January 1st. Others think there will be so much damage to the grid that it will be weeks before its infrastructure will recover. My sense is that the power might be off for a few hours or a day or two, but it probably won't be much more than that. Fortunately, January 1st falls on a Saturday. Our utilities will have a full weekend to fix things before any outages begin to have significant effects on commerce, which seems to be the overriding concern.

The International Scene

The scariest thing about Y2K is what might happen in countries that are less developed and wealthy than ours. They don't have the kind of controls that we have over nuclear weapons and power, and they don't have the resources to devote to the problem. Reports coming from Russian Y2K consultants reassure us that problems with strategic nuclear weapons are cured. But they say that there may still be problems with air defense and early warning systems. We can hope that if early warning systems fail, it will not result in a retaliatory strike based on misinformation. Russian officials have agreed to allow NATO officials to look over the systems for problems.

Nuclear power reactors are another story. It was estimated in mid-January that the Russians needed an additional $500 million to go through the rest of their nuclear systems to look for problems. Their country is in financial crises. Where are they going to get that kind of money? The U.S. and other nations should weigh in, since they can more easily afford such an important expense.

Many nuclear nations out there are not providing even a single clue as to how, or if, their Y2K programs are proceeding. The International Atomic Energy Agency sponsored a seminar in early February to help countries identify courses of action to take. Grants and loans were available so countries could participate in the conference. But there has been little information on what money is available to help poorer countries through Y2K. We don't even know how widespread the problem really is.

Back in the U.S.

The emphasis on commerce and business seems to be one of the problems that we need to deal with in the U.S. There's a recent trend that puts corporate need ahead of public health and safety. But it's a double edged sword. On one side, the desire to keep making incredible amounts of money has not been good for the environment and society. On the other side, the very same desire is what will probably keep Y2K down-time to a minimum. It is hard to fathom our corporations going without electricity for a significant amount of time. Their heavy pressure on utilities and power producers will be tremendous, and will minimize down-time.

Nuclear Weapons Facilities and Y2K

The U.S. Department of Energy (DOE) oversees several nuclear weapons related facilities that are managed under contract by private companies. The DOE has policies designed to identify and correct potential Y2K problems. But it appears that health and safety Y2K concerns are taking a back seat to business and administration related Y2K concerns. The DOE isn't exactly telling the contractors that this is the order of priority, but they seem to be getting that idea.

The DOE says systems identified as "mission critical" are supposed to receive the highest priority and closest scrutiny in Y2K efforts. Unfortunately, mission critical definitions were not interpreted to include the safety significance of equipment, such as furnace and melter controls for plutonium processing, but it does include payroll and accounting systems. This interpretation problem was identified after reviews of Lawrence Livermore National Laboratory and the Rocky Flats Environmental Technology Site (two U.S. nuclear weapons research and manufacturing facilities). The reviews were conducted by the Defense Nuclear Facilities Safety Board, an independent organization set up by statute for external oversight of the DOE nuclear weapons complex. I hope something will be done about this scrutiny problem in time.

Nuclear Power Plants and Y2K

Should we be worried about U.S. nuke plant problems on January 1st? Nuclear power plants rely heavily on grid power to operate, and even to begin shutdown. There is no way that a nuclear power plant can shut down without external power. The Nuclear Regulatory Commission's

(NRC) own estimates are that loss of power, or "station blackout," scenarios constitute about 50 percent of the risk of operating nuclear power plants. If a reactor loses power for any significant amount of time (from a few hours to a few days, depending on the reactor and the situation) the reactor will melt down.

Therefore, the NRC requires that nuke plants have two emergency diesel generators to back up the grid, each capable of powering the entire plant. At any given time, one of those generators can be down for maintenance. According to the NRC, these generators are 95 percent reliable. Nuclear Information and Resource Service (NIRS, an independent nuclear watchdog organization) research indicates that generator reliability may be much lower than that. Even 95 percent is an unacceptably low figure, since U.S. nuke plants are allowed to operate only when the rest of their safety systems are 100 percent reliable. I interpret this to mean that if the grid goes down and a nuke plant is rebuilding one of its two generators at the time, there is greater than a one in twenty chance of a meltdown at that facility.

Additionally, it can take several days to reach "cold shutdown" and a full month before circulating water is not needed in the reactor. That is how long a nuclear reactor would need backup power in a situation where the grid was no longer available. Nuke plants' spent fuel pools also need circulating water until the used rods are about five years old. Without backup power, spent fuel pools could boil off their water in a matter of days. If the rods are exposed, they could release significant radioactivity into the environment.

The NRC's draft contingency plan for year 2000 scenarios is trying to pull a fast one on the public. This regulatory organization has long been recognized as too much of a nuclear promotional organization and not enough of a public protection organization. Now in the Y2K document they place undue emphasis on ensuring power production.

The Y2K plan inappropriately redefines the NRC's mission. The NRC is supposed to protect the health and safety of our citizens and environment from problems at nuclear power plants. Instead, the plan makes a giant leap by claiming that electric power itself is critical to our health and safety and therefore nuclear power plants should be running when Y2K hits. The trouble is that our nuclear utilities may pay too much attention to this newly redefined mission and not enough attention to running their plants safely.

NIRS Petitions

To help improve the proposed NY2K contingency plan, NIRS has petitioned the NRC in several areas. They have requested that the NRC require shutdown by December 1, 1999, of any nuke plant that cannot demonstrate Y2K compliance. NIRS suggests that those nukes should be allowed to restart only when compliance is proven. So far, the NRC has only required that utilities report on July 31 whether they are Y2K compliant or, if they are not, when they will be.

NIRS petitions also request that Y2K certification standards be applied across the board, and not on a case by case basis. For example, the NRC so far has not been requiring the testing and re-certification of "vendor certified" systems. One such system at the Hope Creek reactor was certified by the vendor, but subsequently found to be not ready for Y2K. The petitioner's definition of what should be certified by the utility would be expanded to include all vendor certified systems.

The petitioners have requested that every operating nuclear power facility be required to have a full scale emergency response exercise that includes a Y2K component during 1999.

The petitioners asked the NRC to require each reactor to have both of its emergency diesel generators declared operable as of December 1, 1999; have a 60 day supply of diesel fuel available on site for each generator; declare irradiated (or "spent") fuel pools to be safety related and thus requiring backup power; and require utilities to install an additional source of backup power for each reactor by December 1, 1999.

NIRS petitions suggest that the backup resource come from renewable resources. This is a great idea! A new RE power plant could be added to the grid, creating a mini-grid that becomes stand-alone when the utility grid goes down. Not only does this provide a safe and reliable power source for the nuke plant suffering station blackout, it would be a shining new example for the future of distributed generation. Imagine the implications of a wheezing nuke plant being nursed along by renewable energy!

NRC Reaction

According to NIRS, the NRC staff was sympathetic to the petitions. But the NRC believes that the petitioners have not fully made the case in favor of adopting the proposed rules, especially the case that the NRC should adopt these rules as mandatory. Apparently, the NRC feels that utilities are doing enough on their own, and that reviewing each plant's plans on a case by case basis is adequate. As an example, the NRC said that some plants are planning to start their backup generators on December 30 or 31, 1999, and will keep them running in case they are needed. Apparently the NRC feels that this may be enough preparation for Y2K.

Shameless Plug

Whether you are conservative or liberal, love corporations or hate them, Nuclear Information and Resource Service (NIRS) is a group that is working really

hard to keep nuclear power as safe as possible. Please send them a contribution. NIRS is the information and networking center for citizens and environmental organizations concerned about nuclear power, radioactive waste, radiation, and sustainable energy issues. They have recently been given a grant which will match every dollar donated to them at 2:1. That means that the value of your donation will automatically triple.

Community Building

What good can come out of Y2K, anyway? The largest good actually comes from the preparation for it. Sure, the extra solar panels sold are a boon for our industry and the environment. But just as important, there is a golden opportunity to meet your neighbor and gain a sense of community that may have been missing. Individual survival is not the important issue (although I recommend it highly). This is a prime chance for us to learn to work together to get through a potential problem. We can learn to help our friends and neighbors, who may not have prepared as well as they should have.

This is also an opportunity for us to be ready when a real disaster—a natural disaster—hits us. For example, geologists in my neck of the woods have been warning us for years that a devastating earthquake will hit our area. It's only a matter of time. But the words of warning have gone unheeded. In the past it seemed doubtful that our community would gracefully survive such a disaster.

Because the Y2K scare is in folks' faces with a specific date of disaster, people in this community are meeting regularly among themselves, with officials, and with experts in various fields (including solar energy). We intend to be prepared on a community level. This wonderful new effort is akin to the old barn raisings, albeit on a larger and less personal scale. The feeling is, "we're in this together, and we will survive."

Access

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Net Metering Update

Don Loweburg

California's net metering law was recently revised by the state legislature. Recent changes allow wind plants 10 KW or smaller to be eligible for net metering, in addition to PV. Other changes include annual settlement for excess power generation, explicit reference to national interconnection codes and standards that apply to installations, and language that limits homeowner liability and insurance requirements.

Oregon is about to introduce a net metering law in the state legislature. Oregon's net metering law would include wind, PV, and hydro sources up to 25 KW. Like California, excess power would be settled annually. Unlike California, any excess customer generation would be donated to low income utility customers rather than to the utility. Frank Vignola at the University of Oregon proposed this innovative policy.

Net Metering Triumphs

Last year, readers learned of a threatened reversal of Maine's net metering law. Central Maine Power, on the basis of newly enacted restructuring law, refused to accept new net metering hookups. Quick action by Maine activist Bill Lord and others reinstated net metering after restructuring (see Bill's article in *HP65*). The final ruling became effective December 20, 1998. I asked Bill for a final wrap-up comment to *HP* readers. He writes:

We benefited when Central Maine Power Company overplayed their hand. They started refusing new intertie hookups just before the new restructuring legislation (which would give them that option) went into effect. As a result, my two neighbors—Peter Talmage and Naoto Inoue—had a legitimate gripe. They protested to the PUC and got a favorable decision.

The whole case opened up a can of worms regarding the death of renewable energy policy in the state. The PUC didn't want to see it die and so the three solar musketeers (Peter, Naoto, and I) became activists by testifying before the PUC about future policy. The priceless guidance of Tom Starrs helped the state's regulators find that middle ground that would not just protect shared renewable energy in the state, but enhance it. Stay involved, ask questions, take a position and make the regulators listen—sometimes they actually hear!

Bill Althouse of People for Independent Energy reports that the New Mexico Utility Commission scrapped New Mexico's very generous net metering policy. At issue was the allowance of 1 MW gas turbines. Cost effective, low emission, net-metered gas turbine self-generation is not pleasing to utilities. In a very interesting turnaround, New Mexico utilities are supporting a new PV net metering policy with a 10 KW limit. Sarcastically Bill states, "if you want renewables, push for micro-turbines." New Mexico readers interested in being involved should contact Bill.

Tom Starrs has compiled a Net Metering Summary list of the 23 States that have net metering laws. The list identifies allowable sources, capacity maximums and other pertinent information. Copies are available by email from IPP and the *Home Power* web site.

