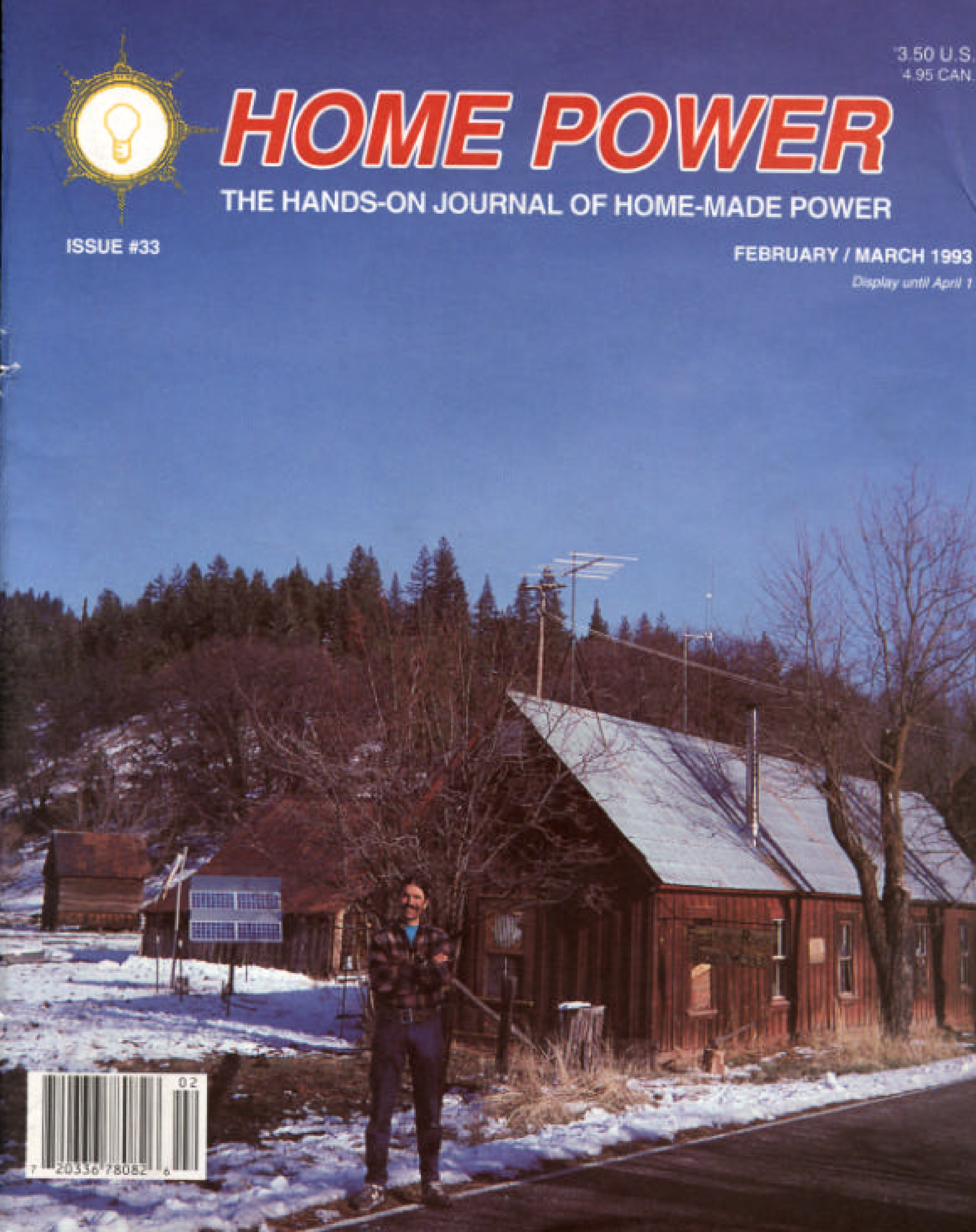

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #33

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Contents

Access

Home Power Magazine
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Ashland, OR 97520
916–475–3179 Voice & FAX
707-822-8649 Computer BB

Think About It

"Man masters nature not by force but by understanding."
Jacob Bronowski

Cover

Old hippies don't die, they just put up PV panels and run solar-powered businesses. See story on page 6.

Photo by Don Clark.

Blessings

Winter, here on Agate Flat, is a magical time. Still, white mornings make you glad to be alive — a time to count blessings. Two more blessings came our way a few months ago.

Add two to the crew

Two of Richard's recent STI students have joined the crew. I admit, I was skeptical at first. You have to be hardy and committed to work in such an isolated place, not to mention such close quarters. We were blessed; they have turned out be as demented as the rest of us. So welcome and thanks, Mark and Amanda.

Counting blessings

We have a lot of blessings to count. We can live and work in a place with wonderful views and music supplied by birds. Home Power is doing well. We found water in our well. We've been having a real winter, with lots of snow. We got more help! Richard and I spent three whole weeks away from the office, without worrying! Blessings to the overworked and underpaid "crew" who stayed behind and took care of business. You are all greatly appreciated.

I'm starting out 1993 happy…

Karen

Above: Amanda Potter and Mark Newell. Photo by Chris Greacen.

People

Bill Battagin
David Booth
George Chase
Joel Chinkes
Don Clark
Sam Coleman
Paul Craig
William A. Gerosa
Chris Greacen
Michael Hackleman
Chuck Heath
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Amanda Potter
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Walt Pyle
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Michael Welch
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PV Dreams

Bill Battagin

I still remember. We were headed to the Sierras to camp; I was 9 years old, gazing up through the rear window of my family's Pontiac station wagon at the clouds. Big white, puffy, cottonball clouds. I dreamed of flying around, through, and under those beautiful, soft, and inviting masses of water vapor and ice crystals. A child's dream turned into reality when I began hang gliding. It took me another 7 years of flying, but I made it up to those puffy cumulus clouds where I physically and spiritually played like never before.

I fulfilled another major dream in my life when, in 1982, I bought a photovoltaic (PV) panel and powered a few small loads in my grid powered house. The bug bit and it bit good. I saw the beauty of what that one panel did for this planet, our biosphere, and my spirit more and more. I bought a couple more panels, a small inverter, and more batteries. Then I made the leap in 1988 and bought eight ARCO M55 PV panels. I disconnected all the loads in my house from the grid, and made the switch to a stand-alone PV system. I was again in those spiritual clouds, playing like I've never played before.

Work can be fun, too

I have yet to see any signposts along my path that say, “Stop Dreaming” or worse yet, “Go Right.” Last year I installed a starter system at my grid-powered business. Though I knew this 4 panel, 600 watt inverter system would never cover all my needs, the seeds would be planted. A good chunk of what I do to keep myself off the streets is build catalytic woodstoves. People had been telling me for years that I couldn't weld with a solar electric system, not for less than a million dollars, anyway. (Of course, people can't fly either).

SEER–ing Experiences

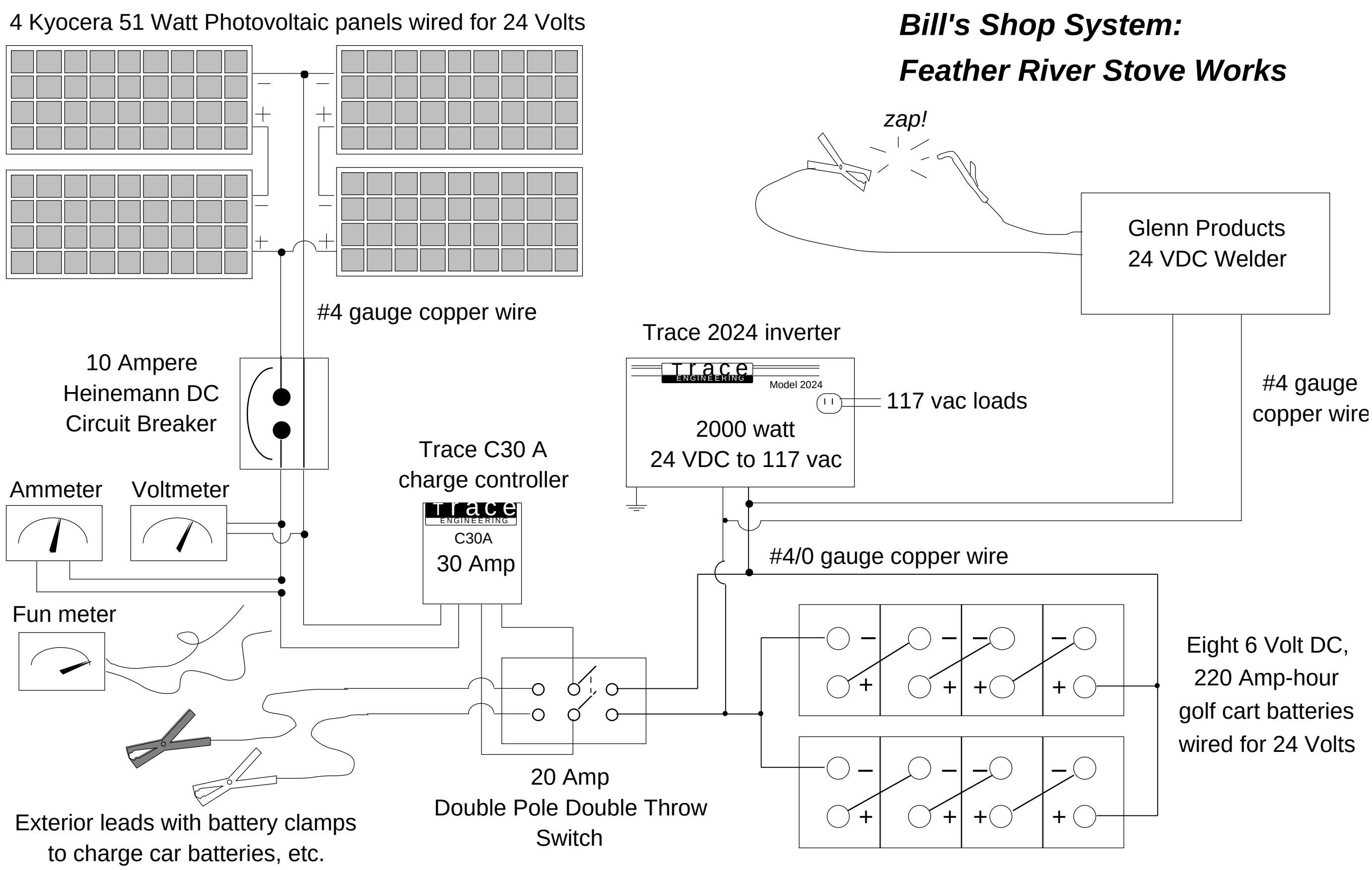
Unable to accept being “grounded” by this limitation, I searched for a workable welding system. I bumped into Bruce Colley of Glenn Products at SEER ‘91 (the Solar Energy Exposition & Rally in Willits, California). He invited me to “run a bead” with his battery-powered wire feeder. Welding with this system — which could easily be powered by the sun — was electrifying! Within a year, Bruce sent me one of his MIG units, adapted somewhat for a “production-type” welding environment instead of the portable, short-job type welding for which the unit had been conceived. I should mention that this welder, being a modified unit, is not yet in production at Glenn Products. Bruce is very concerned about completing all aspects of the R&D on this version of his original machine before it becomes available to the public.

At the time, my system at the shop consisted of four Kyocera 51 Watt photovoltaic panels, and a Heart 600 watt inverter to invert the DC electricity to ac. For storage, I selected the best eight batteries out of the deep cycle pack in my electric van. My guess is that these batteries still have about half to a third of their “chung” left to them — “chung,” you know, umph!! There are 880 Amp-hours at 12 Volts storage.

This new welder needed 24 Volts DC to operate, so some reconfiguration was necessary. I swapped some wires around in the battery box to satisfy the welder's needs — no biggie. I shelled out about a hundred bucks for a controller, but I did not want to spend another wad on a 24 Volt inverter for my 117 volt ac loads. Fortunately, while attending SEER ‘92, I found Dave Katz of Alternative Energy Engineering fame. He was drooling on all the new inverters at the Fair, wanting one but owning a perfectly good 8 year old, 2000 watt Trace 2024 inverter. I should talk, I was in his booth drooling on a used Trace 724. When all the drooling was over, I got Dave's 2024, and Dave had the down payment for his new electric dream box.

Today's System

So, with the same storage, and PVs still at about 200 Watts peak power, I connected the 2024, and Bruce's welder to the batteries. I couldn't help it — I didn't really expect it to happen again — but there was that floaty feeling. It's like eating a real homegrown tomato instead of one of them red things from the store...*flavor*!!! I can see a little “sun” at the tip of the MIG gun melting, filling, and joining steel. It's so direct, simple, and clean compared to the huge infrastructure necessary to make electricity for the grid.



Ac Wiring

My woodstove shop had been powered by the utility grid only, so to wire for ac from the inverter, I just installed "solar" ac outlets next to the grid outlets. This system offers two distinct advantages: If I'm low on power, I don't need to spend more money on a standby/charger option, just move the plug over to the grid outlet. Secondly, I can individually choose which tools I want to power with the inverter, instead of dedicating a whole circuit to one or the other power source. It was easy for me to do this additional ac wiring.

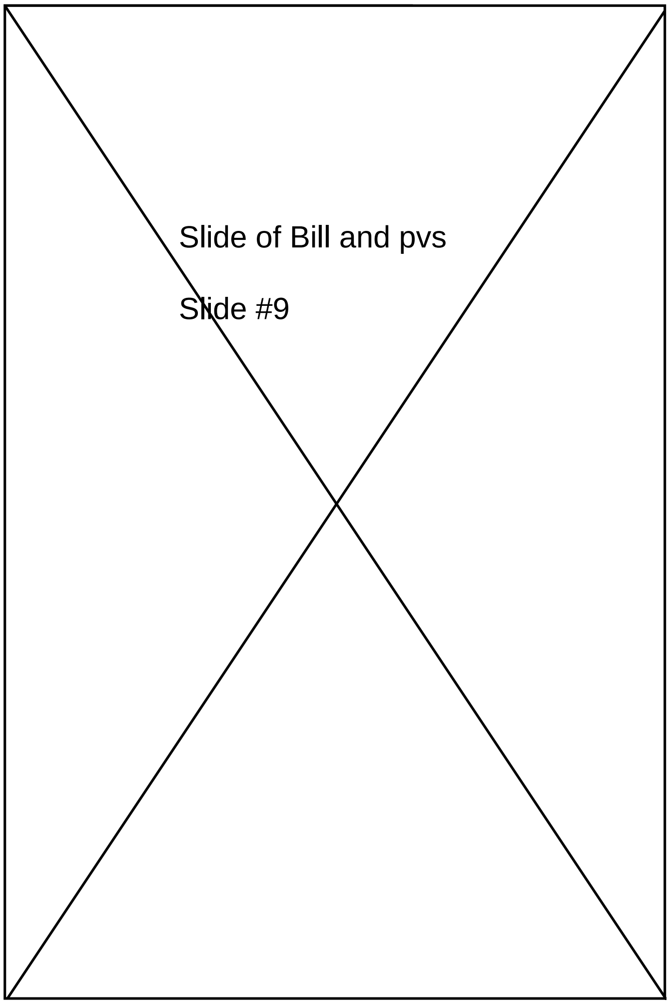
I did pretty much the same thing with the lights. I have two sets: one grid-powered, one solar-powered. The lights that are solar powered are Phillips SL18/R40 compact fluorescents with reflectors which are very efficient in a shop type environment. The utility grid will be in the back-up role in another year or two when I can afford to size my system to supply most of my shop needs.

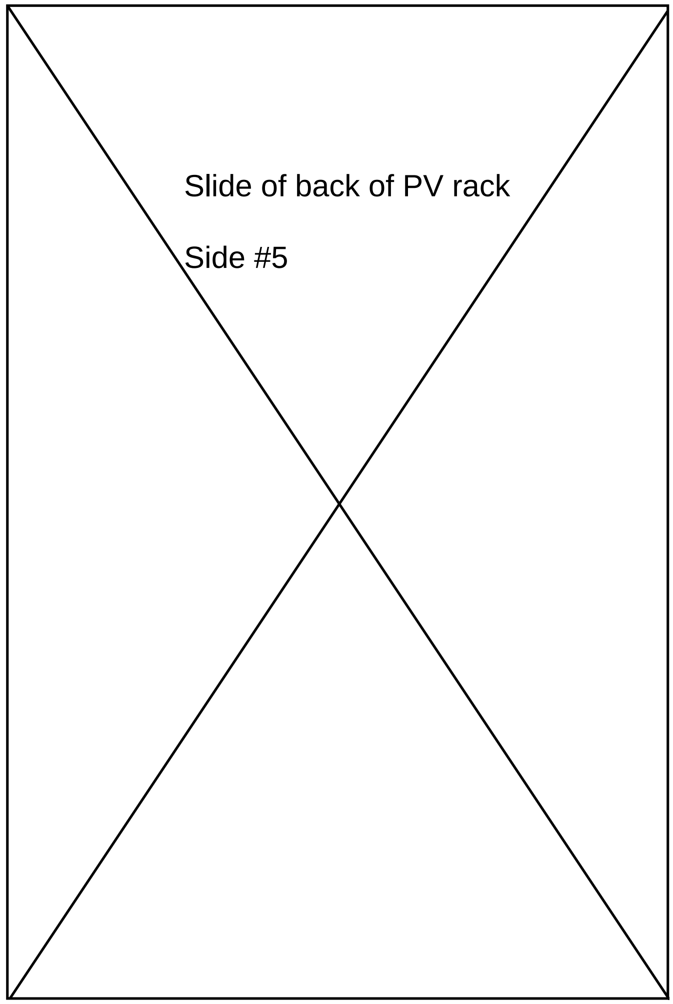
Here's a list of the larger tools and machines the Trace 2024 inverter can run:

Milwaukee 2.25 hp, 13 amp anglehead grinder, #6082
Milwaukee 15 amp, 14" cutoff saw, #6170
Delta 3/4 hp, 12 speed, drill press, #17-900
Craftsman 1 hp 6.8 amp, 8" bench grinder, #257.191601
Craftsman 1 hp, 15 amp compressor, #919.154010
Milwaukee 8 amp Shop vac, #8935
Milwaukee 3 hp, 15 amp anglehead grinder, #6098

Any one of these appliances can be run with the "base load" for a period of time which would run my endurance out before the inverter. The base load of lights, stereo, and exhaust fans is about 500 watts. The only load that sometimes overloads the Trace is the compressor during start-up. The 3 hp Milwaukee anglehead grinder has "controlled start" which the 2024 has a tough time starting, though it runs fine. Fortunately (for the inverter), a person can only operate one major tool at a time, so a one-person shop can be run by a moderately sized inverter. I'm not sure what's to blame, but I have fried an induction type motor in a window fan. Also, the starter in the larger Milwaukee anglehead grinder is acting weirder all the time. These could be attributed to age — I wonder about the inverter, though.

If it's sunny, I can work two "average" days before the battery voltage gets to a point (about 24.0 V) that I feel

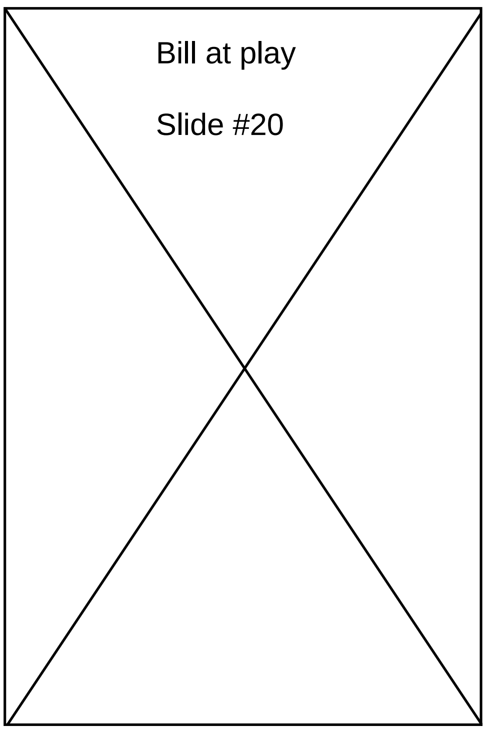


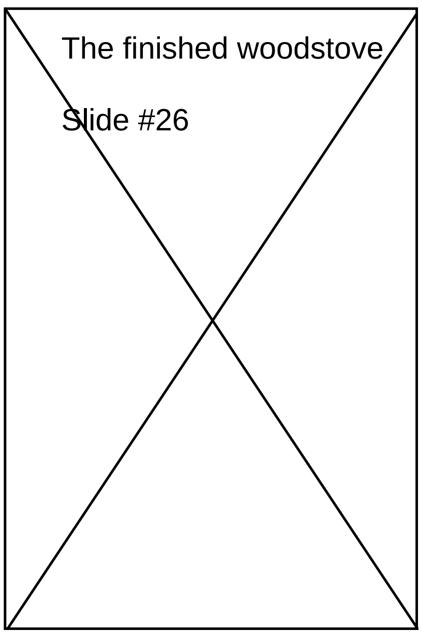


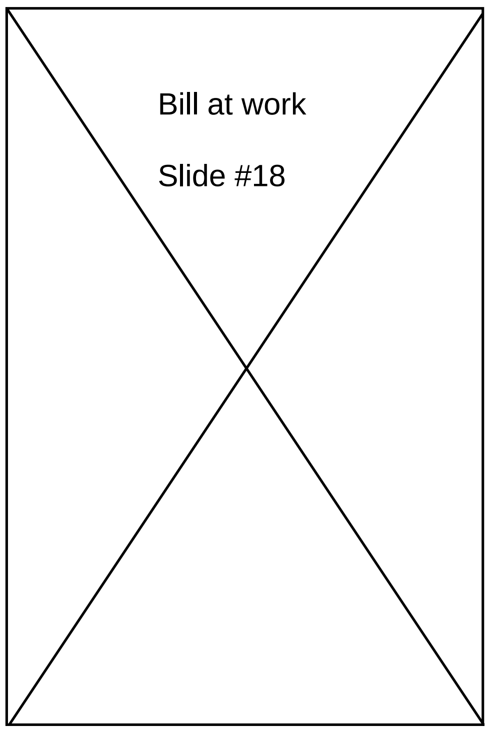
Above: Bill relaxes by his PVs in beautiful Genesee Valley.

Above: Tracking the sun by hand — details of the homemade PV rack.

Below left: Bill uses his grinder on all sorts of things!
Below center: The finished product.
Below right: Bill hard at work.
Photos by Don Clark







the need to use more grid power. If I'm using the welder or the compressor a lot, it might be one day on solar power. Fortunately (for the stovebuilder), I usually put in three days or less at a time in the shop. I enjoy working in the shop because I don't *just* work in the shop. Non-shop days are in-the-field installation days.

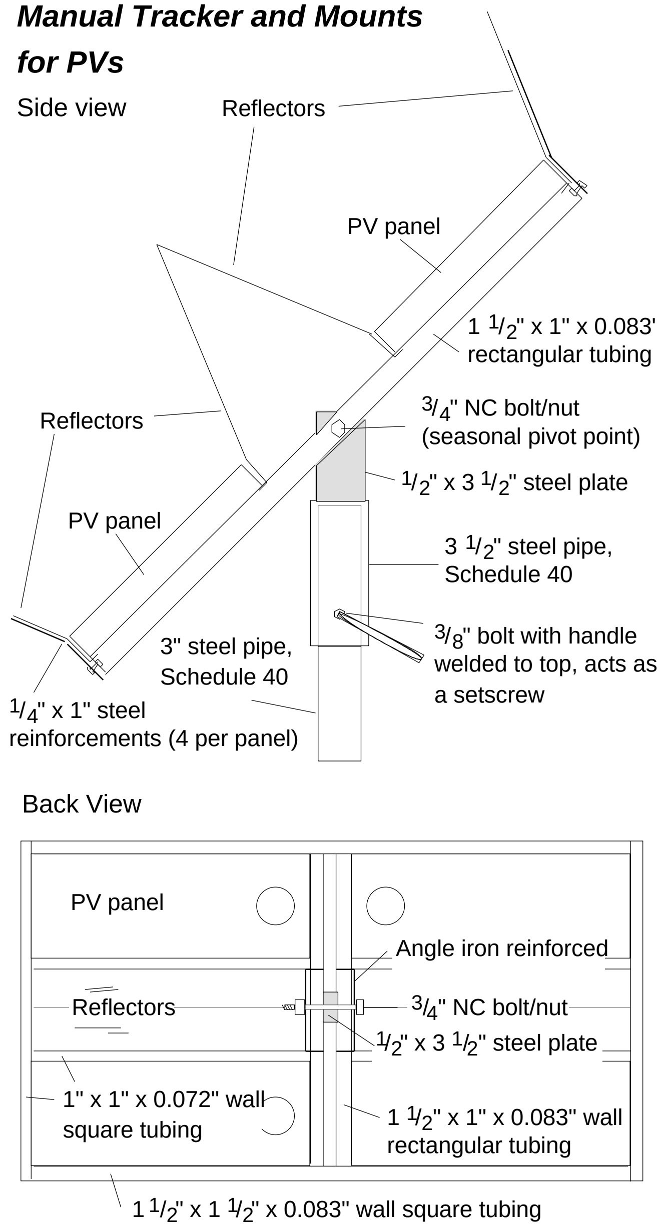
As much as possible, I drive my electric van to jobs within its range. The van is an Eltravan 600, made in Austin Texas by Jet Industries in the early 1980s. I've had the van for about 4 years. The battery pack consists of seventeen 6 Volt, 220 Amp-hour golf cart batteries (102 Volt system). Power is managed through a Curtis PMC controller and sent to a 20 hp series-wound General Electric motor. The motor then powers a conventional 4 speed gearbox/transaxle to the rear wheels. I can see now we've got a future article brewin'!

Tracking by hand!
Other noteworthy items are the home-built manual tracker and reflectors. The frame to which the panels are bolted is bolted to a pivot which is welded to a 3 1/2 inch diameter piece of steel pipe (see diagram). All steel parts are coated with cold galvanizing spray. Seasonal tilt is achieved by loosening the 3/4 inch nut and pivoting the rack of PVs at that axis. I change the tilt of the panels four times a year to follow the seasonal angle of the sun.

The 3 1/2 inch pipe fits over a 3 inch diameter length of pipe stuck in a concrete-filled hole in the ground. The ends of both pipes have steel caps and are lubricated with grease. In a simple way, this arrangement makes the array easily manually trackable. I take a break from work every one and a half to two and a half hours and spend about ten seconds turning the array. I only turn the PV frame on the pipe. The tilt stays the same, so it is perpendicular to the sun's rays only at noon. Though less than perfect, I got a lot of extra PV output for about $15 of materials.

Reflectors
Reflectors are used to increase the amount of them squirrelly little photons being directed at the panels. I'm not sure reflecting is the greatest thing since firm tofu, but I wanted to give it a shot. These reflectors are made out of 22 gauge galvanized sheet metal, cost me $45, and increased my output by 1.0 Amp at 24 Volts. To gain an amp at 24 Volts using more PVs would have cost about $210. Time will tell the effects of the higher cell temps and ultraviolet exposure on panel life. I know that galvanized steel is a very crude reflector material, but it is low tech, easily found and fabricated, and economically far cheaper than more PVs.

Manual Tracker and Mounts for PVs



I chose to use reflectors for a few reasons. Ambient air temperatures at my 3700 foot elevation here in the Northern Sierras are far lower than those found on the Carrizo Desert. Also, my reflectors do not raise panel temperatures as much as commercially available ones would. Another factor is that the times when it *is* hot around these parts, my power needs are the lowest; my tracking system allows a very easy way to turn the array out of direct sun. And dang it, I just wanted to try it!!

What *Are* We Doing Here?
There is one more thing noteworthy about the system: Economics. I did not install this system (or the one at the house) because the economics were practical or because

Cost of the power system for Bill's shop

Equipment	cost	%
4 Kyocera 51 Watt PV panels	$1,200	50.7%
Trace 2024 inverter (used)	$550	23.3%
8 220 A-hr 6 V deep cycle battery cells*	$160	6.8%
Romex, outlets, fixtures, junction boxes	$150	6.3%
wire, meters, battery box etc	$130	5.5%
Trace C-30A charge controller	$95	4.0%
PV panel support & reflectors	$80	3.4%
*Represents used battery prices	$2,365	

it was cheaper than doing something else. My motivation for using photovoltaics in my life is to walk lighter on my path and to take less along the way. I could afford them, so I did afford them. For a look at the financial part of this picture, see chart above. Onward!

Back to work

I'm an addict. I simply cannot get enough PVs to satisfy my habit — dreaming. If I could afford it, I'd give samples to all the kids in school to get them hooked too. So I must go back to work to make more money to buy more panels. My guess at this point is that another 4 panels and increasing my battery storage by about 50% would get me close to 100% solar at the shop. Though I pulled the eight best batteries from the van, they are still four and a half years old and were not treated kindly. The increase in storage capacity would be achieved with 12 new batteries (660 Amp-hrs at 24 Volts). When the shop system is finished, then there's the store where I *sell* my stoves....

What an incredible blessing, loving the work I do. The stoves are keeping folks warm while cooking their food and heating the domestic water. The grid meter spins less and less; the fun meter spins more and more. Living in Genesee Valley. Kinda like a dream. Thank-you!

Access

Author: Bill Battagin, Feather River Stove Works, 5575 Genesee Rd., Taylorsville, CA 95983 • 916-284-7849 (Comments, questions, and feedback welcome)

24 Volts DC Welder: Bruce Colley, c/o Glenn Products, 47 Lafayette Cir., Unit 306, Lafayette, CA 94549 • 510-686-1788

Hydro Power
High in the Canadian Rockies

Paul Craig & Robert Mathews

The Canadian Rockies offer some of the world's most spectacular outdoor experiences: deep powder skiing, alpine hiking, and incredible glacier views. The Purcell Lodge is deep in these Canadian Rockies, near the town of Golden, British Columbia, four miles beyond the nearest (logging) road. Every piece of equipment, all supplies, and the guests are brought in by helicopter. Out here light, heat, and appliances made possible by the lodge's 12 kilowatt hydroelectric system are well appreciated.

A Canadian Classic Hydro System

The electricity generation system uses what has become, in Canada, a "classic" hydro setup with a high head, small pipe, and Pelton wheel turbine. Turbine speed regulation is accomplished by electrically loading the generator to maintain frequency. The location was selected to provide year-round water. Fortunately an insulating cover layer of snow always arrives before ground-freezing weather. Even though the snow season can last six months, there have been no problems with frozen pipes.

The intake weir (head pond, see photo) is a concrete wall in a largely bedrock location that provides a small impoundment basin. The pond stills the flow, allowing heavy debris to settle and light debris to float. The intake pipe is submerged at half-depth and screened. The pond also contains a submersible pump for domestic water.

The penstock is 1440 feet of 4 inch diameter solvent-welded PVC pipe, with pressure rating increasing from 63 pounds per square inch (psi) at the intake to 160 psi at the turbine. Total head is 315 feet and maximum flow is 220 U.S. gallons per minute. The penstock is buried 18 inches, and anchored with concrete and bolts at critical points.

The 8 inch diameter Pelton turbine was built by IPD of Montana. When spinning at 1800 rpm, the wheel moves at 46% of the jet speed at the point of contact. (At 41% to 47% of jet speed, Pelton wheels are most efficient.) The main nozzle is manually adjustable through a spear-type valve. Maximum nozzle diameter is 13/16 inch.

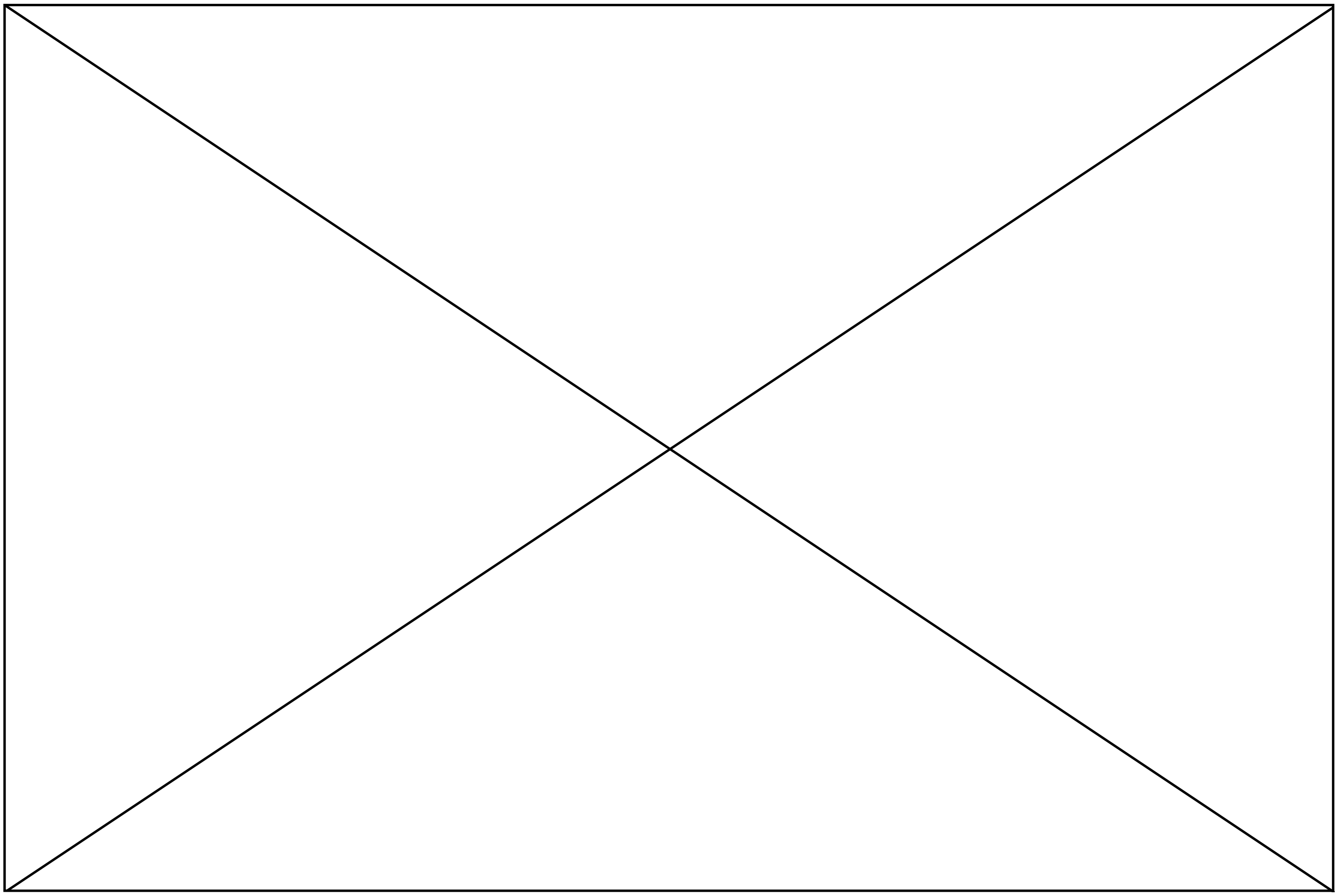
The generator is a Fidelity brushless design rated at 12 kilowatts at 1800 rpm. Maximum power output was initially limited by the available flow to 7 kilowatts. During the fall of 1992, the water supply system was modified to provide the full 12 kilowatt output. Friction loss in the penstock is about 8% at 7 kilowatts, and the turbine-generator converts the water energy reaching it with 56% efficiency. Output is 120/240 volt, 60 hertz single phase ac electricity. The generator is direct-driven from the Pelton wheel. A flywheel maintains speed under high starting loads from induction motors, and provides general stabilization.

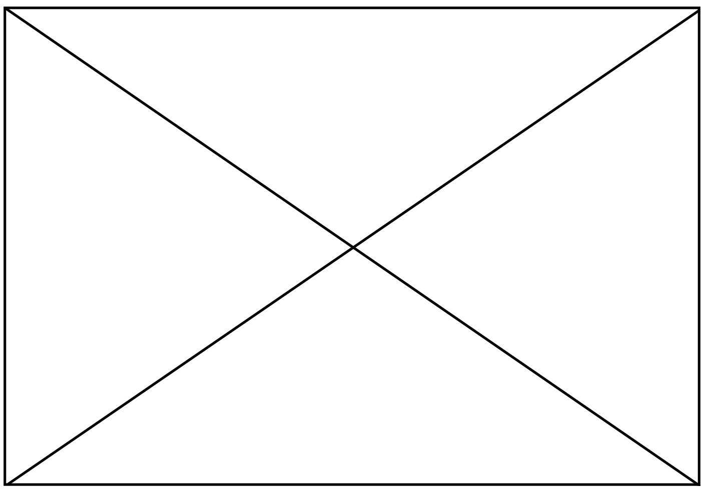
To decrease energy loss and save wire costs, the voltage is transformed up to 600 volts for the 1750 foot run from the power house to the lodge. At the lodge, a second transformer provides 120/240 volt output. Two #6 AWG (American Wire Gauge) RWU copper conductors are mechanically protected by a 1 inch poly pipe and placed under the 4 inch PVC penstock to provide further mechanical protection. Transmission power loss is 2.5% at 7 kilowatt output.

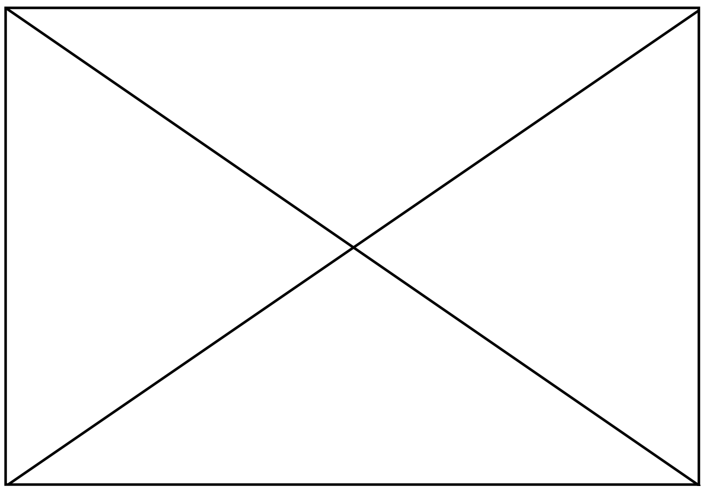
Control by Prioritized Loads

Primary load control in the Purcell system is perhaps the most interesting part of the system. The Lodge uses an Electronic Load Control Governor (ELCG) manufactured by Thomson and Howe Energy Systems. It's easiest to understand this regulator by contrasting it to more traditional control approaches. Solar systems are usually limited by energy. Design focuses on minimizing load, and on turning off loads when not needed. Hydro plants are traditionally controlled by regulating water flow as load varies. Not so in the Purcell environment. Here as in many modern microhydro situations, the water runs whether used for electricity generation or not. Since water is not trapped in a dam, the ecology of the stream is less impacted by this type of hydro system. But, if electricity is not generated, the energy in the falling water is lost.

This makes possible a very different type of regulation, based on using all available water, while switching on and off priority loads to maintain a constant overall load. The more the electrical loading, the slower the turbine and generator run. Since the generator frequency is directly proportional to rotational speed, control of frequency



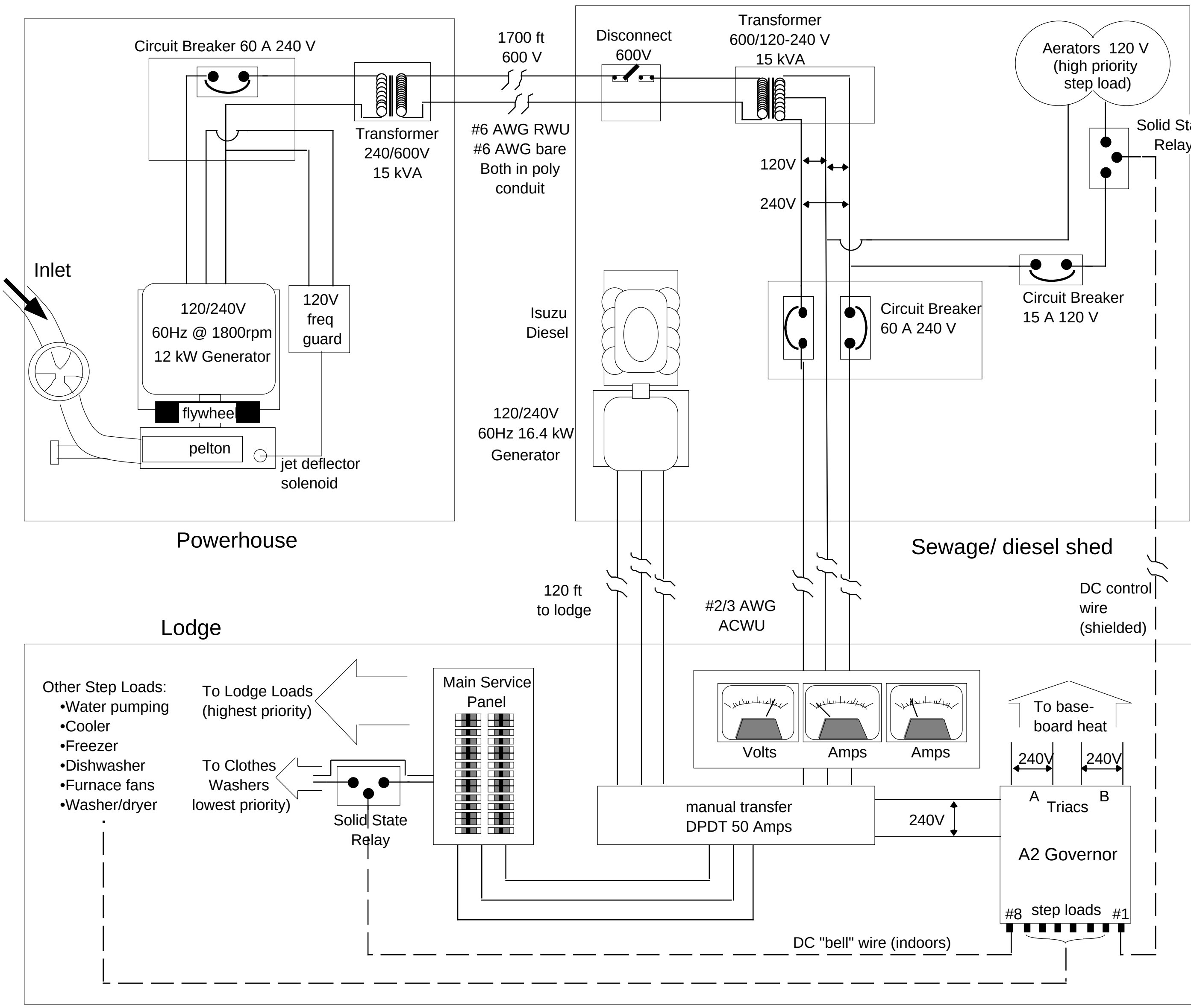




Above: The Purcell Lodge in winter wifth Copperstain Mountain in the background. Winter snowfall here is about 55 feet. Without site-produced electricity, modern living in such a remote location would be impossible. Photo by Paul Lesson

Below Left: The eight inch hydroelectric pelton turbine (painted silver), flywheel (painted red) and 12 kilowatt generator (painted yellow). The Fidelity brushless generator produces 60 Hz, 120/240 volt single phase alternating current, and is regulated by a Thompson & Howe controller. Photo by Bob Mathews

Below Right: Intake weir and top of 1440 foot long penstock which feeds water into the turbine. Total head is 315 feet and maximum flow is 220 U.S. gallons per minute. Photo by Bob Mathews



automatically provides speed regulation. A rise in frequency means that more load is needed to slow down the generator. A drop in frequency means load must be shed.