Anti-Islanding

The Utility Interconnection Standard (IEEE P929) is now in the tenth draft. Grumbling from the ranks suggests enough is enough. Can the end be near? Let's hope so. This standard specifically focuses on PV and inverter systems of 10 KW or less. The last hurdle involves the definition of "non-islanding inverter."

Initially, non-islanding meant that an inverter would disconnect from the grid if there were a loss of power. Then a situation was imagined in which several households with inverters might be sharing a single line transformer, presenting a higher probability for islanding. Additionally, large inductive loads (such as large motors) on the local system might further increase

the probability of islanding. These scenarios can only be created in the laboratory with some difficulty. Some of the required procedures are similar to balancing a ball on a thin stick. Possible, but very improbable.

The purpose of the "non-islanding" specification is that qualifying inverters could be installed without the extra protection switches required by some utilities. For detailed information on this subject, read the December 1998 *Highlights of Sandia's Photovoltaics Program.* The article is titled *Islanding of Multiple Grid-Tied Inverters.*

Merger Mania

In *HP67,* I commented on the pending merger of BP and Amoco. The news of the merger was very fresh and I was perhaps somewhat reactive. Mark Hammonds of BP Solar wrote me this response.

Your article contains several factual errors which I feel you should be aware of. BP and Amoco have proposed a merger of their companies. BP owns BP Solar; Amoco is a joint owner with Enron of Solarex. That merger is currently going through regulatory and shareholder approval; until then BP Solar and Solarex remain competitors. What happens afterward will depend on future negotiations and whether this process is successful.

In any event, Enron owns Zond Wind. Enron is a separate publicly quoted company, unaffected by the proposed BP Amoco merger. Their link remains the joint venture with Amoco in ownership of Solarex. Zond Wind is not part of this joint venture and thus Enron/Zond Wind is independent (of BP).

Secondly, your article implies that BP Solar has recently become vertically integrated. I suspect you refer to our Californian factory. This is in fact our sixth factory (in addition to facilities in Spain, Australia, Thailand, Saudi Arabia, and India), and with our other eleven sales/technical offices around the world, our seventeenth location.

BP Solar owes its origin to Lucas Energy Systems, which operated in the late 1970s in this field. BP bought 50 percent of this venture and then 100 percent in 1981. Since that time BP Solar has always operated as a vertically integrated solar company supplying the full range of services. As the market has grown, so has the retail distributor part of our business. On large projects, such as our $30 million rural development project in the Philippines, we have remained prime contractor providing the full range of services from equipment to installation and training. Regards, Mark Hammonds.

With respect to Enron, BP, and Zond Wind, I was painting with a broad brush and I stand corrected on this detail. Maybe we can say they are related by marriage, since Enron owns Zond Wind and half of Solarex, while BP-Amoco owns the other half of Solarex. My main point was that a significant consolidation of PV and renewable manufacturing was taking place.

Tom Jensen, editor of *Photon* magazine, authored a more recent article on the merger. It appears in the October-November 1998 issue. He outlines the connections and ramifications of the merger. Tom is careful with the details and makes the following points:

A BP-Amoco solar operation will be poised to jump past Siemens Solar and Kyocera to become the world PV volume leader in 1999. These three leaders and a growing Shell Solar could collectively supply the majority of the world's PV demand, and have a significant impact on the future growth and business direction of the industry.... Given BP's aggressive manufacturing and marketing expansion, the industry will look to see how the BP corporate strategy in solar evolves as Amoco and Enron enter the picture to form the world's largest solar organization.

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Perspectives on the National Electrical Code®

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center,
Sandia National Laboratories

The *National Electrical Code (NEC®),* updated and published every three years by the National Fire Protection Association (NFPA), is the most current and comprehensive electrical safety installation requirements document in the world. The 1999 *NEC* has just been published and work is already underway on the 2002 edition.

Hundreds of volunteers work on a three year cycle to review and update the *NEC* with the latest technology and methods of connecting electrical power systems. Representatives from the photovoltaic (PV) industry, academic institutions, the inspector community, Underwriters Laboratories, Inc. (UL), and the electrical utility industry meet regularly to modify and update Article 690 of the *NEC* which deals with PV systems. Although Article 690 covers only nine pages, most of the remaining 644 pages of the code also deal with aspects of PV installations.

The *NEC* has been made into law by over 40 states and by most major cities in the United States. It has been published for over 100 years. It represents the best ideas that have evolved in over a century of electrical power systems theory, design, and installation practice. There is always room for improvement and the document continues to evolve.

Paperback copies of the *NEC* are available for $30-45 at most electrical equipment distributors. The *NEC* and the hardbound *NEC Handbook* are available from NFPA (see Access). The *NEC Handbook* provides significant amounts of explanatory detail and numerous pictures and diagrams.

Safety Requirements

The *NEC* began as a fire safety code, but now includes personnel safety. The *NEC* requires that all equipment be examined for safety. While the local electrical inspector or authority having jurisdiction (AHJ) will inspect the field-installed wiring, the AHJ relies on the listing or labeling mark of an acceptable testing laboratory like UL or ETL to provide an indication that all equipment, conductors, and devices have been examined for safety.

The listing mark ensures that the equipment has been tested to meet a number of appropriate safety standards relating to electrical shock and fire hazards. Many inspectors will only inspect or approve systems that have been assembled with listed components. Insurance and mortgage companies may require electrical inspections, particularly on new construction or on additions to existing policies.

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

All listed equipment comes with labels and/or instructions that define the requirements (developed in conjunction with the requirements of the *NEC*) for installation and use of that equipment. Violations of these instructions or requirements may result in unsafe systems and equipment damage. The inspector, in many cases, will verify that these instructions have been followed.

Almost all of the material that is printed on labels attached to electrical equipment has been placed there to meet a safety requirement—either established by the *NEC* or by the listing laboratory. Much of the material found in equipment instruction and installation pamphlets and manuals is also mandated by safety requirements.

Safety vs Performance

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

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

The 2002 Code Cycle

Although the 1999 *National Electrical Code* has just hit the streets, complete and well-substantiated proposals for changes to the 2002 *NEC* are due to the National Fire Protection Association (NFPA) no later than 5 PM EST on Friday, November 5, 1999. This gives those individuals wishing to change the new 1999 *NEC* less than a year to write and submit proposed changes with the required substantiations. The correct form for submittal to the NFPA can be found in the back of the 1999 *NEC.* Electronic submissions may also be made. Contact NFPA for details.

Ward Bower at Sandia National Laboratories and a team of people from the PV industry will be meeting several times throughout the year to write and substantiate proposals for the 2002 Code. Contact Ward directly if you wish to participate in these meetings. You can also send your ideas to me for entry into the system if you provide, or we can develop, the necessary substantiation. For now, we have the following items under consideration:

- Figure 690-1: Label the Energy Storage
- Section 690-5: Rewording for clarity
- Section 690-6: Developing ground fault equipment requirements for AC PV modules
- Section 690-7: Consider expanding for some thin film devices
- Section 690-8(b): Possible exception for current-limited devices
- Section 690-31(b): Modifying for clarity and technical correctness
- Section 690-45: Rewording or deleting
- Section 690-54: Reword for consistency
- Section H: Adding prohibition on flooded, steel cased batteries in systems operating over 50 volts

What are your ideas? Where have you had trouble with the code or with language not clear to electrical inspectors? What can be added or changed to make your job easier?

Please keep in mind that the *NEC* is a consensus document. If you participate with an input directly to NFPA, you will get a copy of all of the 2002 *NEC* proposals. You will also have a chance to comment on any of them and will get a copy of all of the comments on all of the proposals for the 2002 *NEC.* The proposal and comments documents weigh about eight pounds each and they include the deliberation, comments, and actions taken by each of the code making panels.

Also remember that the *NEC* is not a design document. To quote a senior code making official, "The *NEC* will not contain anything that will keep stupid people from making stupid mistakes."

Jump in—the code-making water is fine!

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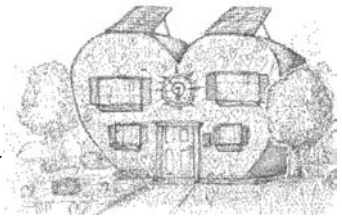
Home & Heart



Kathleen Jarschke-Schultze

It's springtime and I'm going into my gardening mode. Going through the seed catalogs, I find I want *everything.* My herb garden needs some more varieties. What about that new red sweet corn? If I plant some lavender plants now, I'll be able to harvest later this season.

Garden Prep

Since Bob-O and I have a dark brown adobe clay with a mixture of assorted sized rocks as our native growing medium, soil amendments are important. Sure, I compost. But it seems as though I never have all the compost I want or need. As soon as the ground thaws out, I will be tilling what compost I have into selected beds.

Two years ago, we made three raised beds out in the large fenced garden. It was amazing how big the cauliflowers were from one of those beds. I was sold on the whole concept of raised beds. I hope to add more this year.

It is easier to weed a raised bed. It is easier to amend the soil in a raised bed. I find the garden is not so overwhelming when I can say, "I will prep and plant one bed after work today." It's much easier to face than going to the garden gate and seeing *all* the weeds that need pulling throughout the *whole* garden.

Aged manure is my favorite and most common amendment. Since our neighbors the Fletts moved, we do not get the supply we used to. We do put some woodstove ashes into the soil, but you must be careful not to overdo it.

Garden Tips From Friends

My friend, Jaycin, taught me to always let one plant of every variety you grow go to seed. Of course with biennial plants like carrots, it will take two years for them to go to seed. I don't always catch all the mature seeds in the fall. Come spring, there are volunteer plants coming up all over. This is fine with me. When the volunteer lettuces come up, I know it is time to plant my own seeds.

Another friend, BettyAnn, told me, "Once you have cosmos in your garden, you will always have cosmos in your garden." This is true. It also applies to cilantro, dill, and nigella. I love annuals that freely reseed.

Donna taught me to plant tomatoes. First, dig a small trench about eight inches long. Pick off all the leaves of the tomato plant except for the top four or six. Lay the plant into the trench, bringing the topknot of leaves up out of the end. Fill in the trench. Roots will grow all along the stem that lies in the trench. This allows the tomato to get more water and nutrients. It also makes the plant sturdier to be anchored so well.

Sometimes you learn by observation rather than conversation. I had another friend who had a patch of comfrey and one of mint on the edge of her garden. Her husband tilled through the patches and pretty well distributed little bits of the plants throughout their growing area. Every tiny bit sprouted rootlets and grew. They had to abandon that garden and start a new one in a whole different area.

Gardens and Solar Cooking

Gardens and solar cooking are great partners. If you grow your herb garden by your solar cooking area, you can use the freshest herbs to flavor your food. Whole root vegetables and corn on the cob have that delicious homegrown flavor magnified by being cooked in a solar oven.

Anita, my friend and coworker, has plans to build a solar cooking area. It will incorporate an herb garden and a custom home-built barbecue. She wants to build the barbecue from native stones (not river rock, which can hold moisture for a very long time, then crack violently when heated). No problem though—there is certainly enough other rock around. She will have a nice outdoor kitchen area to cook in. While the rice, or squash, or whatever cooks in the solar oven, she can add any barbecue food she desires to round out the meal, all seasoned with fresh herbs.