The lodge load is broken down into a number of circuits. The highest priority circuits, especially those that are safety related and those (such as lights) needed to maintain guest satisfaction, are wired directly to the generator service panel and are not under governor control at all. Lower priority services are connected to the ELCG. Eight circuits are currently in use. These are ranked by priority, with sewage aeration and water pumping followed by refrigerators, freezers, furnace fans, and the dish and clothes washers.

Coarse & Fine Control

Coarse regulation is provided by load shedding. For example, if the water system — a high priority function — turns on, a refrigerator or freezer might be temporarily shut off. Coarse control necessarily leads to large and fast changes in system loading. Without additional control this would lead to unacceptably large frequency (and hence turbine speed) swings. Here's where the ELCG proves its merit. Load swings are virtually eliminated by continuous, rapid control of resistive loads such as baseboard heaters and hot water tank heating elements.

For this fine control, the ELCG uses triac regulators to smoothly change the power delivered to resistive loads, increasing as other load drops, and decreasing as other

load picks up. If the ELCG senses the frequency is rising, it knows that a load is being shed (perhaps someone turned off a light), and increases power to the resistive load. If frequency drops, the ELCG smoothly sheds resistive load. In operation the system is almost unnoticeable. The only indication is occasional slight dimming of lights when a large motor starts up. (But of course this occurs with utility power too).

If the load increase is too great to handle with the resistive load alone, the ELCG throws a relay to drop the lowest priority load connected. As load decreases again, the highest priority non-connected load is reconnected. There is a special circuit to keep track of and slowly correct for short-term excursions from 60 Hz due to extreme conditions, so that clocks will keep proper time. Maximum frequency correction is kept to 0.1 Hz.

The wave form from the generator is excellent for all purposes. However, the switching triacs introduce considerable waveform distortion in the power going to their loads. Resistive balancing loads, such as hot water heaters and baseboard heaters, are used which are indifferent to waveform. It is important to assure that the system always has enough load available to maintain frequency. To accomplish this, priority loads and the resistive regulating loads must be connected at all times.

Any regulation system based on the concept of loading is vulnerable to open circuits, which would lead to system runaway. Failsafe emergency protection is required. This is located adjacent to the generator. A mechanically interconnected water jet deflector safety system is actuated by a weighted lever. The turbine is shut down by a frequency guard sensor if frequency deviations become too wide (typically outside the range 53–67 Hz) for too long. The weighted control lever is held up by a normally energized solenoid which releases on power failure.

Heat, Biodegradable Soap, and Solar Radios

Although the building is heavily insulated, auxiliary heat is needed in winter. Since the available water flow doesn't provide enough energy to heat the building under extreme conditions, propane is used for backup. Because the lodge is above timberline, firewood must be helicoptered in. Sewage is handled with a small biotreater plant. Treated waste goes to a carefully monitored leach field. To minimize loads on the facility, biodegradable products are used exclusively. Guests are asked to use the biodegradable soap and shampoo provided, rather than any they may have brought.

At Purcell Lodge reliable communications can mean the difference between life and death. A radio repeater on a nearby mountain provides complete coverage between the lodge and the skiing and hiking parties, and the base at the airport in Golden, BC. The repeater is powered by a deep cycle battery and a solar charger.

The Purcell Lodge system has operated without major problems since startup. The system provides pollution free, clean and reliable power in a location where commercial power is not an option. To the visitor, the years of careful planning and the extensive use of high technology are virtually invisible. Without them the rare combination of comfort and wilderness provided at Purcell Lodge would have been impossible.

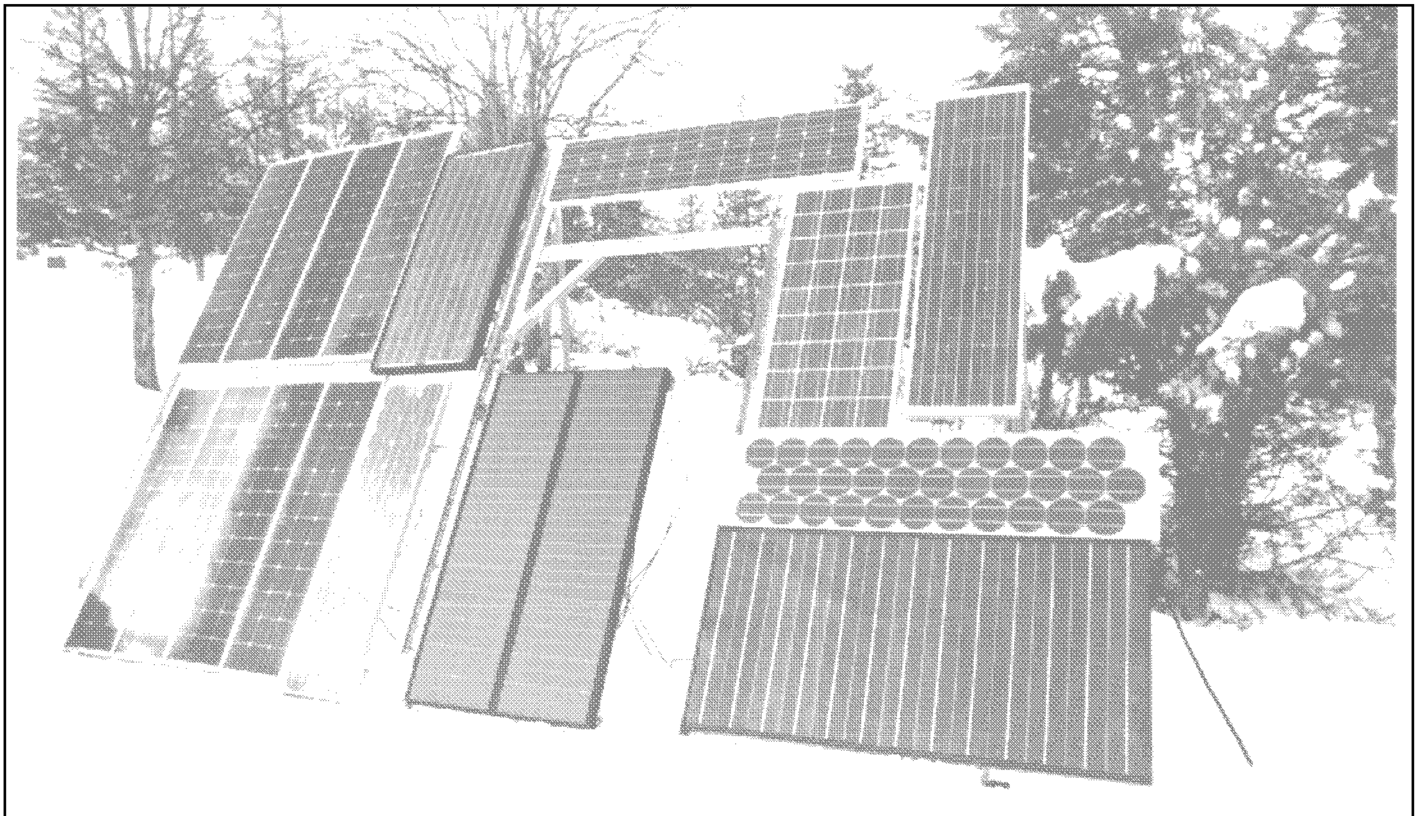
Access

Authors: Paul P. Craig, College of Engineering, University of California, Davis 95616 • 916-752-1782 and Robert Mathews, Appropriate Energy Systems, Box 1270, Chase, BC V0E 1M0, Canada • 604-679-8350

Purcell Lodge: Russ Younger and Paul Leeson, ABC Wilderness Adventures Ltd., PO Box 1829, Golden, BC, Canada • 604-344-2639 • FAX 604-344-6118

Hydro controllers: Thomson and Howe Energy Systems Site 17, Box 2, SSI, BC, V1A 2Y5, Canada • 604-427-4326

Brushless generators: Fidelity Electric Co, Inc. 328 N Arch St, Lancaster PA 17604



Above: Home Power's "Democracy Rack" where just about every available PV module gets tested in real world conditions.
Photo by Mark Newell.

PV Performance Tests

the Home Power Crew

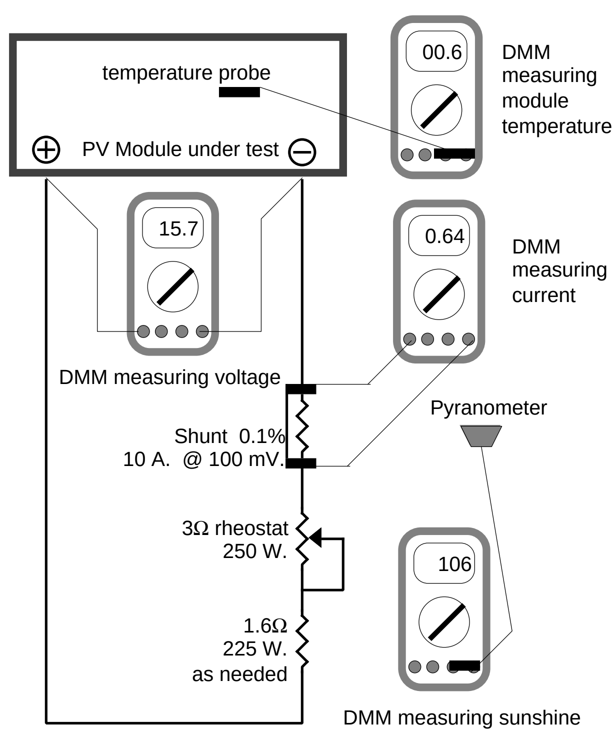
Ever wonder exactly how much power a cold PV module makes? We have. We placed just about every make module widely available on our "Democracy Rack", out in the sun. Then we measured their electrical output, temperature, and solar insolation. Here is what we found.

The Test Jig & Procedure

See Home Power #23, page 20 for a complete rundown of our PV module test jig and procedure. Here's what we do in a nutshell. The diagram to the right shows our basic PB module test jig.

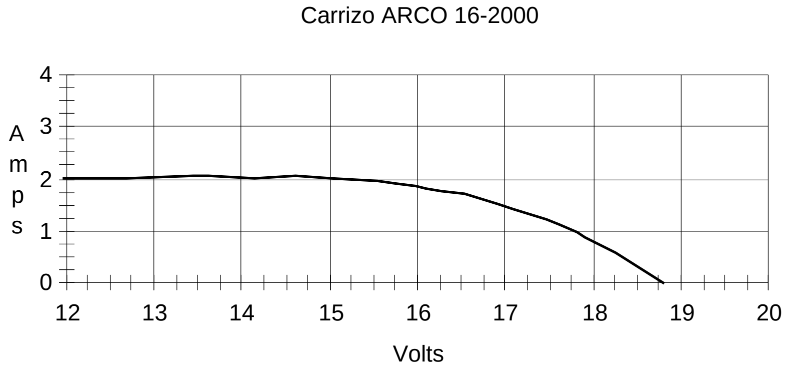
This test jig allows us to take actual data from each module. With four Fluke 87 DMMs we measure the following data: module voltage, module current, module temperature, air

Home Power's PV Test Jig



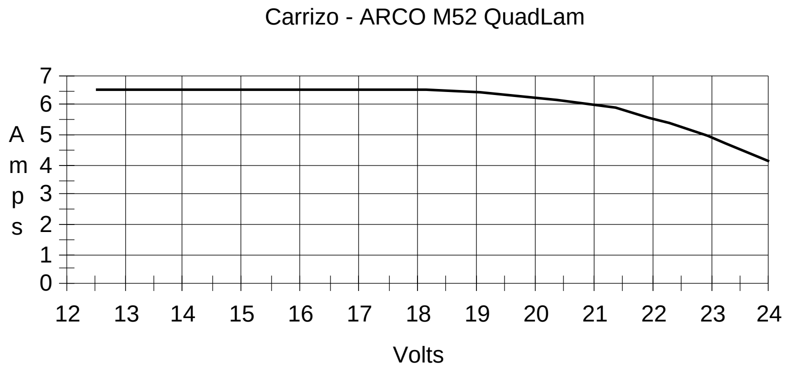
Carrizo ARCO 16-2000

	Rated Value	Measured Value	Percent of Rated	
Isc	2.55	2.07	81.2%	Amperes
Voc	20.50	18.79	91.7%	Volts
Pmax	35.00	30.64	87.5%	Watts
Vpmax	15.50	15.02	96.9%	Volts
Ipmax	2.26	2.04	90.3%	Amperes
PV Temp	25	18	71.6%	°C.
Insolation	100	107	107.0%	mW/sq. cm.



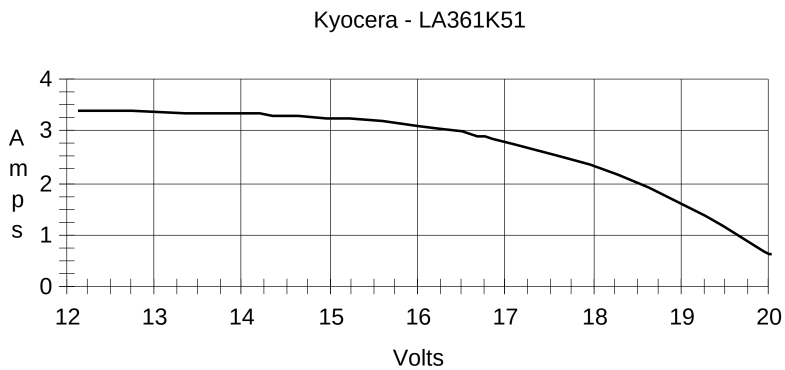
Carrizo - ARCO M52 QuadLam

	Rated Value	Measured Value	Percent of Rated	
Isc	6.00	6.59	109.8%	Amperes
Voc	25.00	27.07	108.3%	Volts
Pmax	105.00	126.82	120.8%	Watts
Vpmax	19.00	21.35	112.4%	Volts
Ipmax	5.50	5.94	108.0%	Amperes
PV Temp	25	23	91.2%	°C.
Insolation	100	106	106.0%	mW/sq. cm.



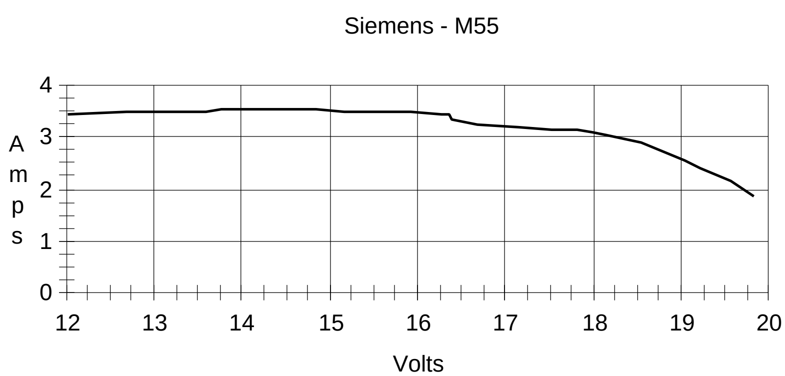
Kyocera - LA361K51

	Rated Value	Measured Value	Percent of Rated	
Isc	3.25	3.42	105.2%	Amperes
Voc	21.20	21.56	101.7%	Volts
Pmax	51.00	50.05	98.1%	Watts
Vpmax	16.90	15.99	94.6%	Volts
Ipmax	3.02	3.13	103.6%	Amperes
PV Temp	25	22	87.6%	°C.
Insolation	100	113	113.0%	mW/sq. cm.



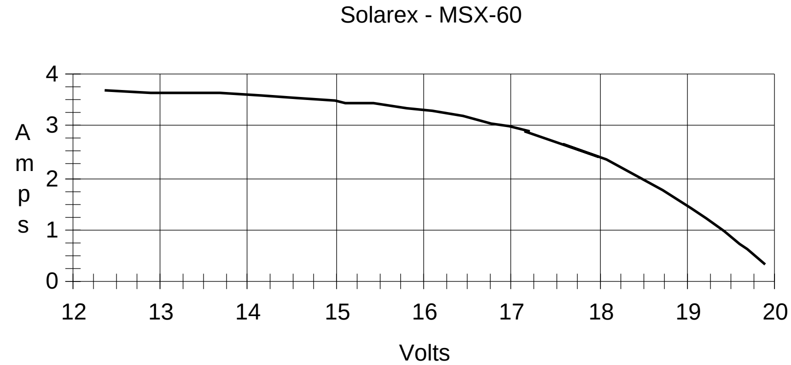
Siemens - M55

	Rated Value	Measured Value	Percent of Rated	
Isc	3.35	3.44	102.7%	Amperes
Voc	21.70	21.19	97.6%	Volts
Pmax	53.00	56.13	105.9%	Watts
Vpmax	17.40	16.27	93.5%	Volts
Ipmax	3.05	3.45	113.1%	Amperes
PV Temp	25	20	78.0%	°C.
Insolation	100	112	112.0%	mW/sq. cm.



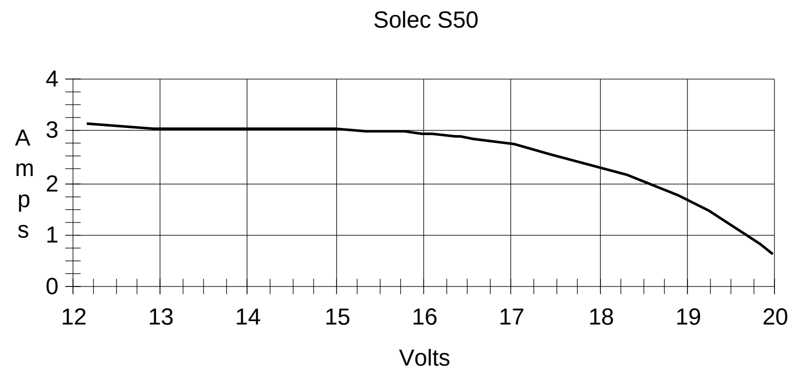
Solarex - MSX-60

	Rated Value	Measured Value	Percent of Rated	
Isc	3.86	3.85	99.7%	Amperes
Voc	21.10	20.11	95.3%	Volts
Pmax	58.90	53.05	90.1%	Watts
Vpmax	17.10	15.79	92.3%	Volts
Ipmax	3.50	3.36	96.0%	Amperes
PV Temp	25	18	73.6%	°C.
Insolation	100	111	111.0%	mW/sq. cm.



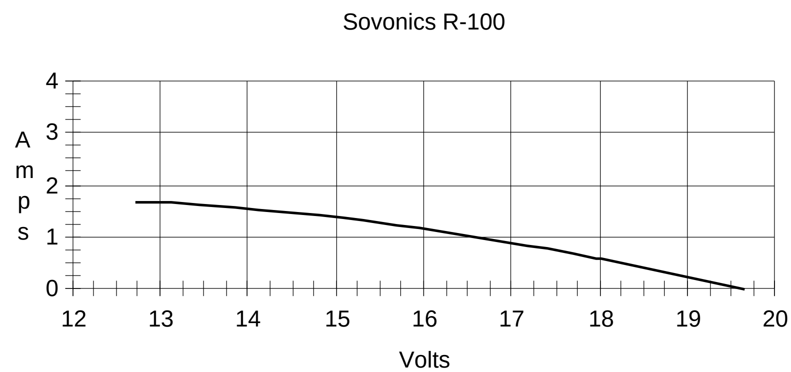
Solec S50

	Rated Value	Measured Value	Percent of Rated	
Isc	3.30	3.30	100.0%	Amperes
Voc	20.30	20.46	100.8%	Volts
Pmax	50.00	47.71	95.4%	Watts
Vpmax	17.00	16.34	96.1%	Volts
Ipmax	3.00	2.92	97.3%	Amperes
PV Temp	25	19	76.0%	°C.
Insolation	100	110	110.0%	mW/sq. cm.



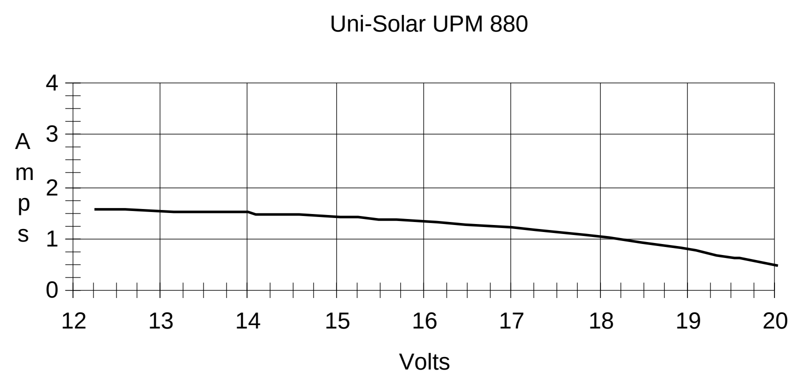
Sovonics R-100

	Rated Value	Measured Value	Percent of Rated	
Isc	2.74	2.52	92.0%	Amperes
Voc	25.00	19.64	78.6%	Volts
Pmax	37.00	21.77	58.8%	Watts
Vpmax	17.20	13.44	78.1%	Volts
Ipmax	2.10	1.62	77.1%	Amperes
PV Temp	25	19	76.0%	°C.
Insolation	100	99	99.0%	mW/sq. cm.



Uni-Solar UPM 880

	Rated Value	Measured Value	Percent of Rated	
Isc	1.80	1.74	96.7%	Amperes
Voc	22.00	21.59	98.1%	Volts
Pmax	22.00	21.81	99.1%	Watts
Vpmax	15.60	15.69	100.6%	Volts
Ipmax	1.40	1.39	99.3%	Amperes
PV Temp	25	19	76.0%	°C.
Insolation	100	111	111.0%	mW/sq. cm.



temperature, and solar insolation. The DMM measuring voltage is connected directly to the module's terminals. The DMM measuring module current uses a shunt (10 Amp., 100 milliVolt, 0.1% accuracy). A Fluke 80T-150U temperature probe measures both module temperature and air temperature. A Li-Cor 200SB pyranometer measures insolation. This data was taken at Agate Flat, Oregon (42° 01' 02" N. 122° 23' 19" W.) at an altitude of 3,320 feet. The date of this test was 12 January 1993.

All modules are mounted on the same 12 foot by 12 foot rack, i.e. they are in the same plane. This assures equal access to sunlight. All modules were measured with the same instruments in the same places. Ambient air temperature was 0.2°C (32.3°F) to 3.7°C (38.7°F) with a slight breeze blowing. The ground was covered by two to three feet of snow. We froze our butts off getting this data!

The Photovoltaic Players

Most of these modules have had their performance measured by us during the summer of 1991. We reported on their hot weather performance in Home Power #24, page 26. What follows here is winter testing of the same six different brands of modules modules, with two new brands added. All modules are listed alphabetically.

Carrizo ARCO 16-2000

This is a 9.5 year old ARCO 16-2000 module we purchased on the open market. It has 33 series connected, single crystal, round PV cells. We've had this module out in the sun for the last 1.5 years.

Carrizo ARCO M52 "Gold" QuadLam

This is a set of four ARCO M52 laminates wired in series to make a single QuadLam module. This 8.5 year old module was supplied for testing by Mike Elliston of Carrizo Solar. The resulting module of four laminates contains 48 series connected cells and a total cell count of 144. The PV cells used to make these laminates are 3.75 inches square and are single crystal types. We've had this module out in the sun for the last 1.5 years.

Kyocera K51

We tested a K51 Kyocera module that we purchased new on the open market. This module contains 36 series connected square multicrystal PV cells. We've had this module out in the sun for the last 1.5 years.

Siemens M55

We tested a M55 Siemens module sent to us new by its maker. This is a current production, single-crystal, PV module. This module contains 36 series connected square PV cells. We've had this module out in the sun for the last 1.5 years.

Solarex MSX-60

We tested a 1.5 year old, MSX-60 Solarex module that we purchased new on the open market. The performance data of this multicrystal module is printed on its back. This data is the result of flash-testing of this specific module, not a "generic" rating like almost every other module. After flash-testing, a computer prints a label with the data for that specific module. This module contains 36 series connected square PV cells. We've had this module out in the sun for the last 1.5 years.

Solec S50

The Solec S50 is a single crystal silicon module with 36 series connected square cells. This S50 was purchased retail and has been out in the sun for six months. This is an older model module and was made six years ago.

Sovonics R-100

This is an amorphous silicon module supplied by Nick Pietrangelo of Harding Energy Systems. We've had this module out in the sun for the last 3.5 years.

Uni-Solar UPM 880

This is a model UPM-880 amorphous silicon module sent to us by United Solar. This module is brand new and had only seen sunshine for three weeks before this test.

The Data

We are content to let the data speak for itself. We used manufacturer's ratings at a 25°C module temperature. In the comparison tables, the maker's performance specification is listed in the column called "Rated Value." Our measured data is in the column labeled "Measured Value." The column called "Percent of Rated" compares our measured results with the maker's ratings. The solar insolation data from the Li-Cor Pyranometer is accurate. At Agate Flat, we often have solar insolation as high as 115 milliWatts per square centimeter.

Conclusions

The modules that have remained on the rack for the last eighteen months show no significant performance degradation. The cold temperature has increased the performance of all the repeat tests. Coming up this summer, another hot weather test of all the modules on Home Power's "Democracy Rack."

Access

Author: Richard Perez. Intrepid PV Testers: Chris Greacen, Mark Newell, Therese Peffer, Richard Perez, and Amanda Potter, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

PV Module J-Boxes & Mounting

Mark Newell and Richard Perez

From a user's standpoint, mounting and wiring a photovoltaic (PV) module means dealing with the module's framework and junction box (J-Box). From a dealer/installer's standpoint, they practically live inside J-Boxes. Every make of PV module is different. We decided to photograph, measure, and evaluate the mounting requirements and junction boxes of the most commonly available modules.

Mounting Dimensions and Requirements

The table lists the physical dimensions of virtually every available module. Also included on the table are the dimensions between the module's mounting holes and the diameter of the mounting holes. Some modules offer many holes for mounting, some only offer four. Specific module physical differences will be covered under the description of each module. All dimensions given here are from our actual measurements. There are bound to be minor and insignificant variations between the information on this chart and manufacturers' specifications.

J-Boxes

After you rack 'em and stack 'em, it's time to wire 'em up. This means getting into the module's junction box and making efficient, long-lasting electrical connections. Each J-Box is different. Some are roomy enough to hold four to eight USE insulated #10 gauge wires, some are not. Some offer massive, high pressure, mechanical connections, others are more wimpy. Some require tools for entry, some do not. Some offer strain-relief for wires, some do not. Some are ready for conduit installation, some are not.

Covered in the table are various categories. The category "Positive & negative in one box?" indicates if both the modules positive and negative output are located in the same junction box. In some PV modules, such as the Siemens and ARCO modules, there are two junction boxes on each module, one for positive and one for negative. These boxes are located on opposite ends of the module's backside. The category "J-Box entrance tool" tells what type of tool is required to secure entrance into the module's junction box. The category "Terminal tool" tells what type of tool is required to make the electrical connections within the junction box and "Terminal type" describes the type of terminal found in the J-Box. The category "Connector type" describes the type of electrical connectors, if any, that the connections inside the J-Box are designed to accept. The "Width", "Height", "Depth" and "Volume" refer to the interior dimensions of that J-Box. The category "Roominess" indicates the actual working volume within the box. Consider that a "big" box will allow wiring six to eight #10 gauge wires with USE insulation and "huge", up to ten. A box rated "comfy" will accept four #10 gauge wires with USE insulation. A J-Box rated "Tight" will accept two #10 gauge wires with USE insulation. The category "Conduit Ready?" indicates if the

PV MODULE PHYSICAL DATA

Module maker	*Module model*	*Width inches*	*Length inches*	*Depth inches*	*Module area*
ARCO	16-2000	12.0	48.0	1.5	576.0
ARCO	M51	12.0	48.0	1.5	576.0
Carrizo	M52	12.0	48.0	1.5	576.0
Kyocera	J51	17.5	38.8	1.4	678.1
Kyocera	K51	17.5	38.8	1.4	678.1
Siemens	M55	12.9	50.8	1.3	653.7
Solarex	MSX–60	19.8	43.6	2.0	861.6
Solec	S50	13.0	50.8	1.5	659.8
UniSolar	UPM–880	13.5	47.0	1.1	634.5

PV MODULE MOUNTING HOLE DIMENSIONS

Module maker	*Module model*	*Dia. inches*	*Holes (see diagram)* A	*B*	*C*	*D*	*E*	*# holes*
ARCO	16-2000	0.25		47.0			11.3	4
ARCO	M51	0.31	11.5	47.0	26.0		10.1	8
Carrizo	M52	0.25		47.0			11.3	4
Kyocera	J51	0.25		36.6		18.3	16.0	6
Kyocera	K51	0.25		36.6		18.3	16.0	6
Siemens	M55	0.25	12.2	49.8	26.3		11.3	8
Solarex	MSX–60	0.31	9.3	42.3	24.0		18.4	8
Solec	S50	screw		50.3			8.5	4
UniSolar	UPM–880	0.25	11.3	45.1	22.8	22.8	13.0	10

JUNCTION BOX STUFF

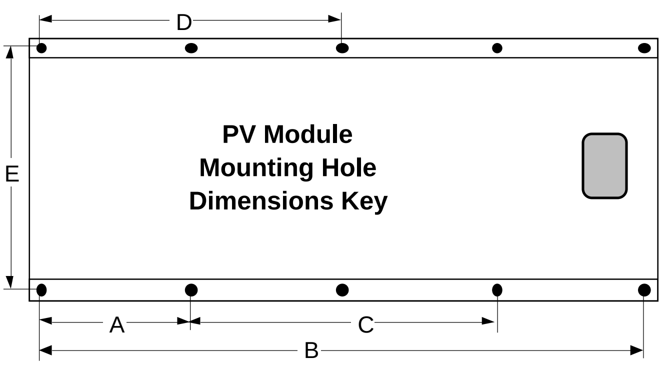
PV Module Maker	*PV Module Model*	*"+ & –" in one box?*	*JBox entrance tool*	*Terminal tool*	*Terminal type*	*Con-nector*	*Width inches*	*Height inches*	*Depth inches*	*Volume cu. in.*	*Room-iness*	*Conduit ready?*	*JBox distance to side*
ARCO	16-2000	no	none	flat screw	post	#8 ring	NA	NA	NA	NA	tight	no	1.0
ARCO	M51	yes	none	flat screw	post	#8 ring	round	5.3	1.3	27.0	huge	yes-3	2.4
Carrizo	M52	no	#2 Phillips	3/8" nut	bar	#8 ring	2.3	3.8	0.8	6.8	comfy	yes-2	1.3
Kyocera	J51	yes	none	#2 Phillips	post	#8 ring	round	3.5	1.3	12.6	big	yes-4	5.5
Kyocera	K51	yes	#2 Phillips	#2 Phillips	post	#8 ring	2.4	3.8	0.8	7.2	big	yes-2	1.0
Midway	Tracker	yes	flat screw	flat screw	bar	#8 ring	6.0	6.0	4.0	144.0	huge	yes-1	NA
Siemens	M55	no	flat screw	flat screw	clamp	none	1.8	1.8	0.8	2.5	tight	no	2.4
Solarex	MSX–60	yes	flat screw	flat screw	bar. strip	#8 spade	3.0	4.6	1.3	17.3	big	yes-4	0.3
Solec	S50	yes	flat screw	3/8" nut	post	#6 ring	2.8	2.8	1.0	7.6	comfy	no	2.5
UniSolar	UPM–880	yes	#2 Phillips	flat screw	bar	none	3.0	5.3	0.8	12.8	comfy	no	3.1

J-Box is designed to accept, and if so how many, either plastic or metal wiring conduits.

There are two elements in a long lasting, low resistance, low voltage, mechanical connection. The first element is large contact surface area. The second element is high contact pressure. All the J-Boxes surveyed here have the ability to make a good connection, if the installer does his part. The installer must solder the wires to their connectors. The installer must ensure that the connectors are tightly fastened to the mounting points inside the J-Box.

All of the J-Boxes surveyed here are made of plastic, with the exception of the Midway Labs tracker which is metal. When working with metal screws in plastic, be careful not to over-tighten the screw and strip the threads from the plastic. The place for forceful tightening is the electrical connections within the box, not on the box's lid.

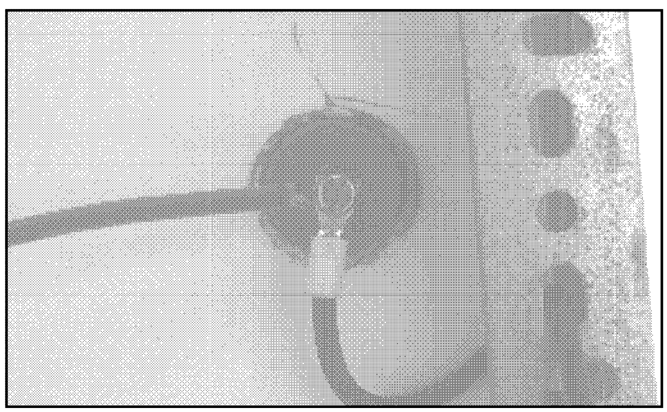
While the table gives you much specific information about each module's J-Box, the dimensions alone don't tell the entire tale.



J-Box Jamboree!

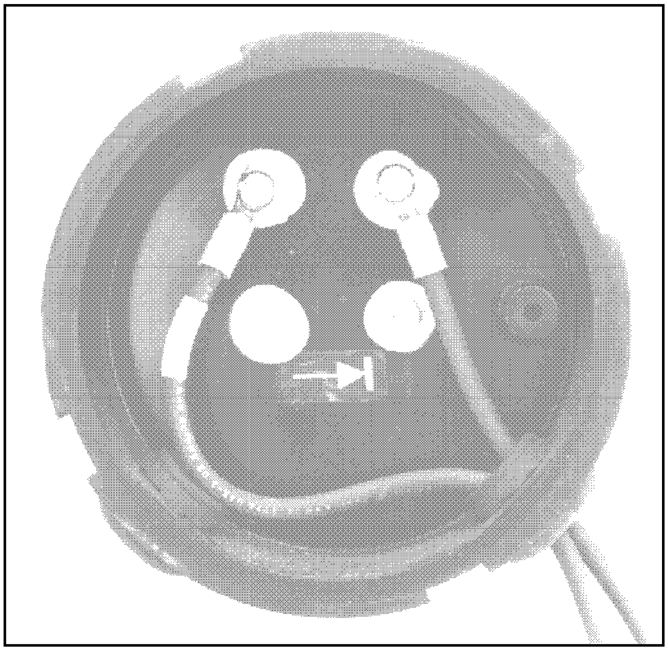
Here is a description of each module's particular requirements and a photograph of its junction box. All the photographs (except Midway Labs concentrator) were shot by Mark Newell using the same lens at the same distance from the J-Box. All the resulting photographic prints were reduced by the same amount before printing here. This means that the relatively sizes of the boxes in these photos are a good indication of their relative real physical sizes.

All modules are listed alphabetically by maker.

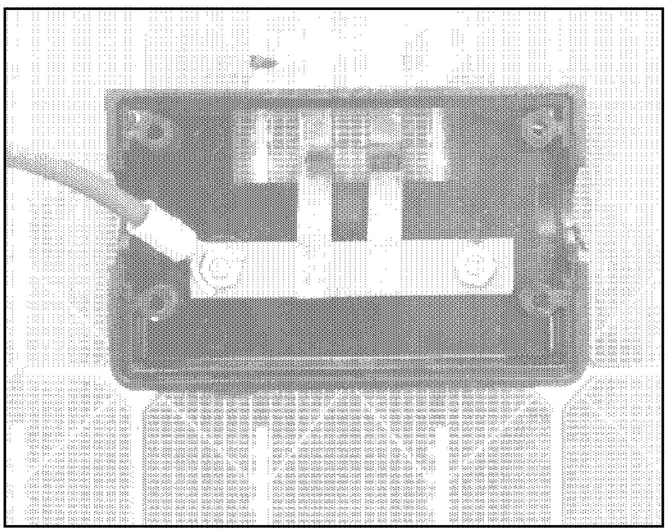


ARCO 16-2000

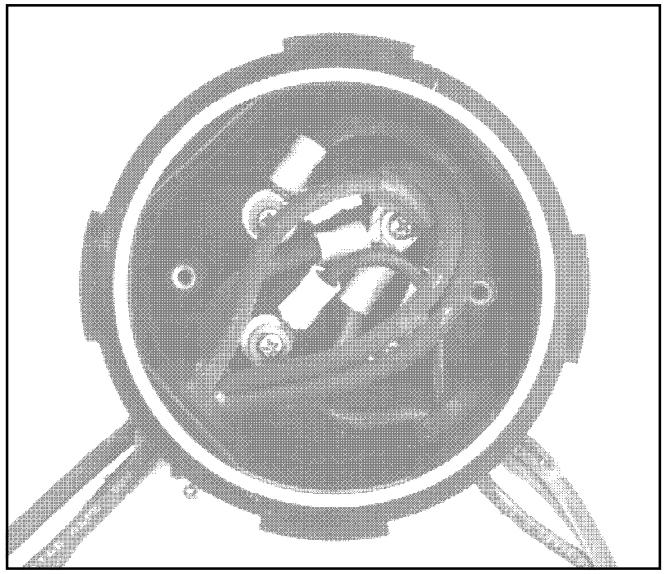
This ancient module above really has no junction box. Two terminals are provided on each end of the module's back. One terminal is positive and one is negative. These terminals are massive, but have no protection from the weather. This type of exposed electrical contact should be coated with silicon rubber to ensure a long lasting, low resistance electrical connection.



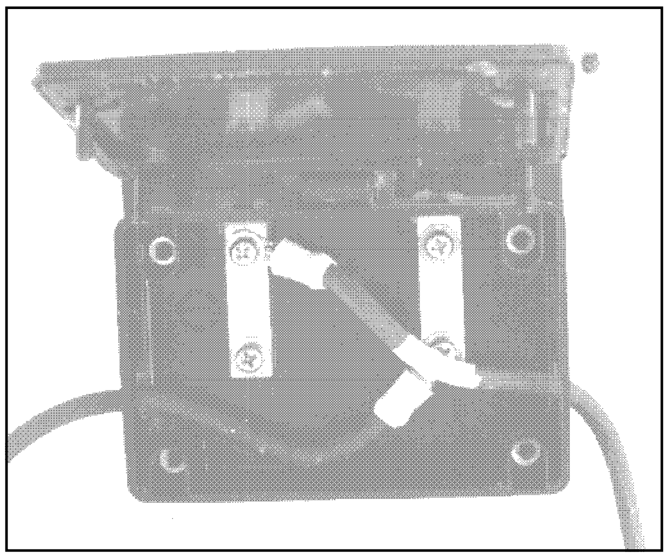
ARCO M51
This ancient module has one of the finest junction boxes we surveyed. It can be accessed without a tool, has palatial volume, and heavy duty electrical connections.



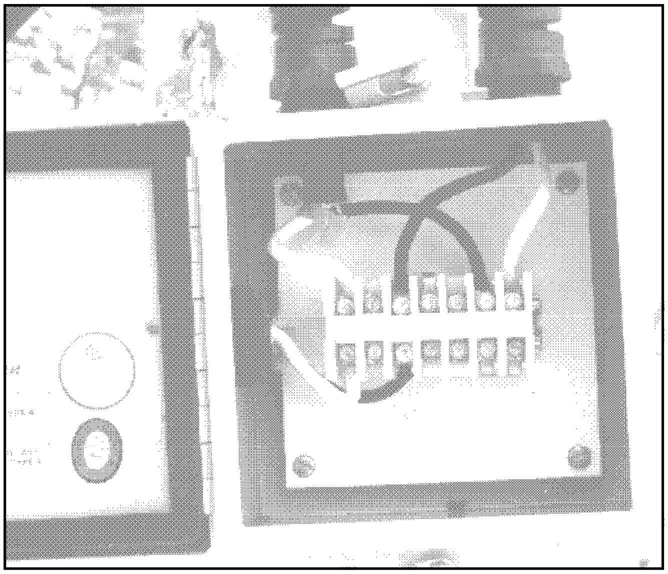
Carrizo QuadLam (ARCO M52)
The M52 laminates were intended for utility-scale tracked arrays. Each reseller of these recycled laminates now adds his own module mounting framework and junction boxes to each Lam. Each Lam has two J-Boxes, one for postive and one for negative. Four Lams are used in series for 12 Volt operation. The J-Box pictured here is from Carrizo Solar Corp's Gold QuadLam.



Kyocera J51
Another fine working J-Box. We like its easy accessibility without using tools, its massive electrical connections, and its roominess. Just for jollies, we have wired eight #10 gauge wires with USE insulation inside this box. The photo above shows six #10 USE insulated wires inside.

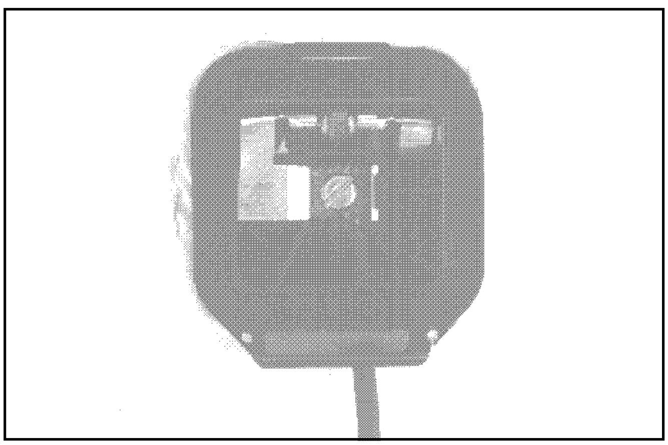


Kyocera K51
This is the newer version of the "J-series" box. It is smaller than the box on the Kyocera J51 and requires a #2 phillips screwdriver for access. This J-Box is one of three that has its cover attached. This one has the added feature of screws that are permanently a part of the cover. Anybody that has installed PVs on a roof will appreciate this. It also has brass posts that the cover screws are screwed into. While it was a squeeze, we have wired six #10 gauge wires with USE insulation inside this box.



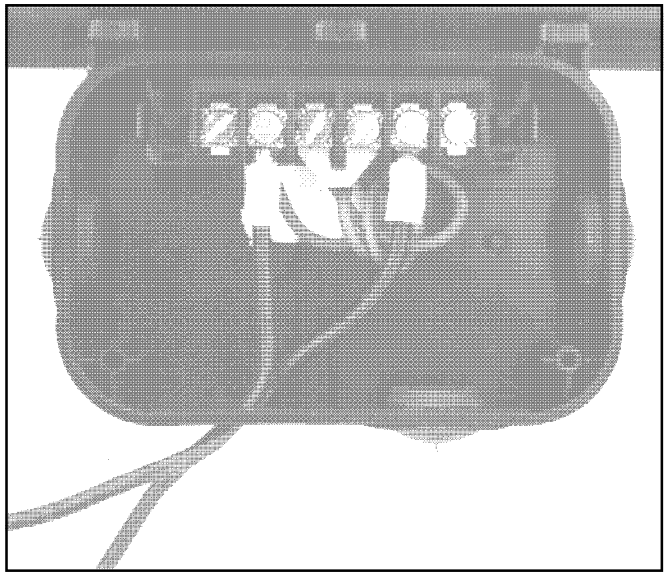
Midway Labs Concentrator

This J-Box is absolutely world class. It offers metal construction, serious strain relief, and massive barrier strips. While it is a J-Box, it isn't mounted on the modules, but on the Wattsun tracker holding the 150-sun concentrator PV modules. While it is not fair to compare this box with those on the back of flat plate modules, we included it so you could see what concentrators are using for connections.



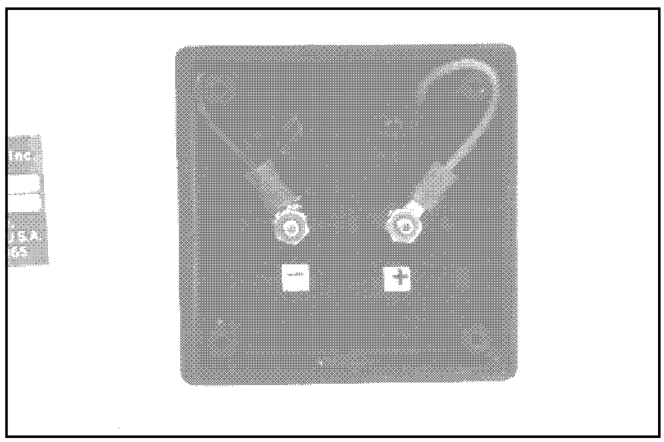
Siemens M55

This module has two J-Boxes, one for positive and one for negative. While this approach works well for series-wiring modules into high voltage arrays, we have found it more cumbersome for wiring the modules into 12 VDC systems. This J-Box is only one of the two we surveyed that does not require a connector be affixed to the wire. Simply strip the wire's insulation, insert and tighten the large screw. It also has a cover that's attached and won't get lost.



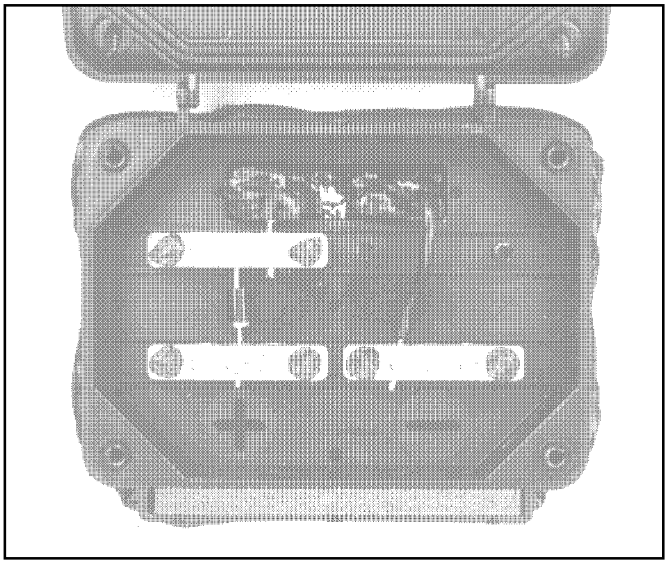
Solarex MSX-60

This major power module features a programmable J-Box. The module can be configured to operate at either 6 or 12 Volts. The room in the box is generous and the connectors secure. However, we could do without the little rubber washers and screws to drop and lose in the dirt.



Solec S50

This J-Box is very tight, with room for only two #10 gauge wires with USE insulation. The #6 connector size is also smaller than #8 size used in most other modules. The terminal bolts are imbedded in plastic so be careful tightening the nuts. The mounting framework of this module has only four threaded mounting holes. The extrusion used in the framework makes it impossible to drill and use new mounting holes.



UniSolar UPM-880
This J-Box has a hinged cover that flips out of the way. It also has the best electrical connections of any surveyed. Instead of post or clamp style electrical connections, the UniSolar uses small brass buss bars. It doesn't use connectors that must be soldered to the wire ends. The stripped wire is inserted into the buss and secured with a screw. This approach has very low electrical loss.

Our ideal J-Box looks like this:

- requires no tools for entry
- holds at least eight #10 USE insulated wires
- has only metal-to-metal screws and holes
- is conduit ready and also has strain relief built in
- is located so that mounting structure does not interfere with opening the J-Box's cover
- has J-Box cover and cover screws (if any) held captive and not drop-able

We also are very much to be liking this J-Box on the back of a two dollars per watt PV module…

Access

Authors: Mark Newell and Richard Perez, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

Cookin' On Hydrogen

Stove Burner Conversion

David Booth and Walt Pyle

Converting conventional stove top burners to run on hydrogen is a simple process. Knowing the proper handling procedures of hydrogen will make your installation safe and efficient.

Theory Before Practice

Hydrogen burns differently than either propane or natural gas. In particular, hydrogen's rate of diffusion and flame velocity are roughly ten times or greater than that of propane or natural gas. Diffusion rate measures how long it takes a gas introduced in one side of a room to be detected on the other side. Flame speed is how fast a flame travels to burn available fuel-air mixture.

Flashback of the flame into the primary mixture of fuel gas and air must be prevented in all burners. This is typically achieved with natural gas and propane by adjusting the fuel velocity so that it is higher than the normal flame velocity. The flame velocity of hydrogen is too high for this technique to be practical. Another flashback control strategy employs burner ports with a minimum quenching diameter which theoretically will not allow the flame to pass back through the port. In practice, however, it is very difficult to make the holes small enough to quench a hydrogen flame. Fortunately, flashback can be minimized by preventing hydrogen from mixing with air before the burner port. Some flashback may still occur creating a loud popping sound but this noise is usually harmless.

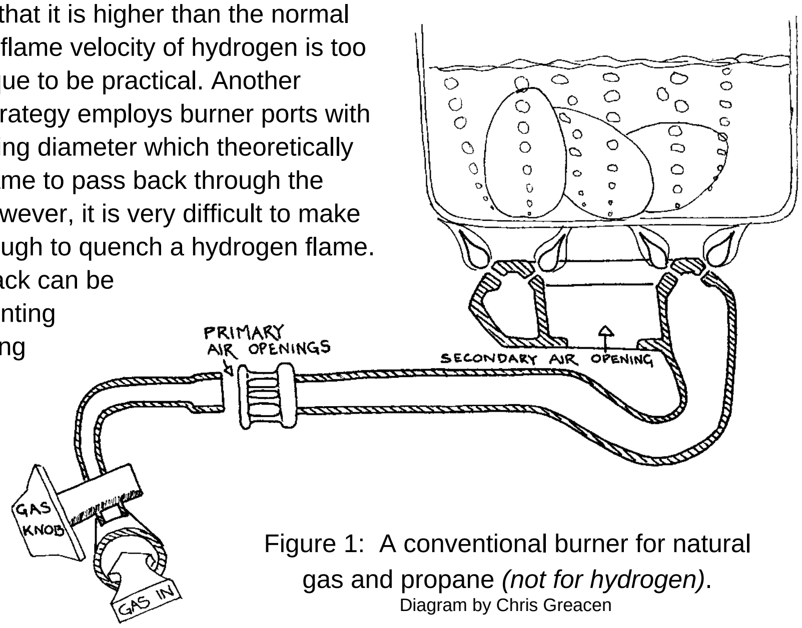


Figure 1: A conventional burner for natural gas and propane *(not for hydrogen)*.
Diagram by Chris Greacen

Figure 1 shows the principal parts of a typical range top burner used with conventional gaseous fuels. Usually the fuel streams in through a gas orifice with a delivery pressure between 3-15 inches of water column. Primary air is then drawn in with the gas stream through an air-gas mixer. Secondary air openings to mix in more air may or may not be present. Finally, as the mixture exits through the burner ports, combustion occurs, if a spark ignition source or pilot light is present.

Horse of a Different Color

This burner design will not suffice for hydrogen in an unaltered state. Burners optimized for hydrogen combustion require that undiluted hydrogen be delivered directly to the burner ports without primary or secondary air mixing. So, if we are trying to work with an existing burner in a typical gas appliance, we will have to find a suitable method to seal off any openings that were installed for this purpose. There's no method that will work in all instances. The actual openings we are referring to may be an integral part of a cast iron body. Or the primary air openings may be a modest distance from the burner head in an aluminum delivery tube with an adjustable closure. We used silicon sealant with stainless steel tape and ring clamps in one recent alteration, but this simple Coleman stove conversion hasn't been subjected to long term use as yet.

From Scratch

One might opt to build a simple hydrogen burner and direct fuel delivery apparatus from the ground up, rather than deal with the problem of sealing off a nagging assortment of useless holes. Burners and their attached parts get hot, and transfer heat readily through conduction. Sorry, duct tape and chewing gum won't cut it.

Our first attempt at a simple hydrogen conversion utilized a rudimentary two burner range of cast iron construction. See Figure 2. After we tossed the existing burner assembly, and removed the screwed-on brass orifice, a threaded adaptor was exposed. To this we attached a 1/4 inch NPT straight coupling followed by a short length of black iron pipe

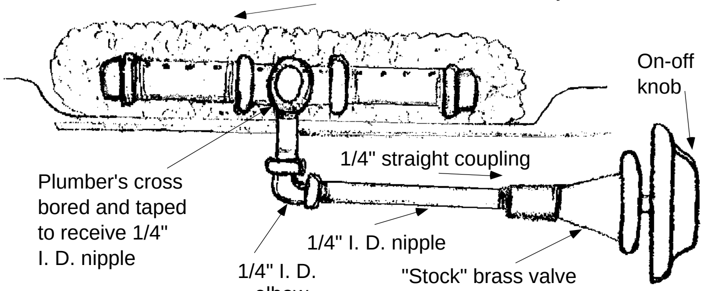


Figure 2: Pure hydrogen is delivered to burner ports without primary or secondary air mixing.
Diagram by David Booth

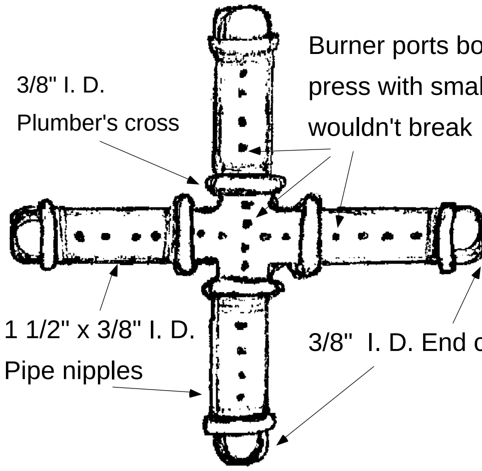


Figure 3: Top view of radial burner made from scratch using black iron pipe fittings.
Diagram by David Booth

of the same diameter. Don't use galvanized pipe, because of the fumes that will be released at high temperatures. Then we installed a 90 degree elbow followed by a short vertical nipple of more pipe. Next a 3/8 inch NPT fitting shaped like a cross with four female threaded openings was drilled and tapped to create a fifth hole. See Figure 3. This threaded onto the short vertical nipple, and four slightly longer nipples of equal length extended out radially from the remaining holes. Finally, these terminated in threaded end caps. A drill press is almost essential for drilling a series of very fine holes which line up along the top of the radial burner arms, and through the top of the cross. Ideally, these burner ports would have a 0.057 cm (0.0225 inch) diameter or less, which is the approximate minimum quenching diameter.

The Catalytic Advantage

It has been observed in early experiments that the flame combustion of hydrogen/air mixtures can lead to unacceptable levels of nitrogen oxide (NO_X) pollutant emissions. The primary end product of hydrogen combustion is simply water vapor. However, if the temperature of combustion exceeds a threshold level of about 1315°C (2400°F), a significant amount of oxygen and nitrogen from the air may react and form this unwanted byproduct. This also occurs with natural gas (primarily methane), propane, and other hydrocarbon fuel combustion.

Fortunately, you can use a catalyst to lower the combustion temperature thus preventing the formation of nitrogen oxides. The catalytic material is not used up or altered in any fashion in the process.

There are two catalytic conversion techniques which succeed in producing negligible levels of NO_X emissions. The first approach is based on Billings and his associates' work with flame assisted catalytic burners. Their conversions utilized the catalytic properties of stainless steel at elevated temperatures. Later, in another article, we'll describe the conversion of a catalytic space heater which optimizes "flameless" combustion with a small amount of platinum.

Flame Assisted Catalysis

The technique developed by the Billing's research team to reduce NO_X formation relies on controlling two interacting phenomena. First, as has already been described, hydrogen/air mixing is inhibited by blocking off any primary air openings. Second, a stainless steel wire mesh is arranged tightly around the circular burner head or radial burner arms, as shown in Figure 2.

Where does one find stainless steel wool or wire mesh? Look for stainless steel pot scrubbers in a large, thoroughly stocked supermarket in the housewares section.

Getting our NO_X Off

This stainless steel wool blanket around the burner actually serves two complementary functions. It inhibits the mixing of air and hydrogen thus producing a zone immediately surrounding the burner head where the concentration of hydrogen is very high and the concentration of air is very low. The wire mesh should be thick enough so that the flame does not radiate above it or out too far laterally.

Stainless steel also works as an excellent catalyst for hydrogen combustion. If there isn't a sufficient amount of stainless steel mesh, the catalytic capability and ability to

prevent NO_x production could be lost. Hydrogen and oxygen are thus combined on the surface of the catalyst at a lower temperature than would occur without the catalyst. The result of the lowered combustion temperature is that nitrogen oxides are virtually eliminated. The steel wool proceeds to glow bright red even at these temperatures, indicating that the otherwise invisible hydrogen flame is present.

According to Roger Billings in *The Hydrogen World View*, the flame-assisted catalytic technique can lower NO_x emission from hydrogen combustion in range burners, ovens, and space heaters to negligible levels. The resulting data showed NO_x emission levels between 1 and 5 parts per million (ppm) for a catalytic assisted burner. This can be compared with 40 ppm for conventional range burners operated on natural gas and up to 250 ppm for a hydrogen burner without a catalyst. These burner emission levels are all quite low, however, compared to internal combustion engine exhaust gas NO_x production.

More to Come

We need to build a sound understanding, before we can confidently proceed to implement hydrogen for scores of potential uses. If you'd like more information, dig into the references at the end of the article.

In the next issue, we will delve into a technique for transforming the chemical energy stored in hydrogen to available heat energy without the presence of a flame. This form of combustion is possible when hydrogen is oxidized in the presence of certain specific catalysts such as platinum. This is considered "pure" catalytic combustion. Water vapor is the only byproduct along with heat, so no venting of the appliance may be necessary (if means to prevent oxygen depletion for the room air is assured). At this time, most city and county building codes require an exhaust flu for stoves running all gaseous fuels, and we recommend that the room where the stove is being used be vented to the outdoors.

We're in the process of putting together a system that will convert renewable solar electricity into the storable chemical energy of hydrogen through the process of electrolysis. The process is still underway but we will offer detailed accounts of our endeavors in forthcoming issues.

Spreading the Invisible Flame

There may well be a wealth of undiscovered and untapped hands-on information available from other hydrogen enthusiasts out there scattered through the countryside. If you are among the other backyard tinkerers and hydrogen pioneers who are putting theory into practice, let us hear from you. The time has come to spread the word about hydrogen's unique advantages. It is clearly the hands-down winner among the possible candidates of alternative fuels for the future in our environmentally beleaguered world.

A Note on Safety

Remember that storing pure hydrogen can be regarded as a relatively safe procedure, but storing hydrogen /air or hydrogen/oxygen mixtures is foolhardy and strictly inadvisable.

Much of the research that we referred to in this article was performed by Roger Billings, N. R. Baker, and their associates of the now defunct Billings Energy Corporation. This pioneering work was done mostly in the 1970s. An early research endeavor involved conversion of all the gas appliances on a Winnebago recreational vehicle from propane to hydrogen operation. To demonstrate hydrogen's practicality even further, five natural gas appliances were converted to hydrogen. This multi-phased project in Provo, Utah was called the Hydrogen Homestead. Included among the appliances converted for this home were an oven, a range, a barbeque, a fireplace log burner, and the booster heater for the home's heat pump system.

Access

Authors: David Booth, Alternative Energy Engineering, POB 391, Miranda, CA 95553 • 707-923-4336

Walt Pyle, WA6DUR, Richmond, CA • 510-237-7877

Further Reading

1. *Oxides of Nitrogen Control Techniques for Appliance Conversion to Hydrogen Fuel*, technical paper #74003, by N.R. Baker is available from the International Academy of Science, 26900 Pink Hill Road, Independence, MO 64057 • 816 229-3800.

2. *Hydrogen Homestead*, technical paper #78005, by Roger Billings is available from the International Academy of Science.

3. *Fuel from Water* by Michael Peavey is available from Alternative Energy Engineering for $16 and Real Goods.

4. *The Hydrogen World View* by Roger Billings is available from the International Academy of Science.

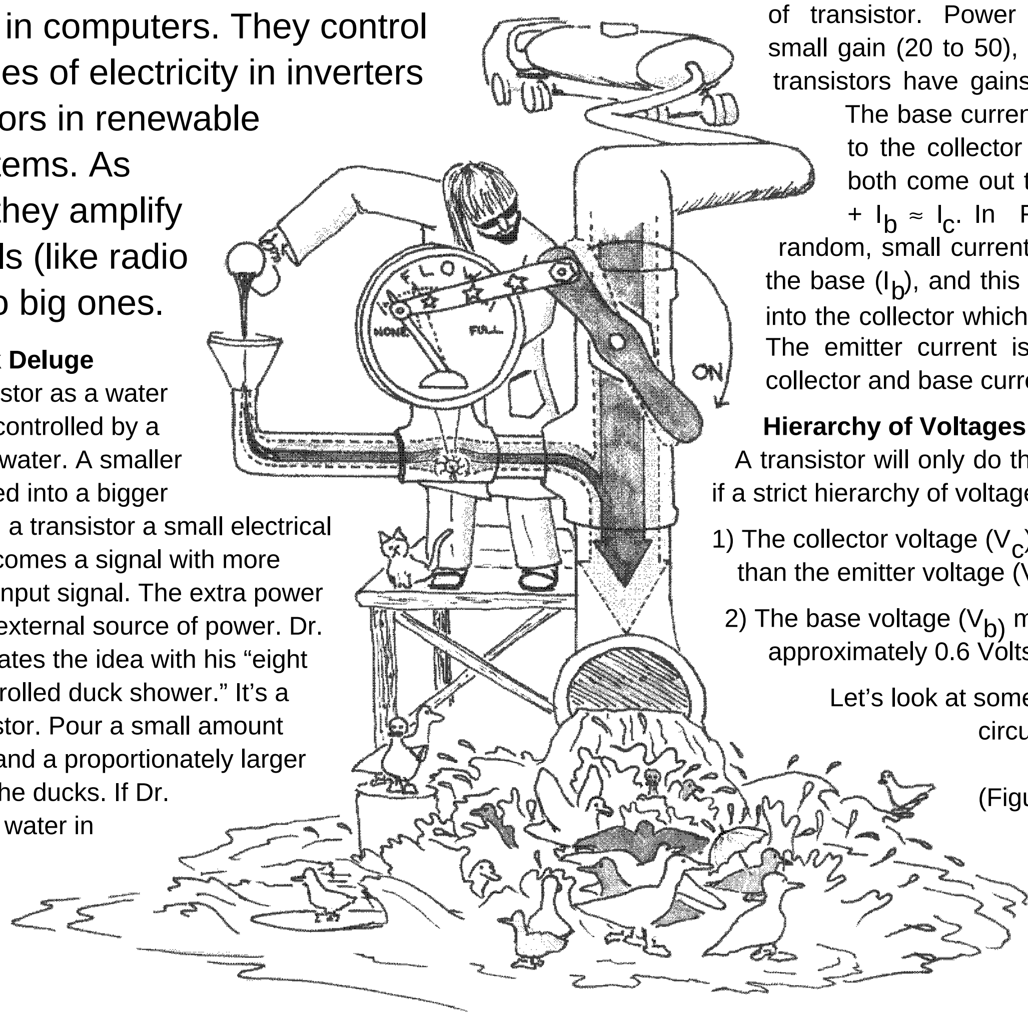
Introduction to Transistors

Chris Greacen

This is the column I've been waiting for. After resistors (HP #31), and diodes (HP #32), we're ready to dive into the heart of electronics: transistors. Transistors are used everywhere that electricity controls other electricity. They create and listen to the pulses of electricity that transmit information in computers. They control the big pulses of electricity in inverters and regulators in renewable energy systems. As amplifiers, they amplify small signals (like radio signals) into big ones.

Dr. Klüge Duck Deluge

Think of a transistor as a water faucet which is controlled by a small stream of water. A smaller signal is amplified into a bigger signal. You feed a transistor a small electrical signal, and out comes a signal with more power than the input signal. The extra power comes from an external source of power. Dr. Klüge demonstrates the idea with his "eight fluid-ounce controlled duck shower." It's a plumbing transistor. Pour a small amount into the funnel, and a proportionately larger flow dumps on the ducks. If Dr. Klüge pours the water in slurps and spurts, giant slurps and spurts spill on the ducks.



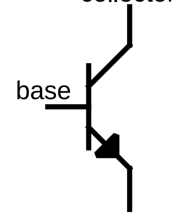


Figure: 1 NPN transistor

An electrical transistor is considerably smaller, and does not require a water truck. Figure 1 shows the electrical symbol for a typical NPN transistor and its electrical symbol. It has three legs, called the *base*, the *collector*, and the *emitter*. The *base* corresponds to the funnel in Dr. Klüge's Duck Shower. The *collector* corresponds to the top pipe of the Duck Shower, coming from the water truck. The *emitter* corresponds to the output of the Duck Shower.

Feed a small current into the base (I_{base} or I_b) and you control a larger current into the collector ($I_{collector}$ or I_c). Just as the deluge out of the duck shower is many times larger than the water poured in the funnel, I_c is much larger than I_b. Mathematically, $I_c = \beta I_b$ where β (often written h_{FE}) is called the "current gain" of the transistor, and is typically 20 to 300 depending on the type of transistor. Power transistors have small gain (20 to 50), while small-signal transistors have gains of 100 or more. The base current (small) is added to the collector current (big) and both come out the emitter $I_e = I_c + I_b \approx I_c$. In Figure 4, a rather random, small current signal is fed into the base (I_b), and this controls a current into the collector which is β times bigger. The emitter current is the sum of the collector and base currents.

Hierarchy of Voltages

A transistor will only do this amplifying stuff if a strict hierarchy of voltages is observed.

1) The collector voltage (V_c) must be greater than the emitter voltage (V_e).

2) The base voltage (V_b) must be approximately 0.6 Volts greater than V_e.

Let's look at some typical transistor circuits. In the "emitter follower" circuit (Figure 2), the voltage across the load (the emitter voltage) changes with (follows) the base voltage, but

is always about 0.6 Volts lower. This is a direct consequence of rule #2. What's the point of the circuit? You get less voltage out (V_e) than you put into the base (V_b) — see Figure 3. But your low amperage control current (I_b) controls a larger current through the transistor ($I_c \approx I_e$) — Figure 4. Even though the voltage out is lower, the power (voltage times current) output is greater.

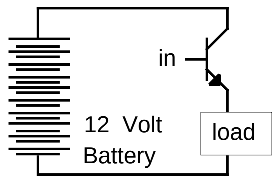


Figure 2: Emitter follower

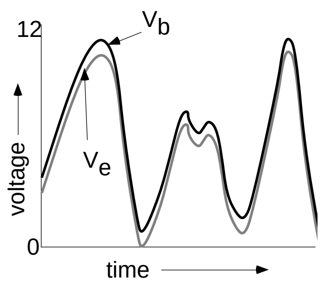


Figure 3: V_e follows V_b and is 0.6 Volts lower.

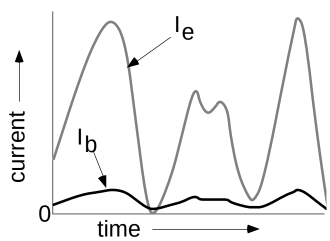
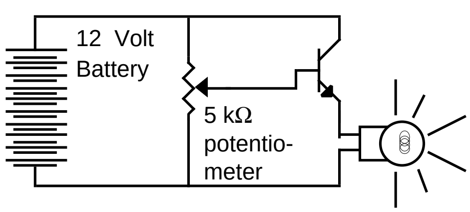


Figure 4: I_e is an amplified copy of I_b.

You could use it as a fancy, rather inefficient dimmer for a 12 Volt light. In this case for the variable voltage source you might use a 5 kΩ potentiometer as shown in Figure 5 below.

Figure 5: Emitter follower as light dimmer



Common Emitter Amplifier

Emitter followers show clearly the hierarchy of voltages in an operating transistor, but often you want to amplify low voltage signals. Emitter followers don't do this — the output voltage (V_e) is always lower than the input voltage. If you connect the load from the collector to ground, and connect the emitter to ground with a small resistor, the circuit is called a "common emitter amplifier" — Figure 6. We'll use a lot of Ohm's law and algebra to look at this circuit. Skip to the "Touch-Controlled Light" if this makes you uncomfortable.

This circuit amplifies the voltage of small signals. Let's see how it works. For the sake of argument, let's start with 1.6 Volts on the base. (Later we'll vary the voltage on the base and see what happens.) The emitter voltage is then 1.6V – 0.6V = 1 Volt. If there's 1 Volt at the emitter, then the current through the 240Ω emitter resistor is I_e =1 Volt/240Ω = 4.2 mA. In a way, this 240Ω resistor "programs" the transistor by setting how much current drains out of the emitter. Now remember that $I_c \approx I_e$, so the current flowing through resistor R is approximately I_e. Therefore the output voltage (V_c) = 12 Volts – I_eR. If you choose R = 2.4 kΩ, the output voltage is 12 – (4.2mA)(2.4kΩ) = 2 Volts.

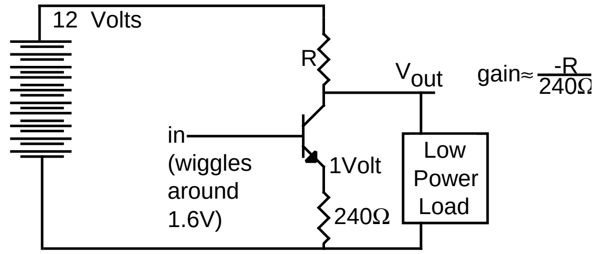


Figure 6: Common emitter amplifier — it amplifies the voltage of low-voltage signals.

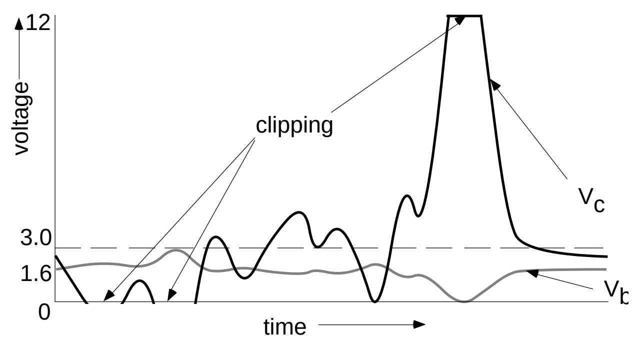


Figure 7: Collector voltage varies with base voltage in the common emitter circuit in figure 6.

OK, I hope your head doesn't hurt yet. Hang on just a little more. Let's say we raise the input voltage by 0.1 Volts to 1.7 Volts. Now V_e= 1.1 Volts, programming I_e =1.1 Volt/ 240Ω = 4.58 mA. Now V_{out} = 12 – (4.58mA)(2.4kΩ) = 1 Volt. The bottom line is that changing the input voltage by 0.1 Volts (that is 1.7V minus 1.6V) changed the output by 1V – 2V = -1 Volt! The change in the output voltage is -10 times the change in the input voltage. We say the "gain" of the transistor is -10. Don't be worried that the gain is negative. Negative gain just means that a positive change in the input signal causes a negative change in the output. The signal is magnified ten times and "flipped over." If you were listening to the signal on an amplified speaker, you'd never notice the difference. If we changed

R to something else, the gain would be -R/240Ω. Build the circuit with a potentiometer in series with a 1 kΩ resistor for R so you can change the voltage gain with a knob.

Clipping

What happens when we put in, say, 3 Volts in the base? This increases the original V_b by 1.4 Volts. We'd expect to see a change in the V_c of -10 x 1.4 Volts = -14 Volts. The output would supposedly be 2V – 14V = -12 Volts. This won't happen of course since the voltages available to the circuit are zero to twelve, determined by the battery that's powering the thing. In this case, the output is simply pinned at zero Volts. When the output is flattened like this, we say it is "clipped". See Figure 7. Conversely, if you make V_b = 0 Volts, a change of -1.6 Volts, you'd expect to see the output change 16 Volts — again output is pinned, this time at 12 Volts. Usually amplifiers are designed so the output wiggles around half the supply voltage — in this case six Volts. We could get this amplifier to wiggle around 6 Volts by choosing R = 6 Volts/ 4.2mA = 1.43 kΩ, at the expense of less gain.

Biasing the Common Emitter Amplifier

In the amplifier above, the input signal wiggled around 1.6 Volts. Typically the small signal you want to amplify wiggles below and above zero volts. If you were to feed this into the common emitter amplifier you would only amplify some of the positive parts of the signal. To amplify the whole signal, we need to boost it up so that it wiggles around 1.6 Volts. This is called biasing the transistor. A component called a capacitor (labeled "C" in Figure 8) passes the wiggles up to the biased base voltage. We could bias the base with a 1.6 Volt battery (Figure 8). But since batteries are expensive, wear out, and only come in certain voltages, in practice, biasing is usually done with two resistors forming a voltage divider, as shown with 72kΩ and 10kΩ (Figure 9).

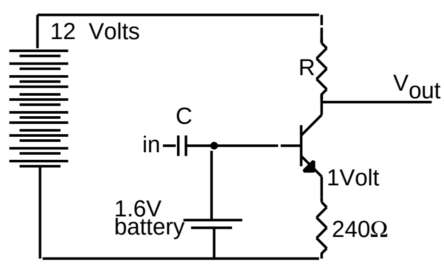


Figure 8

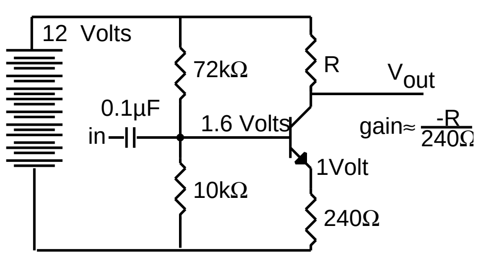


Figure 9

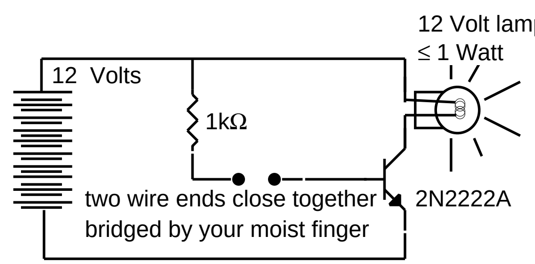
Drawbacks of these Amplifiers

Notice that in the common emitter amplifier, all current going to a load has to go through resistor R. Any load this circuit drives must have a high resistance compared to R or else V_{out} will sag. For this reason, voltage amplifiers often drive current amplifiers so they can drive bigger loads (like audio speakers). The common emitter circuit (Figure 2) is a current amplifier, but you won't find an emitter follower driving a common emitter inside your stereo. These simple amplifiers have lots of distortion, poor temperature stability, and they can waste power when there's no incoming signal. These are the concerns of amplifier designers, and the techniques to improve amplifiers are deep and devious.

Touch-Controlled Light

On the other hand, a very similar circuit is useful and common as a transistor "switch" (Figure 10). Here's a circuit which sums up all the demented transistor stuff we've been looking at. It's a common emitter circuit used to control a lightbulb. If you touch a moistened finger to both wires, a small current (I_b) flows through it (you won't feel it). A proportionately larger current $I_c = \beta I_b$ lights the light bulb. The 1kΩ resistor keeps too much current from flowing into the base if your finger has too little resistance, or if you touch the wires together. Touch a dry finger lightly to the two wires, and the lamp will light dimly. Moisten your finger and make a good contact, and the light will be bright.

Figure 10: NPN touch-controlled light



Incidentally, you might try the circuit without the transistor (Figure 11). Put your finger across the two wires, and nothing will happen. Your finger has too much resistance to conduct current to light the bulb.

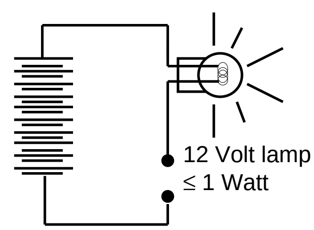
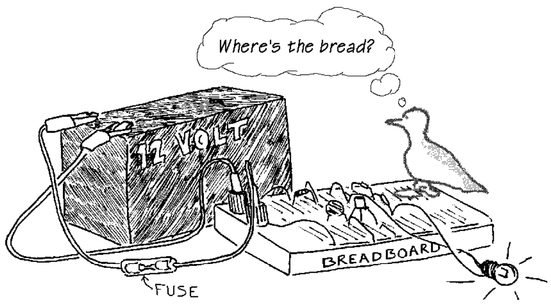
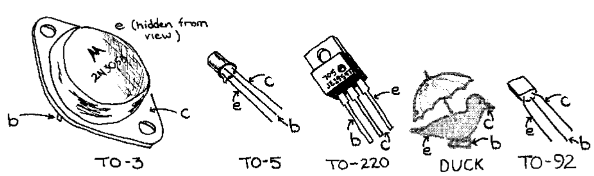


Figure 11



Build These Circuits

You can look at these on paper, and you'll get a certain understanding of what's happening. But electronics doesn't happen on paper; it happens in the circuits. Build them! Make mistakes! Be creative! As long as your battery is fused, the worst you can do is fry some inexpensive parts. If you're careful and make sure every wire is in the right place before you power it up, you won't blow up anything. You'll need a 12 Volt battery with a 1 amp fuse and a "breadboard" to wire up circuits. I like breadboards with "banana plugs" for external connections so that there's as few loose wires as possible. You'll also need some 24 gauge wire pieces, and the pieces in the schematics. The NPN transistor in these circuits is the common 2N2222A. The PNP transistor is a 2N2905. All this stuff is available at your local electronics store. For the most edifying electronics experience, find an electronics nerd who has an oscilloscope, and you'll be able to watch voltages within the circuits.



Common transistor packages. The transistors used in this article come in the TO-3 case.

PNP Transistors

So far we've been talking only about NPN bipolar transistors. They're turned on by feeding a positive current into the base. Bipolar transistors come in another common flavor: PNP. They're sort of an upside down cousin of the NPN. All the voltage hierarchies of NPN transistors are reversed, and you turn them on by "sucking" current out of the base.

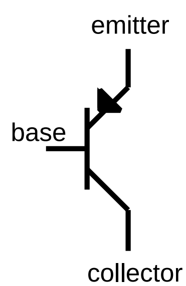


Figure 12: PNP transistor

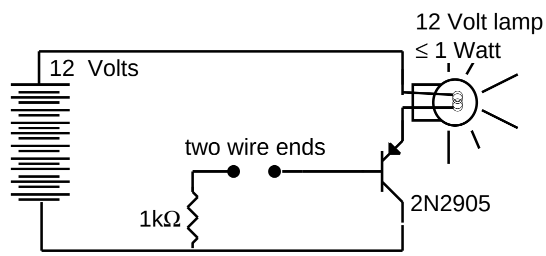
PNP Voltage Hierarchy

1) The emitter voltage (V_e) must be greater than the collector voltage (V_c)

2) The base voltage (V_b) is approximately equal to the emitter voltage (V_e) minus one diode drop (0.6 Volts).

Here's the touch controlled light using a PNP transistor. Notice that here when your finger contacts the two wire ends, current is sunk to ground. This makes the PNP conduct from emitter to collector, turning on the light.

Figure 13: PNP touch-controlled light



Next time: Transistors as Electronic Switches

All the circuits we've looked at so far take advantage of the ability of a transistor to work like a faucet turned partway on — we say it is "operating in its linear region." This is inefficient because leaving the transistor part way on dissipates energy as heat. Consider the emitter follower light dimmer in Figure 5. Lets say you've set the base voltage at 6.6 volts. Then the emitter voltage (the voltage across the light) is 6 Volts (6.6 – 0.6 Volts). The current in the light is 6 Volts ÷ 100 Ω = 0.06 Amperes, dissipating IV = 0.360 Watts. But where did the other six Volts go? You're supplying the circuit with 12 Volts. The remaining six Volts are eaten by the transistor, which also dissipates IV = 0.360 Watts.

A more efficient way to make a light dimmer is to switch the transistor fully on and fully off quickly. The circuit is just like the common emitter above, but designed so that the base voltage is either zero, or at 0.6 Volts, and doesn't spend much time in between. You "drive it hard" — give it more than enough current to turn it on, and when you turn it off, make sure it's turned off. You do this many times a second, and adjust the amount of "on time" and "off time." This technique is called "pulse width modulation" and is found in nearly all inverters, charge controllers, and other equipment like Linear Current Boosters. See the Pulsar article in HP#31, page 54 for more discussion on pulse width modulation, and a homebrew circuit using this technique in a flashlight battery charging circuit. Next issue we'll look more transistors in "switch mode" and some integrated circuits (chips) which make the on/off signals which control the

transistors. We'll also look at a new generation of power Field Effect Transistors (FETs) which are ideal for switching large amounts of current.

Access:

Author: Chris Greacen, c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-3179

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Electric Car Motors

Shari Prange

"Pssst! Hey, buddy, over here! Wanna buy an aircraft generator?" If you meet this fellow in an alley, don't walk, run in the other direction. He will bring your electric car nothing but grief.

The motor is the center of the electric car's universe. It is the first component you need to install. It has a pre-determined position in the center of the engine compartment, and all other components must fit in around it. The type of motor you use will determine what other components you use, and what performance you will get. It is not the place to skimp.

The Early Days

In the rugged early days of the modern electric car (meaning the late '70s), the aircraft generator was the most common motor used simply because there were few options available. It made a great aircraft generator, but a marginal electric car motor. It was rated at 24 Volts, but for automotive use it was operated at 48 to 72 Volts. Not surprisingly, the generator often refused to take such abuse and died. Also, the rpm band of the generator was not suitable for a car, causing it to suck up great rivers of current, which translated to a short driving range.

Today, these generators are still emerging from basements with "For Sale" signs, but they are less appropriate than ever. For one thing, the shaft has a 16-tooth spline that is very expensive to mate to an adaptor. For another thing, they are incompatible with modern motor controllers.

Another motor of yesteryear was the Baldor. These had a disturbing habit of spontaneously disassembling themselves.

An interim motor of the mid-'80s was the China Motor. Designed as an improved version of a generator, it operated well at 72 Volts, but not higher, and it had the same spline problem.

Today's Motor

The motor of choice today is the series DC motor. The most popular is manufactured by Advanced DC Motors. It is efficient, reliable, readily available from various distributors, affordable, and most important, it is designed to be an electric car motor. This motor dominated the 1992 Solar & Electric 500 in Phoenix.