Organic and Open Pollinated

I advise you to get organic seed for your family's vegetable garden. Why? Because it just makes good sense. You don't want your family eating the chemicals some growers use to treat their seeds and seed stock.

If you buy open pollinated seed, you can save some from year to year. If you try to save seeds from a hybrid variety, the plant will revert to one of its ancestors the second year. One way to tell if a variety is open pollinated is if it is labeled "heirloom." People have saved and grown this kind of seed for a long time,

mostly because the fruit or vegetable has exceptional taste or because it's a really dependable plant.

Most large growers now do what is called mono-cropping. They all grow acres of the same variety of hybrid, whatever it is. Most hybrid varieties for commercial growers are bred because the fruit or vegetable looks good, is all the same size and color, or ships well in packaging. Taste does not usually factor into it. Luckily there are a lot of seed companies selling non-hybrid open pollinated seeds. I find it exciting to add new varieties to the old favorites.

Make a Statement

Gardening is the most popular outdoor sport in America. There's a reason for that. It's good exercise. It relaxes you and lowers your blood pressure. The food you grow is the best you can eat. The two biggest political statements you can make in America today are to grow your own food and produce your own power.

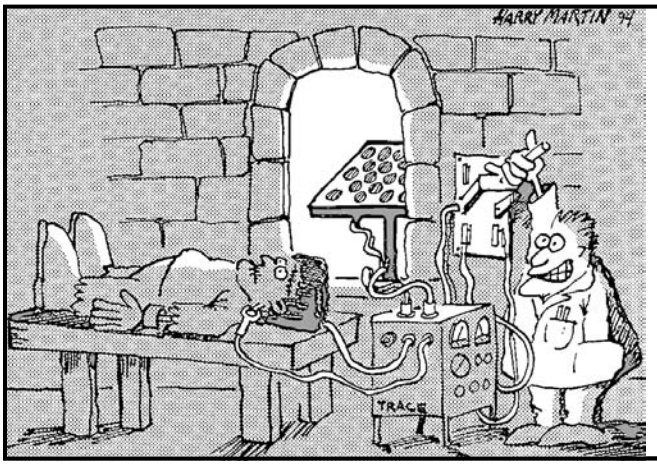
Access

Kathleen Jarschke-Schultze is planting her garden and beating the weeds at her home in northernmost California, c/o *Home Power*, PO Box 520, Ashland, OR 97520 • 530-475-0830
kathleen.jarschke-schultze@homepower.com

Seeds of Change, PO Box 15700, Santa Fe, NM 87506-5700 • 888-762-7333 • 505-438-8080
Fax: 505-438-7052 • gardener@seedsofchange.com
www.seedsofchange.com

Bountiful Gardens, Ecology Action, 18001 Shafer Ranch Road, Willits, CA 95490 •707-459-6410
bountiful@zapcom.net

Frost Dancing, Tips from a Northern Gardener
This great little 24 page book by Sue Robishaw is full of useful ideas. $5 postpaid for *Home Power* readers.
Many Tracks, Route 1, Box 52 E, Cooks, MI 49817
877-644-2598 • 906-644-2598 • manytrac@up.net
www.up.net/~manytrac



Writing for Home Power Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in Home Power.

Informational Content
Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—Home Power is hands-on! Articles must be detailed enough so that our readers can actually use the information.

Article Style and Length
Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible. We prefer simple declarative sentences which are short (less than fifteen words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in Home Power. After you've studied a few, you will get the feeling of our style. System articles must contain a schematic drawing showing all wiring, a load table, and a cost table. Please send a double spaced, typewritten, or printed copy if possible. If not, please print.

Written Release
If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article. This will help us respect the privacy rights of individuals.

Editing
We reserve the right to edit all articles for accuracy, length, content, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get published first.

Photographs
We can work from any photographic print, slide, or negative. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs. Please provide a caption and photo credit for each photo.

Line Art
We can work from your camera-ready art, scan your art into our computers, or redraw your art in our computer. We often redraw art from the author's rough sketches. If you wish to submit a computer file of a schematic or other line art, please call or email us first.

Got a Computer?
Send us the text for your article on 3.5 inch computer floppy diskette, either Mac or IBM format. We can also read ZIP disks (either Mac or IBM), and Magneto-Optical disks (128 MB, 230 MB, 1.2 GB and 1.3 GB all Mac only). This saves time and reduces typos. Please also send a hard copy printout of your article. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use your "Save As Text" option from within your word processor. Please don't just rename the file as "text" because it will still include unreadable (at least to us) word processor formatting.

You can send your article via Internet to richard.perez@homepower.com as an enclosed ASCII TEXT file. If you are sending graphics, or articles with embedded graphics, then use this special email address: rap@snowcrest.net

It is wise to telephone or email ahead of electronic file submission. This is particularly true concerning graphics files. There are many, many, many ducks and they all need to be in a row....

Got any questions? Give us a call Monday through Friday from 9–5 Pacific Time and ask. This saves everyone's time.

Access
Richard Perez, Home Power Magazine, PO Box 520,
Ashland, OR 97520 USA • 530-475-3179
Fax: 530-475-0836 (24 hours a day)
richard.perez@homepower.com
www.homepower.com

HAPPENINGS

CANADA
Aug. 11-14, '99: North Sun '99. Biennial Conference on Solar Energy in High Latitudes. Edmonton, Alberta. Call for papers. Info: Solar Energy Society of Canada, 116 Lesgar St. #702, Ottawa, Ontario K2P 0C2, Canada
+1-613-234-4151 • Fax: +1-613-234-2988
northsun.99@cyberus.ca
www.solarenergysociety.ca

Alberta Sustainable House: Open on 3rd & 4th Saturdays (except holiday weekends), 1-4 PM free of charge. Cold-climate features/products based on principles of occupant health, environmental foresight, conservation, AE, recycling, low embodied energy, self-sufficiency, & appropriate technology. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing, 9211 Scurfield Dr NW, Calgary, Alberta T3L 1V9, Canada • 403-239-1882
Fax: 403-547-2671 • jdo@acs.ucalgary.ca
www.ucalgary.ca/~jdo/ecotecture.htm

Electric Vehicle Society of Canada, Toronto Chapter promotes EVs to reduce the impact of conventional autos (and has fun!). We are enthusiasts, inventors, Sunday mechanics & environmentalists sharing the belief that EVs are a viable alternative. Meetings: 3rd Thursday each month, Sept-June. New members welcome! Info: Howard Hutt, 21 Barritt Rd, Scarborough, Ontario, M1R 3S5, Canada • 416-755-4324

The Institute for Bioregional Studies demonstrates & teaches ecologically-oriented, scientific, social & technological achievements for ecological, healthy, interdependent & self-reliant communities. Info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada • 902-892-9578

Vancouver Electric Vehicle Association, Call for meetings. Info: 1402 Charlotte Rd., North Vancouver, BC V7J 1H2, Canada • 604-987-6188
Fax: 604-253-0644 • rcameron@statpower.com

NEPAL
April 1-9, '99: Participate in "Solar Sisters"—Install solar in Himalayan communities, giving women the opportunity to provide hands-on solutions to energy problems faced by Nepalese communities. Volunteers come to Nepal for intensive installation training course, contribute to the cost of a solar home system, & install the systems for the benefit of the local community. Info: Stephanie Davis, Himalayan Light Foundation, PO Box 9219, Kathmandu, Nepal 977 • 1 418 203
Fax: 977 1 412 924 • hlf@mos.com.np

NETHERLANDS
May 25-27: World Sustainable Energy Fair, Amsterdam. The premier meeting point for the sustainable energy industry. Info: PO Box 259 Bromley, U.K. BR1 1Zr • +44-181-289-8989
sustain@emml.co.uk

PORTUGAL
Nov 10–14, '99: International Exhibition on Environmental Technology, Energy and Natural Gas. Info: Feir Internaciojnal De Lisboa, 351-1-360-1500 • Fax 351-1-363-3893
expoambiente@aip.pt • www.emml.com

RUSSIA
May 25-28: ICEF '99, The Ecological Revitalization of Great River Basins: Experience and Problems. Nizhny Novgorod, Russia. An international congress and exhibition, including some RE and other energy technologies. Info: ICEF, 13 Sovnarkomovskaya st., Nizhny Novgorod, 603086, Russia • +007 (8312) 34-55-95
Fax: +007 (8312) 34-55-68 • tatiana@yarmarka.ru
www.yarmarka.ru

NATIONAL U.S.
May 22-29, '99: 11th Annual American Tour de Sol, US EV Championship. 50 EVs traveling from Waterbury, CT to Albany, NY and beyond. Info: NESEA, 50 Miles St., Greenfield, MA 01301
413-774-6051 • Fax: 413-774-6053 • www.nsea.org

American Hydrogen Association nat'l headquarters: 1739 W. 7th Ave, Mesa, AZ 85202-1906
602-827-7915 • Fax: 602-967-6601
aha@getnet.com • www.clean-air.org

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

National Summary Reports on State Financial and Regulatory Incentives for RE. Current info on state and federal tax, grant & loan programs. To order: 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 and Renewable Energy Clearinghouse (EREC) offers free info: 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). Info: EREC, PO Box 3048, Merrifield, VA 22116 • 800-363-3732
TTY: 800-273-2957 • energyinfo@delphi.com
www.eren.doe.gov

Energy Efficiency and Renewable Energy Network (EREN) provides links to hundreds of gov't and private internet sites & offers an "Ask an Energy Expert" online form to email questions to specialists. www.eren.doe.gov • 800-363-3732

Green Power web site: Forum for consumers, policy makers & green providers to discuss green power including deregulation, "green" electricity choices, technology, marketing, standards, environmental claims, & varying national & state policies. Links, articles & news. Global Environmental Options (GEO), & the Center for Renewable Energy & Sustainable Technology (CREST).
www.green-power.com • other web sites:
www.greendesign.net • www.greening.org
Sustainable energy info: www.crest.org

Kids to the Country is an ongoing program to show at-risk urban children a country alternative. Info: PLENTY, 51 The Farm, Summertown, TN 38483
615-964-4391 • ktc@thefarm.org

Non-profit Tesla Engine Builders Association (TEBA): info & networking for building Tesla disk turbines. The 18" diameter, single stage steam version, operating at 9,000 rpm, has been documented to consume 38 lbs of saturated steam per hp/hr @ 125 lbs inlet pressure & free exhaust. Send a SASE to TEBA, 5464 N Port Washington Rd Suite 293, Milwaukee, WI 53217
teba@execpc.com • www.execpc.com/~teba

Sandia's web site includes "Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices," "Working Safely with PV," & balance-of-system technical briefs, providing information on battery & inverter testing. www.sandia.gov/pv

Solar Energy & Systems, an Internet college credit course. Fundamentals of RE for the homeowner or small village. Weekly assignments reviewing various texts, videos, WWW pages, weekly chat room, & email questions and answers. Mojave Community College. Tuition $100 plus $10 registration. 800-678-3992
lizcaw@et.mohave.cc.az.us Or:
chacol@hal.mccnic.mohave.az.us

The Federal Trade Commission offers free pamphlets: Buying An Energy-Smart Appliance, the EnergyGuide to Major Home Appliances, & the EnergyGuide to Home Heating and Cooling. Contact: EnergyGuide, Federal Trade Commission, Room 130, 6th St & Pennsylvania Ave NW, Washington, DC 20580 • 202-326-2222
TTY: 202-9326-2502 • www.ftc.gov

The Interstate Renewable Energy Council (IREC), SEIA, & Sandia National Labs: Handbook to guide state and local government procurement officials and other users in the specs and purchase of RE technologies. Biomass, PVs, solar domestic water & pool heating, small wind systems, technology specs, RE equipment, photographs, vendor contact info, & simple methods for estimating the pollution benefits of RE systems. Send US$15 ppd (make checks to ASES) to Interstate RE Council Distribution Center, c/o ASES, 2400 Central Ave Ste G-1, Boulder, CO 80301

New interdisciplinary solar energy curriculum for upper elementary & intermediate grades—Free! Six week stand-alone science curriculum or individual sessions creating an awareness of the potential of solar energy and demonstrating basic solar concepts and applications. More than 30 classroom presentations and demos of solar water heating, photovoltaics, solar cooking, etc. All exercises use free or low cost materials and give full info on background, vocabulary, objectives, procedure, and results. Includes a detailed bibliography, list of Web sites and photos. Student tested, teacher approved. Now available through the Florida Solar Energy Center at www.fsec.ucf.edu • For more info: FSEC, Susan Schleith, 407-638-1017.

ALABAMA
The Self-Reliance Institute of Northeast Alabama seeks others in the southeast interested in RE, earth sheltered construction, & other self-reliant topics. Info: SINA, Route 2 Box 185A1, Centre, AL 35960 cevans@peop.tdsnet.com

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

CALIFORNIA
April 30–May 2, '99: U.S. National Electrathon Championships, at the Velodrome, Los Angeles. Contact: Electrathon America, 1225 W Sepulveda Blvd., Ste 142, Torrance, CA 90502

May 1-3, '99: Take Your Bedroom Off the Grid workshop, Arcata. Showing people how to put solar electricity on their home a little at a time. Info: Redwood Alliance, PO Box 293 Arcata, CA 95518
707-822-7884 • redwood.alliance@homepower.com
www.igc.org/redwood

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

Rising Sun Energy Center. Ongoing Solar Energy Classes incl. electricity, water heating, cooking, & kids day. Schedule and info: PO Box 2874, Santa Cruz, CA 95063 • 408-423-8749
sunrise@cruzio.com • www.cruzio.com/~solar

Siemens Solar Industries offers two levels of PV training: Basic PV Technology Self-Study Course, & Comprehensive Photovoltaic System Design Seminar (call for dates). Self Study program includes: 500 pg training manual, video lessons, applications, w/exercises & examples. ($500). System Design Seminar: 5 day intensive lecture, hands-on assembly, labs, & team system design problem solving. ($1000). Contact: Siemens Solar Training Dept, 805-388-6568 • Fax: 805-388-6395 cvernon@solarpv.com • www.solarpv.com

June 26–27, '99: Fourth Annual SolFest celebration, Real Goods Solar Living Center, Hopland, CA. Inspirational speakers, educational workshops on renewable energy and sustainable living, entertainment, renewable energy booths, electric car parade, & more. 707-744-2017 www.realgoods.com

Real Goods Institute for Solar Living presents its ongoing Sustainable Living Workshop series through October. Beginning & advanced solar electric systems, passive solar, ecological design, sustainable waste water design, strawbale, cob & rammed earth construction, & more. Call 800-762-7325, or write ISL, PO Box 836, Hopland, CA 95449

COLORADO
Solar Energy International (SEI), a non-profit dedicated to the practical use of RE. Hands-on workshops: solar, wind, & water power. One & two week sessions: PV Design & Installation, Advanced PV, Wind Power, Micro-hydro, 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. Workshops may be taken individually or as a comprehensive program. $500/week. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

National Wind Technology Center, operated by the NREL, near Golden, CO. Assisting wind turbine designers & manufacturers with development & fine tuning. Computer modeling & test pads. Call in advance: 303-384-6900 • Fax: 303-384-6901

FLORIDA
August 23–25, '99: Second Annual Energy '99, Achieving Your Goals Conference, Orlando, Flordia. In-depth program for energy professionals interested in energy & water efficiency, & renewable energy. Contact: JoAnn Stirling 800-395-8574 • Fax 407-638-1010 joann@fsec.ucf.edu
Complete info: www.energy99.ee.doe.gov

ILLINOIS
April 24, '99: Earth Fest 99 annual celebration. Hosted by Davis Caves, builders of earth-sheltered homes. 10 AM–5 PM, rain or shine. Free admission, parking, shuttle to event, tours of earth-sheltered homes, workshops on earth-sheltered homes, PVs, wind. Design consultants, pony rides, music, kid activities, food, antiques & crafts. Armington, IL (between Chicago & St Louis) on U.S. Rt 136, 7 miles west of I5 (exit 145) at McLean, Il & 7 miles east if Interstate 155 (exit10)

IOWA
Iowa Renewable Energy Association (IREA) to sponsor workshops this spring. Two on straw bale houses (April 16-21 or 23-28), domestic hot water installations, & DC PV systems at Prairiewoods Nature Center near Cedar Rapids, Iowa. Contact IRENEW or Tom Snyder, 611 Second St. SE, Dyersville, IA, 52040 • tsnyder@mwci.net
Or: Prairiewoods, 120 E Boyson Road, Hiawatha, IA 52233 • 319-395-6700

May 15, '99: Iowa Electrathon, sponsored by IRENEW and the Center for Energy and Environmental Education (CEEE) at the University of Northern Iowa, Hawkeye Downs racetrack; Cedar Rapids, Iowa. Contact Iowa Electrathon Hotline at 319-273-6912 or Tom Deves at 319-556-4765

Sept 23–26, 1999: IRENEW Energy Expo/Convention. A four-day energy expo/conference. Sheraton Four Points Hotel and Convention Center, Cedar Rapids, Iowa. Many events: Solar cars, electric cars, Cedar Rapids Electric bus, Electrathon cars and races, demos. Many workshops—PV, wind, active vs passive, political issues. A second Iowa Electrathon Race will be held—following the first race in May—close to Hawkeye Downs. Info: I-Renew, PO Box 2132, Iowa City, IA 52244 • 319-338-3200 • Fax: 319-351-2338 irenew@igc.org

Iowa Renewable Energy Association (IREA) board meetings: 2nd Sat every month at 9 AM, Prariewoods, Cedar Rapids. Everyone welcome. Call for schedule change. I-Renew, PO Box 2132, Iowa City, IA 52244 • 319-338-3200
Fax: 319-351-2338 • irenew@igc.org

KENTUCKY
Appalachia-Science in the Public Interest. Ongoing projects & demos in gardening, solar, sustainable forestry, & more. Info: ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • aspi@kih.net www.kih.net/aspi

MAINE
June 12-17, Solar 1999: Growing the Market, American Solar Energy Society's Annual Conference. Devoted to taking solar energy into the 21st Century. Growing strong & sustainable markets is our compass. Portland, ME. Info: NESEA 413-774-6051 • Or: American Solar Energy Society 303-443-3130 • ases@ases.org www.ases.org/solar

June 7—12, Women's PV Design & Installation Workshop, Portland. Hands-on basics of electricity, site analysis, system components, wiring & safety. Women guest instructors from the RE field. In conjunction with the ASES conference, Solar '99. Contact SEI, PO Box 715, Carbondale, CO 81623 970-963-8855 • Fax: 970-963-8866 sei@solarenergy.org • www.solarenergy.org

MARYLAND
April 29–May 1, '99: EnvironDesign3, the premier conference on sustainable design and building practices, Baltimore, MD. Contact: EnvironDesign3, PO Box 13079, North Palm Beach, FL 33408 Fax: 561-694-6578 • www.isdesignet.com

June 5, '99: Sun Energy Fair, sponsored by The Potomac Region Solar Energy Association (PRSEA) and Montgomery College. At Montgomery College, Germantown, Maryland. www.prsea.org

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

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

MISSOURI
SOLTECH 99: The major solar energy industry event in the U.S.! Kansas City, Missouri. Focus: current energy applications, issues in agriculture, distributed power, telecommunications, disaster relief, Y2K, & other infrastructure applications important to America's Heartland and the nation. Find out more: www.SEIA.org • 301-941-2553

MONTANA
Sage Mountain Center: Life Skills Workshops. One day, comprehensive classes: Inexpensive earth-friendly home building, straw bale construction, making log furniture, cordwood construction, natural & non-toxic interiors, & more. $55 incl literature. Info: SMC, 79 Sage Mountain Trail, Whitehall, MT 406-494-9875

NEW MEXICO
Profit From The Sun Workshop Series, Moriarty, NM. Workshops on renewable energy, energy conservation, sustainable living & energy independence. Contact: James or Marek at PSF,Inc, 505-832-1556 days, or James at 505-832-1575 evenings & weekends • proffit@flash.net

NEW YORK
April 24, '99: The North Country Sustainable Energy Fair, "Sustainable Energy Options for the North Country." McKenney's Middle School, Canton. 10 AM–6 PM. Guest speaker: Beth Sachs of Vermont Energy Investment Corp. Seeking exhibitors. Seedcorn is a not-for-profit, voluntary community organization dedicated to improving the quality of life in St. Lawrence County by promoting economic and environmental sustainability. www.northnet.org/seedcorn/energy.html.

May 26-27: Hybrid-Electric Vehicle Symposium. Society of Engineers and NESEA presents the latest technology and research. Info: NESEA, 50 Miles St., Greenfield, MA 01301 • 413-774-6051 Fax: 413-774-6053 • www.nsea.org

OHIO
Solar/Wind classes taught at rural solar & wind powered home with utility backup. Second Saturday of each month, all classes 10 AM to 2 PM. Technical info, system design, NEC compliance, efficient appliances, & Y2K applications. Tailored to students needs. Students will see equipment in use. Maximum 10 students. Register in advance. $65/person $85/couple (spouse only for couple rate). Lunch provided, please advise of dietary restrictions. Available in spring: a hands on project in straw bale post & beam building. Solar Creations, 2189 S.R. 511 S., Perrysville, OH 44864 419-368-4252 • www.bright.net/~solarcre

April 23–25, '99: Introduction to Permaculture Course,.at Niches', a deep ecology retreat in Vinton County, Southeastern Ohio. 7 PM Friday–12 PM Sunday. Instructors: Mark Cohen, Permaculture Designer, Organic Farmer, apiculturalist, mycologist, philosopher, business consultant, co-founder of Far Valley Farm, a 25-year-old intentional community; Executive Director of the Belize Agroforestry Research Center, & Lou DeWein, PhD. Deep Ecologist, Professor, and Founder of 'Niches.' Tuition $200, includes lodging, healthful vegetarian meals, & copy of Introduction to Permaculture by Bill Mollison with Reny Mia Slay. Enrollment limited: 12 students. Tuition assistance available. Contact course sponsors Frank & Bonniethem at 740-969-2045 gamma@fairfieldi.com or bigmoose@hempseed.com