Other usable motors are the Prestolite and G.E. The Prestolite is the forerunner of the Advanced DC motor. It is a little larger, heavier, less efficient, and less well ventilated. If cost is a factor and a used Prestolite is available, it will serve you well. This motor is no longer in production.

The G.E. motor (not the same as a G.E. aircraft generator!) is also adequate, and has approximately the same slight drawbacks as the Prestolite. If you are buying a used G.E. motor, be sure to check the rpm rating. It should be 5100. There were some in circulation that were only rated at 3900 rpm. They had lots of torque, but no top end speed.

Modern Motor Types

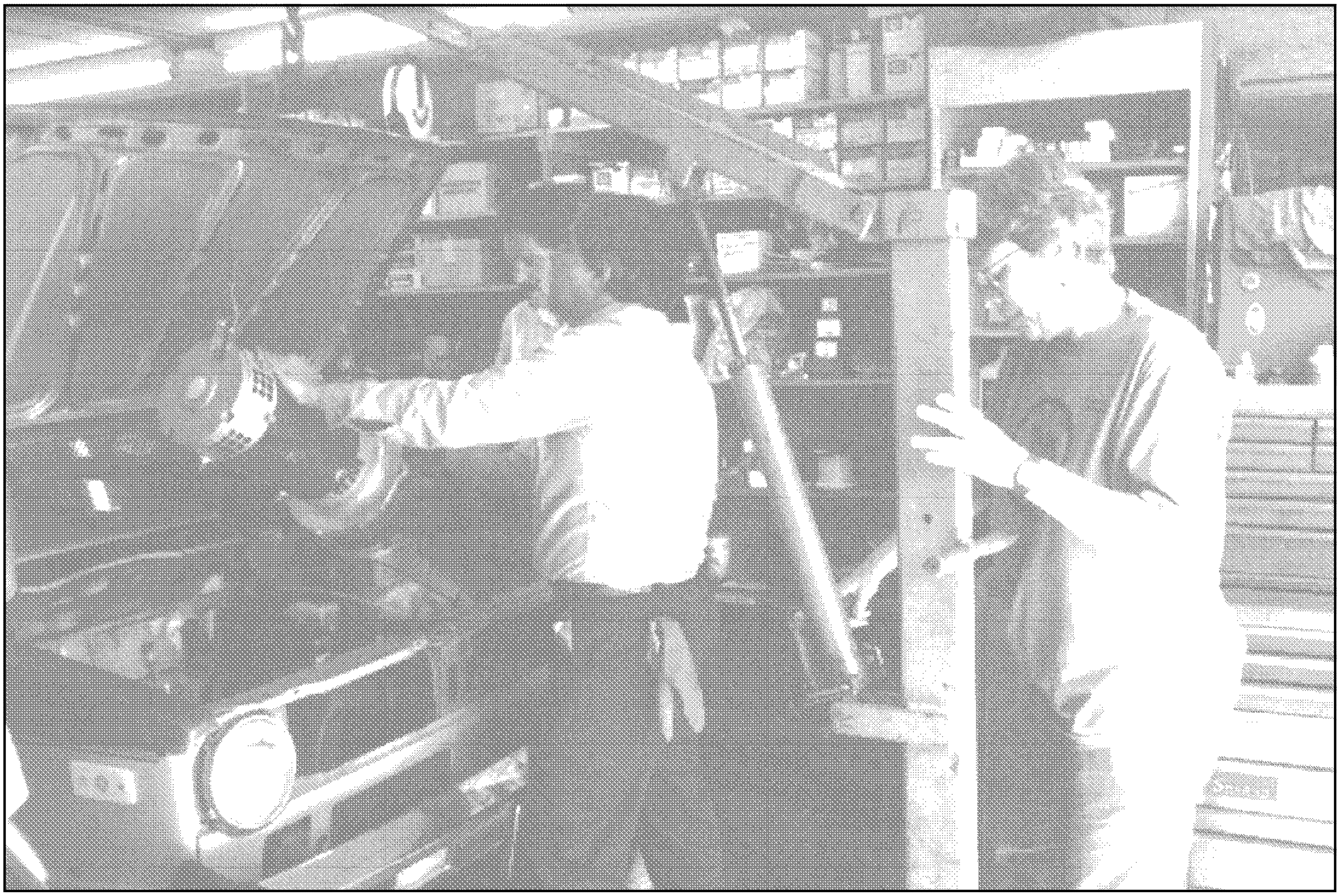
What about other types of electric motors: shunt, compound, permanent magnet, brushless DC, or ac? All of these suffer from limited or non-existent availability in sizes suitable for cars. Shunt and compound motors have less acceleration than series motors. Permanent magnet motors have a narrower efficiency vs. rpm band than series motors. This means that permanent magnet motors are most efficient at a constant speed. In normal driving, however, speed varies greatly. Permanent magnet motors are least efficient at the low rpm used most in stop-and-go driving.

Brushless DC and ac motors are available primarily from a company called Solectria in Massachusetts. While brushless motors are slightly more efficient than series motors, their control systems are much more expensive.

Then there are the rare earth motors, and similar exotics. These are at the opposite end of the spectrum from generators. These are the unproven dreams of tomorrow. They are laboratory animals, available only as hand-built test prototypes. They are still being debugged, and are not commercially available in regular production. Don't design your electric car around something that is still a half-formed pipe dream.

Honda Alert

If you are converting a Honda, be sure to inform your supplier when you buy your motor. Hondas rotate in the opposite direction from everything else. Some motors can run in either direction. On the Advanced DC motor, there



Above: an electric motor finds ist new home in a Volkswagen Rabbit.

is an adjustment the supplier makes to make the motor most efficient in the right direction. Some motors will not work in this reverse application.

Motor Installation Tips

Once you have your motor, you need to install it in the car. When you disassembled the car, you should have taken some measurements to lock in the original position of the transmission. You want to duplicate the transmission's position when you install the electric motor. In order to do this, you will need to design your motor mount precisely. This is essential for proper shift linkage and driveshaft angularity, among other things. Any change in the position of the transmission will impair smooth efficient performance.

In air-cooled Volkswagens, no motor mount is necessary. The electric motor hangs off the transmission, just like the original gas engine did. For all other cars, read on.

Motor Mounts

Install the motor on the transmission with an adaptor plate. Use a floor jack to raise the motor until the transmission is back in its original position. Now design your motor mount to fill that space between the motor and the chassis.

There are two types of common motor mounts. One is a cradle that supports the motor around its middle, with a strap over the top. This is appropriate for a car with an in-line engine. This type of mount arrangement requires a torque rod to brace the motor against spinning in its cradle.

For a transverse engine car, use a plate which mounts to the anti-drive end of the motor and extends to a mounting bracket.

There are some bolt heads exposed on the case of the motor. Do not loosen these or in any way try to use them for your mount. They hold the field coils in place inside the motor, and they are installed at a specified torque. Loosening them will cause damage to the motor.

The original motor mounts are "metalastic" pieces. That is, they have a rubbery part enclosed in a metal frame. This is great for reducing vibration and noise, so you should use the same technology. Design your mount to attach to these mounts. If the original mounts aren't too misshapen, use them for your design phase, then buy new ones for the actual installation. If the original style of mount won't work, try to find another style from a different model of car at your auto parts store.

Keep it Clean and Cool

Keep the motor's commutator covered with a cloth or masking tape while you are working on the car, to prevent any tiny chips or debris from falling into it and damaging it. Normal road splash will not be a problem, but don't try fording puddles that might actually immerse the motor. A small amount of belly shielding is recommended, especially in areas where the roads are salted.

Be sure the shielding does not obstruct airflow for cooling. If it does, duct air from another area to the motor. Prestolite and G.E. motors should have an external cooling fan. This is not necessary on the Advanced DC motor.

The electric motor beautifully simplifies a car. If it is chosen, installed, and driven properly it will give many years of reliable, smooth, quiet performance.

Access

Shari Prange, POB 1113, Felton, CA 95018 • (408) 429-1989

Battery Rooms
— a cellular home

Richard Perez

Everything needs a home. Electrochemical cells are not any different from anything else — they need a home. And like any home it needs to suit its inhabitants.

Battery Housing Requirements

Electrochemical cells allow us to store electric power in reversible chemical reactions. A collection of cells is called a battery. Cells have very specific housing requirements for safe, efficient, and long lived service. Providing a good home for your battery is not difficult. Building a containment for cells starts with understanding the battery's requirements.

This information applies to small batteries located in battery boxes and large batteries housed in their own rooms. The battery containment is called a "room" here, regardless of the containment's size. The containment may or may not be within an existing building.

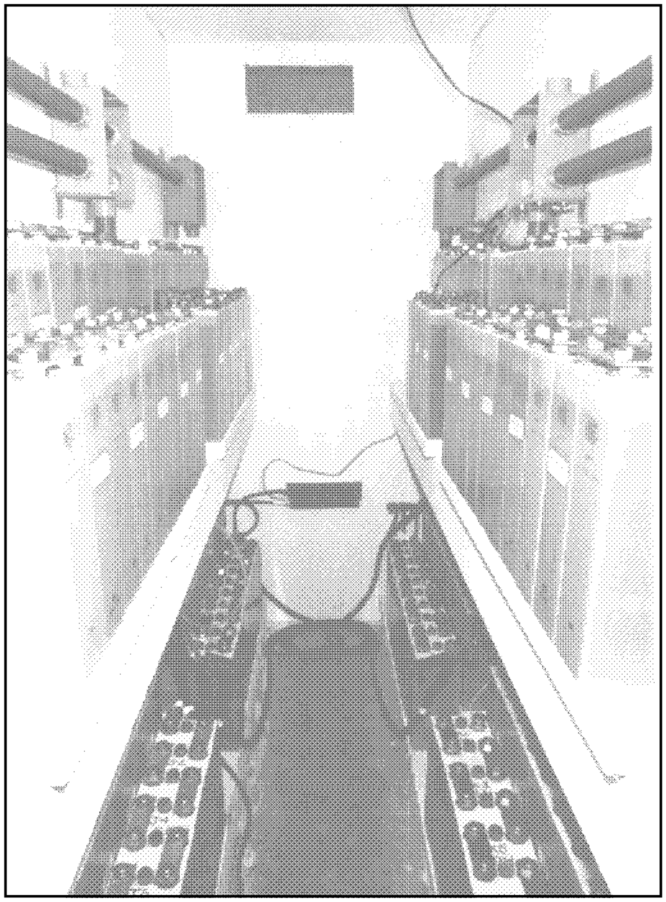
Much of the info here comes from building a battery room here at Home Power Central. We now house 160 nickel-cadmium cells in their own room. The main system's battery has 150 cells and the radiotelephone system has 10 cells. We learned much during this experience.

Location

The battery usually has one specific location in the system where it functions best from an electrical view point. The rule is to minimize the voltage loss in low voltage transmission lines. This means short low voltage wire runs and sizing the conductors properly.

From a human point of view, locate the battery away from areas where you spend much time. While a battery can effectively store power for us, we don't need to invite it into the living room.

The location of existing buildings and their ability to accept a battery room addition also determine the battery room's location.



Above: Home Power's battery room. Note the stair step shelves holding the cells.

In our case, we built our 7.5 foot by 3.5 foot battery room as an addition to our existing building's west wall. While this located the battery further from the PV arrays, it worked better from a human standpoint. The battery and inverter rooms are as far as they can get from our high traffic areas.

Security

The materials used within electrochemical cells are highly reactive. If they weren't chemically aggressive, then these materials would not store enough power to use in cells. Cells are inherently chemically nasty and must have a secure home away from living things.

Even a car battery can store enough power to be dangerous when short circuited. Many home power systems are now storing twenty times more power than a car battery. A short circuit can weld even a heavy wrench, burn the hand holding the wrench, and possibly touch off an explosion.

Protect your family and environment by giving your battery a secure home. This means a locked box or a

locked room. Mark the battery room door with a sign reading, "DANGER — Battery Charging Area — No Smoking." Children, animals, and casual observers must not be allowed easy access to your cells. Keep the battery room locked!

Safety Equipment

The following pieces of safety equipment must be inside, or next to, every battery room. This means even small systems with a battery in a small box.

Fire Extinguisher — Use an extinguisher rated to handle both wood and electrical fires. Size the extinguisher to match your battery size. We use a First Alert model FE2A10. This unit is rated A (for wood fires), B (for liquid or grease fires), and C (electrical fires). It is a dry extinguisher containing 4.5 pounds of Foray® pressurized with nitrogen gas. It is ozone friendly and large enough to deal with a large battery room. It cost $32 at a local discount store.

Smoke Alarm — Place a smoke detector in the battery compartment to warn you at the first sign of fire.

Rubber Gloves — Use elbow length, industrial thickness rubber gloves. Don't fool around with lightweight dish washing gloves sold in supermarkets.

Safety Glasses — Use safety goggles which fit around the face firmly and protect from splashes. These are under ten bucks at any hardware store.

Neutralizing Agents — Use a chemical to neutralize any electrolyte spills. Neutralization means adding a chemical to the electrolyte that renders it relatively harmless and stops it from eating holes in the floor. If you are using lead-acid cells, then keep baking soda (sodium bicarbonate) on hand. It takes two pounds of baking soda (sodium bicarbonate) to neutralize a quart of sulfuric acid electrolyte.

The most available, effective, and inexpensive neutralizing agent for alkaline cells (nickel-cadmium or nickel-iron) is muriatic acid (a 31% solution of hydrochloric acid in water). It takes slightly less than one quart of muriatic acid to neutralize one quart of spilled alkaline electrolyte. It takes over ten quarts of vinegar to neutralize a quart of alkaline electrolyte. Our local swimming pool supply store sells muriatic acid for $13.95 for four gallons. muriatic acid is dangerous in its own right and needs to be stored where it is safe. This means in unbreakable containers locked away from children. Be careful not to add too much Muriatic acid to the spill, or you will have an acid spill instead of a caustic spill.

Litmus Paper — Use litmus paper to determine if the electrolyte is really neutralized (pH 7). You can buy litmus paper at a well-equipped drug store or a chemical supply house. Litmus paper turns a red color in an acid and a blue color in a base.

Ventilation

When recharging, all types of cells evolve a potentially explosive mixture of hydrogen and oxygen. All battery containments must be ventilated. If you are using a battery box inside an existing structure, then provide a ventilation tube to the outside. If you are building a battery room, then provide an exhaust vent at the top of one end of the room. This vent moves air outside the building and may be either passive or active. If you add a fan to exhaust the battery room's air, then use a fan with a sparkless motor. See Amanda Potter's Homebrew in this issue for a detailed discussion of Home Power's battery room fan setup.

If the battery room has a door into the building, then arrange the venting so that the battery room sucks air from the building and exhausts this air to the outside. This assures that battery room vapor winds up outside instead of inside your home.

Temperature

Electrochemical cells don't like it too cold or too hot. Ideally all the cells we are likely to use in a home power system want to operate at 78°F. If lead-acid cells are operated below 32°F, then they lose effective capacity and efficiency. While alkaline cells have a much lower operating temperature range (-50°F), they too are happiest at room temperatures. All cells also dislike operation at temperatures above 120°F.

The bottom line is some degree of temperature control in a battery room. Insulation is a very good idea. Provide some form of winter heat input. In our case we insulated the exterior walls, floor, and ceiling of our battery room to R-19. We did not insulate the interior wall. Our main building loses heat into the battery room during the winter which keeps the cells warm. During the summer's heat, the cells have their own insulated room which is the coolest place in the building. There are over 3,000 pounds of cells in a very small insulated space. Our battery room contains a tremendous amount of thermal mass in relation to its highly insulated volume.

If the battery room is a stand alone building, then consider solar heat. A superinsulated (R-40+) building with adequate solar access can keep lead-acid cells from freezing in most locations. The cells themselves act as thermal mass. Superinsulation keeps in the solar heat received through double glazed south facing windows.

Since a battery shed is not large, neither is the price tag for a superinsulated building with a couple of high tech windows.

Electrical Networking

The reason we have assembled all these cells together is to store electrical power. Here we are at the mercy of Ohm’s Law and topology. From the standpoint of networking electrons, we need to provide all cells with equally low resistance electrical paths. Working against cell electrical equality is the physical universe. If the battery contains many cells, then not all cells can possibly have the same length electron path (i.e. wire resistance).

If you are not familiar with the series and parallel connection of cells, then see the article “Battery Basics” in HP#27, page 30. Series connection means connecting the negative pole of a cell to the positive pole of another cell. Parallel connection means connecting the positive pole to positive pole and negative pole to negative pole.

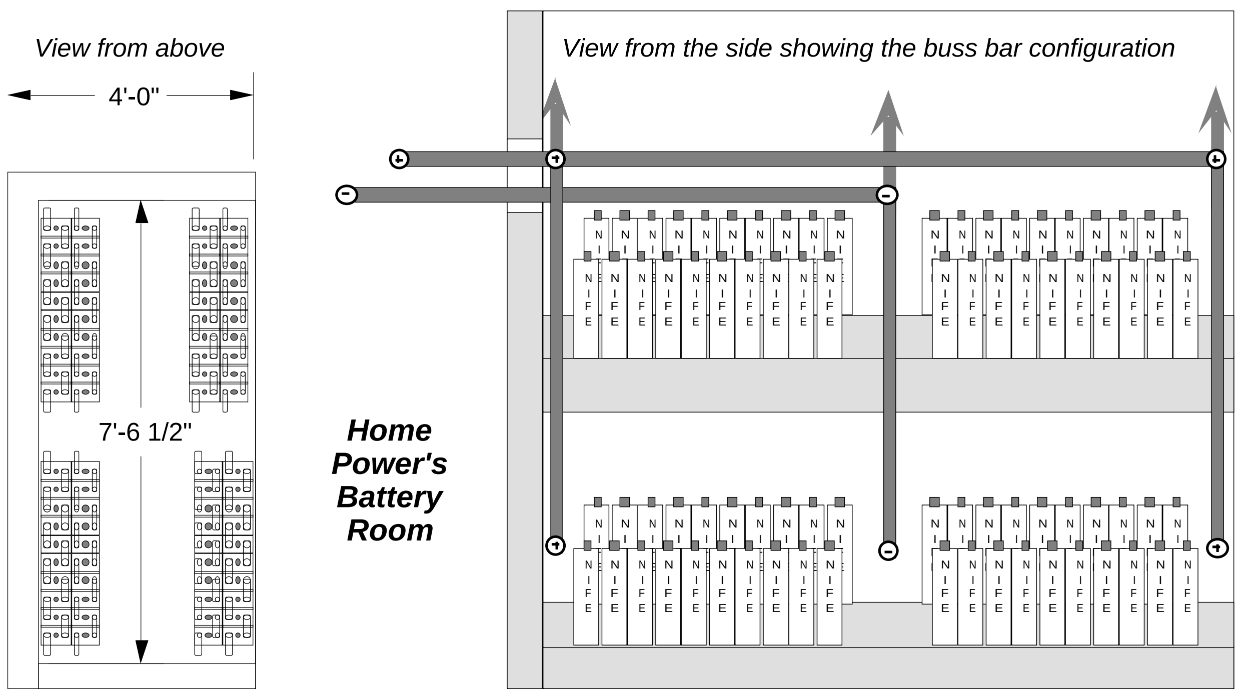
Cells are connected by series wiring into strings to increase the voltage of the resulting string. For example, a lead acid cell has a nominal voltage of 2 Volts. By wiring six cells in series, we get a resulting battery with a voltage of 12 Volts (2 x 6 = 12). While adding cells in series increases the voltage of the battery, adding cells in parallel increases the capacity of the the resulting battery. Both series and parallel wiring techniques are used in most large batteries. Our battery here at Home Power is composed of 150 nicad cells. Each cell has a nominal voltage of 1.2 Volts. Each cell has an electrical capacity of 100 Ampere-hours. We wire ten cells into a series string to obtain a 12 Volt string. We make fifteen of these ten cell series strings and connect them in parallel to form a battery of 1,500 Ampere-hours at 12 Volts.

Each cell has three physical dimensions and two electrical connections. In some types, like 6 Volt lead-acid batteries, several cells live in a single case. Every type, has specific dimensions and two electrical terminals.

What we have here is a classical problem in network topology. And what’s worse, it’s different for every collection of cells. Our case is a classic example. We had to series connect ten cells to make a single 12 Volt string. The NIFE cells we are using come with factory made cell interconnect buss bars and nuts. This setup works only in one configuration, a line of cells each with its longest side flat against the next cell. This means that we had fifteen of these ten cell strings (about three feet long, eight inches wide, and one foot tall) to parallel connect.

Add to this electrical networking topology problem the physical requirements of our existing building. The only side of the existing building available was the west side. The west side addition was limited to four feet in width by a large old Black Oak.

Every application is different. What I am trying to communicate here are the design concepts involved in planning and building a battery containment. It is up to you to apply these concepts for your specific situation.



Home Power's Battery Room

Cell Configuration
Here is a diagram that shows the basic configuration we used to connect our cells within our battery room. Please note that we designed the room as a walk in with cells along both sides. The resulting room offers just enough working space for one person. Ideally the cells should have been clustered as a block in the center of the room, but there just wasn't enough room to do this in our case.

Stair Step Racks
Stair step racks make it easier to check the electrolyte levels and to service the cells. The stair step racks also provide vertical separation for the side by side strings of cells. This separation means less danger of short circuit if a tool is dropped on the cells.

Battery Room Size
The size of your battery determines the size of the room. If you are using two golf cart batteries, then the room could be a plastic picnic cooler. These coolers make excellent enclosures for small systems. A bigger battery requires a bigger room. Our battery room occupies just under 200 cubic feet of space. A little engineering on configuration of the cells and their connections will make a smaller enclosure. Be sure to allow enough room for maintaining the cells. Make sure that the floor can handle the weight of the battery (ours weighs over 3,000 pounds).

Buss Bar & Cables & Connections
Copper buss bar makes networking large collections of cells easy and efficient. Each series string of cells is connected to the buss bar by short (less than 1.5 foot) #00 gauge copper cables with soldered ring terminals. The copper buss bar is 6 feet long, 1.25 inches wide and 1/4 inch thick. This size bar will just slide into 1.5 inch diameter plastic conduit. Our battery room used about 60 feet of copper buss bar to make the parallel connections. Our design called for walking through the middle of the battery. We used six #00 copper cables to connect the left banks of cells to the right bank of cells. These heavy cables run up the wall and across the ceiling. Every ring connector used in a battery room should be soldered to its cable. Anything else is just temporary.

Power Processing Area
When designing a battery room be sure to include an adjacent power processing area. Here the inverters, distribution panels, and controls can be close to the battery and away from humans. We ran the buss bars through the battery room wall and into the adjacent power processing room. Here the buss bars bolt directly to the DC power distribution center (in our case an Ananda Power Center IV).

A Happy Home…
A battery needs a secure, warm, low resistance home. After years of cells in our living room, I'm sure glad they now have their room. They are happier and so are we.

Access
Author: Richard Perez, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

Tech Notes:

Battery Interconnects

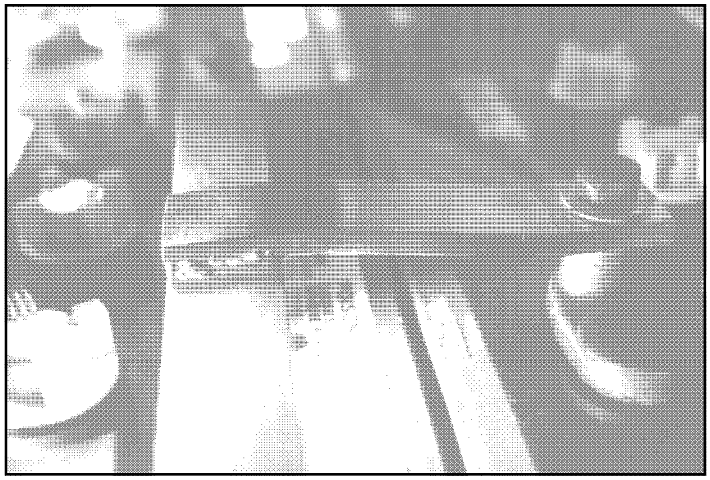
George Chase

The wire interconnects of a battery bank in an alternative energy system have numerous possibilities for energy loss. After seeing the article in HP #30 on Home Power's neat installation of a new alkaline battery bank, I decided a new approach to my battery interconnect cables was due.

The old system: wire interconnects
Most of us cannot afford an alkaline battery bank. We usually rely on six Volt lead acid golf cart batteries. My battery bank consists of eight 6 Volt batteries wired in series-parallel with cross-wiring. Cross-wiring helps maintain an even state of charge between the batteries in the pack by providing a parallel path for current. The eight batteries has sixteen posts.

Back in HP #7 were instructions for making your own battery cables. I followed Richard's advice and made my own also. The process took me a long time but when finished, I felt the cables would last the rest of my life. Today those cables are as good as the day I made them but I could tell by monitoring that all my batteries were not being treated equally. I got tired of trying to keep all those connections in good condition.

New connections with copper bar
To reduce as much resistance as possible from the battery bank, I decided to try a solid bar system. I got some solid copper bar (1 inch by 1/4 inch by 12 feet) and made a battery interconnect system that cuts the resistance points to the lowest possible number. It also makes maintenance a snap, and looks great!



Above: Soldered buss bars lower resistance and simplify maintenance in batteries. Photo by George Chase

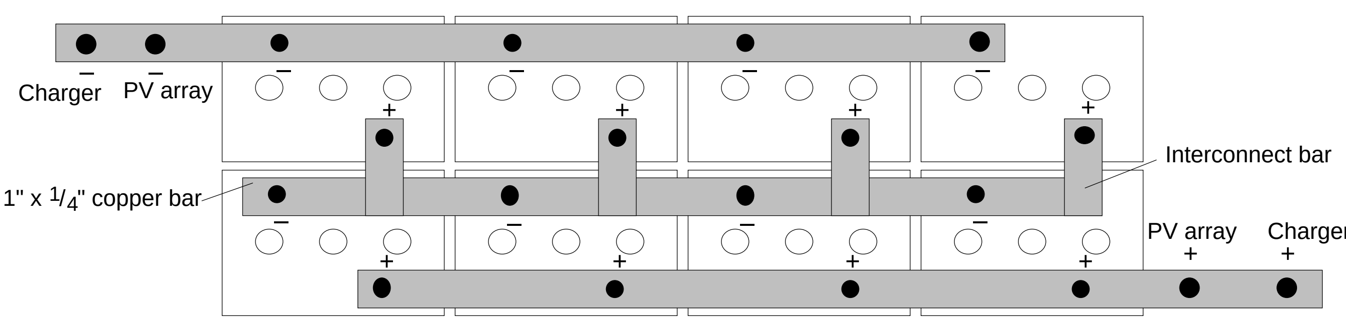
Here's what I did:

1. Place the batteries in proper position, (positive leads in straight line and negative leads in straight line.) See diagram below.
2. Cut bar to proper length allowing room for connections of the PV array and backup charger on the positive and negative bars.
3. Measure distance between posts (center to center) and drill holes in bar.
4. For the offset connections I cut the short bars to size and soldered them to the long bar first. Then I measured and drilled the holes. See photo above.
5. Tin the side of the hole that will make contact with the lead post.

You need to protect the metal from accidental shorts from wrenches or other tools that might touch them. I priced "heat shrink" tubing but it proved too expensive. I bought liquid electrical tape at the hardware store in a can with a brush cap. You just paint it on where needed.

This system has been in use for about six months now and is a pleasure to maintain. Once a month I remove the bar, polish connection points with steel wool, read and

Eight 6 Volt DC golf cart batteries connected in series-parallel and cross-wired with copper buss bar



record the voltage of each battery, and replace the bar and add grease to all areas not rubber coated. All this takes about 5 to 10 minutes. Then I apply a 3 hour freshening charge to the bank with my backup charger. This gets a good bubbling action going to remove the sulfate from the plates.

An equalizing charge should be applied if voltage varies by 0.05 Volts from 2 Volt cell to 2 Volt cell. Since on most 6 Volt batteries it is not possible to measure from cell to cell, an equalizing charge should be applied if voltage varies by 0.10 Volts from 6 Volt battery to 6 Volt battery. So far the voltage of each of my 6 Volt batteries has remained within 0.01 Volts of each of the others.

It took me about 5 hours to make the system which cost about $60. The cost is a little more than making cables out of large wire but the ease of maintenance and equal power distribution should far offset that cost in longer battery life. The copper bar could be reused on future batteries or even different batteries by soldering in the holes and redrilling new holes if necessary.

It works great! I'm more than satisfied.

Access

George Chase, 1183 Girl Scout Road, Arcadia, FL 33821

Utility Intertie Systems: Part 2

Mick Sagrillo

Connecting a renewable energy system to the grid entails dealing with that RE arch-enemy: THE UTILITY. However, if you know how to approach your utility, and how to prevent them from taking advantage of you, it can make for an enjoyable, long-lasting relationship.

In Part One of this article (HP #32), we looked at PURPA (the federal law regulating utilities and co-generators), intertie equipment, utility requirements, avoided costs, and the advantages and disadvantages of utility intertie systems. Now we'll address how to deal with your local utility, metering options, and buy-back options and rates.

Your Utility

Contact your utility before even considering buying a utility intertie renewable energy system. You may purchase equipment only to find that your utility's interconnect requirements are too stringent for you to meet, or their buy-back rates are ridiculously low. Then you have equipment that won't be used in a grid intertie system, and that you may not be able to use in a stand-alone system which utilizes batteries for storage. Now what?!

While I know of people who have connected RE systems to the grid without their utility's permission, I consider this a foolish venture. By law, any utility has the right to disconnect a co-generator who is backfeeding into their grid without meeting their requirements. Some of these people have been ignored by their utility. Some have not. Others have been disconnected from the grid, with no recourse.

Anyone who has ever tried to interconnect to the grid can vouch that their utility was the most formidable hurdle to cross in their entire RE experience. Utilities are veritable catacombs of bureaucracy, rivaled only by the IRS. However, like most computer maze games, there is a key player. Your job is to find that person!

In all likelihood, there is no one specific person in the utility who deals with permitting wind generators or PV arrays for grid intertie applications. Subsequently, no one wants to make "that crucial decision." In addition, there are lots of "old wives tales" circulating around the utility hallways about linemen being electrocuted by runaway wind generators and other such nonsense. However, you could get lucky. Your utility may have done a wind or PV demonstration project sometime in the past. If that's the case, try to find out who the project director was and start with him/her.

Hydro and biomass generators are a different story. Hydro has been used by utilities since their inception, and many utilities still operate their own small hydro plants. Biomass generators are typically associated with big industries, such as paper mills, pulping facilities, saw mills, and wood products manufacturers. Quite often, these large industries will generate a certain amount of their electricity by burning wood, pulp, and paper wastes. Because of possible prior utility experience, permitting should be easier if you co-generate with either of these technologies.

Making Contact

It may help to call the Public Utility Commission in your state before contacting your utility. The Public Utility Commission is the state regulatory agency charged with overseeing electric, gas, and/or water utilities. Find out who in the agency handles questions concerning RE technologies and co-generation. These people should know the permitting process for the various utilities under their jurisdiction, or at least be able to put you in touch with someone who does.

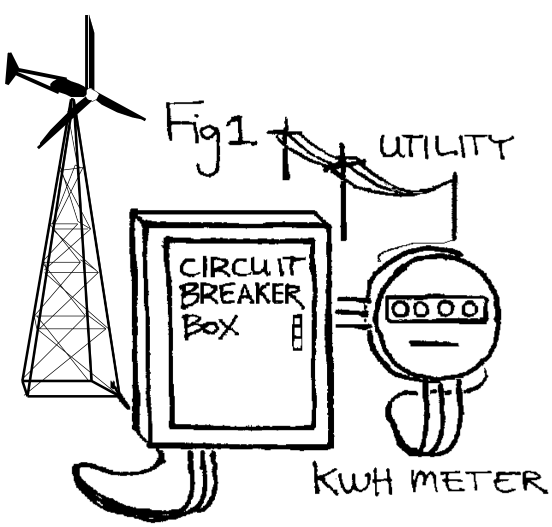
When you finally do contact your local utility, be a name dropper. Mention that you have been in touch with the Public Utility Commission and who you have dealt with there. This lets your utility know that you have done your homework. Try to find out who in your utility will review your plans and who is responsible for making the final decision concerning your interconnection. Deal with that person only. Do not let the utility trap you in a frustrating bureaucratic shuffle.

Your utility will likely request block diagrams, electrical schematics, or blueprints of the proposed installation, including a diagram of the site with component placement. Be very prepared! If you can't answer a question, admit it, then go out and get the answer. Do not expect them to do your homework. Your project is not their priority. Utilities are not interested in researching a project they are probably skeptical about in the first place.

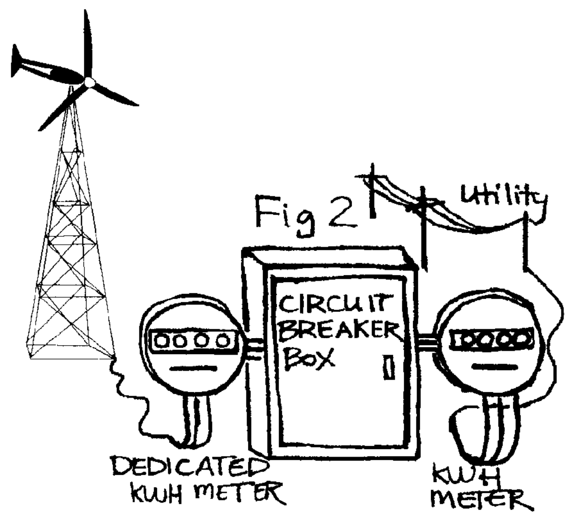
Let your utility know that you expect to be treated respectfully and expediently. Delaying tactics are their forte. Set a time schedule that you can both live with, then hold them to it. However, keep in mind there is no bigger turn off than having to deal with an arrogant know-it-all. While you may be in the right, they are a lot bigger than you are, with much more legal expertise. Your utility can make your permitting process either very easy or unbelievably difficult. They not only have all the marbles, they've also got the bag, and they know it! Few homeowners have the resources to challenge a utility in court. Your best bet, in the case of irreconcilable differences is to work closely with the Public Utility Commission.

Metering Options

There are two basic metering options available to the utility. The first is to use just one kiloWatt-meter for your home and RE installation (fig. 1). When you are consuming more electricity than you produce, your kiloWatt meter runs forward, as it normally would. When you are producing more electricity than you are consuming, your meter will be running backwards. By allowing your meter to run backwards, the utility is basically paying you the same for your electricity that you pay for theirs: the retail rate. The utility will just bill you for whatever electricity you use on a monthly basis, plus the meter rental and reading charge. This is called net billing, and is the best buy-back you can hope for.



The other metering option that the utility has is to install a second kiloWatt-hour meter. This meter is installed so that it is dedicated to the generating device (fig. 2). In this situation, both meters would be ratcheted; that is, they will move in one direction only and cannot run backwards. Because the utility can now monitor your production separate from your consumption, they are able to differentiate between the two. This is where the problems can arise. The utility may begin by offering to pay you the retail rate for your electricity, then later pay only the wholesale rate for your kiloWatt-hours. Or they may offer to pay only the wholesale rate from the start. Additionally, the utility will bill you for the meter rental as well as reading that second meter on a monthly basis. It is in your best interest to convince the utility that only one meter is necessary.

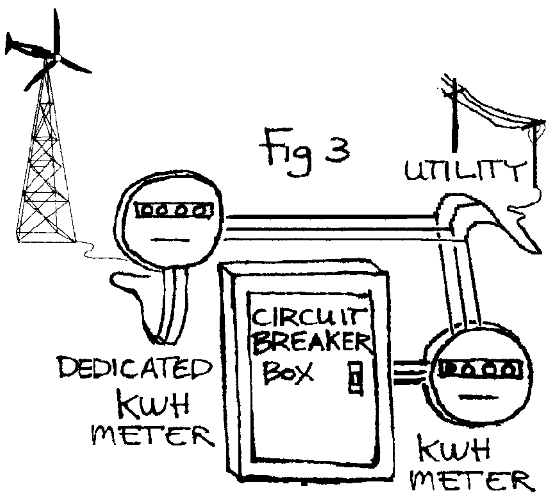


If the utility does install a second meter, be very careful as to the placement of that meter. The correct connection is shown in fig. 2. I have seen utilities wire the second meter as illustrated in fig. 3. It may be a subtle difference, but let's examine the two configurations more closely. In fig. 2, the second meter is on your side of their primary kiloWatt-hour meter. In other words, you are deferring the purchase of their kiloWatt-hours with your own. Even if they pay only the wholesale rate for excess production, you are still reducing the number of retail kiloWatt-hours that you have to purchase.

In fig. 3, the second meter is wired on their side of the primary meter. In this case, the utility is purchasing your kiloWatt-hours at a wholesale rate, only to turn around and sell them immediately back to you at the retail rate. At a handsome profit, I might add. A nice business, if you let them get away with it!

Buy-Back Rates

Once you have jumped through all of the hoops, it's time to negotiate what the utility will pay you for the excess electricity you will be producing. Negotiation of buy-back rates is extremely important for you, the independent power producer. What the utility pays you for your



electricity directly affects the economics of the entire installation.

Net billing is the most desirable buy-back, because it means that the utility pays you the retail rate for your excess production. Here in Wisconsin, any RE installation of 20 kiloWatts in capacity or less is eligible for net billing. According to Mike Bergey, president of Bergey Windpower Co., there are eight states, besides Wisconsin, that offer net billing. These are include Connecticut, Iowa, Maine, Minnesota, New Hampshire, Rhode Island, Oklahoma, and Texas. In those states, the Public Utilities Commission have mandated net billing for all of the utilities operating within the state.

If you don't live in one of these states, don't give up hope of net billing. Individual utilities may allow net billing, even though they are not required to do so by the state Public Utilities Commission. For example, Bergey says that Southern California Edison also offers net billing, but you have to ask for it.

At the other extreme, you may be offered only the wholesale price for your excess electricity. Note I said "excess" electricity and not "the electricity you produce." This may seem like I am splitting hairs, but remember who you are dealing with: a rather slick, large corporation who has been granted a monopoly in a given service territory. "Excess" means just that: the kiloWatts you produce over and above that which you consume. Don't let the utility beat you down on this one. You cannot go to a competitor for the same product, as is possible with any other non-utility purchase that you make.

The worst case scenario (Fig. 3) is that they may want to pay you the wholesale price for everything you produce. By buying at retail and selling your production at wholesale, you are in effect paying a premium for the privilege of connecting your RE system to the grid. Why should you pay extra because you are using less of their product? If you replaced a kiloWatt guzzling refrigerator with a high efficiency model, would they charge you more? Of course not! As a matter of fact, they would call this approach to electricity consumption a "demand-side reduction." The argument can be made that there is little difference from the utility's perspective whether you reduce your consumption through energy efficiency or "grow your own."

So, if you wind up on a wholesale rate, make sure that the rate only applies to excess kiloWatt-hours. If this is your situation, you will want to size the RE installation very carefully so that you are not over-producing. This is far easier to do with technologies, like hydro or a biomass generator, that have the ability to run at 100% capacity factor, that is at maximum output. Because wind and solar resources are affected by erratic weather patterns over which we have no control, the systems are usually oversized. While there are daily and seasonal resource availability patterns, you have little control over the monthly production of electricity.

While all of this may sound trivial, consider the following. Mike Bergey has testified that some utilities charge from 12 to 19 cents per kiloWatt-hour while paying only 1.3 cents per kiloWatt-hour for electricity generated by a wind system. The payback period for those wind systems is 10 to 15 times longer than the payback period when one is offered net billing. If you find yourself in this situation, work closely with your Public Utilities Commission. They may be able to exert some pressure on the utility.

Buy-Back Options

If your utility balks at paying you for your electricity, get creative. You don't necessarily need money. For example, in my situation, the utility does not send a check each month. They issue a credit to me for my wind generator's production. This works out great for us because of the seasonal nature of our wind resource. Nine months of the year, the wind blows fairly continuously. However, during the summer months, the air is virtually still. No fuel! Ah, but I have credit built up from the previous fall, winter, and spring. We just use that credit up over the summer. No money changes hands, yet everyone is happy.

In fact I actually make out on the deal in two ways. First, if our utility sent a check for nine months, yet got the money back over the summer, I would be making income in the eyes of the IRS. I would have to pay taxes on that income. But the utility is issuing credit in kiloWatt-hours

over the winter, then collecting those same kiloWatt-hour credits over the summer. No taxes! Better than money!

Second, the cost of electricity is higher in summer than in winter due to higher demand placed on the utility by the air conditioning load. Also, the price of electricity is always increasing due to inflation and higher utility operating and fuel costs. Since I am issued credits, the value of my kiloWatt-hours increases too. Again, better than money!

Getting Creative

So, at least one rate payer has been able to snooker The Utility. Here's another idea that I would like to try this summer.

Our usual retail rate is about seven cents per kiloWatt-hour (kWh). However, because of high air conditioning use during the summer, our utility began offering Time Of Use (TOU) rates last year. Billing works like this: if you go on TOU, the utility will charge you more during daylight hours in the summertime than at night for the electricity you consume. From 8 AM to 7 PM, TOU customers pay 12 cents per kWh. The rest of the time, TOU customers are charged only three cents per kWh. The idea behind this scheme is to dissuade customers from using their air conditioners during peak industrial and business hours. It works! Customers on TOU become very conscientious about when they use electricity-guzzlers like air conditioners, water heaters, and dryers.

Coincidentally, those hours perfectly match peak solar hours for PV production in Wisconsin. I have a friend, who lives in an all-electric home, who is a TOU customer. We'd like to install a 1 kW PV array, just to see how the utility reacts. I'll keep you posted.

In the meantime, do any of you readers out there have any experience with creative utility intertie installations involving hydro or biomass generators? Or wind, or PV, for that matter. Write to Home Power and share your ideas and experience with us.

Access

Author: Mick Sagrillo sells electricity to his utility at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

Water Wells

Richard Perez

What do you do when the creek stops running and the springs go dry? Drill for water! Drilling a water well is a cross between praying in church and high stakes poker in Las Vegas. Drilling is a high stress, big risk undertaking. Here's how to avoid some of the potential mistakes.