OREGON
Aprovecho Research Center is a non-profit educational institute on forty acres nestled in the forest of Oregon. Internship programs March 1, June 1, and Sept 1. Six week winter internship in Baja, Mexico: Studying and researching appropriate technology applications, learning Spanish, teaching in a grade school, & working in fruit orchards & gardens. Info: Internship Coordinator, Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 541-942-8198

April 15–18, '99: Eco Design Arts Conference, Equity and Ecology. Exploring methods of defining and achieving social and ecological equity in our neighbors, society, across cultures & around the globe. Workshops, plenary sessions, & a costume party. Info: University of Oregon, School of Architecture and Allied Arts, H.O.P.E.S., Lawrence Hall, 5249 University of Oregon, Eugene, OR 97403-5249 • 541-346-0719 http://gladstone.uoregon.edu/~hopes hopes@laz.uoregon.edu

April 30, '99: "Photovoltaics in Buildings, Solar Architecture: Design Guidance for Practicing Professionals." workshop, by Steven J. Strong, President of Solar Design Associates, Inc. At Two World Trade Center, Portland. PV cell and module technology, commercial and residential technology options & applications, systems configuration, building integration details, case studies, codes, economics, & incentives. Sponsored by Portland General Electric, Portland Chapter AIA & the Committee on the Environment, Solar Energy Association of Oregon, OSEIA, Oregon Million Solar Roofs Coalition, University of Oregon Solar Information Center, & Cascade Solar. NEEI is supported by the Northwest Energy Efficiency Alliance. Contact: The Northwest Energy Education Institute, (NEEI), 800-769-4723 • NEEI@lanecc.edu • www.nweei.org

TEXAS
April 12-17, PV Design & Installation Workshops, Austin. Hands-on basics of electricity, site analysis, system components, wiring, & safety. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 Fax: 970-963-8866 • sei@solarenergy.org www.solarenergy.org

SEASUN, El Paso Solar Energy Association www.epsea.org

The El Paso Solar Energy Association (EPSEA) is proud to offer a bilingual web page. Access info on energy and energy saving ideas in Spanish. www.epsea.org • www.epsea.org

April 26: Texas Clean Transportation Seminar '99, Austin. Contact: Russel E. Smith, TREIA, PO Box 16469, Austin, TX 78761-6469, • 512-345-5446, Fax 512-345-6831 • R1346@aol.com

WASHINGTON
GreenFire Institute: Workshops and Info on straw bale construction. Info: GreenFire, 1509 Queen Anne Ave #606, Seattle, WA 98109 • 206-284-7470 Fax: 206-284-2816 • wilbur@balewolf.com www.balewolf.com

1999 Hands-On Permaculture Workshops. Learn to apply sustainable ecological design at one of North America's premier permaculture sites—The Bullock Brothers' Homestead, Orcas Island, WA. Horticulture for Permaculture Landscapes, April 23–26; Permaculture Skills Intensive, July 10-August 6; Water Harvesting, September 17–20. Contact: Bullock Workshops, c/o WE-Design, PO Box 45472, Seattle, WA 98145 or Michael Lockman, 206-567-5447 michaellockman@juno.com

WISCONSIN
June 18-20, '99: 10th Annual Midwest Renewable Energy Fair, Amherst, Wisconsin. Hundreds of workshops, speakers, exhibits, and demonstrations. Events for children, educators, and the public. Bus and bike tours of RE homes, on-site model home, & entertainment. Info: MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166 • Fax: 715-824-5399 mreainfo@wi-net.com

Midwest Renewable Energy Association (MREA) Workshops. See ad in this issue. Call for cost, locations, instructors & further workshop descriptions. MREA Membership & participation: all are welcome. Significant others 1/2 price. Info: MREA, PO Box 249, Amherst, WI 54406 715-824-5166 • Fax: 715-824-5399 mreainfo@wi-net.com

the Wizard speaks...

Omens

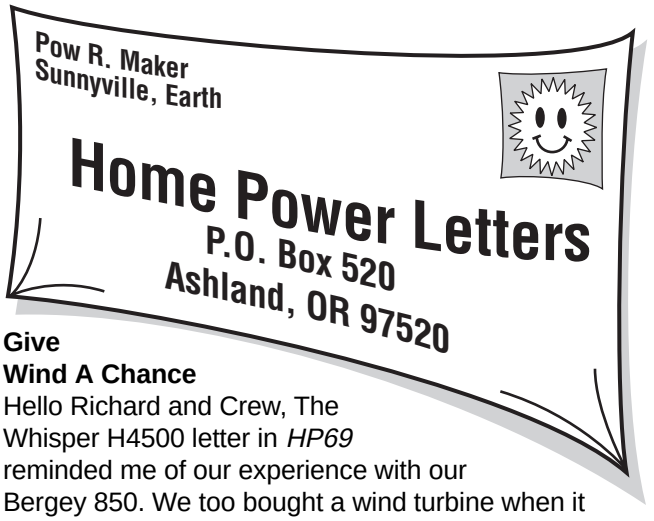
Throughout the world there have been many signs which suggest that all is not well with our environment. These omens are everywhere, from the inorganic to the organic.

On the inorganic side, there are volcanos and earthquakes. There is the ozone hole and the melting of Antarctic ice and Arctic permafrost. Weather phenomena such as El Niño, hurricanes, tornadoes, and floods are increasing in frequency and severity. Ocean level rise has been measured at more than one millimeter per year in some places.

Omens on the organic side are equally worrisome, if not more. Species are both mutating and dying. There have been mutations in the sexual organs of alligators, fish, polar bears, and amphibians. Most of the planet's coral reefs are in danger of disappearing. New diseases and parasitic life forms are beginning to appear. Large dead zones have been observed in both the northern Pacific Ocean and in the Gulf of Mexico.

These are just some of the portents of severe ecological and environmental problems. If steps are not taken soon to reverse the trend of environmental degradation, it may become too late to effect such a reversal. The longer such decisions are put off, the more drastic any potential solutions must become.

In the short term, all forms of environmental pollution and degradation must be curtailed. The mid-term solution involves total recycling and the use of renewable resources. In the long term, population limitation may be the only viable solution.



Give
Wind A Chance

Hello Richard and Crew, The Whisper H4500 letter in *HP69* reminded me of our experience with our Bergey 850. We too bought a wind turbine when it was first introduced.

Ours was one of the first 850s installed by a customer. Being an early adopter didn't bother me, given the Bergey reputation for quality. Unfortunately, there was an early design glitch that prevented the 850 from furling under certain wind conditions. Our site on the front range of the Rockies in northern Colorado is not a friendly one for wind turbines. We installed it and were immediately hit with 90 mph winds. That's when we found out the turbine didn't furl.

What's worse, there was an error in the 850 manual that caused us to put in fuses that were too small. So picture our poor 850 up there in the gale with no load, freewheeling away and no way to turn it out of the wind short of lowering the tower (which is a poor idea in 90 mph winds). It sounded like a helicopter landing on our roof. The fuse problem was quickly identified by Bergey but the furling problem took a couple of months. Finally, Karl Bergey solved the problem and sent us all the parts we needed to rebuild the turbine.

Throughout this troubleshooting, Bergey was very responsive. Except for a minor incident when the tail fell off (a year ago) the 850 has been in continuous use. Fixing the tail only disabled the turbine for the few hours it took me to notice and fix it. The tail rivets simply fatigued and failed. I replaced them with machine screws and reported the failure to Bergey. Karl says they stopped using the rivets some years ago. Thanks for letting me know, Karl!

My point is simply that new products, even from reputable companies, sometimes have problems. Fortunately, good companies stand by their products and will remedy those problems. I sincerely hope, and expect, that your wait for the WPT H4500 will be well worth it. If we needed another wind turbine, I'd buy another 850 in a heartbeat.

PS. The freewheeling in 90 mph winds apparently caused no damage to the turbine. This machine is made to survive such abuse. I can believe this because it's still putting out 1 KW at its peak wind speed. According to Karl, it was cheaper to over-engineer the turbine than to put in a brake. Bob Gobeille igs@verinet.com

Your point is well taken, Bob. As Steve Hicks points out in the interview in this issue, "wind's got headaches." If people want an RE system that is simple and reliable, they should buy PVs. You can't expect a machine that sits in a severe environment and rotates at high speed to work flawlessly all the time. And though I love wind power, I'm glad not to be in the business of making wind machines. That's one tough job! The manufacturers who can stay in business have my respect, even if I do occasionally want to prod them to improve their products and customer service. Ian Woofenden

Bus Help

Dear *HP* Readers, I am installing PV panels, a small wind genny, a large battery bank and an inverter on my school bus which I am converting to an RV. I plan to live out of the bus full time once it is completed. Having never done this before, I am looking for folks with similar experience who would be willing to help me with questions as they come up. I have a decent grasp of the basics and have read extensively in past *HP* issues as well as on a couple of Internet bulletin boards devoted to bus conversions. Still, I would like to be able to bounce ideas off others before implementing them on my bus so as to avoid mistakes as much as possible. Thanks much. Jacob Gatschet, PO Box 306, Hays, KS 67601 • jgatschet@dailynews.net

Toxic?

I just about fell off my chair after reading Mark Hammonds' comments in Letters, *HP69.* I thought I was in a Dilbert cartoon!

In defending NiCd batteries, Mark said "everything is toxic," then goes on to use Coke as an example of something in our everyday lives that is toxic, given the appropriate dose.

Here's the glitch in Mark's sophistry: I can choose to drink (or not to drink) Coke. If cadmium has inadvertently seeped into my groundwater due to someone's ignorance or negligence, and I don't know about it, that choice is made for me. And until I somehow discover that I'm being poisoned against my will, I will probably continue to drink the water that I trust. I don't think a Coke ever snuck up on anybody!

While there are several options for industrial recycling of NiCd batteries, recycling these batteries is an

enormous headache for the responsible homeowner on renewables. Scrap yards just won't touch them. It is for this reason that most RE dealers no longer handle used NiCds. I have seen some very frightening situations where old NiCds were merely dumped in "the back forty" once they were no longer usable in an RE system.

I have been told that one major difference between lead and cadmium is the way it moves up the food chain. While both are heavy metals, lead concentrates in the fatty tissue of carnivores. Cadmium, however, can be absorbed by the lettuce in my garden. In my mind, this puts NiCd batteries in a very different category from lead-acid and NiFe batteries.

Finally, I don't think that one can consider the cadmium imbedded in PVs as a doping compound in the same way you would consider cadmium in a NiCd battery. One is inert, inaccessible and not soluble in water, while the other is not. Equating these two, or as Mark does with cadmium and Coke, is the absurd type of legalistic corporate logic that has gotten us into so many environmental dilemmas in the past. Or were those all really "challenging environmental opportunities?"

At any rate, I would encourage Mark to continue his education. Mick Sagrillo, Sagrillo Power & Light, E3971 Bluebird Road, Forestville, WI 54213
Phone & Fax: 920-837-7523 • msagrillo@itol.com

Small Battery Recycling
The whole issue of waste and recycling is a huge and growing one. It will continue to be important in the future. As the human race has evolved and the planet has become more crowded and polluted, this has assumed even greater importance. Already in Europe it is the law that manufacturers supplying products over a certain size have to take back packaging.