The Rules
The rules of the well game are simple. Pick a well site, hire a driller, pay lotsa money, and hope to hit enough water. If the well produces enough water, then you win and can go immediately to the pumping/storage stage. If the well is dry, it still costs the same to drill as a wet hole. The only option is to drill again in another site.

Once the well comes in, then the water must be pumped from the well. Basic physics determines the rules of water transfer from well to usage point. In this area, we stand a fighting chance of seeing our work and money realized. Every well, water system, location, and water need is different. I am interested here in not making expensive mistakes during the potentially disastrous drilling phase.

Determine your water needs — how many gallons a day do you need? An idea of how much water you need and your checkbook are the only things you need to start.

The Well Site
Find and use all the data that you can collect about water wells in your area. Any close neighbor with a water well can provide valuable information. Wells are registered in most counties. These records are public. The big questions are how deep and how much water. Some folks use a dowser to locate water. I have no hard knowledge about their veracity, but I figure well drilling is a gamble and data is data. Take a good look at your local terrain. Wells on hilltops are generally less productive and deeper than wells in canyons.

Unless your area has a history of artesian (naturally pressurized) wells, a pump will be necessary. The location and depth of the well, specifically the entire vertical distance that the water must be pumped, directly determines the cost of the pumping system. The higher you have to pump the water, the more the pump will cost and the more power it will consume.

Pumping the well is not the determining factor in locating the well. Finding water is the idea here — finding enough water at a depth that is both affordable to drill and pump.

Finding a driller…
Most counties require a permit to drill any type of well. Without this permit, no licensed or bonded operator will drill your well. The first question any driller asks is, "Do you have a permit?" Cost is about $50. The permit has minimum specifications for the proposed well. For example, most counties exclude ground water from the well. This means a steel casing from ground level to a depth of 25 to 50 feet.

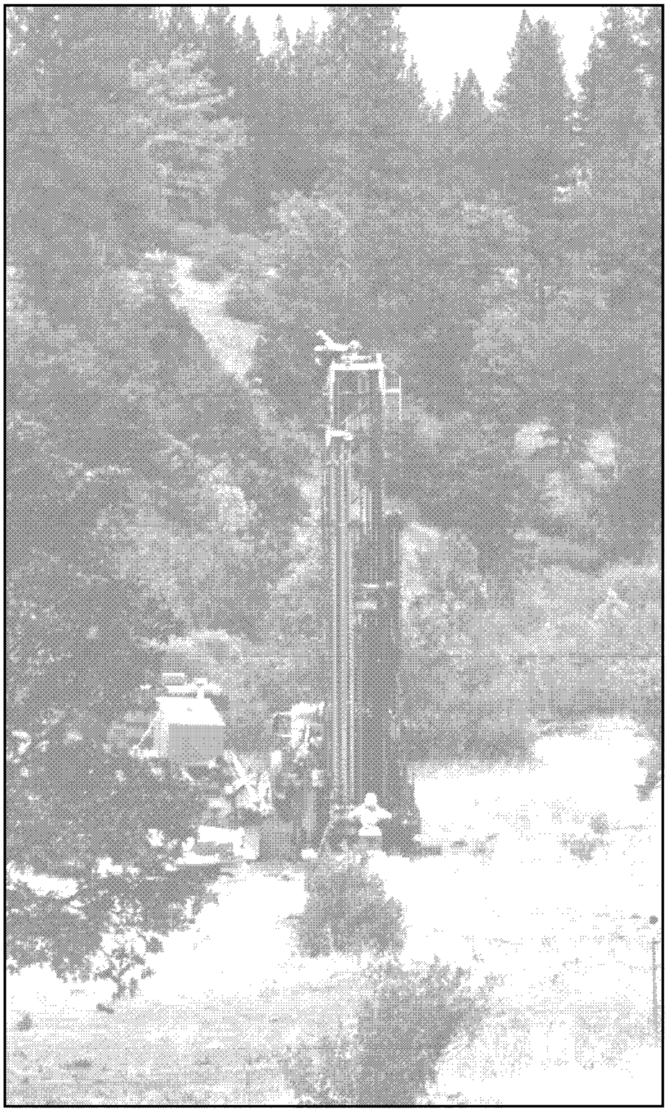
Discuss your specific well plans with a number of local drillers. Ask your neighbors what company drilled their wells and were they happy with the driller. Check the Yellow Pages. The driller will want to know what diameter well you want, how you want the well cased and lined, and where you want it drilled. Most drillers work this way. The following info pertains to a six inch diameter well, lined with 4 inch diameter poly pipe. A 4 inch diameter liner is the smallest that will accept a solar sub pump.

First there is a setup charge for moving the drilling equipment to your site and setting it up. This fee varies greatly with location. If you live miles from town, or down a bad road, then the setup cost is considerable. Look for setup costs from $200 to $1,000. The next item is drilling the hole at $12 to $20 per foot. These charges happen even if the hole comes up dry.

If the hole is wet, then it is a well and must be cased and lined. Steel casing costs about $7 per foot. Most wells are lined for their entire depth at a cost of about $3 per foot for poly pipe.

Prepare yourself
Before beginning to drill plan a firm budget for the well. Set a maximum amount to spend on drilling and be firm. Don't forget to budget the cost of setup, casing, and lining. You are entering a space and time that is more risky and seductive than high stakes poker. The temptation to drill another hundred feet is virtually irresistible.

Drilling the Well
The permits are stamped and the drilling rig is in place — the game begins. Tell your driller how deep you want him to go before beginning. The drill's speed depends on what it encounters. In general, slow drilling below fifty feet is



Above: a drilling rig in place. Photo by Richard Perez

good news. It means the drill has encountered hard rock. Water is often found at hard rock boundaries.

You have done your work; the rest is luck, or karma, or whatever. This is a good time to relax. Try not to constantly check how the well is going. Try not to think that each dry foot has cost about twenty bucks and you still don't have a drink of water.

At a certain point, even on a high budget it becomes prudent to go no deeper. Today's solar powered submersible pumps work well up to 250 feet in depth. Solar powered jack type pumps can go 800 feet deep. Conventional 120 vac or 240 vac submersible rotary pumps will pump at 500 feet depth. If you reach these depths, still have a dry hole, and have some drilling budget left, then drill again elsewhere.

The Water System

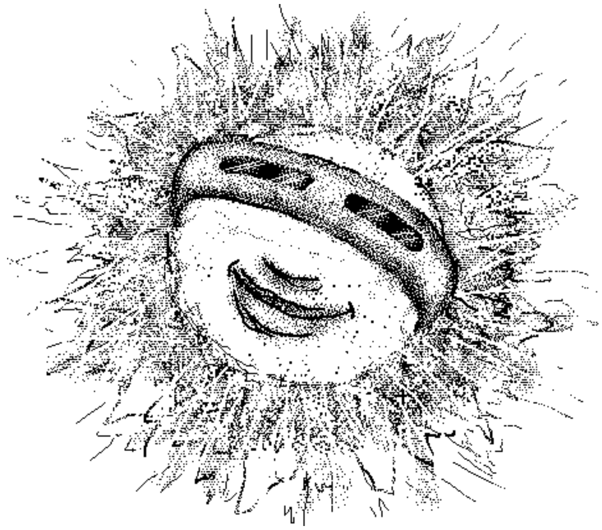
A well is only part of the working water system, the most important part, but still only one part. Water still must be pumped from the well. In solar pumping systems, the water is almost always stored in a holding tank. And if the tank has insufficient elevation, then a booster pump may be required. But all this can be accomplished with a high degree of certainty. The gambling is done.

Take Heart!

We recently drilled a well. When the driller quit for the weekend with a dry hole at 240 feet, there was little joy here. Monday morning and sixty feet deeper, we cheered a flow of 10 gallons per minute from the well. Total cost? A shade over six thousand dollars and easily the best money we ever spent.

Access

Author: Richard Perez, c/o Home Power, POB 520,
Ashland, OR 97520 • 916-475-3179



Home Power's 2nd Annual Solar Cooker Contest

¡WIN! ¡WIN!

1st Prize — a Solarex MSX-60 PV Module
2nd Prize — Choice of a PowerStar POW200 Inverter or a Solarex MSX-10 Lite PV Module
3rd Prize — Solar/Dynamo-powered AM/FM Radio

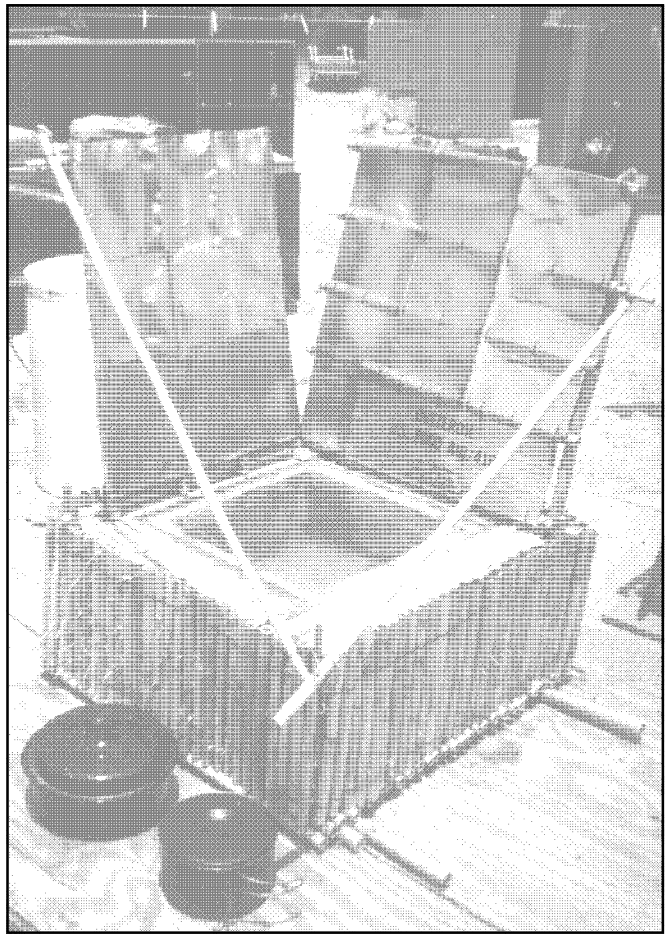
Two centuries ago a Frenchman, Horace de Sassure, built a small insulated box and put it in the sun. This was the first recorded effort to cook with sunlight. Now it's time for you to do your bit! Home Power announces its Second Annual Solar Cooker Contest. Help all of us put the sun's energy to work.

Solving problems with the sun

With a solar cooker you can cook without fuel. Directly collecting the sun's radiant energy with a solar cooker is simple and pollution free.

What we need are designs which are easy to build, use inexpensive, easy-to-find parts, and work well. Designs should fit your climate. For example, in tropical climates the solar cooker must survive rainy seasons without taking up inside space. The cooker must fit the needs of the people and use readily available materials.

The challenges facing solar cooking are more than just a good design that cooks the beans. History has shown that social acceptance is the biggest hurdle to overcome. We need some innovative ideas that make solar cooking an everyday occurrence.



A solar history

Solar cooker design and improvement began in earnest in the 1950s by scientists and engineers of the United Nations. Even then, the need in communities for an alternative to using wood for cooking fuel was a growing concern. The U.N. conducted studies in the '50s and early '60s and found that solar cookers were not widely accepted in developing countries because people would not easily change their traditional cooking methods. Experience in the U.S. has shown that over-developed nations are also slow to change their cooking habits!

In the '70s and '80s, solar cookers experienced a revival of interest in this country. The back-to-the-landers, seeking a simple lifestyle, spawned a plethora of publications which included solar cooking.

Now, in the '90s, many people all over the world are embracing solar cookers as an environmentally safe way to put hot food on the table. There are an estimated 10,000 solar cookers in use in the U.S. today. It isn't difficult. We insert our dinner in the morning, adjust the cooker to catch the noon sun, and return in the evening to cooked food.

Now it's your turn
What can you come up with? The more people who work on a solution, the faster a problem will be solved. So, go sit in the sun, feel its warmth, and be inspired to turn your energy into goodness for all.

Goal: Design and build a working solar cooker that is simple to make, inexpensive, and is easy to use.

The Rules

1. Within the bounds of the four main criteria, (works great, simple, cheap, and easy) you may use any building materials you like. Keep in mind that ultra high tech may work great, but high tech materials are often made from unobtanium and not cost effective.

2. Your cooker must cook. It must reach at least 212°F (100°C) on a sunny day. Interior volume should be large enough to simultaneously cook 1 cup of dry beans and a 1 cup of rice.

3. Design, build, and test your solar cooker. We will not accept designs that have not been actually constructed and tested.

4. Send the plans for your cooker to Home Power Magazine by July 1, 1993. Plans must include a photograph(s) of your assembled cooker and data on how long it takes your cooker to boil one quart of room temperature water (70°F [21°C]). Plans should be clear and complete.

5. Designs will be judged on (1) performance – how well it cooks, (2) buildability — use of materials, skills, and tools commonly available, (3) ruggedness, and (4) beauty of design.

6. Although some materials are easy for you to obtain, they may be difficult to find elsewhere. We reserve the right to use similar materials where necessary. You have the option of sending us your finished model if you think we will be unable to fulfill its material requirements.

7. The top five final designs will be judged by the Home Power Crew. If you are a finalist, we will notify you by mail. All entries will cook the same meal in same amount of time during the Cook-in. We will build a cooker from your plans and use it in the Cook-in. You are invited to bring, or send, your cooker to us at 19101 Camp Creek Road, Hornbrook, CA 96044.

8. Winners will be chosen by the Home Power Solar Cooker Contest Judges at the Solar Cook-in and Potluck. This will be July 30 & July 31, 1993 at Pacific Power and Light's Camp Creek Recreation Area on Iron Gate Lake, 14 miles east on Copco Rd from Hornbrook, California. The plan is to build the cookers on Friday and hold the cook off on Saturday between 10 am and 4 pm.

First prize is a Solarex MSX-60 PV Module. Second prize is the choice between a PowerStar POW200 inverter or Solarex MSX-10 Lite PV Module. Third prize is a solar/dynamo-powered radio. You need not be present to win. Employees of Home Power and their relatives are not eligible to enter. All designs become the property of Home Power. The winning design will be featured in an article in Home Power Magazine. Home Power promises all entrants that these designs will only be given away and never used for commercial purposes. This Solar Cooker Contest is for our planet, not for bucks!

So get off yer buns and start solar cookin' now!

Access
Send solar cooker entries to:
Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-3179

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The following information regarding your usage of alternative energy will help us produce a magazine that better serves your interests. This information will be held confidential. Completion of the rest of this form is not necessary to receive a subscription, but we would greatly appreciate this information so we may better serve you.

FOR OUR PURPOSES WE DEFINE ALTERNATIVE ENERGY AS ANY ELECTRICAL POWER NOT PRODUCED BY OR PURCHASED FROM A COMMERCIAL ELECTRIC UTILITY.

I NOW use alternative energy (check one that best applies to your situation).

☐ **As my only power source**
☐ **As my primary power source**
☐ **As my backup power source**
☐ **As a recreational power source (RVs)**

I want to use alternative energy in the FUTURE (check one that best applies).

☐ **As my only power source**
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☐ **As my backup power source**
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My site has the following alternative energy potentials (check all that apply).

☐ **Photovoltaic power**
☐ **Water power**
☐ **Wind power**
☐ **Other**

HP#33

I now use OR plan to use the following alternative energy equipment (check all that apply).

NOW	FUTURE		NOW	FUTURE	
☐	☐	**Photovoltaic cells**	☐	☐	**Gas/Diesel generator**
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Sun Communications

William A. Gerosa - N2RSV

After completing and defending my thesis entitled "The Economic Feasibility of Photovoltaic Implementation", I wanted to step out of the academic circle and get my hands dirty. I wanted to construct an actual system that proved some of the tenets put forth in my writing. I assembled a solar-powered amateur radio communications system. This system allows conversations with friends and family whether they are at home, in the car, by the pool or miles from the tether of a telephone. The best part is that my setup is completely powered by the sun. The system, and its power source, is a one time investment and there is never a "per call" charge.

The System

The heart of the setup is an Alinco DJ-580T 2 Meter / 70 Centimeter portable transceiver connected to a 35 Watt RF Amplifier made by Communications Concepts. The antenna is a Cushcraft AR-270 quarter wave ground plane mounted on a housetop approximately 40 feet above the ground. Power is supplied by two 10 Watt amorphous silicon panels sold by Pak Rat Electronics. The two amorphous panels charge a Sears (#96522) deep cycle marine battery through an 8 Ampere charge controller (#20-210) sold by Pak Rat Electronics. The battery is capable of holding 115 Ampere-hours. This storage capacity is more than adequate.

Power Consumption

The Alinco transceiver consumes 95 milliAmperes when squelched, utilizing battery saver mode and waiting for a signal. I leave my system on 16 hours a day so this works out to be: 0.095 Amperes x 16 hours = 1.52 Ampere-hours per day for the receiver. The Alinco draws close to 1.5 Amperes when transmitting at high power. This is close to 4 Watts at just under 12 Volts. I rarely talk for more than one hour in a twenty-four hour period. This would be one-half hour of transmitting assuming a 50/50 ratio of talking to listening.

The figures are: 1.5 Amperes x .5 hour = 0.750 Ampere-hours per day for the transmitter. The RF Amplifier does draw some idling current, so I connected a relay with a switch to the microphone's push to talk switch so that the RF amplifier only uses current when the Alinco is transmitting. The amplifier consumes close to 3.5 Amperes and produces 35 Watts of RF output at high power. I rarely use high power, but using this figure puts the system to the test. Using the same half hour figure for transmit time, one day's usage = 3.5 Amperes x .5 hour = 1.75 Ampere-hours per day for the Amplifier.

The aggregate power consumption figure comes to 4.02 Ampere-hours per day for the whole radio system. These numbers are somewhat overstated because most of the people I talk to are within thirty miles of my house and I only need about 5 Watts of RF output to contact them. This situation reduces the total power consumption from 4.02 to 2.77 Ampere-hours per day.

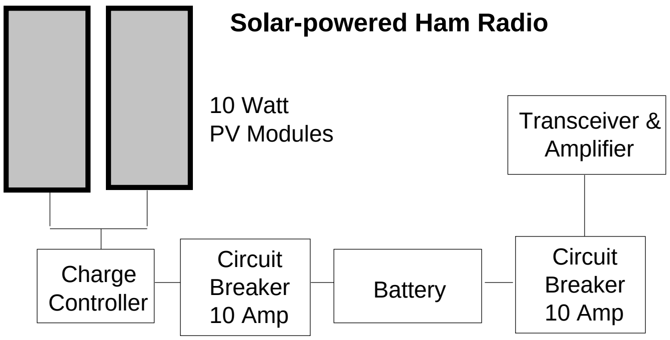
Power Creation

My calculations indicate that on any fairly sunny day each panel produces 0.6 Amperes per hour at 16 to 18 Volts. All measurements were made shortly after the system came online during July and early August, when conditions were ideal. This is the average current and voltage over the four and one-half hour period that the panel receives "full sun." Currents of 25 to 100 milliAmperes at 14 Volts, per panel,are present before and after this period, but are minimal compared to the bulk of the charge occurring between 11 AM and 3:30 PM. For the "bulk" of the charge my calculations are: 0.6 Amperes x 2 panels x 4.5 hours = 5.4 Ampere-hours per day. When the communications system is used under the above parameters on high power we see that there is a surplus. Even when the system is running at high power this gain is 1.38 Ampere-hours. At low power the surplus is 2.63 Ampere-hours. This situation is desirable because we get our share of cloudy days during the winter.

Hardware Costs

The panels were $54 each including extruded frames. The Sears battery was $74.95. The charge controller was $45. All other accessories such as fuses, connectors and wire amounted to approximately $20.

Solar-powered Ham Radio



Benefits

"On site" power is becoming more common. We are seeing a parallel development in the communications industry as cellular telephone sites and satellites play an increasingly larger role in communications. Cellular phones can be charged from the sun. Remote areas can have reliable two way conversations with mainstream society, without the need for large expenditures on power cables and telephone lines over many miles.

PVs and communications are perfect partners because most communication gear demands DC voltage at relatively modest currents. These systems do not require inverters, circumventing that loss. Wire losses can be reduced when the communications equipment is situated near the power generation site. Photovoltaic power generation is absent of electrical noise or ripple voltage often present in standard ac to DC power supplies, a real plus in radio communications.

Additions

I am working on powering a Commodore 64 computer from PVs. This computer will act as an "answering machine" for my radio when I am not around the house. It will be an added benefit, but will probably require the addition of one or more panels.

Access

Author: William A. Gerosa, 405 Tarrytown Rd., Ste 212, White Plains, NY10607

Alinco Electronics, 438 Amapola Ave., Unit 130, Torrance, CA 90501

Communications Concepts, 508 Millstone Dr., Xenia, OH 45385

Cushcraft Corp., 48 Perimeter Rd, Manchester, NH 03108

Pak Rat Electronics, POB 690073, Houston, TX 77269

A Fresh Vegetarian Ham

Mark Newell

I did It! And it wasn't even that hard. After several weeks of worrying and a lot less time studying I walked in and a half an hour later I had passed my Code-Free Technicians exam.

What is a HAM?

A ham license allows me operate radio bands (frequencies) set aside for amateur use. Now I am a part of the most powerful free communications network in the history of the world. There are five license levels which, as you move up, allow wider use of frequencies. Recently the FCC (Federal Communication Commission) introduced a new level which doesn't require knowledge of Morse code. Now the process is much easier. The code-free part of my Technician's license means that I didn't take the five word-per-minute Morse code test.

With the license comes a call sign that is my identity on the air waves. I'm so fresh I don't even have mine yet. The call is made up of letters and numbers. The numbers signify the origin of the caller and the letters, the level of the caller. [The first letters also tell the location: the US uses A, K, N, and W] The lowest level, Novice, has five letters and the highest level, Amature Extra, has three.

Why become a Ham?

Having a means of radio communication really fits in with remote living. Whether amateur radio is your primary or alternate means of communication, it will provide contact with the outside world. In fact, I think it would be dangerous to be in a remote location without a channel of communication. The situations when our radio phone goes out, as it often does during blizzards, are just the time that I would need to use the radio.

Stories abound around here of times when the radio network has helped to save lives. This part of the ham's duties enticed me get my license. Times when normal channels of communication are cut are just the times when people are in need of help. Providing for others in need is a major part of being a ham. Never before have I had so many friends willing to lend me a hand.

Being practical doesn't mean ham radio is all serious. In fact, the most typical use for radio communication around here is chatting with the neighbors and reminding the people who have gone to town not to forget the cat food. There are times though when the radio is indispensable, especially when the town crew gives us the five minutes-before-arrival-with-cold-pizza-warning so that we can pre-heat the oven. No, I have the license because it is another tool that is useful in remote living and gives me a sense of being a bit more self-sufficient.

The world of electronics

So what's the process? Well there is a book that gives you all the possible questions and answers to the test. It's called *Now You're Talking!* I got mine at Radio Shack for about 17 bucks. Reading this book has been incredibly educational. In the world of electronics, there are many mysterious things. Being up here at Home Power can be an overwhelming experience at times. Many of the conversations around here begin with resistors and end with thyristors. As I read through *Now You're Talking!,* my level of understanding definitely increased. This book gives great, simple explanations of all the basic components of conventional electronics. The clear diagrams show what most of the common parts look like.

The most notable aspect of this book is the clear explanations of things like capacitors, resistors, and inductors. All these little pieces that make electricity behave differently are not that hard to understand if good explanations of their inner workings are given. It seems

that all electronic circuits are big game boards for electrons to play on. The trick is to get them to play to our advantage. It has certainly made electronics a lot more fun for me.

I recommend this book to anyone who wants to better understand how basic electronics work, regardless of whether or not you want become a ham. If you are studying for the license, the big thing is not to get frustrated because it seems so overwhelming. There is a lot of information covered pretty quickly, but most of it is not on the test. If you study the text and answer the questions at the end of each section, you will be more than prepared. It's really not that bad.

Access

Mark Newell, who hasn't received his call from the FCC yet, can be reached c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

Well, we can’t exactly promise another earthquake on the day of our fair like happened in 1992, but who knows — this is California, after all. Because our fair was solar powered, our event was the only public place in Humboldt County that did not suffer a power outage! This fair takes place in our Redwood Community Park, proclaimed by those in attendance last year as the most beautiful place in the U.S. holding an energy fair. We are proud to continue Arcata’s tradition of being in the forefront of providing services like this to the American public.

Since SEER won’t be having a public exposition this year, we invite you to attend and even exhibit in our Second Annual Renewable Energy Fair.

For further information or an exhibitor’s application write to us at:

R.E.F., PO Box 4179, Arcata, CA 95521 • 707-822-3481

Sponsored by: Campus Center for Appropriate Technology, Citizens for Social Responsibility, Solutions and Redwood Alliance.

Hot Rocks & Solar Sounds!

Michael Johnsen

Over the Thanksgiving holiday I attended an annual gathering of climbers, naturalists, and environmentalists in Joshua Tree National Monument in southern California. A friend offered me a cheap round trip ticket (non-stop to boot!) I couldn't refuse. A week in the desert sounded like the perfect break from Washington DC's city life.

I only had a few weeks to get things together. In addition to climbing, hiking and relaxing, I planned on testing some simple solar equipment I had compiled from my meager salary. Not wanting to bring the city with me, I kept the gear simple and functional — just a few small panels. The main photovoltaic panel, a 10 Watt Solarex MSX–10 Lite, measures about 10.5 inches by 17.5 inches. I could plug this panel into a 12 Volt AA battery recharger, laptop computer, or tape player. In addition I had a few smaller panels for AA battery recharging packed away. I unified my battery needs to all AA type. I tossed my four nickel metal hydrides (NiH) AA cells from Harding Energy Systems and four Golden Power AA Nickel Cadmium (nicad) cells into my carry-on luggage along with a diverse collection of jazz, industrial dance, and classic rock cassettes.

The jazz played on...

Over the few days I was there I used the the equipment and learned a few things. First of all, I was completely satisfied with the nickel metal hydride batteries. I could get well over 5 hours of continuous cassette play on my Walkman with two AAs, even with the phantom load LCD clock. I used a Petzl headlamp for light, which requires 2

AAs, and could count on powering the halogen bulb for over four continuous hours. The tape player boom box ran on six AAs (four NiH cells and two nicad cells) and ran for about 2 hours.

The small battery chargers worked OK, but I didn't like to take the chance of not getting the full charging time. I usually slapped the dead batteries into the 12 Volt charger, powered by the 10 Watt panel, which recharged 4 AAs in a day's worth of sun. I wanted to make sure that the nicads were fully charged before sundown to prevent memory effect. Sintered-plate nicads, such as flashlight batteries, must be fully charged and discharged to retain their full capacity. Nickel metal hydride batteries don't suffer from these memory problems.

The panel also had no problem powering the nine Volt tape player boom box. I used a cheap DC voltage regulator which allowed me to plug the 12 Volt panel into 3–12 Volt DC appliances. With the panel putting out over 15 Volts, even in the waning afternoons with decreased sun intensity, the jazz played on.

Future Designs

To improve my setup, I'll develop a small, lightweight battery bank, something like the "power station" Real Goods is carrying. I think I could design and build a better one tailored to my needs, using the nickel-metal hydride batteries. I could probably get rid of the smaller chargers, although I did use one that I modified. I added a small Solarex panel (2 inches by 4 inches) in parallel to shorten the charging time. I might need to streamline the 12 Volt battery charger — it was bulky and didn't need to be. A flexible, zippered, fold-out amorphous panel like those made by Sovonics would be nice, but to get the same kick it would need to be larger.

In this situation my applications were not complex or difficult. The main objective was to shape the power generation around my current energy use, not create a larger load just because I could generate more power. I probably could have used a smaller panel, but I have a tendency to "over-power" systems to make sure that I am charging at full force even on partially cloudy days.

Take the sun with you!

As we enter "cyberspace", a future littered with portable technology, information, virtual reality and nano-technology, the need for portable power systems will increase. Solar power can make a strong stand in the portable energy field as many people find themselves working with computers and instruments in the outdoors and other unusual situations away from the plugs of everyday life. My trip to Joshua Tree not only reaffirmed my connections with nature, but also reassured me that technology can help us lead lower impact lifestyles. It is also nice to know as I type this in overcast Washington DC, that my walkman, playing Dee-Lite's latest CD, is running on sunlight gathered in the California desert.

Access

Mike Johnsen, c/o Greenpeace, 1436 U Street, N.W., Washington DC 20009 • 202-319-2412

Utilities and PVs

Allan Sindelar

Most renewable energy users do so because of the utility: either their local electric company wants $25,000 a mile to run a line to their remote home, grid power is not reliable, or they want nothing to do with the way the electricity was produced. Nevertheless, utilities are becoming increasingly involved in photovoltaics (PVs). This article — first of a series — is an overview of the different types of electric utilities, how they operate, and the changes that are causing many of them to investigate PVs.

Utilities Come in all Shapes and Sizes

Five major utility sectors provide the nation's electricity. Seventy-five percent of electric customers are served by 213 private, or investor-owned utilities (IOUs). Fifteen percent get their power from 2203 nonprofit community-owned public power systems (munis). The rest are served by 865 rural electric cooperatives (co-ops). Most of these were set up through federal efforts in the 1930s and 40s to electrify areas not profitable to the IOUs. In addition, 13 federal agencies supply wholesale power to utilities, but don't sell directly to customers. Finally, there are 2800 independent power producers, or cogenerators, which aren't considered utilities, as they generally serve themselves only. But they account for 75% of all new capacity additions since 1980.

The IOUs, with an average of 365,000 customers each, serve most of the urban areas of the U.S. and own three-fourths of the installed power plants. IOUs can most afford to support research and development (R&D) efforts to better serve their customers and cut operating costs. The co-ops average 13,000 customers each, and the munis half of that. The co-ops own only four percent of the plants, and buy most of their power wholesale from the government. However, they own and maintain far more miles of distribution lines per customer. Some of these lines run miles to a few farms, wells, or other small loads. Co-ops need innovations like PV systems that will cut their transmission and distribution costs.

The Role of PVs

According to John Bigger of the Electric Power Research Institute (EPRI), 66 utilities presently have cost-effective PV systems in operation. Pacific Gas & Electric (PG&E), an IOU in northern California, has the most with over 1000. A few utilities have about 100 systems installed but most have fewer than 20.

Photovoltaics can supply power in three major areas for utilities: large-scale bulk power, low power/high-value applications, and high-value grid support. Bulk applications reflect the traditional "supply-side" approach to power generation. Early utility perceptions of renewable energy centered on developing the technology for large central generating stations; some met with success. Seventeen thousand wind turbines, most of them in California, are now feeding about 1500 megaWatts (mW) of cheap electricity into the utility grid. Solar thermal plants in the Mojave Desert supply peak power to 150,000 southern California homes.

This supply-side approach was good for R&D, but required expensive PVs to compete with cheap conventional fuels. Now, used quadlam PV modules are sold from dismantled demonstration plants, and PVs are widely misperceived as not cost-effective.

Small-Scale Applications

Photovoltaics can be economically competitive in low-power/high value applications; these are low-power (from a utility's perspective) situations where grid power is not readily or cheaply available. Home power PV systems are of this type. Most use an array, controller, and batteries to supply low-voltage DC power for a specific task.

EPRI has identified 65 of these applications common to most utilities. Cost-effective PV applications can be tiny, such as sensors for stream level and flow rates or as remote warning sirens at nuclear power plants for radiation leaks. Water pumping is a good application of PVs. A well pump doesn't use enough electricity to cover the cost of maintaining sometimes miles of power line to a remote well, much less the cost of rebuilding lines after an ice storm. K.C. Electric Association, a co-op in eastern Colorado, installed a 600 Watt PV-powered pump system instead of replacing a downed line.

Several utilities are investigating using stand-alone systems to supply power to remote customers in their service areas. Idaho Power has begun offering remote

home systems in a three year trial program. These standardized systems are designed, installed, and maintained by the utility; the customer pays an initial fee and a flat monthly charge for the electricity.

In an unusual "large small-scale" application, Public Service Co. of Colorado (PSC) is replacing a five-mile power line serving White Pine, Colorado, a town of 45 mostly summer homes, with a 35 kW hybrid PV/generator system. While the system is nearly four times the cost of a new line over the mountains, PSC sees it as a good learning experience for future installations.

Most utility uses of PVs are in small-scale applications. Many have already proven to be cost-effective immediately, or with short payback periods. Thousands of these applications currently exist in the U.S., and most utilities haven't taken advantage of them.

High-Value Grid Support

PVs have certain advantages as a generating source which make PV power more valuable at the site of use than it would be at a central power plant. PVs are modular, and can be installed cheaply and quickly. Systems can be sized and located where they will fit a specific need for power, from a few watts to hundreds of kilowatts. Since PVs are visually attractive and nonpolluting, panels can be placed on rooftops or light poles. Peak sunlight hours often correspond to the peak demands of commercial buildings.

Adding to PV's competitive advantage, some states are requiring utilities to include the costs of environmental impacts in choosing new sources of electricity. A PV "feeder support" system near a growing community could be cheaper and more environmentally acceptable than a new power line or upgraded distribution equipment. Some utilities are researching 3–8 kW grid-connected arrays on neighborhood rooftops and larger arrays on commercial buildings. PG&E, through its Photovoltaics for Utilities Scale Applications (PVUSA) program, expects to bring a new 500 kW grid-support plant on-line during 1993.

New Ways of Thinking

Utilities, especially IOUs, are conservative. As monopolies with a regulated profit margin of about 12 percent, they have little incentive to be innovative. If they gamble and win, they make little or no more money for their stockholders; if they lose, the stockholders, ratepayers and regulators object.

In the past, as electric demand increased, utilities simply built more plants. Many overbuilt using projections of increasing demand. As ratepayers learned to conserve in the 1970s, the energy boom collapsed, and some utilities faced bankruptcy. Now, with demand increasing and many older plants wearing out, utilities are reluctant to again make large capital investment in centralized plants.

Heeding Amory Lovins' dictum that negawatts are cheaper than megawatts — that is, efficiency is cheaper than building new plants — many are looking to use the existing power more efficiently and thereby reduce demand. But doing this requires making thousands of efficiency improvements at the points where electricity is used and this runs counter to traditional, top-down utility management.

Utility profits have historically been tied to the amount of electricity sold. In order for utilities to afford to promote efficiency, they must be allowed by state regulators to separate profit from the amount of power they sell — to make more money from selling less electricity. This is a radical idea to many utilities as well as regulators, but has happened in several states. PG&E offers rebates on compact fluorescent bulbs and efficient appliances, and PSC has paid to replace electric heaters with gas furnaces.

SMUD — A Shining Star

Sacramento Municipal Utility District (SMUD) is the fifth largest muni in the U.S., and one of the most progressive. In 1986 its customer-owners voted to shut down its Rancho Seco nuclear plant. On the site is the largest operating PV power plant in the country. SMUD's goal is to obtain 1200 mW from conservation and renewable sources by the year 2000.

SMUD is currently analyzing bids for adding 700 kW of new PV generation during 1993. Two hundred kiloWatts will come from construction of a grid-connected PV substation. Another 100 kW will be installed on one or two commercial buildings. The remaining 400 kW will be supplied by small grid-connected systems of 3–4kW each, owned by the utility and mounted on customers' rooftops.

According to Donald Osborn, Solar Program Project Manager at SMUD, utilities can't assume that by the year 2000 PVs will be available to play a substantial part of our energy supply. They need to purchase systems now on a sustained basis and in substantial amounts in order to maintain the market volume that will ensure rapid development and reduce prices.

Not all utilities are as forward-thinking as SMUD, which has a progressive management and a clear mandate toward conservation and renewable energy from its ratepayer owners. As a muni, it doesn't need to receive state Public Utility Commission approval on its investment decisions. This freedom means that SMUD can more

easily invest in strategies that require higher initial costs but pay off in the long run.

On the East Coast, Florida Power Corporation has been a pioneer in exploring PV applications. It has been using PVs since 1975 to supply power for navigational buoys on Tampa Bay. Florida Power was also involved in an electric vehicle project with the University of South Florida. Part of the project was a 20 kilowatt (peak) array to charge the vehicles, with the remaining power fed into the electrical grid. Florida Power's installation of a dozen PV-powered irrigation controllers on highway median strips is a good example of a high-value application. Even though grid power was readily available, using PVs eliminated "jack and bore" costs of running lines under roadways, and was a cheaper solution.

What it All Means

Few people at NASA, who developed PVs for the space program, imagined that there would be a huge demand for PVs on earth, much of it initiated by backwoods types. PVs are a fledgling industry, developed by small entrepreneurs serving a diverse, self-reliant clientele. Both dealer and customer have been generally opposed to or disinterested in big business. Home Power readers are where the real expertise lies. We are the ones living with PVs and know how to conserve. But many of us haven't noticed that meanwhile, PVs have been quietly entering the mainstream.

If Home Power readers want to change how the U.S. and the world do business, then the utilities must be involved. Photovoltaics offer specific, practical, and economic benefits while reducing energy consumption and environmental damage. Every utility has cost-effective applications; rural utilities have the most. Some utilities are starting to recognize this, but thousands more haven't.

Home power users have nothing to gain by an adversarial relationship with their utility. Even an IOU responds to public pressure. The process is education rather than opposition. Every utility should know about PV applications, and we can make this happen. Whether an IOU, muni or co-op, every utility has a trade organization that can provide information. If a utility starts replacing its most expensive line extensions with PVs, it lowers its overall cost of doing business, which may even translate into rate reductions.

We can get involved with our state public utility commissions, and teach them the need to allow utilities to profit from conservation. Unregulated munis and co-ops, which still associate their well-being with the amount of electricity they sell, can benefit from our educational efforts as well. Since these are owned by their members, they respond to direct community involvement. They are paying more for new electricity too, and the community's best interests are served by keeping prices down. Donald Osborn of SMUD sums this up: "In the absence of a rational national energy plan, it is up to local communities, states, utilities and the public at large to take the lead in demanding and providing for the extensive use of solar energy."

Access

Allan Sindelar, 120 Alta Mesa Court, Moraga, CA 94556 • 510-284-1368

Special thanks to Kay Firor of Blue Mountain Energy for her assistance with this article.

Opportunities

Michael Welch

"Welcome, President Clinton. We hope you have the courage to give us what we need, we hope you have the courage to stand up to the powers that be, and we hope you will make the difference that saves our world from the downward spiral of environmental pollution."

We should all take a few minutes to communicate these or similar thoughts to our new President. I maintain that our new president will respond to the wants and needs of the public as long as we keep the pressure up.

A Time for Action

In every column I have written, I have stressed the importance of all of us helping to make a difference, whether it be by exerting pressure on politicians and bureaucrats, or by voting for the candidates that will most likely change things for the better. Just because we have made an important change in our federal government doesn't mean we can relax our vigilance and efforts. In fact, it is probably more important than ever to Get Involved!

We must tell our new government now what it must do! We need to make certain that the new administration puts a high enough priority on these and other important issues. The changes we seek are not going to happen on their own. We cannot allow complacency to take hold of us at this time. Without our pressure, President Clinton will not place enough emphasis on our issues.

Jobs Versus the Environment

Remember that the main issue of the last election was the economy. Many corporations and special business interests will undoubtedly try to use this to their advantage by claiming that the economy cannot get better if they are required to take better care of the environment. They already are trying to induce the "jobs versus environment" hysteria that is their strategy for increased short term profits. In Northwestern California, I have watched corporations get to politicians and bureaucrats by mobilizing workers with this strategy. It was only through hard work and the worthiness of their cause that local activists have been successful in minimizing the damage that these companies would have done.

A Workable Solution

The issue is not "jobs versus environment." In fact, much success can be had in both areas by cleaning up and maintaining the environment, including the energy field. Just imagine how much money could be made and jobs created in the United States if we were to put the same effort into solar technologies that we put into subsidizing and cleaning up after the nuclear, coal and fossil fuel industries! Our duty is to ensure that our nation does not sleep through the solar age and let other countries become the leaders in the field. So far, the home power industry has grown *in spite* of political, bureaucratic and corporate efforts to ignore and even derail it. Our young industry would do extremely well with the active support of the Clinton administration and its new energy secretary.

That leaves it up to you and me. In order to gain the necessary support, we need to make those phone calls and write those letters. The addresses and phone numbers you need are listed at the end of this article.

Presidential Appointments

As usual, there's good news and bad news for the renewable energy world. Like everything political, potential cabinet appointments have a lot more to consider than just what is right or wrong. As most of us are aware, factors such as who donated money, who helped a candidate get the goods on someone, and who is supported by influential industries, can reach their slimy tentacles into the process of who gets appointed to what. A good sign was that Clinton apparently changed his mind for the better in some cases where environmental, energy and women's groups loudly protested some of his upcoming appointments. This reinforces my point that we at least now have an opportunity to be heard, and that we already have been effective by using that opening.

Secretary of Interior

Probably the most promising presidential appointment to date was that of Arizona Governor Bruce Babbitt to the position of Secretary of Interior. What a far cry from the likes of James Watt and Manuel Lujan! Babbitt is the President of the League of Conservation Voters and a well-known protector of public lands in the West. This appointment came as a direct result of environmental groups protesting the impending appointment of Bill Richardson. Boy, is it nice to be heard for a change.

Secretary of State
An interesting appointment was that of Clinton transition team head Warren Christopher as Secretary of State. As chairman of the law firm O'Melveny and Myers, Christopher is probably best known as the behind the scenes negotiator that achieved the release of the American hostages from Iran early in the Reagan administration. His negotiating skills are legendary, but he is known to be very closed mouthed about what he is doing. Being an apt negotiator can go either way, however. It all depends on the goal of the negotiation.