When I lived in Fairfield [California], the local community had periodic days when batteries, oils, and other similar substances could be turned in. The reality is that the nickel cadmium battery industry has reacted to concerns and instigated voluntary policies in this area. They recognize that this is better than having draconian regulations imposed.

For information on recycling small rechargable batteries, visit www.dacom-co.com/rbrc.htm, or call 800-8-BATTERY. This WWW site describes a cost-effective and environmentally sound recycling program for rechargable NiCd batteries. The California company is set up to have people mail in batteries for recycling. This is one little extra step we should be willing to take. Mark Hammonds, BP Solar, Inc.

Cooling with Soil & Cadmium Toxicity
The idea of cooling buildings with pipes in the ground is not new, but it is only advisable in very dry climates. In more humid climates, the humidity will condense on the inside of the pipe, so you will have a dark damp area—a perfect breeding ground for molds. Your house will get a steady supply of molds inside, to the detriment of your health.

Another reader commented that cadmium is not so bad, as too much of anything is dangerous, such as iron. True, but cadmium is a heavy metal, which takes decades to remove from the body again. The body needs iron to function, and thus gets rid of it eventually. Cadmium belongs together with mercury and lead, as a controlled substance. Steen Hansen
steen@dds.dent.ohio-state.edu

Cooling with Soil & Steam Power
Chris Snyder in *HP69* Letters wanted more information on cooling with soil. An excellent book on this is *Passive Annual Heat Storage, Improving the Design of Earth Shelters.* It is by John Hait, published in 1983 by Rocky Mountain Research Center, PO Box 4694, Missoula, Montana 59806, ISBN: 0-915207-00-1. Don't let the title fool you, it describes heating and cooling and can be applied to above ground homes.

W. Van Aller asked about steam power to generate electricity. In the '50s, Iron Fireman Company developed a family of steam turbine-driven, forced air unit heaters for residential and commercial applications, under the name Selectemp. The same inventors are working for TRD to build a furnace with the ability to generate 600+ watts of power. The main component for generation in the Turbotherm power unit has only one moving part. For more info contact: Peter Kneasker, President, TRD Corp., 5181 W 161st St, Cleveland, OH 44142 • 216-433-7775 • Fax: 216-267-8063. I hope you find this helpful. Michael Champagne, Nashua, New Hampshire

More on Cooling with Soil
For an answer to Chris Snyder's letter in *HP69,* check out the article in *HP41, How to Stay Cool in the Hot Desert.* Author Van Meter gives a detailed description of a cooling tube idea which seems eminently workable, especially when coupled with the wind scoop idea he describes. Keep up the excellent work—we love *HP!*
Doug Parham • DSParham@mq.psd.k12.ca.us

Detailed Installation Articles
The utility intertie/guerrilla articles/debate you've been doing are excellent. Keep it up as this represents a huge market—the economic & political power ramifications are deep.

A series of detailed installation articles would be appreciated. For example, “OK, now we’re ready to connect the modules in series/parallel using this #10 USE wire, strip off 1/2 inch of insulation, poke it through the negative seal, smear on anti-ox grease and tighten...” You get the picture (lots of pictures a plus). Step by step. It could be tedious, but would result in safer and better installations. Your crew does a great job! Barry Northrop, Boulder, Colorado

Hello Barry. You’re right, we need to be doing more of these step by step articles. I’ll see what we can do in the future. The number of folks doing their own installs is rapidly decreasing as more and more installing dealers are available. This has caused us to run fewer of these articles lately. We’ll get on it! Richard Perez

Selling Small RE Parts

It dawned on me that as more RE systems come on line, age, and become updated, used RE parts are beginning to be available as never before. The *HP* micro ads, while very reasonable in cost, do have a potential lag time of up to two months between publications. It is also not very cost effective to spend more for the ad than one would hope to recoup on smaller items.

I have a possible solution to this. The Internet site, www.eBay.com, is set up to handle auction sales of items. There is not a separate category for RE parts, so the Miscellaneous grouping is the where these parts should be listed. Buyers can search for products/services within an eBay category so you don’t have to wade thru all the misc. items to find a “charge controller” or “PV panel” or “inverter” etc. as long as the seller uses these common names. The Web site explains how to use the service.

I want to make it very clear that this is *not* intended to go around or bypass the *HP* micro ads. I have been a very grateful reader since *HP1* and while *HP* may not have been the first RE publication, I have yet to find a better one. The amount of information and heart that we receive with each issue is way above the cost for it. To undermine this would be killing the goose that laid the golden egg—plain stupid. (My personal curse for anyone who hurts *HP*—permanent cloud cover over your home!)

My main motivation is to develop a “swap meet” for RE stuff, a new level of recycling! Besides, our faithful Trace 612 is to be replaced by an upgrade and I’m sure there’s an *HP* reader, if not a dealer, looking for cheaper parts. I truly want to see this industry grow so that we all can have better products. If we can recoup some investment on our initial items, we are more likely to buy the “new and improved” sooner.

Thanks, Richard and the *HP* crew! If this works out, I’ll bet we can talk eBay into creating a category within Miscellaneous for RE parts like the ones they have for photo and sports equipment. I’ll be looking for you all there. Suncerely, Katcha • sandbill@garlic.com

Sounds like a great idea, Katcha—have at it! Let us know how it works out. Richard

Appliances and Optimism

Great job. *Home Power* keeps getting better and better. Keep the pressure on with the Guerrilla Solar. The online download is great as long as you can do it. Still helps having a hard copy. Helps the batteries on the old notebook go a lot farther. There is nothing I don’t like about *Home Power* magazine. You’re the greatest. And I mean that. We all do what we can, but you put in 100 percent and it shows.

I got an efficient front loading washing machine and switched the dryer from electric to gas. All the lights are compact fluorescent and I’m working on the insulation. Gotta get some more solar installed before the 31st so I can get 10 percent back on the price on my federal taxes this year.

The energy star fridges (not near the Sun Frost, yet) are out now (www.energystar.gov). Also, the White House is greening up nicely and the million solar roofs will be up and going quicker than anyone thinks. Maybe someone can help prime the system more by getting together more volume purchases, though it is hard to organize this type of thing.

It really helps learning from others’ mistakes. Let us know if and how the utilities crack down. I’m going to be guerrilla net metering myself pretty soon if they don’t make it legal here in the next few months. Batteries are just not that environmentally friendly. I read that NiFe batteries are going to be available from China. Anyone know anything about these? Please publish what you find out. Thanks for all your hard work. Jim, Blacksburg, Virginia

Hello Jim. Great job on all the energy conservation measures—that’s really the first step in going solar. I recommend going with lead-acid batteries. The recycling mechanisms are already in place and very effective. The Chinese NiFe cells we tested here failed. I stick with well made lead-acid cells—they are very cost effective and easily recycled. Richard Perez

Left Brain vs Right Brain

I was simply amazed when I found your Web site! I have been a subscriber to *The Mother Earth News* for 25 years, and a *Popular Science* reader since childhood, but have not seen anything to compare to the depth and breadth of information on energy sources

in one issue of your magazine (which I downloaded from your site). For example, the articles comparing wind generators, and PV, and the thorough article on hydrogen purification gave very clear diagrams and explanations and comparisons that are straightforward and informative.

I have several questions, almost left brain vs right brain in nature. Right brain says I love the concept of non-pollution, non-fossil fuel generation of energy, but the left brain says "show me the numbers." To paint you a picture, ours is a passive solar, active solar home on a twenty acre wood lot. We are currently a grid dependent electrical consumer with a Co-op Utility charging 6.3 cents per KWH. I am also in an area with low solar light levels, thus even though they have a long life, PVs would seem to have long payback.

The average wind speed provided from NOAA for our area is 13.1 mph, thus we are in a "high wind" area. What I am looking for is a cost/benefit analysis in matrix or spreadsheet on installing a wind generator and PVs. I'm imagining something relating factors for sizing a wind only system (like the average number of KWH consumed, the cost per KWH from utility, the cost per KWH the utility buys back the excess, the KWH produced based on generator size at average wind speed), to the cost of a wind generator for intertie and a full off-grid system. It also could include factors relating to sizing a PV array (like the level of light available, fixed and tracking output numbers based on light levels) to the cost of a PV for intertie and a full off-grid system. And what about a combination cost benefit using both wind and PV?

Also do you have any articles relating to the cost of a phased approach in going first to an intertie system, then moving to an off-grid system? And how do I set up an intertie to move easily to an off-grid system with the least cost/hassle? Or what about the middle ground of a complete grid-intertied system, selling excess to the grid? Jim Daily, Stewartville, Minnesota

Whoa, Jim! Nothing like asking for a PhD dissertation in the letters section of a magazine! Fully answering your query is far beyond the scope of this forum. It would require a series of articles to address it properly. That gives me an idea...

Anyway, if you'd like to do some research, one of the best payback analyses available on home sized wind systems is in Paul Gipe's book Wind Power For Home and Business, *available from Chelsea Green Publishing, 800-639-4099.*

A couple of observations and comments. First, it is extremely difficult for any *home sized RE system to compete financially with heavily subsidized utility electricity. At $0.063/KWH, it is really only possible with "utility sized" equipment, that is, several hundred KW of capacity. The order of most cost effective to least is usually hydro first, followed by wind, with PV bringing up the rear. The order may be quite different for off-grid systems, depending on electricity use versus available resources.*

A 13.1 mph wind resource certainly makes your site a serious candidate for considering a utility-intertied wind system. While I rarely recommend a wind only off-grid system, adding PV to a grid-intertied system with your wind and solar resources would substantially lengthen your "payback."

Use Gipe's book and spreadsheets to determine your economic payback, and see if it is an acceptable investment for you. Please note that many RE system users do not necessarily install their systems for purely economic "paybacks." Many of us consider the environmentally friendly nature of RE systems heavily into our cost/benefit analysis. Mick Sagrillo

Hello Jim. Wow, that's quite a spreadsheet you want! As far as I know, it doesn't exist, but if you write it, please send me a copy. Here's what I know. A modern RE system can be either on-grid, utility-intertied, or completely off-grid. The difference between on-grid and utility intertie is power direction. On-grid you strictly consume from the utility, but with utility intertie you can also place your RE on grid. Financially speaking, the best deal is a utility-intertied system in a state with a net metering law, such as Minnesota. Next comes on-grid and finally the most expensive approach is off-grid. The only real difference in these systems technically is the presence and size of the battery—all the major hardware is the same. Hybrid systems, such as the wind and PV you mentioned, are more cost effective off-grid than anywhere else. If I lived in Minnesota which allows up to 40 KW of net metered RE, then I'd go with a big wind system and utility intertie it. Richard Perez

Grounding

As of June 1, 1999, I will have been off-grid for 15 years. I want nothing to do with the grid, which runs underground across the front of my property. I started with two tail light bulbs, an eight inch fan and one battery. I have a file of all *Home Power* issues—we were lucky enough to receive the first free issues. I do not ground my 12 VDC system. I ground my frames, boxes, etc. and the ground side of my 110 AC inverter power. I like what works and medium sized system articles. W.E. Stephens, Sanger, Texas

Thanks for your comments. It sounds like you might have a medium sized system, W.E. Should we be looking out for the article you're writing? Ian Woofenden

Surfing
I just stumbled upon your Web site, and was amazed at the amount of information available. I have been researching PV power for several months now, and have most of the components needed to build a complete 1 KW PV system. I was doing some surfing last night, and when I came across your site, I just *had* to get a subscription right away. What really helped was the *free* issue you had available for download. I'm hooked! I just ordered a year of *Home Power* magazine, the CD ROMs, and *Heaven's Flame.* I have found in the past that the best research material comes from specialty magazines on the subject. I look forward to reading your magazine! Thank You! David Shemenco, Parlin, New Jersey

Potential Roof Problems
In your magazine I have seen applications of photovoltaics where they are being bolted down to a roof. There is a real problem with this. Asphalt roll and shingle roofing needs to be replaced every 20–30 years. You have to remove all of the solar stuff from the roof, then put it back on after the roofing job.