For example, Christopher once represented Pacific Gas & Electric Company in backroom negotiations that eventually led to the utility receiving extraordinarily high rates of return on PG&E's Diablo Canyon Nuclear Power Plant. This in spite of overwhelming evidence of misconduct and unnecessary cost overruns for the construction of the plant. If this is the kind of work that Christopher will be doing on behalf of the Clinton administration, then we'll have to keep a close eye on him. His reputation of not being communicative to the public could work against us.

Additionally, his law firm has offices in Japan, and there may be conflicts of interest when it comes to keeping American technologies like solar within our borders. On the other hand, Christopher directed the search team that eventually chose Al Gore, an environmentally sensible person, as Clinton's running mate.

Energy Secretary
An unknown in the Clinton cabinet is Hazel O'Leary, chosen for the position of Energy Secretary. It has been difficult to obtain information on this person before press time, but it is widely reported in the media that the utility company she worked for, the Minneapolis-based Northern States Power Co., is known for its commitment to renewable energy and conservation. It has been reported that she held the positions of Executive Vice President for Corporate Affairs and President of their Natural Gas Division. Northern's energy mix includes nuclear and several forms of fossil fuel powered electric plants. This particular company is known to be quite active among nuclear utilities.

She most likely knows about the things an energy secretary must know about, but it remains to be seen if she will go her own road or become an advocate for what utilities want. She doesn't know much about nuclear weapons, which comprises 70% of the DOE's budget, and that is probably a mixed blessing. On the one hand, maybe the DOE will concentrate more on energy and less on weapons, but on the other hand maybe the nuclear weapons industry will be able to overwhelm her lack of knowledge on the issue. It all seems to depend on whom she appoints as undersecretaries in these areas. While she has a reputation in Minnesota as being open and fair, we will still need to keep an eye on Hazel, as well.

Transportation Secretary
A couple of more Clinton appointments that bear watching are Frederico Pena and John Gibbons. Pena was Denver's mayor and was appointed Transportation Secretary. Pena's "strong" point has been investment in infrastructure; that is freeways and airports. The question is: do we have a transportation secretary willing to take on mass transit as a major component of our transportation strategy? Folks in Denver liked Pena on several fronts, mostly with regard to his successful efforts to clean up Denver's previously horrible air pollution. His sensitivity to clean air issues may bring us some welcome changes to vehicle air pollution problems.

Office of Science and Technology
John Gibbons was appointed to head the White House Office of Science and Technology. As a nuclear physicist, Gibbons has a lot of credibility in the scientific community. This, combined with a solid understanding of the connections between economics and the issues we are concerned about, will likely make him a favorable appointment. Let's say that there is a lot of good potential here for helping renewables and energy efficiency. We'll watch these two appointments closely and try to help them out.

Energy Fairs
On another note, the SEER fair in Willits, CA this year will be taking on an entirely different look. The 1993 version will not include the public exposition that all the previous SEER fairs had featured. This year's fair strategy will probably still retain its electric vehicle rally, but the main focus will be a Solar Summit. SEER staff and volunteers hope to pull together a big meeting that will focus national attention on how to support, promote and obtain our solar future. They intend to include every major group, utility business, and government representative that can help us toward our goals. Call them at (707)459-1256 for more information.

If you still want to attend and participate in a people's energy fair, check out the Happenings section (page 89) for the where's and when's.

ACCESS
Author: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521 • 707-822-7884

Nuclear Information & Resource Service, 1424 16th St. NW, Suite 601, Washington, DC 20036 • 202-328-0002

Union of Concerned Scientists, 26 Church St., Cambridge, MA 02238 • 617-547-5552

Clean Water Action Project, 899 Logan, Suite 104, Denver, CO 80203 • 303-839-9866

President Bill Clinton, The White House, 1600 Pennsylvania Ave., Washington, DC 20500 • 202-456-2168

Your Senator's name (each state has 2), Senate Office Bldg, Washington, DC 20510 • 202-224-3121, or try your local phone book

Your Representative's name, House Office Building, Washington, DC 20515 • 202-224-3121, or try your local phone book

The 1993 National Electrical Code and The Inspector

John Wiles

The 1993 National Electrical Code® has been published and is now available from the National Fire Protection Association (see access), local electrical supply houses, and some bookstores. There have been some changes to Article 690, which discusses photovoltaic systems. They will be discussed below and a large number of changes in other sections of the code too numerous to discuss. As always, working with the local inspector requires a degree of creativity, some patience, and hard work. Tried-and-true methods of working with the inspectors are outlined below.

The 1993 Code

Section 690-4 now requires that inverters used in photovoltaic (PV) systems be identified for such use. This means that when the inverter goes through the testing and listing process by a Nationally Recognized Testing Laboratory, like Underwriters Laboratories, the process must use procedures that relate the product use to PV systems. The PV industry now has three manufacturers selling listed products (Heart, Trace, and Dimensions Unlimited), but not all are identified for use in PV systems.

Section 690-8 was modified slightly to ensure that short-circuit currents are used to calculate conductor sizes and overcurrent device ratings when PV circuits are involved. This section also has an addition (paragraph c) to alert those who are tapping a 24 Volt battery at 12 Volts that the common return conductor (usually negative) must be sized to handle the total current flowing in both of the positive conductors.

The grounding and disconnect requirements have been clarified in Section 690-13. Ungrounded current carrying conductors to the PV array must have switched disconnects or circuit breakers. Grounded conductors shall not have switched disconnects and should only use bolted disconnects. A bolted disconnect is where two conductors are spliced or connected together with a compression connector, wire terminals and bolts, terminal strip or other device which allows the conductors to be easily disconnected by a qualified person.

Section 690-31 now allows USE (Underground Service Entrance) and SE (Service Entrance) single-conductor cables to be used for module interconnect wiring in addition to the previously allowed UF (Underground Feeder) cable. Note that UF cable is falling into disfavor. Reports are surfacing which indicate that PVC insulation softens when UF single conductor cable carrying direct currents is used in moist environments.

Working with the Inspector

In areas where either the NEC or a local electrical code is in effect, the electrical inspector plays a key role in ensuring that any electrical power system is safely installed. Early involvement of the inspector will benefit all concerned for a number of reasons.

While the local inspector may not be familiar with direct current or PV electrical power systems, he or she is very closely acquainted with the code and the interpretation of the codes in that location. The inspector is also familiar with the electricians and electrical contractors in the region and whether or not they are up to an installation using a relatively new technology.

A team composed of a PV dealer/installer and a local electrician has the best chance of getting a PV system installed in a safe manner that will pass inspection. Most electricians know how to obtain the proper permits, where to get the proper equipment, how to do power wiring that meets the code, and how to work with the inspector. The PV dealer/installer brings the knowledge of PV design and equipment to the team. Both of these parties working together with the inspector can synergistically achieve a safe, durable, high performance PV system.

Because of the scarcity of PV systems and residential DC power systems, the PV dealer/installer frequently has to educate the inspector in these areas. This usually requires that the PV expert meet the inspector early in the process to discuss the basics of PV systems and to solicit any advice that the inspector might have. Having a written description of the system that can be left with the inspector is usually a good idea.

The system write-up should start with a very basic description of PV systems. A one line diagram of the system should be presented and a more detailed full system schematic included in an appendix. Literature on all of the equipment that is to be used should also appear in an appendix and that literature should show the UL listing information where possible. The main body of the system description should address how the system will meet the code requirements in each major area. These areas include grounding (both system and equipment), disconnects, overcurrent protection, and wiring methods. Ways of meeting the intent of the code with unlisted equipment should also be discussed. The more detail that can be provided to the inspector, the more educational information he or she will have, and the more likely the installation and inspection process will go smoothly.

Rough-in inspections are frequently required when the wiring is installed in the walls or conduit, but the outlets, switches, and breakers as well as other equipment is not installed and no power is connected to the system. In a PV system, the modules would be installed, and the batteries, charge controller, and inverter would be in place. The wiring and cabling would be installed, but should not be connected.

If the PV system is being used to provide temporary power for construction, then the temporary installation must also meet all of the NEC requirements. If the inspector sees a messy, jury-rigged temporary PV system, he or she is liable to walk away and not come back! The NEC requires workman-like installations of all power systems — even a temporary one. The inspector is used to seeing contractors using a temporary power pole in a safe manner. Jumbled batteries, loose cables, no fuses or disconnects, and unmounted modules will not only turn the inspector off, but are very unsafe.

The safest, most efficient, and most durable PV systems are the result of a team effort between the user, the PV dealer/installer, an electrician, and the electrical inspector.

For those who would like a detailed example, a 120-page PV system description prepared by the author describing his own home system is available for $28.00 from the Southwest Technology Development Institute.

Access

Author: John Wiles, Southwest Technology Development Institute/NMSU, PO Box 30,001/Dept 3 SOL, Las Cruces, NM 88003 • 505-646-6105

Tech Notes

Installer Insights

Chuck Heath

These tips are not in any particular order. Your additions to this list are always welcome. By sharing we will all do a better job.

1. SCREW installation in cramped spaces is made easy by coating the screwdriver tip with office-supply glue-stick. It's water soluble too

2. HONDA generator remote-control units can be extended at least 300 ft. using 10 conductor, #18 gauge Sprinkler Control Cable. It is direct-burial (waterproof). The remaining conductors can be used for a remote amp-hour meter.

3. SHIELDED twisted pair cable, #18 gauge, is available from Carol Wire.

4. SQUARE D brand 70 Ampere load centers can be ordered with oversized main lugs (up to 1/0, I believe) for those long DC runs.

5. 24 VOLT ARRAY WIRING is much simpler wiring one-half as 12 Volts then combining the other half 12 Volt side just once in series.

6. LONG CONDUIT PULLS with heavy wire can be simplified by dry-fitting every 40 feet and all sweeps (bends). Be sure to mark the dry-fit locations to be glued after the wire pull is complete.

7. THIN-LITE DC light fixtures that are creating RFI (radio frequency interference) can be quieted with a mylar capacitor available from the manufacturer who still refuses to install them at the factory.

8. GFCI (Ground Fault Circuit Interrupter) are about a 2-watt phantom load. Too many will "wake-up" a "sleeping" inverter. For the cost of about 5 GFCIs, you can install a GFCI breaker in the AC circuit breaker panel to reduce the number of GFCI loads.

9. PVC pipe in trenches can be cut with nylon string in places you cannot use a hacksaw.

10. If you suspect a problem with DIP SWITCHES, try exercising each one several times to break the conformal coating for better electrical contact.

11. LIQUID LEVEL CONTROLS for 12 and 24 VDC are available from Warrick Controls, Inc., 4237 Normandy Court, Royal Oak, MI 48073 (313) 545-2512. These are frequently used in water storage tanks to control a well-pump using small-gauge wire. The storage tank and pump can be up to 2 miles apart.

12. CALCIUM SCALE in home water systems can be largely eliminated with a magnetic descaling unit which draws only 3 watts and runs on 12 VDC or 120 VAC. No maintenance, it is all electronic. The unit I have is called ScaleWatcher and is about $400. It works!

13. LIGHTNING DAMAGE can be reduced by forming a loop in wiring, coaxial cables, etc. and leaving the down feed at right angles from the tower, pipe, mast or PV array. One of the best sources for lightning solutions is PolyPhaser Corporation, POB 9000, Minden, NV 89423 (800) 325-7170. Their product line covers everything from twisted pair/cable protectors to satellite dishes.

14. PV ARRAY interconnect wiring using Tray Cable (designated type TC) is often less expensive than USE or SO type cable. TC is UL-listed direct-burial (waterproof) and UV resistant. I use TC 10-2 stranded for arrays up to 25 Amps output.

15. HOT WATER TANKS to make a solar batch-type unit can often be obtained free from your local propane supplier or plumbing house. Usually they are electric models traded in on propane tanks.

16. BATTERY EQUALIZATION should be done after disconnecting all DC loads and removing Hydrocaps, if you have them.

17. CELLULAR TELEPHONES range can be greatly extended using an 800 mHz. Yagi antenna and low-loss feedline. My neighbor does this successfully over an 83 mile path (from his home)!

18. A SECONDARY SURGE ARRESTER that looks like an ac power & cube and fits a standard 1/2 inch electrical knockout is offered by Square D Company. Can be used on 3 wire 120/240 Vac load centers or 2 wire 120 Vac. It's their #SP1175.

19. EMI/RFI INTERFERENCE from inverters may be reduced by a line filter rated at 120/240 Vac, 30 Amperes available through Trace Engineering. A cheaper solution from Richard Perez of Home Power Magazine is to twist both the DC input and AC output cables during installation. Make the cables about one-third longer before twisting as the overall length shrinks during twisting.

20. OWNING YOUR OWN PROPANE TANK allows you to shop for the best price but beware, used butane tanks

are only rated at 125 psi. Propane tanks are rated 250 psi. NEVER put propane in a butane tank! I'm saving about 1/3rd by owning rather than renting from the supplier. Check the tank label.

21. SERVEL REFRIGERATOR parts including new burner assemblies and door seals are available from Jeff's Gas Appliances, 549 Central St., Willits, CA 95490 (707) 459-5223. Wholesale and retail.

22. Always draw a block diagram/schematic of your ELECTRIC SYSTEM. Someday, it will need trouble shooting by you or someone else. Color code, label, detail every connection. See Home Power Magazine for good examples. Post system-shutdown instructions. Someone else may have to shut it down quickly.

23. BATTERY BOXES can be made from discarded chest type freezers. Put it outside. Extra insulation can be added in cold climates. I put 2 - 6x6 timbers across the bottom covered with scrap 2x6 boards for better access. Vent the top. Seal the electrical conduit into the house to prevent any hydrogen entering (canned foam insulation). Check your appliance dealer for a free, gutted unit.

24. BATTERY WATERING is simplified by using a special jug available at auto parts stores. The spring-loaded valve opens when you press it down into the cell. Remove it when the water no longer flows. Under $10 and no funnel.

Please do add your own ideas to this list.

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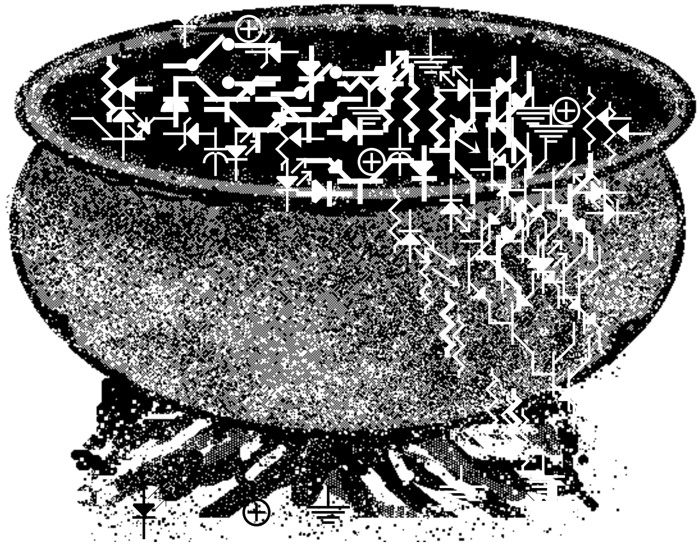
Author: Chuck Heath, Suntricity, POB 1159, Coulterville, CA 95311 • 209-962-7012 • 209-878-3557

Homebrew



High Voltage Detector

Amanda Potter

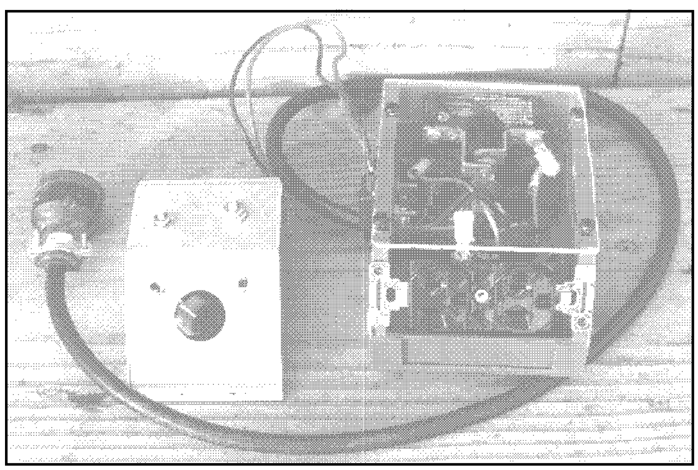
Can you think of an application for a circuit that turns on a load at a specified voltage? How about turning on an electric heater or water pump that could be turned on when your house's batteries are full. Or a drain back valve of a passive water heating system could be operated at low temperatures. We'd like to turn a fan on at high voltages. This will disperse the hydrogen being produced by charging batteries. With very few modifications, Chris Greacen's short circuit regulator in issue 28 can be used to do this (see circuit).

Detect the Voltage
The LM723 detects the voltage. Pin 9 goes high when the input voltage rises above 7 Volts. The 3.0KΩ / 3.3KΩ voltage divider lowers the voltages to within this range. The 1KΩ potentiometer can be varied to set the high voltage point.

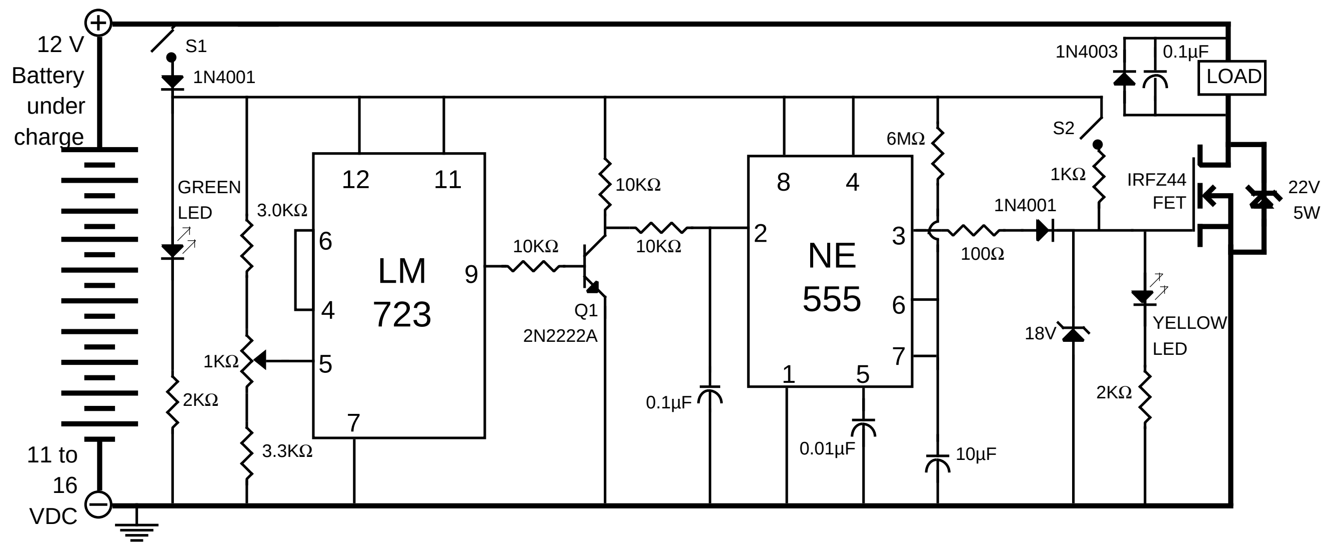
Ensure Against Oscillation
The NE555 timer ensures that oscillation does not occur. The LM723 turns on the load when the voltage rises above the setpoint. Without the NE555, a large enough load will decrease the battery voltage enough to turn off the LM723. The result is that the LM723 and the load oscillate on and off. The NE555 stops this by turning on for a duration of time specified by the capacitor and resistor at pins 6 and 7 (time = 1.1RC). In our circuit, the fan turns on for a minute at a time. If the voltage has not fallen after the specified time, the NE555 will stay on until it does fall.

The output of the NE555 (pin 3) goes high when there is a falling pulse at the input (pin 2). The 2N2222A ensures that a rising pulse at the output of the LM723 produces a falling pulse at the input of the NE555.

Turn on the Load
For DC loads under 15 Amps, such as the fan, an N channel MOSFET can be used to turn on the load. A high signal at pin 3 of the NE555 turns the MOSFET on allowing current to flow from the battery through the load and MOSFET to ground. The 1N4001 on pin 3 prevents the NE555 from sinking current when S2 is closed. The 18 Volt and 22 Volt zener diodes protect the MOSFET; gate to source voltages higher than 20 Volts and drain to



Above: Here the circuit drives a relay which controls an ac outlet. Plug the ac appliance into the relay box outlet and the relay box plug into an ac outlet.
Photo by Mark Newell



source voltages higher than 60 Volts will blow up the IRFZ44 FET. The circuit could also power a relay that drives an ac load. This can be done by replacing the load with a relay. The relay we used was a Magnecraft W199X2. Its coil rating is 12 VDC, 150 mA. Its contact rating is 30 Amps, 300 VAC. Dark lines in the schematic indicate high current carrying wire. Sixteen gauge or thicker should be used, depending on the load.

A diode and capacitor should be put in parallel with an inductive load or a relay. The capacitor minimizes RF noise. The diode stops the inductive load from reverse biasing the FET by providing a path for current when the load is turned off.

Our load is a 102 cfm DC muffin fan rated at 24 VDC (12-28 Volt range), 0.86 Amps. The IRFZ44 is rated at 35 Amps. The word at HP is that its better not to push the transistor over half its rated current. The IRFZ44 should still be properly heat sunk. We heat sunk it to the metal enclosure.

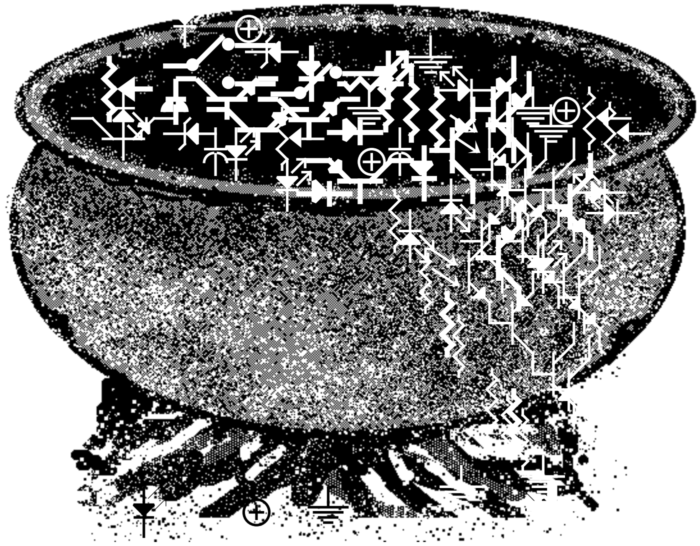
Cicuit Indication and Control

The LEDs tell us what the circuit is doing. The green LED indicates that the circuit is on. The yellow LED indicates that the load is on. There are two switches in the circuit. Switch S1 turns the voltage detector off. Switch S2 turns on the MOSFET, which turns on the load, independent of the battery voltage.

Access

Author: Amanda Potter, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

Homebrew



A Beginner's ac Ammeter Project

How to Measure Actual ac Current Without Cutting Your Power Cord

Joel Chinkes

Disclaimer: This project is designed for the complete beginner, but not for the complete klutz. It is possible to kill yourself and/or damage your property if you are not just a little bit careful. Be prepared to take responsibility for your own actions.

All solar energy books tell you to first add up the power requirements of your lamps, tools, and radios. What they don't tell you is how to get an accurate current measurement without disassembling the power cord.

Why not simply rely on product labels when adding up your loads? Surely the manufacturer has tested power draw at the factory. Well, yes and no. Every ac gizmo is labeled with some sort of power consumption number (watts or amps), but these numbers are often overstated or misleading.

My method will also simplify finding “phantom” loads. A phantom load is an appliance which is switched off, yet continues to draw a small maintenance current. This may be to keep a memory chip alive, or for some timekeeping function. My video cassette player, for example, is a phantom load. It "stands by” using electricity 24 hours a day, waiting for somebody to stick a VCR tape in its mouth to suck on. What a waste!

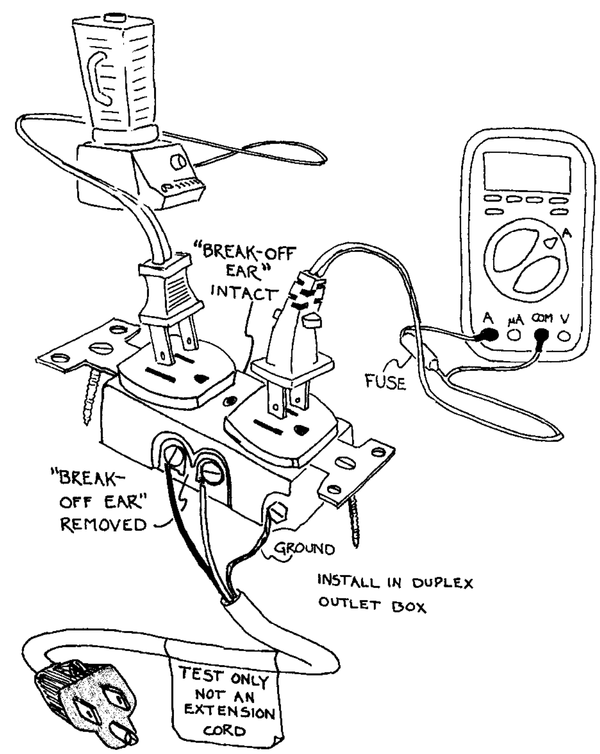
Custom probe

An ordinary ammeter needs to be connected in series with the current it is measuring. Most appliance plugs are molded plastic, and the power cord disappears unbroken inside the gizmo. With lethal voltages at the plug, you have no safe place to attach an ammeter. Until now!

Enter the Fiendishly Clever Extension Cord (FCEC): a custom wired dual plug that will accomplish our goal using only cheap, commonly available parts. The secret is the fact that ordinary duplex outlets have break-off ears connecting the two pairs of contact screws.

These ears are provided on the off chance you want to separately control the two halves of a duplex plug. This could happen when half a duplex hall lamp outlet is controlled by a switch near the door, while the other half is live all the time. This is why there are four screws provided when two screws would do.

In this case, we will break only one of the two ears off, which is probably a violation of some silly rule. Even more non-standard, we attach the incoming power cord to the two screws on the same side of the duplex outlet, whose Siamese Twin status has just been severed when you ripped its ear off. On a normal ac extension cord the



power cord goes to either side of the plug. Here, both sides of the incoming power have gone to the same side of a plug with one jumper “ear" removed.

Once you have this wacky wiring in place, button everything up in a safe receptacle box with lid, and you are ready to take some measurements. Very Important: Put a big red label on your project that says “Test only — not an extension cord!”

Here's how you connect up in four steps in order:

1. Plug your appliance to be measured into one outlet of the FCEC.
2. Stuff your ammeter probes into the other outlet of the FCEC.
3. Plug the FCEC into a wall socket (Phantom loads show up here).
4. Turn on the appliance and read your ammeter.

Electrons from the wall socket will now race up one side of the ac cord into your appliance, out the other side of the appliance, across the remaining ear inside the plug, into your ammeter, then out the other side of the ammeter back to the wall socket. This complete circuit puts your ammeter in series with the load being measured, simply by plugging them both in to an ordinary outlet box, wired a little funny on its insides. See diagram.

Don’t Fry Your Ammeter

Suppose your ammeter is not set for ac amps. Or you forgot that the appliance might draw 20 amps and you left the ammeter on its 50 milliamp range. Or you only have a 10 ampere scale on your ammeter, but the toaster you are measuring has a 1500 watt sticker on it. These are user errors, so don't come crying to me about your fried meter.

Suppose you can't make good contact with your ammeter probes inside the ac outlet? You might want to construct an ammeter probe with a regular ac plug on one end, and banana plugs (or whatever fits your ammeter) on the other end. Recall that you are dealing with lethal voltages, so you want to be particularly careful with the exposed banana plugs if the ac end gets plugged in some place it shouldn't be. If you plug your ammeter probes into a live outlet, expect to smell smoke!

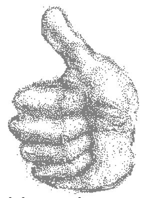
If your ammeter lacks an internal fuse, consider putting an external fuse into this circuit to protect your life and property. Fuses are always cheap insurance. Likewise, you should ground wires. If you choose to use three prong plugs and sockets, connect the ground wire in the usual way. It should be common between both sides of the duplex outlet.

Keep this ordinary looking but non-standard extension cord in a safe place when it is not in use. Others may mistake it for what it isn't!

Access

Author: Joel Chinkes learned everything he vaguely remembers about electricity at The Bronx High School of Science and can be reached c/o Home Power, POB 520, Ashland OR, 97520

Things that Work!



Things that Work!
tested by Home Power

Vanner Voltmaster Battery Equalizer

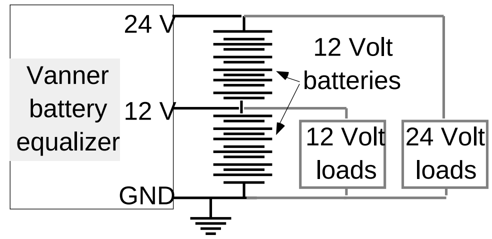
tested by Dan Lepinski

Ever try to purchase 24 Volt appliances? They're out there, but they're nearly impossible to find and are much more expensive than their 12 Volt cousins. So why use 24 Volts for the battery voltage instead of 12 Volts in a home power system? Simple! When you double the battery voltage in your system, you reduce four-fold the power lost in wiring and connections. In systems that use more than 4,000 Watt-hours daily, a 24 Volt system is highly recommended.

To run your 12 Volt appliances from a 24 Volt system, you "could" connect them across one half of the battery bank. You would get the 12 Volts you need. You'd also be discharging only half of the battery in the process and be setting yourself up for some serious battery troubles by unevenly cycling the batteries. Unevenly cycling batteries can cause considerable damage, especially in lead-acid battery systems.

The Voltmaster

The Voltmaster, manufactured by Vanner, Inc., is designed to allow the use of 12 Volt devices in a 24 Volt system, but without any of the problems just mentioned. By keeping a careful electronic watch on your 24 Volt battery, the Voltmaster transfers current from the stronger 12 Volt half to the weaker 12 Volt half whenever one discharges more than the other. It keeps the charge level equal in the two halves, regardless of your 12 Volt loads.



The voltmaster allows use of 12 Volt loads (or charging sources) on half a 24 Volt pack.

Packing & Documentation

The Voltmaster packing was excellent. The carton-within-a-carton protection scheme plus the environmentally nasty styrofoam nuggets form a substantial shield against the roughest handling almost any shipper could dish out. The instructions are printed on a giant vinyl sticker conveniently and permanently attached to the unit. The large print is easy to read and leaves little room for error. Additional information such as alternate circuit configurations, recommended wiring sizes, and technical information are available directly from Vanner.

Installation

With only three connections, the Voltmaster is very simple to install and operate. There are no meters, adjustments, switches, or anything else to confuse the non-techie. Vanner thoughtfully provides a wire table with recommended wire sizes for each of their models. By looking up the model in use, and the distance from the battery, the minimum wire size recommended by Vanner can be easily determined. Vanner establishes a maximum of 0.1 Volt loss in the wire as their criteria for suggesting wire size.

The connections to the Voltmaster are made through nickel plated 1/4 inch studs mounted securely on the case. While these are well-suited to handle the maximum 50 Amp load rating of the largest Voltmaster, they fall a bit short of dealing with the lugs needed for wire sizes larger than number 4 AWG. The studs are long, however, and allow for the use of large washers whenever the larger lugs are required.

The Voltmaster in Use

We tested the Vanner model 60-50A, the top of the Vanner line. It can shuffle 25 Amps (continuous duty) from one 12 Volt battery to another in a 24 Volt string. Thus you can run continuous 50 Amp 12 Volt loads. You can run 12 Volt loads even bigger than this off half your 24 V pack, as long as the loads are intermittent so the Vanner has a chance to catch up.

The Voltmaster is absolutely silent. No fans. No humming. No noise. Period. The only way to tell that the Voltmaster is operating is with an accurate voltmeter measuring the voltage across each half of your 24 Volt battery. Vanner's optional EM70 monitor can only activate user-supplied external devices such as lights or an audible alarm. A simple battery voltage imbalance warning device and low voltage alarm for use in renewable energy homes would be a welcome addition.

A Slight Gremlin

The Voltmaster does create some radio interference. This is not a malfunction. It is simply caused by the way the circuits operate. In today's modern power equipment, digital (on/off) switching is used to achieve the very high efficiencies we all enjoy. I found that the interference was worst around 20 kHz on my ham radio. The strength of the interference varied from just perceptible to moderate, at times completely masking weaker signals.

Efficiency

The Voltmaster's idle current (energy consumed when no work is being done) is a scant 17 milliAmps (0.4 watt) or about 10 watt-hours per day. Under sustained heavy loads that used between 30 and 50 Amps, the unit was just perceptibly warm, indicating that the Voltmaster's efficiency is high. I took measurements with two Fluke multimeters. During periods of heavy charging when the current into the battery exceeded 80 Amps, the Voltmaster consumed only about 60 watts. In one test, I charged half of my 24 Volt, 160 Ampere-hour nicad pack with a 60 Ampere, 12 Volt nicad Todd charger. In this configuration the Vanner was forced to transfer half of the current to the remaining 12 Volts of the pack. The Vanner did the job with 91.3% efficiency. In a dozen other tests the Voltmaster's measured efficiency never fell below 90%.

Reliability

The 60-50A has been in use in our home for more than six months. Since installation it has never skipped a beat. The unit has been run beyond its specifications on several occasions without a failure.

Mr. Chuck Bennett, VP of Sales and Marketing at Vanner, told me the unit can be operated without the center tap connected to the batteries, using only the Voltmaster to provide half of the input voltage. He also said that the Voltmaster is so reliable that the output from the 12 Volt center tap can be shorted to either the +24 Volt or ground points without damage. While I don't recommend that this be duplicated, I tried it. The results? It's still working! Under short circuit conditions, the Voltmaster limited its output current to slightly over 64 Amps, or about 30 percent higher than the 50 Amps specified for this model. The Voltmaster comes with a 1 year parts and labor warranty.

Additional Benefits

1) Charges 24 Volt batteries from a 12 Volt source. This can mean a great deal to the owner of 24 Volt system. Normally, to increase the size of the PV array in a 24 Volt system, you must purchase PV panels in pairs. With the Voltmaster, this is no longer true. By connecting a single PV panel between the +12 Volt and +24 Volt studs on the Voltmaster, it will automatically distribute the charging current between the two halves of your battery. The only extra item needed in this arrangement would be a diode in series with your panel to prevent any current from flowing back through the panel at night. Later, when you can afford the next panel, you can restore a normal wiring and charging arrangement by merely connecting the two new panels into the proper series and parallel configuration with your existing PV array.

2) Makes life easy for weak half of battery. If half of the 24 Volt battery turns out to be weaker, its voltage will drop more under discharge. The Voltmaster transfers current from the stronger half to the weaker half, keeping them at a more nearly equal charge level. Your weaker battery will have life easier, and its condition will deteriorate more slowly.

Price

There are three models of Vanner Voltmasters. The ten Ampere 60-10 runs $216.55 retail. The 60-20A can supply twenty ampere continuous DC loads, and retails at $304. The 60-50A (the one I tested) costs $457 retail.

Conclusion

If you're in the process of designing a 24 Volt home power system, or if you're using a 12 Volt system right now and are contemplating the move up to 24 Volts, including a Vanner Voltmaster in your design plans could be a very intelligent addition to your system. Not only will it let you continue to use your 12 Volt equipment with the new system (and treat your batteries right), but it can actually make expanding your PV array easier on the budget by providing a simple means to add one panel to your system at a time.

Access:

Author: Dan Lepinski, 791 Lakeshore Dr., Klamath Falls, OR 97601 • 503-885-5698

Manufacturer: Vanner, Inc., 4282 Reynolds Dr., Hilliard, OH 43026 • 614-771-2718

Work in Progress

Therese Peffer

Trains and orchestras need conductors to guide their way, and well, electrons need them too! I'm still putting together a small system for the trailer I live in. I figured out my loads, bought a 60 Watt photovoltaic (PV) panel to produce electricity, and have a car battery to store it in (discussed in last issue, HP #32). Now what? I need to connect the two and plug in!

What is a conductor? I have a very basic understanding of electricity. I know that there are negatively charged particles called electrons revolving around the nucleus of all atoms. Some materials are made up of atoms that let their electrons wander around, moving from atom to atom. If we can induce a current, that is, a continuous movement or flow of these electrons in a material, we call that material a conductor. For example, metal is a good conductor of electricity — copper in particular, but also aluminum. Metal wires are typical conductors.

If you look around your home, you may see many cords, for the telephone, for lights, for a radio, extension cords, or maybe battery jumper cables. Essentially all the cords are doing the same thing: conducting electricity, but in different ways.

One size does not fit all

One difference is the size of the wire. Sometimes I think of wires as freeways for electrons. A small wire, say #20 AWG (American Wire Gauge), could be a single lane road, but a larger wire such as #10 AWG would be a one way 4 lane road, and #0000 AWG is an Los Angeles interchange of 7 lanes and more stacked up!! Lower numbers correspond to larger diameter wire. The bigger the cross section of the wire, the more capacity the wire has to carry these electrons. It is called ampacity; electrical current is measured in Amperes.

There are no affordable perfect conductors. Wire conducts pretty well, but even copper wire has a certain resistance. If a wire is too small for the amount of current it's carrying, then it will heat up! I think of a traffic jam — too many electrons trying to move at the same time.

Part of figuring out how to hook up my photovoltaic panel to the battery was figuring out the size of wire to use! My PV panel produces about 3 Amperes of electrical current at about 17 Volts. I think of the voltage as the force that causes the electrons to move. Time to do a little math! A fellow named Ohm discovered a relationship between voltage, current and resistance which can be expressed as Resistance = Voltage divided by Current, or $R = {}^{E}/_{I}$. If you have current flowing through a bit of wire, you can measure the voltage drop across it, and figure out the resistance!

Reducing the heat

Here's another equation: the amount of power (in watts) is equal to the voltage times the current. Low voltage systems such as my 12 Volt system, carry a lot of current compared to 117 volts ac from the utility for the same amount of power. If you look at the cords around the house you'll notice that your cords for appliances are much smaller than the battery jumper cables. If I used a small wire for my 12 Volt system, some of the power that the panel is producing turns into heat in the wire instead of reaching the battery. More math here: Power (lost to heat) equals the voltage loss times current, P= EI. (Aside: Voltage loss equals current times wire resistance, E=IR, so substitute IR for E, and Power equals current squared times resistance, $P=I^2R$. For a constant resistance (a piece of wire), if you double the amount of current, you quadruple the power lost to heat!)

The resistance of the wire should be as low as possible so the voltage loss will be as low as possible. The PV panel may produce 17 Volts, or on a sweltering summer day, the panel may only produce 15 Volts. For the panel to charge the battery, the voltage produced by the panel has to be larger than the voltage of the battery. This wasn't obvious to me when I first started my system, but it makes sense! The electrons flowing from the panel have a hard job; jump-started by the sun, they have to have enough force (voltage) behind them to overcome the resistance of the connections, the wire, the regulator, and finally, the battery voltage. If the voltage of the current when it reaches the battery is only 12 Volts, then the battery won't get charged.

So the idea is to find wire with low resistance. The total resistance of the wire depends on the type of metal, the

diameter, and also the length. Wire tables list the resistance per 1000 feet of wire for different gauges and types of wire. The voltage difference (or loss) from what the panel is producing and what the battery is receiving should be about 2.5 to 5%. My system is a 12 Volt system, and I decided a 2.5% loss of voltage is okay. So 2.5% of 12 Volts is a 0.3 Volt drop; a 0.3 Volt loss is acceptable along the total length of wire between my PV panel and my battery.

How long a wire?

And what is meant by "total length of wire"? This confused me at first. After all, when you look at the cords all over the house, these are just single wires, aren't they? Nope. It turns out that if you cut a cord you'll see two or three insulated conductors (the third is for ground). Why two? Basically one conductor carries the electrons coming to your appliance and the other conductor carries the electrons going back into the outlet. For electrical current to flow in a circuit, there must a loop. Electricity comes from a utility, travels through lines to your home, travels on one conductor from the outlet through your toaster oven and then returns via the second conductor back to the outlet and to the utility.

I understand DC (Direct Current) a lot better than ac (alternating current)! The way I visualize this electrical path is as a grooved path for say, an endless line of marbles, all touching each other. But the trick is that they can't leave the grooved path: if the grooved path (or wire) is cut, the marbles (or electrons) don't fall out, they just stop. If there is a complete loop for the marbles, once they are put into motion, all the marbles in the loop move at the same time and at the same speed. I picture marbles put into motion by the PV panel traveling to the battery and back again to the panel.

So basically, I need two conductors from the panel to the battery. Positive and negative are the terms used to differentiate them. The positive lead from the panel is connected to the positive post of the battery, and the negative lead to the negative post. (This wasn't obvious to me either until I thought about the panel's voltage overcoming the battery voltage.) In chemistry classes I learned that electrons flow from negative to positive; physics classes taught that current moves from positive to negative. It means the same thing; this is all just notation. At any rate, the convention is to label the positive wire with red electrical tape and the negative with black tape. (My ac extension cord has the conductors labeled white for neutral (common), black for line (hot), and green for ground. Go figure — maybe they'll get it together someday!)

Copper Wire Table

Standard Annealed Copper, American Wire Gauge

Wire Size	Ohms Per 1000 Feet	Feet Per Ohm	Ohms Per Km.	Meters Per Ohm
OOOO	0.049	20400	0.161	6218
OOO	0.062	16178	0.203	4931
OO	0.078	12830	0.256	3911
O	0.098	10174	0.322	3101
2	0.156	6399	0.513	1950
4	0.248	4024	0.815	1227
6	0.395	2531	1.30	771.4
8	0.628	1592	2.06	485.1
10	0.999	1001	3.28	305.1
12	1.59	629.5	5.21	191.9
14	2.53	395.9	8.29	120.7
16	4.02	249.0	13.2	75.89
18	6.39	156.6	21.0	47.73
20	10.2	98.48	33.3	30.02
22	16.1	61.94	53.0	18.88
24	25.7	38.95	84.2	11.87
26	40.8	24.50	134	7.467
28	64.9	15.41	213	4.696
30	103	9.689	339	2.953
32	164	6.093	538	1.857

Right now I have a car battery that sits under a seat in the trailer. I measured the distance between the panel and the battery as about 25 feet; so I need 50 feet of wire total. I need to choose a wire size that will carry 3.5 Amps (the maximum that my panel produces) over this length with only 0.3 Volts loss.