In the evolving solar hot water industry, panels are placed at the roof peak, where they can be flashed and re-roofed easily. The panels are laid flat on the roof, and not on some quirky south facing platform. They are glazed with glass that will not yellow.

The PV manufacturers should make panels which have flashings around them like skylights do. The solar cell-in-a-shingle concept has the same problem—20 or 30 years roll around sooner than you think. (Noticed any grey hairs lately?) Michael Meredith, Springfield, Virginia

You make some excellent points, Michael. I'm not a fan of roof mounts, though I do still have 14 panels racked on our metal roof. If I could start over I would go with a pole mount next to the house. Racks for pole mounting are readily available and easy to install. They not only make re-roofing easier, but are handier for seasonal angle adjustment. Ian Woofenden

Y2K and Happy Birthday to Me
Hi Kathleen, My name is Geri (short for Geraldine) and this is the eve of my 50th birthday. I have been enjoying your column, and *Home Power,* for years now and finally must write to you about your most recent column featuring Y2K. It had me in stitches, but it was helpful too—it was great!

For more than ten years I have had a keen desire to become self sufficient. My biggest goal (only a daydream at first) was to "go solar" and now that is a reality, with the help of my husband (I finally met the perfect guy at age 43). For years I have been buying how-to books and now I think I could fix all sorts of things and make candles and soap, and raise chickens, etc. (We are building a chicken pen soon). Then Y2K came along and it all started to make sense. Or at least now I had a good excuse to indulge in all these things I was dreaming about. All my life I have had horses and for years have had an old harness in a trunk. I got that harness out of the trunk the other day and started to oil it. 'Course, I don't have a buggy or wagon—yet...

More goals for this year: Plant a 90 percent successful garden. Get into solar cooking and solar food dehydration big time. I love your definition of running water. It is hilarious, but it could come to that for a lot of people. I guess that is the beauty of a holding tank and gravity feed.

Prepare for two months of dicey services... I think I will prepare for four or six, or maybe what I really want is for things to really change, for the good. Do you ever see any of the Co-Op America stuff? Their recent newsletter talks about Y2K as being a great opportunity to build community resources, get together with your neighbors, etc. It makes sense.

Most important—yes, I certainly intend to enjoy the trip. We are about to experience something interesting, at the very least. We really do need a change. *Home Power,* all the great people who produce it, and you, are helping create a vision for that change. Blessings to you, and best wishes for 1999 and 2000.

My Dad was a "do-hickey" guy from a farm in Nebraska, always finding new ways to use things. Duct tape is "hippie chrome"? I always tried and wanted to be a hippie, living in Southern California, and only just in the last 20 years in Oregon have I discovered the joys of duct tape. It really works (holds together the broken manure fork handle and keeps splinters at bay on the wheelbarrow handles). Geri Orchard svasak@ccountry.net

Hey Geri, Happy Birthday. Congratulations on reaching some goals and being closer to others. Bob-O and I are gearing up for chickens again. I had some before but had a hard time keeping the varmints out of the henhouse. Once a mountain lion came down into our orchard at midday and snatched a hen right up and slunk back into the forest. As far as Y2K, I would think preparing for two months would be a minimum amount. If I'm wrong you can still eat the food. Kathleen Jarschke-Schultze

My Last Issue...HA!
To the Home Power Crew, *"HP69*—This Is Your Last Issue..." Ha—I think not! I subscribe to *Astronomy, Sky and Telescope, Solar Today, Arizona Highways,* and *Home Power,* and the last subscription I would ever let

expire or cancel is your fine publication. You might as well paint my PVs! You might as well feed my pig ham! You might as well put me back on *the grid!* (I wish I could find my last electric bill from when I lived in Phoenix four years ago, I would frame it).

Home Power is not only educational, informative, and enlightening, but is also a link to all who strive to live in harmony with the elements. It's not perfect, but just browsing through the back issues from the beginning, it is evident that there is no "status quo" mentality present. You have made remarkable improvements in a relatively short time and I think that deserves recognition. Bravo!

Last issue? It's not going to happen. I am constantly trying to update my system, minimize my maintenance, and improve my system's efficiency, and *Home Power* allows me to keep up with the latest technologies to do just that.

So to the crew of *Home Power* magazine I regret to inform you that you have made a mistake! *HP69* will not be my last issue. As far as I am concerned you are the *first* on my list and would be the *last* subscription I would ever relinquish. Rick Hamilton, Tonopah, Arizona

Aw shucks, Rick, thanks for the very kind words and for sticking with us! Richard Perez

Street Price vs List Price

You guys (and girls) are doing a great job. You are doing so many things right that I have difficulty finding anything to complain about, so I won't. I particularly appreciate your not breaking articles up with advertising. This has been one of my pet peeves for years and I was beginning to think that there was some formatting rule that the print industry was not talking about.

I also appreciate the advertisers that print pricing. I understand that there is a difference between list price and street price, and many advertisers are concerned about printing one over the other. List price is OK. Generally, I use these for quick mental price benefit ratios, and will follow up with the distributors when I get serious for actual pricing. Keep up the good work. I am learning a great deal from you and your contributors. Maybe someday I can return the favor. Ray Curtis, Hillsboro, Oregon

Living in TVA Country

Like Tom Phillips (whose letter you quoted in *HP68,* page 89), I too live in TVA (Tennessee Valley Authority) country and continue to be disappointed in TVA not seriously considering alternative energy and doing little to support energy conservation. I keep thinking about a project I would like to see and wonder if other *Home Power* readers might agree.

I live in Knoxville, Tennessee, and realize that most of us are not very savvy when it comes to batteries, amps, volts, watts, or whatever. What if someone were to build a home for the non-savvy people most of us are? For example, most of us want nothing more to do with our water heater other than turn the faucet, or to keep comfortable by simple turning the thermostat up or down. Suppose further that the choice locations were quite limited. For example, where I live, wind would hardly be a viable option, but forty-eight inches of rain a year could certainly be stored in cisterns and be more than adequate for all one's needs.

I think batteries are too much for us simpletons. PV panels on roofing shingles that would have to be replaced every twenty years could very well be considered a hassle too. For us nobodies, it must be all but trouble free and require no day-to-day maintenance. The cost would have to be within current bounds. In Joel Davidson's recent article the twenty thousand dollar cost to add to an existing house is far more than most in this area would be willing to spend, or could even afford. But if the cost in building were such that it was little more than current cost of houses, then those of us lacking savvy might well become interested. And I believe that is what must take place; namely, make it attractive to those who do not want to be bothered with any technology.

It seems to me that the capacity to join with the grid is the approach for the simple minded. If one could roof the south slope of a roof with PV shingles (you keep saying they are coming) and then tie it with the grid then there would be nothing to do but enjoy. Tie that with good energy saving construction and energy consumption and there it is. I have land in the city of Knoxville, but not the funds. I would love to see someone in Knoxville take on the public utility and TVA and win on the very necessary issue of clean energy. Just think of it, TVA is 27 billion in debt over nuclear energy! Imagine what that could have done for clean energy! I'd love to hear thoughts from anyone. Claude C. Crawford, Knoxville, Tennessee threeseas@netstarcomm.net

Ozonal Notes

Richard Perez

New Paper for *Home Power*

Karen and I wish to thank all of our readers who wrote in about our new paper. Everybody, including our printer at St. Croix Press, likes this high postconsumer content, non chlorine paper. We are going to stick with it!

Oregon Net Metering Bill

Well, after months of work, we have Oregon's net metering bill in the state legislature. This bill is has passed through the Legislative Committee and has a tentative number, H.B. 3219. Now the bill is undergoing utility lobbying and compromise prior to its sponsorship by the House Commerce Committee. I wish I had better news to relate on how this bill is faring.

It looks as if we may lose the section of the bill which gives our RE surplus to low income families. Instead, our surplus will probably be given to the utility for resale (for profit) to our neighbors. It seems that many of Oregon's utilities perceive donation of our surplus RE to low income families as legislating their rate base (pricing structure). So the bill will either have to lose the low income donation or be opposed by the utilities. Our lobbyists (yes, we actually have two) tell us that the bill stands zero chance of passing unless we drop the low-income donation requirement, so we are compromising.

I'm really between a rock and a hard place with this bill. On one hand, I am dedicated to getting this bill passed. On the other hand, I'm sickened by the compromises and the utilities' blatant use of of their power. While utilities don't vote, they do have a fleet of lawyers and a ton of money. They are doing in Oregon what they've done in most states—their best to keep our RE off of their grid and to hold on to their profits.

Stay tuned. This bill is in the depths of Oregon's political machine and anything can happen.

Guerrilla Solar

This issue begins our one page features of Guerrilla Solar electric systems. The two systems profiled in this issue on pages 32 and 38 are not only guerrilla solar, but also guerrilla wind. Both systems have been up and running for years now with no problems. Both of these solar guerrillas will be receiving their free Guerrilla Solar T-shirt and international, though anonymous, recognition. Any other solar guerrillas out there who would like to see their systems profiled in *Home Power* should send in a short description of the system and a few words on why they became a solar guerrilla. We will keep all access data strictly confidential.

The response to the Guerrilla Solar T-shirts has been overwhelming. Many readers have written in demanding to buy a shirt even though they are not active solar guerrillas. Many folks who are living on RE off-grid also want to wear the Guerrilla Solar T-shirts. One activist pointed out to me that we need thousands of folks wearing these shirts and going to PUC and utility meetings. All right, we relent. We'll make these shirts available to everyone, but they are still free to anyone who writes up their working Guerrilla Solar electric system for publication in *Home Power.*

We are discovering that there are many Guerrilla Solar electric systems spread across the USA. Many of these systems have been placing RE on the grid for years without authorization. Once again, technology has produced a new tool which society is incapable of controlling. In this case, society does not even need to control this tool.

I have received letters from "engineers" who say that the practice of guerrilla electricity is not safe and endangers utility workers. This is simply not true. The very same equipment is used in both authorized and guerrilla systems. If the authorized system is safe, then the guerrilla system is safe. There are no technical differences between an authorized utility intertied system and a guerrilla system. The difference is strictly utility authorization. With so many utilities blocking placement of RE on their grids, it's easy to see why folks go guerrilla.