Math Continued...

I know the voltage loss I will accept along my length of wire. If I can figure out how this translates to resistance, than I can look it up on the wire tables to choose the right size wire. It works like this:

$$R = \frac{E\ (1000)}{I\ L}$$

R is equal to the Resistance per 1000 feet of wire. E is the acceptable voltage loss. I equals the maximum current that will pass through the wire. And L is the total Length (round trip path) of the conductor. In my case, Resistance = the voltage drop that I will accept (2.5% or E = 0.3 Volts) times 1000, divided by the amount of current (I = 3.5 A) times the length of the round trip (L = 50 feet). R = [0.3 Volts (1000)] / [3.5 Amps (50 feet)] = 1.714 Ω per 1000 feet. The most resistance I will accept is 1.714 per

1000 feet. I look at the wire table under the Ohms per 1000 feet column for a resistance less than this amount. Twelve gauge wire has a resistance of 1.59 Ω per 1000 feet, so I can use #12 wire or larger (i.e., #10, #8...) from my panel to the battery.

I got to know this equation and table very well in the process of wiring my system!

My next step is to wire the 12 Volt outlets so I can finally unplug from Home Power Office and Power, and turn on my lights and music on my own power! I haven't finished with these equations yet!

Access

Therese Peffer, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

No renewal notices will you find
So to trees we can be kind
Your mailing label check now fast
For this issue may be your last!

HAPPENINGS

NATIONAL

Electric Vehicle Safety Survey: In order to establish meaningful standards, the Electric Vehicle Industry Assn. is seeking data on the safety of EVs already in use. Anyone who has had any experience with EV accidents is invited to share their information. The survey takes 10 minutes to complete. Final data will be made available for publication. To participate, contact Shari Prange, Electro Automotive, POB 1113, Felton, CA 95018 • 408-429-1989

The Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) is a national service, funded by the U.S. Department of Energy, that provides the general public and educators with free information on renewable energy and energy conservation. They also maintain a referral network of approximately 500 organizations that provide more technical information. CAREIRS is interested in organizations that can benefit from being part of their monthly mailing list. The mailings are most useful to organizations who have direct contact with the public. For more information contact CAREIRS, POB 8900, Silver Springs, MD 20907 • 800-523-2929

SOLTECH 93: April 22–28th, 1993, Washington, DC, Solar Emerging: The Reality. Three major solar energy conferences will be held jointly: The American Solar Energy Society (ASES) Solar 93 Conference, the SOLTECH 93 Conference, organized by the Solar Energy Industries Assoc. (SEIA), and the American Society of Mechanical Engineers (ASME) International Solar Energy Conference. For information, contact ASES, 2400 Central Ave G-1, Boulder, CO 80301 • 303 443-3130, FAX 303-443-3212. SEIA, 777 N Capitol St. NE, Ste. 805, Washington DC 20002 • 202-408-0660, FAX 202-408-8536 and ASME, 345 E 47th St, New York, NY 10017 • 212-705-7054, FAX 212-705-7674.

Home Energy Magazine is offering a free Directory of Energy-Related Graduate Programs in U.S. Universities with over 60 programs in the fields of energy, resources, the environment, and development. This directory was produced by the Energy Foundation, with the cooperation of Student Pugwash USA, a national educational, non-profit organization. The free directory is available via book, IBM 3.5” disk, IBM 5.25” disk, Macintosh disk, (please specify MS Word 5.0, Filemaker Pro (Mac) or delimited ASCII). Contact *Home Energy Magazine*, 2124 Kittredge St #95, Berkeley, CA 94704

Free *Natural Gas Vehicle Magazine:* Send SASE to Frank Rowe Circulation, *NGV* Magazine, 1410 Grant St Ste A-201, Denver, CO 80203 • 303-863-0521 • FAX 303-863-0918

EV Network: Ken Koch will search his file of 2,000 customers and let you know if there’s an EV owner near you. Send an SASE to: 12531 Breezy Way, Orange, CA 92669

West Coasters: Cross pollinate! Looks like SEER is not happening this year. Take the opportunity to ride a chartered bus with fellow renewable energy maniacs to MREF, the Midwest Renewable Energy Fair, June 18–20 in Amherst, Wisconsin. We need to know how many buses we’ll fill. If there are enough folks, we can charter Green Tortoise buses and drivers (≈$300/person). You’ll probably depart June 15, travel three days cooking out and sleeping on beds in the bus, and arrive the 18th for the fair, with sleeping accommodations in the bus. You’ll return to the west coast on the 23rd or 24th. Tell us how many seats you want, and if you’d like to leave from Portland or San Francisco or L.A. Drop a note to MREF Bus Trip, c/o Home Power, POB 520, Ashland, OR 97520

ALABAMA

The Alabama Energy Extension Service is offering free energy consultation and literature on a wide variety of energy related topics. Contact: Alabama Energy Extension Service, The University of Alabama, Box 870201, Tuscaloosa, AL 35487 • 1-800-452-5901 (AL only) or 205-348-4523

ARKANSAS/MISSOURI

Ozark Renewable Energy Assoc.: Julie Courtney of Ozark Renewables is organizing a renewable energy club to promote RE in the Ozarks. Those interested in participating please contact Julie Courtney at RT3, Box 4305, Reed Spring, MO 65737 • 417-338-8688

CANADA

SW Alberta Renewable Energy Initiative Information Centre provides Canadians with information and workshops on renewable energy. For more information contact Mary Ellen Jones, Information Centre Manager at POB 2068, Pincher Creek, Alberta, Canada T0K 1W0

CALIFORNIA

North San Francisco Bay Chapter of the Electric Auto Assoc. (EAA) holds meetings on the second Saturday of each month at the PG&E Business Center, 111 Stony Cir., Santa Rosa, CA from 9:30 AM–Noon. For

information on the EAA and the chapter nearest you, send an SASE to 1249 Lane St, Belmont, CA 94002, or call 415-591-6698 (10 to 5 on weekdays).

The American Hydrogen Association's Silicon Valley Chapter is now offering access to a bulletin board system with information on solar cells, hydrolyzers, gensets, windmills, hydropower, ocean thermal energy converters (OTECs), bio ponds, thermal cracking and other means of converting solar energy in hydrogen. Learn about technologies for transporting hydrogen by pipeline, storage of hydrogen as a liquid, a gas, and a hydride, combustion of hydrogen with air and by catalytic burning and how hydrogen is electrochemically combusted to produce electricity within fuel cells. Contact: The American Hydrogen Association – Silicon Valley Chapter Headquarters, 1401 Pointe Claire Ct., Sunnyvale, CA 94087, BBS@408-738-4014 Voice@408-235-1177

Offline is having a one day workshop on Designing Your Home PV Power System, Sunday, March 7, 1993. The class will begin with a tour and discussion of a working PV system. We will then develop the following topics: basic system types, determining power needs, the PV array, the battery, and inverters. We will discuss how it's all put together: special wiring needs, code requirements and safety, instrumentation and controls. We will also look at how to live with PV in relation to appliances, computers and entertainment equipment, attitude and awareness. Cost is $35 for one person, $45 if two people sign up together. For further info, reservations and directions please call or write Don & Cynthia Loweburg, Offline Independent Energy Systems, P.O. Box 231, North Fork, CA 93643 • 209-877-7080

The 2nd Tehachapi Wind Fair And Windmill Hike will be held May 22–23, 1993. Sponsored by the Kern Wind Energy Assoc., Southern California Edison, and Mountain Valley Airport, the weekend festival celebrating the success of the area's renewable energy industry will be held at the local sailplane port. The fair will include displays of wind and solar energy, electric vehicles, tours of an area wind farm, kite flying, and sky diving. The annual hike among the wind turbines will be held at 9 AM on Saturday, May 22. For more info about the fair or hike call Tehachapi Wind Fair Committee at 805-822-3222, or contact the Wind Energy Assn. at 805-822-7956.

Arroyo Seco Earth Festival: April 24, 1993. Earth Parade, over 200 environmental exhibitors, environmental theme park featuring energy, transportation, air quality, waste & recycling, food & agriculture, children, recreation, housing, conservation, business, manufacturing, nature and more. Live music, clowns, jugglers, entertainment, food, earth games, and a job fair. For more info contact Timothy Brick, The Arroyo Seco Council, 16 S Oakland Ave., Ste. 205, Pasadena, CA 91101 • 818-792-2917

COLORADO

Solar Home Workshops will be held at the Sustainable Technologies International (STI). These workshops are for owner builders and persons seeking careers as solar professionals. See ad on page 95. For a detailed description of SOLAR HOME PROGRAM WORKSHOPS, costs and scholarship information, write STI, POB 1115, Carbondale, CO 81623-1115 • 303-963-0715

4th Annual Crestone, Colorado Energy Fair: July 21 & August 1, 1993. The Fair committee wishes to thank all the folks who made the 3rd Annual Creststone Energy Fair such a success. Anyone interested in participating in this year's Fair should contact Citizens for Clean Energy, P.O. Box 17147, Boulder, CO 80308 • 303-443-6181

FLORIDA

Florida Solar Energy Center: 1993 PV System Design Workshops: Learn about solar electric technology and the proper way to design stand-alone PV systems. Registration fee: $300. Feb. 9–11, May 25–27, Sept. 14–16 1993. For more info contact JoAnn Stirling, 300 State Rd 401, Cape Canaveral, FL 32920 • 407-783-0300 ext 116, FAX 407-783-2571

MAINE

Hands-On Workshops will include: solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch. For information on sites and dates contact Richard Komp, Maine Solar Energy Assoc., RFD Box 751, Addison, ME 04606 • 207-497-2204

MASSACHUSETTS

NESEA: Over 50 cars, powered by the sun, will race from Boston, MA through New Hampshire, to Burlington, VT, May 23–29 1993, in the fifth annual American Tour de Sol, the solar and electric car championship. There will be free educational displays of these non-polluting cars along the route. Contact: NE Sustainable Energy Assn., 23 Ames St., Greenfield, MA 01301 • 413-774-6051

MINNESOTA

Minnesota Sunfest 93: A three day renewable energy exposition will be held June 25–27, 1993. Events include the finale of the SunRayce 93, featuring 36 solar vehicles built by college students from across the U.S., Solar Boat Regatta at Lake Nokomis, Student Science Contest, Kids Programs, a non-polluting commuter vehicle demo, solar

powered hot water exhibit, entertainment featuring strolling musicians and a live Garrison Keilor radio show, solar workshops and a variety of exhibitors featuring commercial solar products, ecological exhibits, and food booths. Most of the activities will be held at the Minnesota Zoo. For more info contact Stephen Dess, P.O. Box 36, Crosby, MN 56441 • 218-546-5369

NEVADA

Solar Electric Classes taught at remote solar home site. Maximum of four students for more personal attention. Two day class choice on 4th weekend of Feb., March, & April or 3rd weekend in May 1993. Classes on weekdays & other weekends upon request, minimum of 2 students. Class will be full of technical info, product evaluation, sizing systems etc. Students will build a solar system. $75 per person. Call 702-645-6571 or write Solar Advantage, 4410 N. Rancho Dr #148, Las Vegas, NV 89130

NEW YORK

Earth Month 1993: The Earth Month Coalition in Rochester, NY is again sponsoring Earth Month. Earth Month 93 will kick-off on March 20, International (United Nations) Earth Day, and wrap-up the weekend following April 22, U.S. Earth Day. Events are too numerous to list here, but include “The Sense of Wonder”, a play depicting the life of Rachel Carson, and a weekend of Earth Day events including an Alternative Energy Fair. For more details and a copy of the Earth Month calendar please call Susan Dorman 716-271-3550 or Bill LaBine 716-334-2347.

E-DAY 1993 will be held in Olean (O-lee-ann), NY at the city recreation center on Friday, April 30 and Saturday May 1 from 10 AM till 6 PM. “E” stands for energy, environment and everyone. Displays will include energy conservation, solar goodies, solid waste management, electric vehicles, student projects, and much more. 30–40 energy related vendors will also be on hand to showcase their products and services. A nominal, but necessary fee will be charged at the door. For more info, call Don Struchen at 716-933-6175, 7–11 PM EST or write to 91 Brooklyn St, Portville, NY 14770

NORTH CAROLINA

Photovoltaic Design & Installation: the Sustainable Technologies International’s (STI) popular 2 week hands-on workshop will be facilitated by Go Solar Enterprises. Beginning March 8, participants will learn how-to specify and install PV systems. The workshop cost is $400 per week and is for those who want practical non-biased information from professional educators. No prior knowledge of solar or electricity is required. Everyone welcome! For more details write Joe Flake at Go Solar Enterprises, P. O. Box 422, Fairfield, NC 28137 or call 704-463-1405.

OREGON

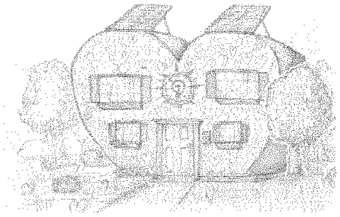
The Appropriate Technology Group is a grassroots and hands-on group formed to explore education, demonstrate projects, provide a community resource for designers and builders, do experimental projects involving energy, transportation, sewage, hazardous and solid waste, etc. The group meets once a month in Portland, OR. For more information call 503-232-9329 (evenings).

WISCONSIN

The 4th annual Midwest Renewable Energy Fair is June 18–20, 1993 at Amherst, Wisconsin. The Energy Fair introduces the public to a wide spectrum of renewable energy technologies and their contemporary applications. The Energy Fair is a fun and educational experience for individuals and families. At the Energy Fair you will have the opportunity to: • see wind and solar actually powering the fair • see, handle and purchase products that will help you conserve energy, protect the environment, and save money • attend informative hands-on workshops (beginner to advanced) presented by experts from across the country • walk through a model home demonstrating energy efficient construction and appliances, and renewable energy, power and heating • see vehicles powered by alternative energy • network with others who share similar interests • dance to live music played on a solar and wind powered stage. Have fun and more!

For more information about the Energy Fair contact: Midwest Renewable Energy Association, 116 Cross St., Amherst, WI 54406 • 715-824-5166 Also see West Coasters Bus to MREF trip on page 90.

Home & Heart



Kathleen Jarschke-Schultze

For the fifth time that day I explained what a Sun Oven was, and why I was hauling that big box around with my luggage. There I was, in Hawaii, about to present solar cooking to people from the Pacific Islands.

Pacific Islands

I speaking on solar cooking at the Renewable Energy, Food Processing, and Eco-Tourism for the Pacific Islands conference on the island of Hawaii. This was a wonderful opportunity for me, so I gathered information and a Burns-Milwaukee Global Sun Oven and took to the skies. The conference was sponsored by the United States Export Council on Renewable Energy and the Committee on Renewable Energy Commerce and Trade. Participants and guests represented the Pacific Islands, including Fiji, Papua New Guinea, the Solomon Islands, Kiribati, Tuvalu, Tonga, Vanuatu, Western Samoa, New Zealand, Savaii, and the Virgin Islands.

Eco-Tourism

Tourism has become the largest industry in the world in the last decade. Eco-Tourism is becoming increasingly popular. Eco-Tourism is defined as responsible travel that conserves natural environments and sustains the well-being of local people. Guest huts or lodges are provided with systems that highlight the use of renewable energies (RE). Attention to the existing ecosystem and education about the local culture are stressed.

Case studies of RE systems currently in use at tourist sites were presented. Workshops on planning critical business issues, financing and technical assistance gave the guests information to begin or enhance their projects.

Food Processing

Food processing is often a big business for small Islands. Guest speakers addressed the elements of developing a successful agribusiness or food processing operation. Reports were offered on icemaking for fisheries in Mexico using solar thermal technology, wood processing and copra processing, ethanol production in Italy, and biomass cogeneration in sugar processing.

Mac Nut Factory

Our last day in Hawaii we took a tour of RE sites around the island. We visited the Mauna Loa Macadamia Nut factory. What a treat! A smiling hostess greeted us, holding out a tray of macadamia nut truffles.

The plant's biomass generator, which produces 85% of the factory's electrical needs (700 kiloWatts), uses both shells and husks from the macadamia nuts and used crankcase oil. The Hilo site was only one of three factories where the Mauna Loa company uses biomass generation for energy production.

Kahua Ranch

Another site, Kahua Ranch used wind power to generate electricity. The Kahua Ranch is 22,000 acres of lush pastures spreading from summit to the sea, on the slopes of the big island's oldest volcano. The Kahua raises cattle, as it has since 1928. Their herd of registered Avignon Charolais and Angus is the state's largest. Sheep are another profitable concern.

The Ranch has diversified and now includes two greenhouses totaling over 30,000 square feet under roof. Fifty different varieties of long stemmed carnations are grown there for use throughout the islands.

Peter Shackelford manages the power system for Kahua. It is a grid intertie system employing twenty-one wind turbines, (three Carters and eighteen Jacobs) to generate 400 kiloWatts (kW). Excess wind energy is used to run a pump that pumps water up a 4,400 foot long, 8 inch diameter pipe into an upper reservoir. When there is no wind the water runs down into a water turbine at 150 psi and ends up in a lower reservoir. The lower reservoir is higher than the 50 hp pump intake so there is no priming problem when the pump starts. Peter keeps a battery bank in the power shed to shut the turbine down slowly in case of a power outage.

The local utility sells power for $0.17 per kiloWatt-hour (kW-hr) and pays Kahua Ranch $0.06 per kW-hr.

Home System

Outside Waimea, Rick Habine has a small RE system installed by Peter and his partner, Joe Clarkson. This was more what I was familiar with. He had 12 Solarex MSX-60 photovoltaic panels on a Wattsun tracker. He uses a Trace 2524SB inverter, a Cruising Equipment Amp/Hour+ meter, a 24 Volt Sun Frost RF-16 refrigerator/freezer, and lead acid batteries. It would have cost Rick $18,000 to bring power to his house. This system cost $20,000. The other tour participants had not seen a home system before and were surprised and delighted at the efficiency attained.

Hawaiian Hydro

Our RE tour bus took us past some of the most beautiful waterfalls on the Hilo side of the island. In Hilo, we visited a system Fred Koehnen had engineered. On a well-manicured residential street, a black lava flow pours down the slope between expensive homes. A cascading waterfall uses the lava flow for a stream bed. This grid intertie hydro system uses a custom-made Canyon Industries turbine. There is 25 feet of head in a 15 inch pipe, which is reduced to 12 inches close to the turbine. This system produces 5 kW. The turbine powers two homes. Automatic utility phasing also a feature. The family uses the small pool at the fall's head for swimming.

Paradise

I met many interesting people, I learned much, and I think I taught a few things too. Hawaii is the paradise everyone says it is. I did feel as if I were in a foreign country though, where the US dollar had been devalued. My mainland dollars just didn't equal Hawaiian dollars. I had a wonderful time. I want to thank Tom Burns of Burns Milwaukee for this opportunity and Dianne Eppler for making the whole thing such a rewarding transference of information and interest.

Old Business

I got the Lehman's catalog. It is just great. I have already ordered and received kitchen tools from them. I recommend it for anyone looking for non-electric household tools.

You can order replacement trays for the American Harvest food dehydrator through J. C. Penny. I used the 15 inch square trays in the solar dehydrator I built (HP #30). They are sturdy and easy to wash.

Access

Kathleen Jarschke-Schultze, c/o Home Power Magazine, POB 520, Ashland, OR 97520

Dianne B. Eppler, consultant, Renewable Energy Trade Promotion, 11523 Hearthstone Court, Reston, VA 22091 • 703-391-0060 • FAX 703-264-7729

Peter R. Shackelford, Renewable Energy Services, Inc., P.O. Box 278, Paauilo, HI 96776 • 808-775-0852

Kahua Ranch, P.O. Box 837, Kamuela, HI 96743 • 808-889-6464

Fred Koenen, Wailuku River Hydroelectric Power Co., P.O. Box 950, Hilo, HI 96749 • 808-966-9325 • FAX 808-966-8522

Carla Garrison, The Ecotourism Society, 801 Devon Place, Alexandria, VA 22314 • 703-549-8979 • FAX 703-549-2920

Lehman Hardware and Appliances, P.O. Box 41, Kidron, OH 44636 • 216-857-5771 • FAX 216-857-5785

the Wizard Speaks…

Magic

Magic has taken many forms over the ages. The original Magi were the scientists of Asia Minor. In the Middle Ages they became the alchemists. The definitions of Magic today are varied. Here are a few of the more famous ones. “Magic is the science of causing changes in accordance with one’s will.” “Magic is the intersection of science and art.” “Magic is any sufficiently advanced technology.” Throughout history, Magic has been on the leading edge of scientific investigation. It is the major paradigm of existence, always looking to the future.

Magic is essentially the science of what works. Theories that explain “what is” are not as important as insights that allow new developments to occur. Magic is an anti-entropic force, breaking down the status quo as it seeks to overturn the limitations of established viewpoints of reality. The Magic of today will be the science and technology of tomorrow. Magic accepts no artificial limits.

Become Magic! Create tomorrow!

Learn Renewable Energy Technology

SUSTAINABLE TECHNOLOGIES INTERNATIONAL

Learn the practical use of sun, wind and water power.

THE 1993 RENEWABLE ENERGY EDUCATION PROGRAM

Photovoltaic Design And Installation – 2 weeks
Learn to design and install solar electric systems. • Fundamentals of Practical Design/Sizing • Typical Applications • Hardware Selection • Safety • Case studies • Field Installation.

Advanced PVs For Remote Homes – 2 weeks
Guest instructor: Richard Perez, *Home Power.*
Learn to design/install residential systems • ac/DC PV/Hybrids • Lab Exercises • Hardware Selection • Code Compliance • Wiring • Retrofitting Appliances • Case Studies and tours.

Solar Water Pumping – 1 week
Guest Instructors: Windy Dankoff. Learn to design and install solar water pumping systems. • Stock Watering, Irrigation, Domestic and Community Water Supply • Field Experiences • Case Studies • Equipment Selection • Commercially Available Products. For those seeking practical knowledge and experience in solar water pumping.

Micro-Hydro Electric Systems – 2 weeks
Guest instructor: Don Harris, Harris Hydroelectric. Learn to install residential water power systems. • Design and Sizing • Commercial Products • Site Installation.

Wind Power – 1 week
Guest instructor: Mick Sagrillo, Lake Michigan Wind & Sun. Learn to design and install wind generator systems. • Aerodynamics • Generators, Alternators & Induction Machines • Tower Design • Site Analysis/Sizing • Safety • Energy Storage • Legal Issues • Hybrid Systems • Installation Procedures.

Solar Cooking, Drying & Water Purification – 1 week
Learn simple, easy-to-use solar technologies which can provide clean water, meal preparation and preservation of food in developing countries • Successful Designs • Practical Use • Field Experiences.

Solar Home Design Principals – 2 weeks
Learn the fundamentals of solar and energy efficiency • Passive Solar Concepts • Design Guidelines • Construction Techniques • Remodel/Retrofit Opportunities • Solar Water and Air Heating • Sunspaces and Greenhouses • Case Studies and Tours. A comprehensive overview for those who want to design/build.

Hydrogen Energy – 1 week
Guest instructors: Dr. Robert Wills & David Booth. Learn how hydrogen can be used in energy applications. • Fundamental Principles • Safety • Historical Overview • Electrolyzer Theory and Operation • Storage • Available Products • Appliance Conversion • Fuel Cells • Future Perspective. Hands-on experience generating and using hydrogen.

WORKSHOP SCHEDULE

March 8 – 18 May 17 – 27	Sept. 6 – 16	Photovoltaic Design and Installation (these dates in North Carolina only)
June 1 – 11	Sept. 20 – 30	Advanced PVs for Remote Homes
June 14 – 17	Oct. 4 – 7	Solar Water Pumping
June 21 – July 1	Oct. 11 – 21	Micro-Hydro Electric Systems
July 6 – 9		Wind Power
July 12 – 16		Solar Cooking, Drying, & Water Purification
July 19 – 29	Oct. 25 – Nov. 4	Solar Home Design Principles
Aug. 2 – 12	Nov. 8 – 18	Advanced Passive Solar Design
Aug. 16 – 19		Hydrogen Energy

Tuition: $400 per week. Discounts for multiple workshops.

For more information, contact:

SUSTAINABLE TECHNOLOGIES INTERNATIONAL
P.O. Box 1115, Carbondale, CO 81623-1115
or call STI at (303) 963-0715, FAX 963-3198

Letters to Home Power

Good News from El Salvador

Dear Home Power, We just finished our second successful PV installation in El Salvador. Things have been going really well. We installed the first system in a community of 250 people called El Sitio. It's an amazing place. About ten community members helped install the system and three of them are in charge of the maintenance. It's a one panel, two light system for the building which acts as their community center, school, and health clinic. They now have adult literacy night classes. People who have always wanted to learn how to read but always had to work during the day, now have their chance. In fact, people from neighboring communities all around El Sitio are going there to study at night. The only problem is all the children want to be in the class as well, and class is disrupted with all of the kids hanging around. So now the community is hoping to put in another system so that the children can have their night classes as well.

We installed the second system in Nueva Esperanza, a repatriated refugee community of about 200 people. It's another amazingly well organized community. Since their community center is larger, the installation consists of 2 panels, 4 DC lights and a 150 Amp-hour nickel iron battery. They're excited that they can now have meetings at night instead of taking time out of the work day, and are looking for a teacher who can teach literacy classes at night.

We are also teaching nine women in Nueva Esperanza how to build and use solar ovens. The workshops are going incredibly well and the women are all very excited to start using their ovens. We cook in ours almost every day, and last week when the beans came out perfect, everyone became a solar oven convert. I think beans were the true test.

It's really exciting working in El Salvador. The enthusiasm for solar energy is incredible. It is also so satisfying to see people putting the energy to such important uses such as literacy classes. Thanks so much for all your help with our project. The project could not have happened without help from people like the Home Power Crew and the Solar Technology Institute.

I hope your Columbian trip went well. I'm looking forward to the next issue, if it makes it this far south, Laurie Stone, Nueva Esperanza, El Salvador

When Laurie, Julie, & Ben left for El Salvador, the news was that Nueva Esperanza and the surrounding area was totally washed away by a major flood. These dedicated folks decided to go anyway, so this letter was cause for celebration. For more information on what Laurie and friends are up to, see HP#31 page 28. Here is a very worthy cause where all donations go to the cause, instead of some fat cat's bank account. If you'd like to help, donations can be sent to Solar Community Projects, c/o Laurie Stone, 5060 Overlook Rd NW, Washington, DC 20016. — Karen

A Unique Opportunity for Solar Energy Education

Dear HP, want to donate my $12,000 "Neah Bay" (Home Power #26), winner of the first solar boat regatta in the US, as a solar energy educational vehicle. I welcome inquiries from high schools, but any other educational use would be just fine.

The "Neah Bay" is fully operational and ready to run. I built the boat to learn about solar energy and solar boats. It fulfilled its purpose for me, but many students could learn how well clean sun power propels a boat without noise and pollution. You have to see and feel it!

I'm moving back to Germany in April, to teach design in the city of Berlin. I'm planning my next generation of solar powered river boats, but I'd like my American solar boat efforts to make a lasting difference.

The "Neah Bay" is an opportunity for a high school to get involved in the growing number of solar energy activities nationwide. The boat encourages hands-on experience in a team setting. Write me for an application kit. Hartmut Ginnow-Merkert, 1840 Lakeview Terrace, Orono, Minnesota 55356, 612-473-8699, FAX 612-476-6135

Iowa RE Fair

The first I-RENEW Energy Fair, October 17, 1992, held in Cedar Rapids, Iowa was one of the most exhilarating experiences one could ever imagine, but the amount of work involved could never have been imagined! Tom Deves, Jim Sievers, and I originally thought last May that an energy fair in Iowa was maybe possible next year (1993). That was our experience! We decided to try the fair idea, with no real idea what was involved. We decided on Cedar Rapids mainly because it was close and, originally, because we were to be the Eastern Iowa Fair.

With a visit to the Cedar Rapids Convention and Visitors Bureau, we realized the idea had a few believers outside

our group. The bureau donated a telephone line to make contacts. One full day day of telephone calls and many miles of walking resulted in $50.00 from one bank. YUK! The bureau did donate 500 brochures and a computer to design our flyer.

Tom Deves returned from the Midwest Renewable Energy Fair in Wisconsin in late June with the announcement that Home Power had an ad in their August/September issue. I-RENEW greatly appreciates this; we received calls from people around Iowa and surrounding states. These calls convinced us this fair was not to be just a local affair.

In late August, Tom Deves and I attended a four day conference near Des Moines sponsored by the Union of Concerned Scientists. The workshop we found most beneficial was on using the media for advertising our fair. The UCS mailed an article about our fair to all its members. My wife even received a call from Denmark. One of the simplest things learned about media was: just ask. We received advertising from radio and TV stations in Dubuque and Cedar Rapids and the Cedar Rapids Gazette even printed an Opinion/Editorial article about our fair. We just asked!

Originally, I thought this would be a nice little local event. What we ended up with was 30 displays and booths as well as Iowa University's solar powered car and an electric/PV truck. The 5 workshop tents were busy most of the day with 24 workshops on active solar, PV well pumping by A. Y. McDonald, Chad Lampkin's shops on photovoltaics, methane by Al Rutan, the methane man, and Mick Sagrillo on wind, to name a few. Chad Lampkin was very generous in setting up a 1000 watt system (with 40 donated Exide batteries). We had a 17.5 kW wind charger on site that could have been used if needed.

Things I personally learned from this experience: The amount of time required to put on an energy fair is unbelievable. Do not spread yourself too thin. I, personally would turn the tent raising, video taping, announcing during the day to others. Do the things that are enjoyable to you. I would make the telephone calls, write newspaper articles, have a booth, and do workshops.

The above description of how to organize a fair is a brief description of the time and events required. There are not enough words, space, or time to do justice to this project. Also, to the many people who had displays, workshops, or just helped, again thanks to all. We will see you all again next October (1993), Tom Snyder, 611 2nd St SE, Dyersville, IA 52040

Thanks Tom! As you can see if you check out Happenings in this issue, Energy Fairs are cropping up all over. Input from folks who have done it is invaluable for folks who want to have a Fair in their area. — Karen There's always room for more fairs! If you are planning one in your area, let us know so we can spread the word! — Therese

News from Down Under

Dear Richard & Crew! A friend gave me a copy of your magazine (issue #24) a few days ago. I'm now trying to get your magazine from the local news agency/book store.


Alpine Cal.
Nov. 1, 1992

Dear H.P. Group
Please continue my first Class Sub –
Aint got no mailing label - The dog ate it..

Thanks and Regards
DM.

DON MACHADO
PO BOX 35
ALPINE CAL 91903

We don't have magazines quite like yours in Australia. I have been dreaming about living off the grid for years, but I have very little knowledge of electronics & electricity. What little money that we have is used for becoming debt-free and to feed my kids. The point is that I will have to Homebrew and scrounge the batteries, generators (alternators) etc. Are there any batteries that could be homemade by persons with above average mechanical ability?

I'm interested in alternative sources of energy, home power, self-reliance, permaculture, home shop machining (A'la Gingery and The Home Shop Machinist), home wine brewing, local self-reliance & related subjects. Would like to correspond with people with the above interests. Yours Sincerely, Bill Beke, P.O. Box 9, King Lake 3763, Victoria, Australia

Ain't it Grand! From little seeds big wonders grow. So sharpen those pencil, click those Bics, and exchange those itty bitty seeds. — Karen. You could make your own batteries by stacking layers of lead in sulfuric acid, or nickel and iron in sodium hydroxide. But the materials are toxic, yet easily polluted by even the minerals in household water. Instead, inquire at telephone companies, airports, etc. for used batteries. As we continue to discover, though, there's no end to the renewable equipment which can be home-built. We were sent a copy of "Soft Technology" published by Alternative Technology Assoc., Inc., 247 Flinders Lane, Melbourne, VIC 3000, Australia • 03-650-7883. Looks like a great magazine, Australia's version of "Home Power". — Chris

You're Late

HELP!

December first has come and gone.

And I've no idea what went wrong.

I've checked the label,

I've checked the date,

and in dismay I have to say,

you're Late!

Expectantly, Pete Ivanashchenko, Round Lake Beach, IL

December was a brutal time,

Everything was not so fine.

The trip down South ran us round ' n round,

Then our printer let us down.

We're sorry that we scared you ever,

But we figure, better later than NEVER!

— Karen & The Wiz

Keeping Cold in Canada

I have an off-grid PV powered cabin which is used about 2 months per year, which we hope will become our full time home in the near future. (6 Solarex MSX-60 PV panels, SCI 30 controller, Trace 2012 inverter, 1500 Amp-hrs of C & D lead-calcium cells. I anticipate added cells and possibly a wind generator should we move in full-time). We use propane for cooking, water heating and refrigeration, inverted PV for water pumping, lighting etc.

Propane refrigerators are now illegal in Ontario for indoor use because of carbon monoxide poisoning incidents and I hope to move to electric refrigeration. However, the $3000 (Canadian dollars) cost of a larger Sun Frost is not all that attractive (though I recognize it would be cheaper in regular use than the cells I would need to power a conventional fridge). Which leads me to my request — I would love to see articles on "build your own" high-efficiency fridges.

For example, has anyone taken a conventional fridge and retrofitted an efficient compressor like a Danfoss and added insulation? How about a through the wall design that takes advantage of winter but has enough insulation to avoid freezing food in a northern climate and has an added insulation panel for summer? What about cold cellar designs that take advantage of ground temperatures and vent heat outdoors in summer, and into the living space in winter? My problem in implementing any of these ideas is figuring out the proper sizing of compressors, box, and insulation for differing ambient temperatures. Are there any plain English design manuals for refrigeration DIY'ers? Thanks, David Poch, 376 Montrose Ave, Toronto, Ontario M6G 3H1

A fellow Canadian, Bob McCormick of Northern Alternate Power Systems describes his homebuilt 12 Volt DC refrigerator in HP #16 using a Danfoss compressor. Also, in HP #21, James Davenport describes his homebrew 'fridge. The Cooks' in Pennsylvania (cover of HP#29) built their own refrigerator/freezer. I have heard about through the wall designs to take advantage of the cold of winter, but haven't seen designs. Sounds like a good idea! Any plans out there, readers? — Therese

Clean Water

Dear Home Power, The project for Colombia's Paez Indians (HP #32) is wonderful. Thank you! The question that came to me reading about it was: what about the ongoing water needs of the battery pack? If this remote community cannot get their shipment of throw-away plastic bottles of distilled water from the city, won't they be tempted to use the local product? By doing this won't they damage the batteries in the long run?

As an owner of nickel-iron batteries I know of their voracious appetite for distilled water. Why not build and supply such remote systems such as these (as well as the systems we are living with) a solar water distiller?

Is there a reader out there with a good design we can all make? Could it be as simple as a flat plate hot water panel with a medium which water can be slowly trickled over in place of the fin and tube absorber. As it heats and evaporates it condenses on the slanted glass cover and then rolls down the glass as pure distilled water to be captured at the bottom? Sincerely, Rob Harlan, 42451 Road 409, Mendocino, CA 95460

Hello, Rob. Laurie Stone and friends took solar water distillers to El Salvador. These mini distillers are designed and made by McCracken Solar, 329 W. Carlos St., Alturas, CA 96101. In the case of Mosoco, Bijou is planning regular visits to check the batteries. — Richard

Just beginning…

Hi HP Crew, Thought I would pull up a typewriter and wish all of you the best for the holidays. Received issue #32 of Home Power this past week. Good solid issue. I skipped through reading what appealed to me the most. Then went back to fill in the blanks. Finally read everything from front to back.

Richard, I enjoyed your article on bringing solar energy to Colombia. Both you and Karen are to be commended for your action. I hope this seed planted will grow and flourish. I hope the undeveloped countries can skip the excesses we went through in becoming an industrialized nation.

Therese, I enjoyed your article, “Me and my panel.” I have a lot of empathy with you as I too try to design a system. And make it grow. I work on a tight budget, so I order one piece of equipment a month. Mail order. Best price I can find. I have a Hoxan 4810 module, a Trace C30A controller, and a 12 Volt DC load center (12 fused circuits). Next month I’ll order a 2 pole-fused disconnect switch. Then two 6 Volt Trojan batteries. Plus the wiring and such that go with the system.

But you have one up on me, Therese. You can check the electronic wizards on the staff. You can look at systems already set up. And you can order from a dealer locally. It’s a bit different in Texas. No dealers. No systems to see and examine. I operate in a vacuum. Call myself a solar sponge. A very dry one. I can always learn something new, when I read about renewable energy.

The only modules I have seen are the ones I have ordered through the mail. The only systems are the ones I plan and dream about. I learn from books, catalogs, and magazines. Especially Home Power. I have a stack of the “bible”, all the issues from start that were available. I find myself going back and looking for subjects. “Things that Work!” Pieces on soldering. Wiring several panels together. Charging small nicads.

Don’t get me wrong. I’m not complaining. I’m having a great time using renewable sources of energy as a hobby. And believe me, old dogs can learn new tricks.

I bought a PowerStar 200 plug-in inverter from Electron Connection. And learned that an inverter uses a lot more power doing its thing. Inverting. I was wondering how many amps a unit would draw after going through the inverter. But never did find out, for the inverter was drawing 20 Amps just switching from DC to ac.

So I learn by trial and error. Have a Black & Decker electric lawn mower. Thought I might be able to power it from my portable unit (see HP #31). Mower has 6.5 amps stamped on label. Hard to read. If 6.5 amps x 110 volts = 715 watts, there is no way my plug-in will work. But I plugged it in and the mower ran. Took a short time to rev up. And it did not have full power. But inverter stayed on.

Although the lawnmowing operation does not work, the inverter does help run some tools in my workshed. The 3/8 drills runs fine. And I hope to see if it will work on the new system. Read somewhere that small plug-in inverters will not work on grounded house systems. Guess I’ll find out.

I recently bought a string of LED Christmas lights from Backwoods Solar. I hung these under a bookshelf in the middle of my trailer. Plugged it onto a 5 watt Solarex module for daytime use. At night, switch it to an Innova 12 Volt DC power pack. Works fine.

Well, I’ll get off the line. Have enclosed two clips form the Dallas Morning News. One about “green” refrigerators. Wonder why they did not just use Sun Frost. Other clip is on a digital phone setup in Texas. Wishing all the staff an Enlightened Christmas. And a real high powered New Year, N. Bleecker Green, POB 304, Royse City, TX 75189-0304

Hi. Glad you enjoyed the article. Part of the inspiration for my system was seeing your system in HP#31! I think anyone can set up a small system; it just takes some time and patience (especially for beginners). I’m a bit spoiled here at Home Power. You can learn a lot with great teachers and I sure have quite a few electronics wizards around here to help me with my system. We try to teach through the magazine, at all levels from beginners like me to homebrewers. But we couldn’t do it without input from readers, sharing your systems, whether simple or complex. We can sure learn a lot from each other! Thanks — Therese. Hello N. Your POW200 drew 20 Amps when you had no ac loads plugged into it!? Mine uses 0.25 Amp (3 watts). I’d check your measurement again, but it sounds like it’s working if you managed to run your lawnmower with it! A 1991 or newer model POW200 will give as much current as it can to a load. If the load is much greater than 200 Watts (as your lawnmower was) then full power won’t be delivered. The POW200 is better suited for loads 200 Watts and under, like your drill. Under no circumstances plug your inverter into your

house's utility-supplied power. But there should be no problem powering small ac loads, whether or not they're grounded. — Chris

Dangerous Diodes

People, Your low ac voltage detector circuit printed in Home Power issue #32 contains a hidden fire/safety hazard. My concern is with the inverse voltage rating of the 1N4003 diodes in the voltage-measuring bridge. At a line voltage of 117, the rms voltage across the bridge will be 100. In a perfect world, the peak voltage would be 142. The filter capacitor would charge to slightly less than this, so the peak inverse voltage across the bridge would be just under 284. The 1N4003's inverse voltage rating is 200 and there are 2 of them in series. Theoretically, this is OK — barely. As all of us know, real power lines have large spikes and surges, and real diodes in series may not share the inverse voltage equally. The PIV of the 1N4003s will often be exceeded. Sooner or later, one of them will short. When that happens, the 10kΩ input resistor will be connected across the line (through a surviving 1N4003) on alternate half cycles. The rms current through it will be 11.7 mA and the dissipated power will be 1.4 W during those half cycles. The average power is only half that, of course.

A typical, unwarned, builder of the detector will probably use a quarter watt resistor mounted on a circuit board. When it is asked to cope with 0.7 watts, something unpleasant will happen. Usually, it will only be smoke and frustration, but we can all think of worse possibilities!

You may think I'm being over-cautious, that 1N4003s will take it. I've had embarrassing failures in a more conservative design. In equipment I build for a living I used 1N4002s (PIV 100V) in a bridge across the 24V secondary of a transformer. Two out of about 15 units failed within a year. I lucked out — the transformers had internal fuses and no serious harm was done. Since then, I have used 1N4005s (more PIV than necessary, but cheap) and added an external fuse. I've had no more problems.

I have two additional, less-important suggestions about your article. I believe any equipment connected to the power line and left in operation unattended should be fused. Also, I suggest that you warn users to be aware of the load controlled by the output relay in your circuit. It is easy to overload a 10A relay with several fridges, freezers, etc. It will operate OK for a while, but may overheat dangerously a few months or years later.