Guerrilla Solar electric systems use exactly the same UL-listed hardware that authorized utility intertied systems use. Guerrilla systems are NEC compliant, and inspected by the local electrical inspector, just like utility authorized systems. Guerrilla systems use the same UL-listed safety gear (fuses, disconnects, etc.) as utility authorized systems. The only thing missing in a guerrilla system is the utility's authorization to put our renewable energy on their grid.

Guerrilla RE is a control issue. Utilities are loathe to give up their century-long monopoly on electric power. Utilities are doing everything in their power to keep our clean and renewable energy off of their grid. Utilities simply cannot profit from energy which is freely and democratically delivered everywhere on a daily basis.

Any on-grid RE system using a utility intertie inverter, such as the Trace SW series inverters, can instantly become a guerrilla system by activating the inverter's *sell* function. With just a push of a button, RE begins flowing onto the grid. This energy will spin the electric meter backwards—defacto net metering without the legal hassles.

As long as America's utilities are content with business as usual, they will have to deal with the solar guerrilla. Left to their own devices, the utilities will give us a replay of the last century—energy as a scarce commodity, made available from a single source and at the expense of our planet's health. If we don't put solar energy on the grid, then who will? Certainly not the utilities—they are content with another century of coal-burning, dammed rivers, and nuclear waste.

Guerrilla Solar is a wake up call to America's utilities. Power generation has been moved to the big nuke 93 million miles from Earth. Conversion of this solar energy will happen on rooftops nationwide. Utilities have already lost their exclusive right to make electricity—they will have to learn to be content with their new role as power brokers and transporters.

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Q&A

Inverters

As you may know, a number of RE catalogs carry a little nightlight made in Austin Texas called a Limelite. They consume a miniscule 0.03 watts and so are touted as a cheap light, as well as a way to monitor the sleep status of an inverter. The problem is that they seem to work fine on grid power, but when I switch my system over to inverter power, the Limelite units work OK for a while, then wink out after about ten minutes, after which they are permanently dead. There is no bad smell, power surge, or other obvious sign of a problem.

My fledgling system is based on a dozen Trojan T-105s at 12 Volts, and a Heart Freedom 2500 watt inverter. (Yes, I know I should have gotten a sine wave inverter, it was a money thing.) On the case of the inverter, it states that the unit produces power with a total harmonic distortion of 43 percent. (I find this interesting because in an earlier issue, you had a comparison of inverters, in which Heart did not specify their THD, which would have put them at the bottom of the list.) The question...am I right in assuming that this is an issue involving the shape of the AC waveform? If so, then other users of square wave inverters should be warned that these units will fry.

An unrelated issue...I have been seeing a lot of ads for, and articles about, the new AC panels that include their own synchronous inverters for hooking up to the grid. No one has mentioned the obvious question: Can these be used in stand-alone systems far from the battery shed to boost inverter power? What would happen under a low-load situation? I assume the inverter would have to be prevented from going into sleep mode, but is this a viable way to boost system power without having to upgrade the inverter? Will they interface with square wave inverters, or do they require a smooth sine wave? Can the AC output of one inverter be used to power the charger of another separate battery bank?

I am asking this last question because I am trying to conceptualize how a solar powered "village" power system would work most effectively. I think it would work to have a largish community-owned hybrid PV/wind facility to provide local "grid" power to a dozen or so homes within a thousand feet or so, each with their own modest "grid-intertied" generating capacity and battery bank. The cumulative initial cost would be large, but the ability of each residence to "island" would build in a dependability factor. If however, it would work for the separate homes to use the AC panels mentioned above, then the same generating capacity could be achieved and distributed much more economically through elimination of a lot of equipment, though dependence on the central facility would be greater. Do you have any thoughts on such village-scale issues?

Another issue....Grid connected homes, at least in our part of the country, always have a 240 V service connection. Yet large inverters (except for the export models at 50 Hz) almost always seem to be limited to 120 V operation, requiring that two be piggy-backed to attain high voltage output, and requiring *major* cash output. Am I missing something here? It seems like there's still no simple way to achieve the basic common goal, which is to replace our grid power with renewable energy.

Finally, while I know that you need to support the dealers and installers that advertise with you, I'd like to occasionally see a more detailed description of installation practices. Many times I read something like, "Then we hooked up our whatchit to the hoodum while isolating the dingus and that's all there is to it!" I want to know stuff like, What size and type of wire? What sort of connectors? Why were those particular ones chosen?...And why do we need to isolate the darn dingus anyway? Like I said, great magazine. No slam intended...I just want more! Thanks, Tom Maringer, Springdale, Arkansas

Hello, Tom. You are correct, the power quality on the mod sine inverter killed the Limelite. If you want an inverter status indicator, get a plug strip with an LED indicator. It serves the same function and they last forever.

The Micro Sine inverters will only operate in the presence of the "grid." While I haven't tried synchronizing them with a pure sine wave inverter such as the Exeltech and Statpowers, I don't see why this wouldn't be possible. How about it readers, has anyone tried this?

240 VAC can be had from any inverter by using a step-up transformer. However, Most RE homes choose not to use 240 VAC appliances.

I hear you on the techie details. We'd love to feature detailed installation articles in Home Power. *We have some projects in mind, but we also invite Wrenches out there to write articles on things like wire sizing, soldering, or just general installation tips. Richard Perez*

More Amps

Hi Richard, I have a small solar electric system with two 50 watt single crystal PV panels and one amorphous 50 watt panel. The panels are connected to a charge controller with twenty feet of #8 wire, which is then connected to an 880 amp-hour battery bank. I have a Heart Interface meter that has never shown more than 5.6 amps in full sunlight from my 150 watts of panels. I have verified all the connections, the functioning of the controller, and the wiring sequence, and am wondering if

I shouldn't be getting more amps. I live in San Francisco and it is winter, which might be the whole problem, but it is at least cool here, and I don't know if winter or smog might be so seriously affecting my power output. Thanks in advance, Anton • antonb@slip.net

Hello Anton. Something is wrong. Re-check all the connections to make sure that they are of proper polarity and are tight and bright. If you don't discover any problems (maybe you have one of the modules wired backwards), then the next step is to check short circuit current on each module. You will have to unwire the array to do this. Richard Perez

PV Output

I have a question concerning PV output. Our system is as follows: 6–MSX 77 panels (16.9 V, 4.56 A) wired in parallel, with a total of 12 feet of #10 AWG wire joined with a barrel splice to 29 feet of #4 AWG wire to the Trace C–30-A charge controller. From there, it's connected to two 8-D 12 Volt "Big Red" batteries. We also have a Bogart TriMetric 2000 monitor with a 500 amp shunt. This is wired and programed per instruction for our system. The "amps" function is *off,* a requirement for on/off charge controllers such as the C–30-A. I use #18 AWG/4 telephone wire with a run of 16' for the monitor.

The array is set to face the sun at 12 noon, daylight savings time, and can be adjusted for the seasons. I have tested each panel individually on a day with clear blue sky and a back of panel temperature of 24° C. They all check out well with over 90 percent of Voc (volts open circuit) and Isc (amps short circuit).

Our TriMetric is on the living room wall in plain sight. When I am home during the day, usually on the weekends, the TriMetric is on and in the +amps mode. Ever since the monitor has been installed (October '98), I have commonly seen amperages in a range from 19 to 23. One cloudy day I saw 25.9. These readings are with no load on the batteries. The batteries are usually charged before noon. My question is should I be seeing amperages more in a range of 24 to 27 amps on a regular basis? Any help will be greatly appreciated. I have excluded all the fuses and disconnects from my description of our system for brevity.

I have really enjoyed *Home Power* since *HP38.* I would like to thank Bill Brooks of NCSU Solar Center for my first look at *HP.* Thanks Bill, and thank you *Home Power.* Thomas Schmidt, Castalia, North Carolina

Hello Thomas, don't worry, everything sounds like it's working fine. We rarely see rated wattage or current from PVs in battery based systems. The PVs are usually hotter than their 25° C rating temperature and the battery is a nonlinear load. Your system sounds like it's doing just fine to me. Richard Perez

Staber

Our water system is FloJet with 60 psi cutoff. According to your test, the Staber will function on this. But when we turn water on, pressure is much lower while flowing. Do you think the Staber will function on this? We have gravity feed to the FloJet, and a lift of six feet with a 25 foot length of 3/8" tubing. Please advise. Les Wilderman

Hello, Les. The Staber will work down to 5 psi, so no worries, mate. We've run our Staber here for two years now with no problems on 8–10 psi of water pressure. Richard Perez

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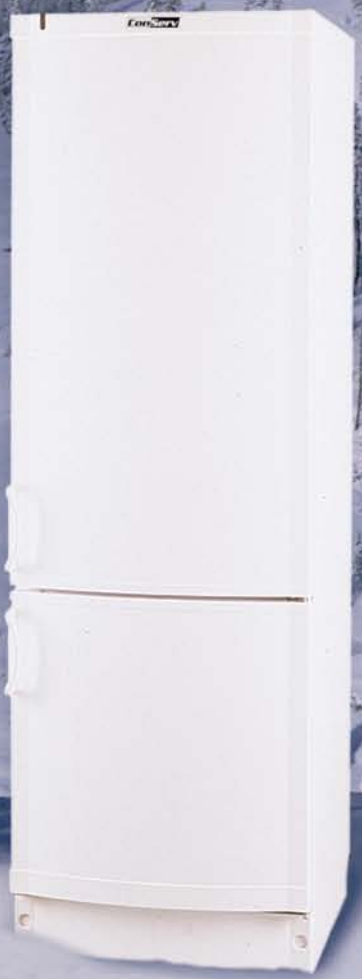

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NOW: I use renewable energy for (check ones that best describe your situation)

❑ All electricity
❑ Most electricity
❑ Some electricity
❑ Backup electricity
❑ Recreational electricity (RVs, boats, camping,)
❑ Vacation or second home electricity
❑ Transportation power (electric vehicles)
❑ Water heating
❑ Space heating
❑ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

❑ All electricity
❑ Most electricity
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❑ Backup electricity
❑ Recreational electricity (RVs, boats, camping,)
❑ Vacation or second home electricity
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❑ Water heating
❑ Space heating
❑ Business electricity

RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

❑ Solar power
❑ Wind power
❑ Hydro power
❑ Biomass
❑ Geothermal power
❑ Tidal power
❑ Other renewable energy resource (explain)

The GRID: (check all that apply)

❑ I have the utility grid at my location.

I pay _____¢ for grid electricity (cents per kiloWatt-hour).

____% of my total electricity is purchased from the grid.

❑ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per KiloWatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply).

NOW	FUTURE		NOW	FUTURE	
❑	❑	Photovoltaic modules	❑	❑	Methane digester
❑	❑	Wind generator	❑	❑	Thermoelectric generator
❑	❑	Hydroelectric generator	❑	❑	Solar oven or cooker
❑	❑	Battery charger	❑	❑	Solar water heater
❑	❑	Instrumentation	❑	❑	Wood-fired water heater
❑	❑	Batteries	❑	❑	Solar space heating system
❑	❑	Inverter	❑	❑	Hydrogen cells (electrolyzers)
❑	❑	Controls	❑	❑	Fuel cells
❑	❑	PV tracker	❑	❑	RE-powered water pump
❑	❑	Engine/generator	❑	❑	Electric vehicle

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