I like your idea of using a 723 as a combined comparator and voltage reference. Neat trick! I'll probably use it in the future. Good luck, and keep up your brewing, Dave Cochran, SE 605 D McKenzie st., Pullman, WA 99163

Our apologies. My only comment is that in our experience, diodes blow open circuit, so the resistor wouldn't have a chance to get hot. But as it stands the diode bridge is a serious design flaw. We should have used 1N4005s, with a 600 V PIV. We also should have used a fuse. — Chris & Amanda

Hydro Help

This letter is due to the surprised reactions I encountered at SEER 92 when I mentioned the fully automatic hydro system installed by my friend Bill Walton at his home near Cazadero, CA. What appeared to him to be simple and logical is apparently not so obvious to everyone.

Bill had developed a spring high on a hillside and wanted to put in a hydro system, but was concerned about running low on water because it was also used for fire control. His solution was to automatically shut off the flow to the Harris wheel when the batteries reached full charge, thereby not only conserving water, but also saving wear and tear on the wheel and reducing noise as well.

This was accomplished after the folks at Harmony Farm Supply provided a sprinkler valve equipped with a 12 Volt DC solenoid (about $45 for the one inch size) and Real Goods supplied a Trace C30 (not C30A) voltage controlled switch to control it. When the C30 calls for charging, it supplies 0.54 Amps to the the solenoid which opens the valve and the wheel starts spinning. At full charge the C30 drops the solenoid, the valve closes, and the wheel stops. Note that since the wheel stops, there is no load diversion necessary and therefore no high current switching!

There is no problem with the water hammer since the valves are built to control a high flow and do not slam closed and also they are only seeing about a 20 pound change between static and dynamic pressures. The power house is a small shed and supplies ac to Bill's home from a Heart inverter. Bill Walton receives his mail at 30862 Bohan-Dillon Rd., Cazadero, CA 95421. Although Harmony Farm Supply is listed as being in Sebastopol, their mail goes to P.O. Box 460, Graton, CA 95444, and their telephone is 707-823-9125. Sincerely Yours, Don Nielsen, P O Box 627, Bodega Bay, CA 94923

Thanks for the letter, Don. Great regulation scheme! Bill's hydro system is a great application for my Homebrew this issue. If you like homebrewing, consider substituting the

Trace C-30 load controller with our simple circuit. The homebrew circuit will be much less expensive and fun to build.—Amanda

Dueling System

Dear Home Power, I am currently working on a solar electric design for my grid-connected suburban home. Although I plan to handle most of our loads using an inverter and the current wiring, I do want to run a couple of significant loads on DC (Sun Frost fridge/freezer, pumps for constructed wetlands and irrigation, some key area lighting, ceiling fans, etc). Because of the loads and wiring necessary, it is very desirable to use a 24 Volt system. However, there *are* still things that want 12 Volt — car stereo, small electronics, etc.— I have seen nothing in my searches dealing with dual voltage systems, save the Vanner charge equalizer. As far as I can tell, this device works by “wasting” energy from the top “half” of the system equal to that drawn from the bottom half. Of course there are always voltage regulators which are another inefficient way to power small loads only. Are you folks aware of other ways to do a dual voltage 12/24V system? Thanks for your time and a great magazine, Stephen Pope, POB 1045, Los Alamos, NM 87544

Hello Stephen. The Vanner is probably what you want; see the Things that Work! review on page 84. It’s not a linear regulator: it doesn’t “waste” half the voltage. It transfers current from the one 12 Volt string to the other in a 24 Volt pack. It does this with over 90% efficiency using high frequency switch-mode power electronics. — Chris

Wind Heat

Dear HPM; Since we have recently bought a new abode here in the Red River Valley (Fargo-Moorhead area) we hope to equip part of our small farm with renewable energies. As you can imagine, wind in this part of the world is in abundance. We hope soon to buy a wind generator for the property for the initial purpose of heating a small (12 foot X 16 foot) greenhouse by hot water heat. (Rural electrical co-op price here is 8.5 cents/kwh.) Have you run into anyone doing this, or have any suggestions for what types of systems to use — heaters, piping, electrical interfaces/inverters? We’re trying to stay at the 1 kilowatt level or less with this implementation.

Although direct solar power is lacking a bit here relative to the southwest, enough sun shines to interest us in the use of small fans placed through out the house for air circulation in both winter and summer. Any leads on who sells a good variety of fans for such a purpose?

Finally — on a more Rube Goldberg note: Many electric golf carts are adorned by a small canopy providing shade for the driver. Would replacing the canopy with a solar panel (3 foot x 5 foot) generate enough juice to recharge the battery (after, say, 1/2 discharging) within a day in the northern midwest? Thank you for any help you can provide on these questions. Sincerely, John J. Weiland, RR #1, Box 44, Sabin, MN 56580

Hi John, On one hand, heating a greenhouse with electric heat produced by a wind turbine has some advantages: when it’s cold and windy, the heater will produce more heat; and the control electronics would be fairly simple. On the other hand, you’ll need a pretty large wind turbine. I imagine it will take at least a couple of kilowatts of electricity to heat a greenhouse that size, and that’s a big, expensive wind machine. Insulating the greenhouse for the cold season, and using some sort of nighttime blankets over the windows would be money well spent if you plan to make your own electricity to heat it. I wouldn’t use an inverter — electric heaters don’t care whether the current is DC or ac.

Lots of folks sell small electric fans. Try Electron Connection, Backwoods Solar Electric, AEE, etc.

On powering electric golf carts with roof mounted solar panels: it sure would be an excellent promotion for PVs, exposing America’s golf-playing executives to solar power. But you couldn’t expect it to recharge the cart in a day. I could see fitting four 50 watt panels on top of a golf cart. Golf cart battery packs are 220 Amp-hours @ 36 Volts. Half discharge, then, is 3960 Watt-hours. It will take the 200 watt canopy array at least 20 hours in full sun to recharge a half-discharged pack.— Chris

Opportunity Knocks

Richard, Karen and the HP Crew: Headlines and TV-news clips I wished I’d seen in the aftermath of Hurricanes Andrew and Iniki:

“Temporary power quickly restored for thousands by portable solar electric systems.”

“Their emergency generator doesn’t need gasoline!”

“Emergency solar-powered lighting helps prevent looting”

There is a real opportunity for our industry if someone will produce such a unit. It could be as simple as a camping-type ice chest, 2 sealed batteries, an unbreakable module on top and a small inverter — transportable by two people (under 150 pounds) Mass production and distribution to major relief agencies such as the military and Red Cross would show millions it really works. Toss in a 50 foot extension cord to plug into an outlet with a waterproof cover and they’re in business.

Such units could also appeal to the survivalist/camping/on-grid folks in these days of increasing grid outages. While we missed the boat this time, perhaps someone can prepare for the next major disaster, and show what really works. A real publicity opportunity.

I'm reminded of the 1987 forest fires here in California, when the beer giant, Anheuser-Busch, shut down their West Coast facility to produce millions of re-labeled beer six-packs filled with drinking water, which they distributed to fire camps free of charge. Today they're collectors' items. No advertising could buy that publicity. Maybe our industry can do something with similar impact to help in the next disaster. For broader public relations; Chuck Heath, Suntricity, POB 1159, Coulterville, CA 95311 • 209-962-7012 • 209-878-3557

Hiya Chuck, good to hear from you again. Phil Jergenson of SunTools (707-459-2453) has developed a small PV/Gel Cell/Inverter ice chest like you describe. I'm surprised that you didn't see it at SEER 92. It should work fine for radio communications, TV reception, or a couple of lights, but to power anything serious — like refrigeration, the thing most needed in Florida — we quickly get into space/weight problems that limit portability. The Voltar (HP28, page 30) portable power system which can fit into the back of a pick-up would be the hot ticket. It has enough power to run a medium-sized camp or emergency kitchen. Combined with a power priority management system such as the Cruising Equipment "Backoff™", it could provide limited power to a small subdivision. The problems are strictly financial. On the industry side, I don't know of many companies who have the bucks to put a number of these things together and sit on them just waiting for an opportunity to show off our stuff. IBM we ain't! On the government side, FEMA and related agencies are looking at pretty short-term goals. In their view, a generator costs X amount and that's it. Never mind the associated fuel and maintenance costs after the purchase, that's the recipients responsibility. Environmental concerns don't even enter into the equation. You can agree or disagree with arguments about the cost-effective use of limited funds, but that's the way it is. The good news is that there may be hope. I've been working with some folks in the Round Mountain, CA area (the scene of a devastating wildfire this past summer) who have convinced a FEMA representative to try some very small scale solar powered water purification installations. If it all works out, you can bet you'll read about it in HP. — Bob-O

Solar Grass Cutter

In Home Power #30, the letter in Q&A asked about battery powered lawn mowers; I have built two prototypes that work fairly well.

The first one had a 5W solar panel mounted on the handle and was powered by two Sears "Die Hard" motor cycle batteries. It ran most of last summer (1991) without a recharge from from my battery charger. It was slow at grass cutting due to low blade rpm.

The second prototype has three 12 volt, 7 Ampere-hour, sealed batteries and works really well (high rpm). It will run between one and two hours before it is totally discharged.

The neat part about mower #2 is; I'm experimenting with a roof mounted solar array to recharge it. I don't have all the bugs worked out yet because of the recharge time and grass growing time, but it looks promising nevertheless.

I suspect we will be using many more solar/battery mowers in the near future. I'd be manufacturing them today if the right people here in Phoenix would take an interest. As yet no one is ready to help.

Most any backyard mechanic can convert a gas mower to solar. I'm surprised there are so few in operation. They are quiet, pollution free, and easy to mow with. Sincerely,

Larry Malinak, The Arizona Solar Energy Association, Box 26, Scottsdale, AZ 85252

Well, Larry, 1,000 more electric lawn mowers are in operation due to a research project by the Environmental Protection Agency. The federal government is letting 1,000 people swap their gas guzzling pollution spewing lawn mower for cordless electric models to develop better ways to cut pollution caused by the gas mowers.

The EPA and the National Consortium for Emissions Reductions in Lawn Care made its offer through nine participating utilities. The EPA tests the gas mowers for emissions. The Consortium monitors the electric mowers for performance. The consumer gets a free electric mower, for keeps. Unless, after a year, he wants his old one back.

The EPA estimates that using a gas powered mower for one hour generates as many ozone creating pollutants as driving a car for 50 miles.— Kathleen

More Mower

Dear Home Power: Re: Noel Perrin's battery powered mower question in HP#30 and Martin Holladay's reply in HP#31. Black & Decker (800-762-6672) has a light duty

12V cordless mower, with optional catcher, which will mow up to 10,000 square foot on a single charge. The price is $500. Aside from the previously mentioned Kansas Wind Power; we folk at EO custom build medium to heavy duty 12–36VDC push and self-propelled walk behind mowers. We also recondition the mentioned GE Elec-Tracs.

These venerable ole machines were one of the best EVs ever made. It hasn't been manufactured since the '70s and I fail to see the relationship to nuclear weapons and the GE boycott. GE did the market place research; engineering; manufacturing; and the initial selling; before licensing the rights to manufacturing to several other companies. They were sold locally by Wheel Horse, New Idea, and John Deere. I've heard others had the rights also; but I've never personally seen them. All companies failed to properly promote them. They were treated as a novelty item. However, they are a serious contender for the IC toys available in their class; as well as being considerably more economical to own/operate. The Elec-Trac is a rugged high torque homestead tractor; which takes all of the disadvantages of a highway cruising EV and turns them to advantage. On top of this, they love solar juice! Several thousand were manufactured and most are still running or reconditionable; a tribute to their longevity. There is a market (at least in these parts) which seems to be growing for obvious reasons. I'd be willing to do an article on this DC beast of burden, if there is sufficient interest. You'll find "ET" owners "cultists" almost to extreme; and I'd be hard put to keep the article short. I'd also appreciate it; if anyone wants info on same to send along a couple of bucks for my time and a serious info return. Vertis Bream, Energy Options, 1755 Coon Rd., Aspers, PA 17304.

By all means, we'd love an article on electric tractors! The benefit (instead of penalty) of weight, the high starting torque of some electric motors, and a tractor's tendency never to travel far from home all point towards battery power. Forget Fossil Fueled Farming! — Chris

Incidently, we received Noel Perrin's book, Solo*, published by W.W. Norton & Company, 1992. As a "non-techie but willing to learn," I learned a lot of the ins and outs of owning and driving an electric vehicle. The book is a nice "slice of life" across America as Noel describes his jouney transporting his EV across the states. Thanks Noel — Therese.*

Q&A

Hydro to Go

Dear Friends; I'm thinking of setting up a mini-hydro system to provide a modest charging current on a 24-hour basis for the electric vehicle. Getting a decent charge rate out of PVs at 36 Volt means buying a lot of panels. We have a nearby location where, years ago, somebody put in a little dam on a creek to run an incredibly inefficient undershot water wheel to generate power. It has long since fallen into disrepair, but the dam still offers a pretty good flow with about a five foot head. If I could squeeze a few hundred watts out of a small Francis turbine, I'd be in business. That issue of HP with such a turbine (multi-kW) on the cover is in my file up in McCarthy, AK. So I am resorting to asking if you know anyone who handles small Francis turbines, or at least the parts. I don't recall seeing any mentioned by your advertisers except a vague mention of low-head hydro by "Powerhouse Paul". This site is about 1000 feet away, so I would want to use a 110 Vac generator to feed variac-controlled rectifier as charger. I suspect I'll have to cobble together assorted parts to keep it economical. Ed LaChapelle, Olympia, WA

Hiya Ed. There are at least two ways to go on this, depending on what a "pretty good" flow turns out to be. Ron MacLeod can and probably will design and build a Francis turbine custom-made for your site. A Francis-type is the most efficient runner to use in a low-head, "pretty good" flow site, but it isn't for the faint-hearted. You'll probably have to rebuild or fortify the dam to accommodate the hydroplant and trashrack. A lot of work, but once done, you could spin a variety of generator/regulator combos to fit your needs and then some. Try for Ron at POB 286, Glenmoore, PA 19343 • 215-458-8133. A less efficient, but lots cheaper, alternative might be one of Powerhouse Paul's Stream Engines™. It's based on a turgo runner which will work (kinda) at heads down to five feet if you've got — you guessed it — a "pretty good" flow. Paul's scheme uses an induction generator to generate high voltage ac which is then transformed and rectified at the batteries. Might just fit your EV charging needs nicely. Paul can be reached at Energy Systems & Design, POB 1557, Sussex, N.B. Canada, E0E 1P0 • 506-433-3151. — Bob-O

The Long and Short of it

Love Will Emerson's cartoon on page 67. Our fledgling distributorship has that very problem as many potential clients just can't get a loan for PV. We have lived 18 miles off the grid for seven years and still love it. Now I have a question for Bob-O regarding Tech Notes, issue 32. Why do you adjust your panels on the equinoxes and solstices? We do ours six weeks before and after: February 7 and August 7, at an angle equal to the latitude (35° here); May 7, latitude minus 15° (20° for us); and November 7, latitude plus 15° (50° here). That just makes more sense to me. Skyview Alternative Source of Energy, Robert (Bobby) Leonard and Evajane Duvall, POB 677, Talihina, OK 74571

You're right! I consulted the Wizard for the times and angles for the seasonal adjustment of photovoltaic modules. The angle θ refers to the angle between the ground (horizon) and the PVs (the modules are facing south for us northern hemisphere types and face north for those down under): On February 21, set θ to latitude (our latitude is 42°). April 21, set θ to latitude minus 18° to 19° (here it's 42° – 18° = 24°). August 21, set θ back to latitude. And on October 21, set θ to latitude plus 18° to 19° (for us, 42° plus 18° equals 60°). And so on... — Therese

About the hardware and software used to make this issue of Home Power Magazine:

ENERGY SYSTEM EQUIPMENT

Power Sources:

A motley assortment of 32 photovoltaic modules made by ARCO, Kyocera, Solarex, Solec, Sovonics, Siemens, and UniSolar. About 1.8 kW peak power.

A Survivor 1 kW wind turbine.

Honda Engine/ Chrysler Alternator and 15 US gallons of processed, non-renewable dead dinosaurs.

Power Processing:

Dynamote 2.4 kW Brutus sine wave inverter, Exeltech 500 Watt sine wave inverter, PowerStar UPG1300 inverter, Heliotrope 2.3 kW PSST inverter, Heliotrope CC120C PV Controller, Bobier LCB80 Linear Current Booster, Cruising Equipment Ampere-hour +2 Meter, and Ananda Power Center IV.

Power Storage:

150 SAB NIFE reconditioned nickel-cadmium cells each 100 Ampere-hours at 1.2 VDC. Total capacity is 1,500 Ampere-hours at 12 Volts DC.

Computer Hardware:

Macintosh IIci with DayStar 50 MHz accelerator, Radius Two Page Gray Scale Monitor and Rodime 660MB hard disk, Mac IIcx with Microtech 240 MB hard disk, Apple Two-Page Display, Microtek ZSF-300ZS Scanner, two Mac SEs, and three Hewlett Packard DeskWriter printers.

Computer Software:

Apple Macintosh Systems 7.1 and 6.0.7, Manhattan Graphics Ready, Set, Go! 5.1, Aldus Pagemaker 4.2, Microsoft Excel 4.0, WriteNow 3.0, Canvas 3.0, 4th Dimension 3.0, Desk Paint 2.3, Adobe TypeManager 2.0.3, and Microsoft Word 4.0.

Communications Equipment:

Carslon OptaPhone+, Hewlett-Packard FAX-310, and Supra FAXmodem V.32bis.

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Must either bust or advertise."
Sir Thomas Lipton — 1870

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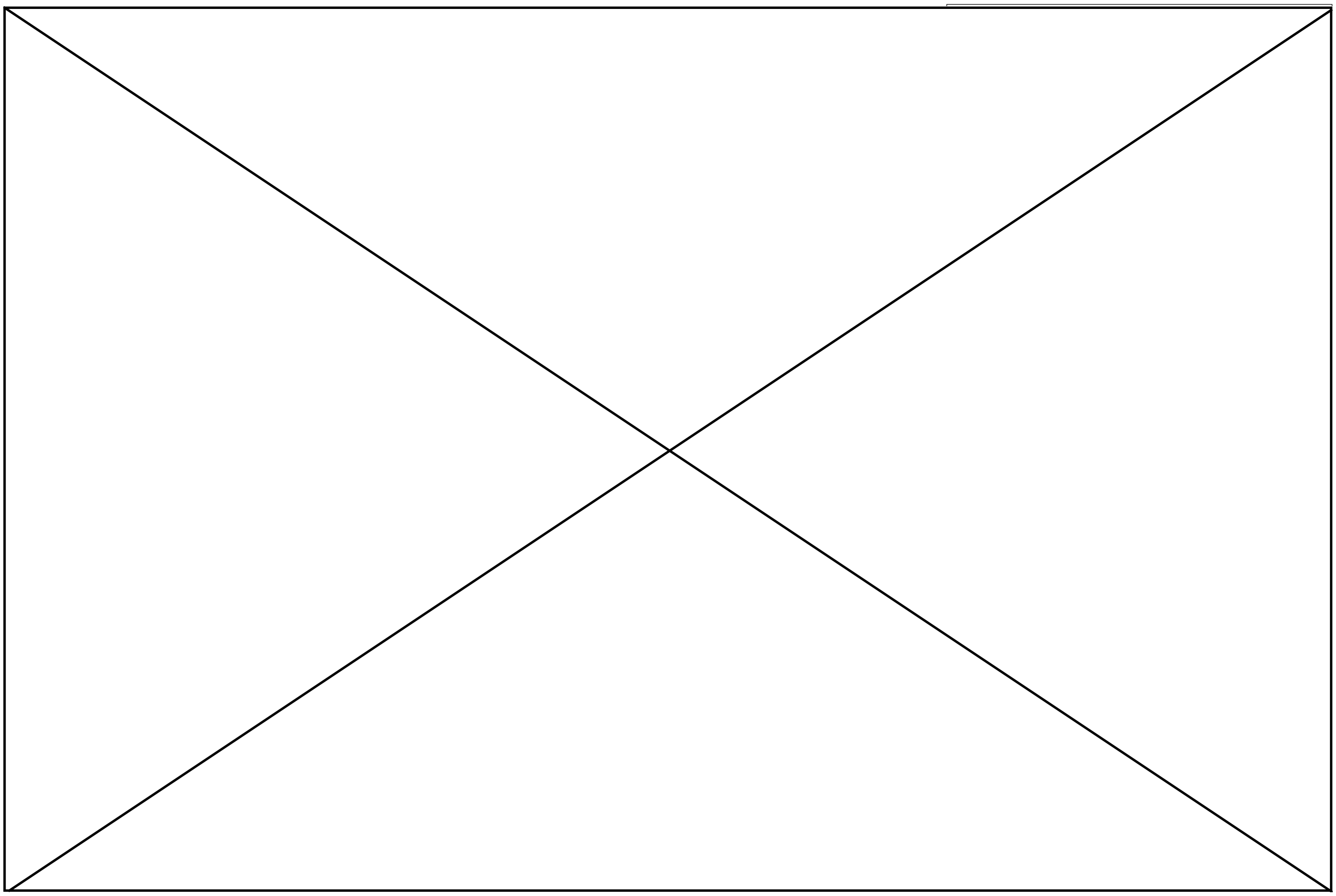


Above: The Formula E car ran consistently at 85 mph in the straightaways, with lap speeds exceeding 70 mph.

The Phoenix Challenge

Michael Hackleman

On April 25–26, 1992, two electric-powered cars built by Ely Schless and me snatched four race trophies — three 1st place and one 2nd place — in the Open and Stock categories at the Phoenix International Raceway. In a low-budget project using off-the-shelf components, the Hackleman-Schless team challenged high dollar, high technology efforts — and left them behind. If electric vehicles are indeed the vehicles of the future — then the future is *NOW*.

Project Background

In 1991, Otmar Ebenhoeck and I entered an electric 1982 Ford Fairmont station wagon in the first Phoenix electric car race. Although we had only a week to get ready, no time to test, and not a prayer of winning, we got there and sweated out qualifications (we stripped material to get under the 4,000 pound maximum weight limit). Our only “gimmick” was a high-rate recharge from an offboard battery pack of higher voltage. Our effort was rewarded. We grabbed a 6th place finish out of 14 cars! With high weight and no aerodynamics. Using current technology and a lightweight and streamlined car, I was certain that we could be highly competitive in 1992 using the same technology of rapid recharge.

I met Ely Schless shortly after the Phoenix event, driving about on the Shawk, his electric-powered Honda motorcycle. I was impressed with Ely’s innovative design

and his workmanship. A ten-year veteran of motorcycle racing, Ely was naturally interested in scratch-building a car for the Open category. I renewed my effort to obtain sponsorship, giving presentations at American Honda and Trojan Battery Company. I wanted to do this project!

The Formula Entry

Trojan Battery was the first to respond, offering materials, technical assistance, and monies toward the Open category. I called Ely to tell him that I had received a confirmation letter from Trojan Battery's president, Rick Godber. Ely's reply was "Good — 'cause I just spent $3,000 on a used Formula 440 race car." I liked Ely's eagerness to commit!

Within a few day's time, the original 65 hp 2-cycle engine and transmission were out of the race car, and two side-packs had been added to hold ten Trojan batteries. Ed Rannberg of Eyeball Engineering sold Ely a 10 hp Prestolite motor and a Curtis PMC controller for the initial trials. A week later, Ely drove the Formula E (E for Electric) racer up to Trojan Battery's doorstep. It's an understatement to say that everyone was surprised!

We assured Trojan that this vehicle might not be anything more than a test "mule" for various motors, controllers, and batteries. Still, it's uncanny how close the hastily assembled Formula E "mule" resembled our final configuration. Following 100 miles of test driving at both the Willow Springs (CA) and Phoenix (AZ) tracks at sustained speeds of 85 mph, we replaced the Prestolite motor with one of several 20 hp series motors that Advanced DC Motor's Bill Rogers sold to us at cost. We stayed with the stock Curtis PMC controller and Steve Post donated two more units "gratis"—one for a STOCK vehicle and one for backup. The 12 Volt stock Trojan 42C3 battery was also kept. Ten of these gave 120 VDC, and the pack's 500 pound weight assured us that we would not exceed 250 pounds per module (two modules per car). This iscritical if two people haveto remove a depleted module and manhandle a fully charged one into the vehicle during a pit stop.

The Stock Entry

Anne Palmer of American Honda came through with a car for the STOCK category — a sleek 1992 Honda Civic VX. It was given to me as a project car (after three years, it will be crushed) for anything I'd like to do with it. It was ideal for Phoenix, but it was February before it was ready to pick up. It was almost too late! But Ely came through, volunteering to do the conversion on the Honda VX, too.

Out came the Honda's engine and the cooling, fuel, and exhaust systems from the Honda VX. The 20 hp Advanced DC Motor was bolted through an Ely-designed adaptor plate to the stock transmission. A Curtis PMC controller was mounted through the hood to a multi-fin heat sink, positioned in the airflow for maximum cooling at race speeds. Twenty 12 Volt Trojan 27TMH deep-cycle batteries were wired into two, parallel packs of 120 Volts each. Evenly distributed through the VX (eight under the hood, twelve directly behind the driver and passenger seats), the batteries shifted the vehicle's front-to-rear weight ratio less than 2% to the rear.

Special Projects personnel at American Honda, including Charlie Curnutt, assisted with suspension changes for the 1,000 pound gain in the vehicle's curb weight. They adjusted for the extra weight with Honda Prelude springs and installed Koni shocks set to maximum stiffness.

I tested the Honda VX by using it to commute to and from Ely's shop on Los Angeles freeways. This included running over the Sepulveda pass, a tough stretch of road for any electric vehicle. It was in these trials that the controller "evolved" into its location. Mounting it through the hood was the only position where it didn't go into thermal cutback going up the pass at 85 mph.

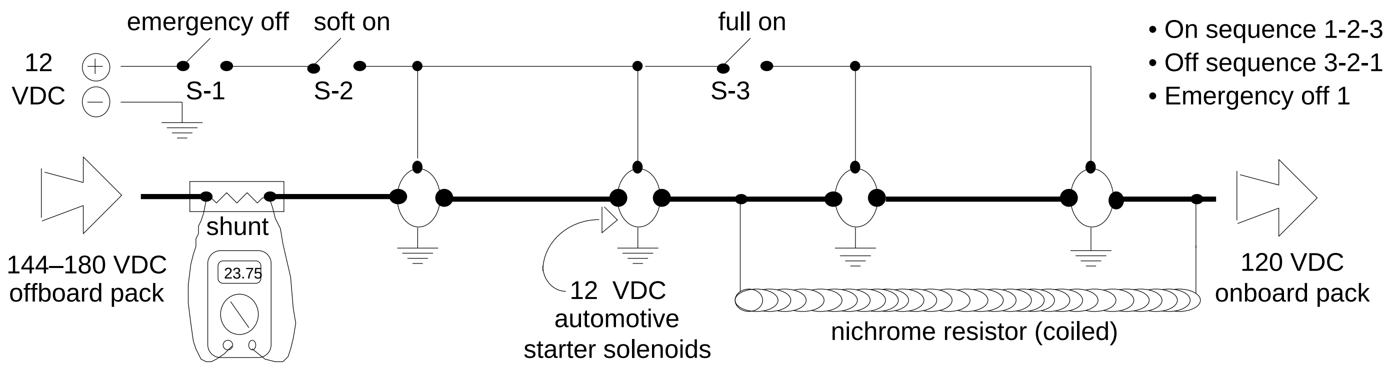
Our strategy: The Exchange

The rules of Open class allowed battery pack exchange. The rules for stock allowed battery "re-charging." Early on, we figured that we would use these conditions to maximum advantage.

The method of pack exchange for the Formula car evolved into distributing the batteries into two side packs, thus allowing easy access to the "modules" for exchange. After considerable discussion and experimentation, we opted for human-power over machinery for the swapout. Each member of the 4 person battery team need only handle a 125 pound weight twice for a few seconds, with a 10 minute "break" between swapouts (the length of time the racer can run at 85 mph).

The primary challenge in this design was how to electrically connect and disconnect the batteries from the car. Anderson connectors would be too slow. Instead, Ely designed and installed a CO_2 ram into the rear of the module area on each side. With a flip of a cockpit switch, he could get both to close a gap of several inches, pushing the "hot" lead against a copper plate that was strapped to the end of the module that held the batteries inside the Lexan "case." This made positive contact, shoving the pack's other copper plate against the stationary contact at the front end of the pack. With this arrangement, the modules acted like big D cell batteries, and team members could throw them into the vehicle like

The Quick-Charge Circuit



a sack of potatoes. Once the ram acted, each module completed the circuit and the pack was securely sealed in the vehicle.

With only six weeks until the race, Trojan Battery recognized a winning entry and sprung for the money to have a custom fiberglass body fabricated for the car. With the help of Pete and Mike Stephenson of Clean Air Machines in San Diego we had a fiberglass body in two weeks. Ely fitted it to the chassis, designed flip-up saddlepack doors and painted and applied graphics to the finished car. It looked ready to race!

The Quick - Charge

In order to participate in the Stock endurance race of two hours or 120 miles, the Honda VX was designed to be rapidly recharged. A rental truck containing 180 Volt, 400 Amp-hour battery packs was parked behind the hot pit wall. When the VX pulled into the pits with a depleted battery pack, the pit crew would connect the 180 Volt packs to the two onboard 120 Volt packs.

The first Phoenix event had run for two hours and the Demi-built Honda CRX had traveled 108 miles — a 54 mph average. I figured that this race would run at least 10 mph faster, and perhaps as much as 15 mph. So, I designed the Honda VX for an average speed of 70 mph. In all bench tests, I discharged at an 85 Amp rate, allowing for a total draw of 170 Amps (in 75–80 mph bursts) from the paralleled packs. I figured the Honda VX could pit any time after 37 miles

The flow of power was controlled by a device we called the ShuntFET, a gizmo I designed using contactors and nichrome-wire resistors. Four sections of #00 welding cable brought the negative and positive leads of the battery pack out to connect with the ShuntFET. This design worked like two fill tubes into one gas tank, allowing an 800 Amp charge rate (400 Amps per pack) into the car. If this 32,000 Watt charge rate was maintained for 3 minutes, it should give a 50% recharg. Wires and terminals would get hot. The batteries themselves would get warmer. My test results showed that each recharging added 20°F and discharging at race speeds for a 40-mile leg added 10°F,. However, as long as we did not exceed 125°F, the batteries should be okay.

The Team

Early on, Ely expressed an interest in driving the Formula E vehicle and I asked Tim Considine to drive the Honda VX. My job was to manage the team and serve as pit chief. Tim's son, Chris, worked alongside my own son, Brett. Photovoltaic and EV expert Greg Glenn also joined my team as did Hughes project manager, Gerald Benson. Gray Marshall (ShuntFET fabricator), Daniel Pliskin (Control Designer); Electrathon Racing Champion, Bob Schneeveis and Jim "Reality Check" Pommerenig also added considerable knowledge and skills to the effort.

The 1st Challenge: Heat Race

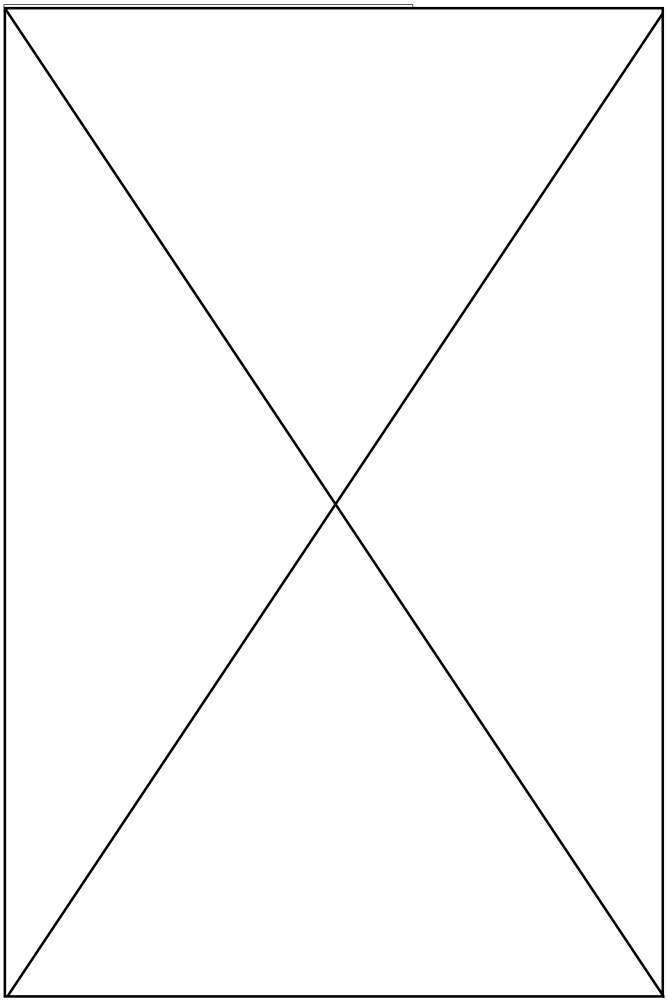
We came to Phoenix ready to compete in the endurance races in both the Stock and Open categories. Since both of these races were on Sunday and the qualifying races were on Thursday, we planned to use the intervening days to get ready.

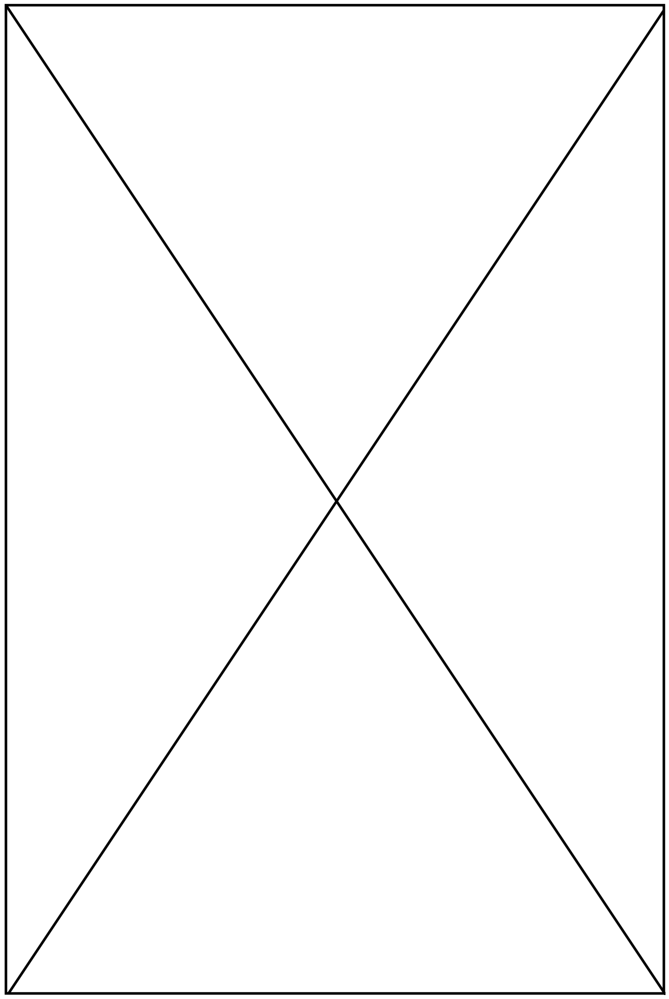
At the last moment (literally an hour before), we entered both vehicles in the 25 mile "heats" for each category on Saturday. Everything seemed ready. If something wanted to break, we would have time to fix it before the next day.

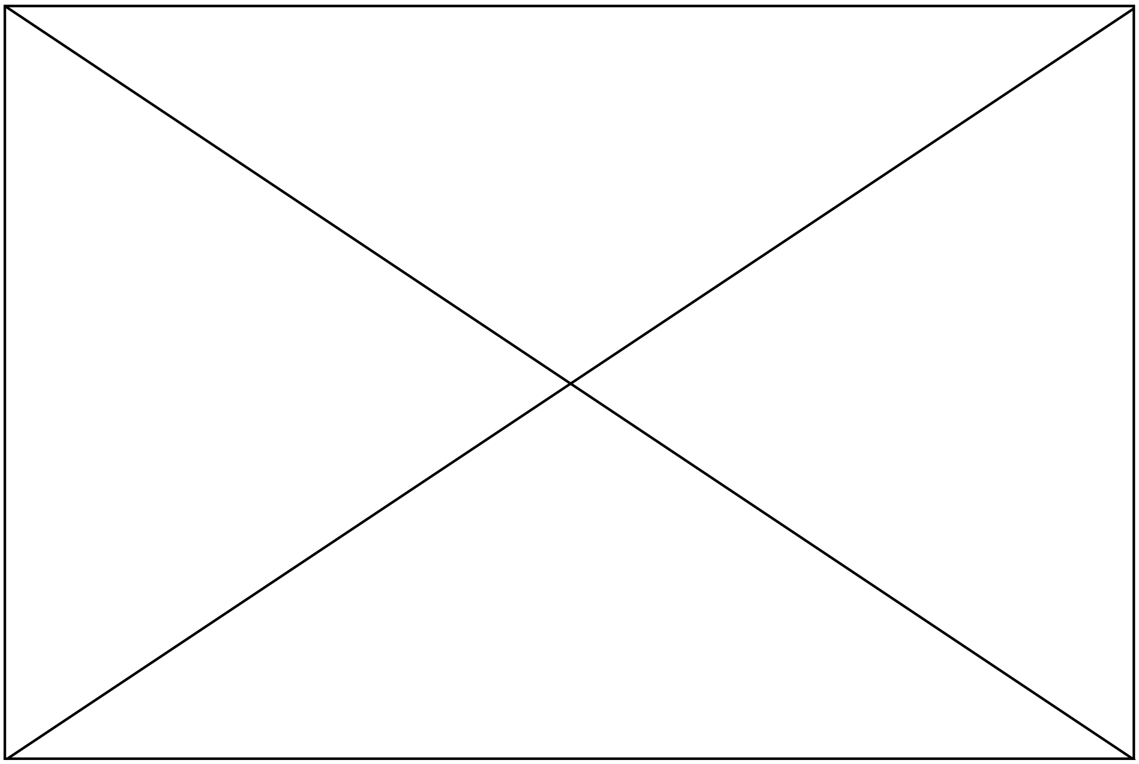
It was a double-header day. Ely drove the Formula E to an easy 2-lap victory and Tim pushed the Honda VX past the checkered flag three car lengths ahead of the highly favored Demi team. That felt really good!

Sunday: Endurance Races

The next day, in the Endurance events, it was not much different. The 1 1/2 hour Open event was shortened to 90 minutes. Ely kept the sleek Formula E behind the larger Exide car, picking up speed whenever it pitted. Ely took the checkered flag, four car lengths ahead of the Exide vehicle. What a victory! But we had precious little time to celebrate. Three down. One to go.







Above Left: Under the hood the Honda VX is roomy enough to hold eight of the car's twenty batteries.

Above Right: Michael Hackleman sits on the hood of his street Honda VX, the controller's heatsink the only reminder of its racing days.

Left: The pit crew finishes a quick battery swap on the Formula E racer.

In the Stock event, Tim immediately moved the Honda VX into a one-lap lead over the rest of the field. We racked up 46 miles at speeds of 70–80 mph before the readout dropped to 100 Volts. Tim screamed into the pit for a recharge. I was nervous. We had never actually practiced a recharge on the full sized packs.

Safety glasses donned, the power transfer went without a glitch. Tim slipped back into the seat through the rollcage and zoomed back up to speed. After 23 miles, it was time to pit again. Sure enough, we had transferred a 50% charge! With a higher voltage from the offboard packs (we could tap higher or lower in 12 Volt increments), we got our 400 Amps average per pack. Much sooner this time, the Honda VX was again out making speed. We managed to pull up to 2nd place. We closed to within three laps of the first place car, Solectria, before we had to pit — again just 23 miles.

At this point Solectria's battery pack breached containment of the zinc-bromine electrolyte, and the race was red flagged — ended. The rest is history. (See HP #30 for more details on this accident.) A little later, one of my crew reported that 1st place had been awarded to disabled Solectria vehicle, and that we got 2nd.

Altogether it was refreshing to put together a few solid vehicles, hang out with some competent and unpretentious people, and work and play hard. The Formula E adorns the Trojan Battery company R&D lobby and the Honda VX is my everyday car. It goes 70 miles at a steady 60 mph and takes a bit more than a dollar to recharge it. The car goes 30 miles when I leadfoot it (get it?), zoom over hills, or do lots of stop and go.

Final Thoughts

The fledgling electric vehicle industry needs your awareness and support. Even a low-performance electric vehicle uses one third the resources (oil, coal) and produces a mere 10% of the pollution of an average gasoline fueled gar going the same distance. EVs need more refinement to successfully compete (viscerally) with gas cars. This and other reasons abound as to why we can't seem to gear up to them. Alas, ignorance, false claims, and a lack of political will plagues this movement. In general, a car company is unlikely to introduce a good EV. It challenges the way they conduct business. Maybe they don't know if anyone would really buy them. Let them know this is not the case! Better batteries would be nice, but we mostly need clean air. Los Angeles is a beautiful place when you bathe it in real sunshine!

Access

Michael Hackeleman is an EV design consultant, the producer of the "Hand Made Vehicles" video series, and the editor and publisher of "Alternative Transportation News" (ATN) magazine. For more information about this technology or for publications list or a sample copy write to: ATN, P O Box 743, Mariposa, CA 95338 • 408-336-5026

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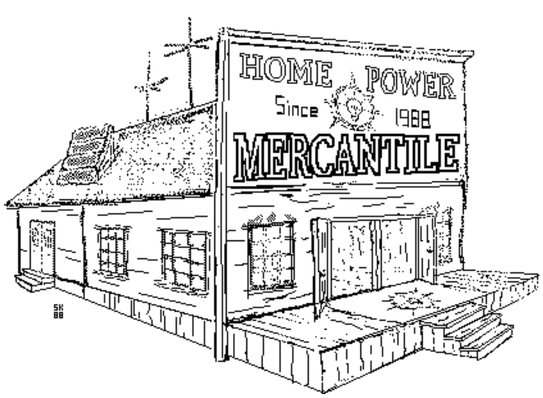

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