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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #38
December 1993 / January 1994
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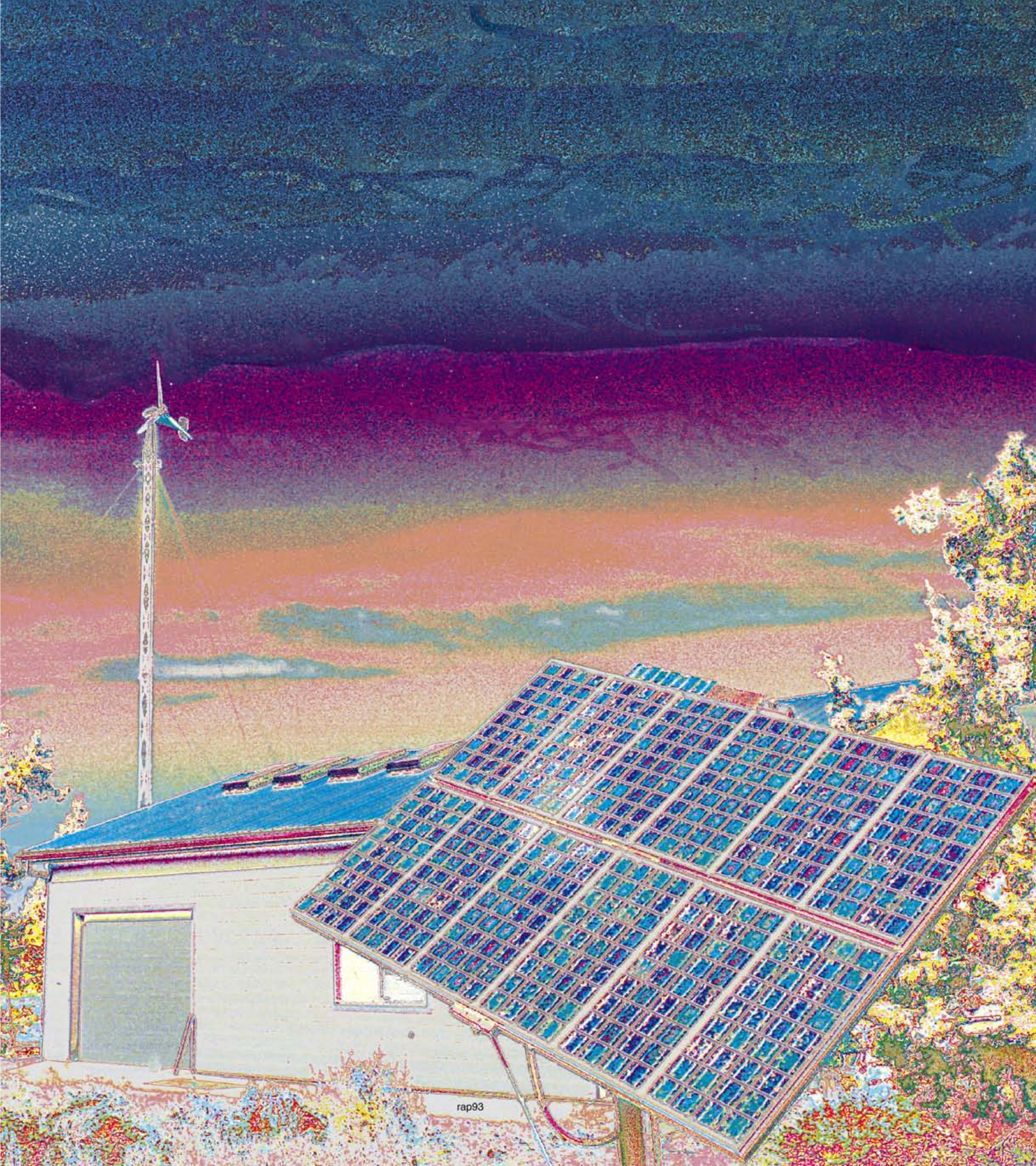

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Issue #38 December 1993 / January 1994

Features

RE Systems

GoPower

Fundamentals

Cover: An imaginative view of Larry Elliott's RE powered home. Photo by Larry Elliott and digital processing by Richard Perez

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Renting Rainbows

Recently, Southern California Edison (SCE) petitioned the California Public Utilities Commission for the ability to market stand-alone photovoltaic (PV) systems off their grid. This move amazed many people who have been living off-grid for years on PV power. The reactions varied. Rightfully enraged dealers see the utilities as megabucks competition from a publicly controlled monopoly. Designers chuckle over the utilities' lack of experience in off-grid residential systems. Consumers wonder why the utility wants to rent the system, but not sell it. Everyone wonders why the same system can be purchased from a local PV dealer at a fraction the price of a utility-sponsored five-year rental.

The utilities see the world's solar future as clearly as anyone. They would love to use solar energy and other renewable energies on their grid. The problem is cost. The on-grid utility customers won't pay the bill.

The real source of all this solar confusion is the value we place on energy. We have become accustomed to energy costs that are the lowest in the world. For decades, we have refused to add in those little extras to the cost of energy. Little extras like wars, pollution, crop loss, health effects, government subsidies, and such like. We have established an energy network of utilities and public utility commissions (PUC). We grant the local utility an energy monopoly and then regulate the utility to make sure that the energy cost is as low as possible. The bottom line is that we don't want to pay any more for our power. We as energy consumers are denying the utilities the opportunity to use renewable energy because we refuse to acknowledge what this energy is really worth.

We are, as usual, our own worst enemies. The utilities are ready for our solar future. It is up to us to get the message to our public utilities commissions that we indeed realize what energy costs. Once energy is fairly valued, PV power is cost effective immediately on-grid. We can then wrangle over the details like who owns the arrays and the energy that they produce. The message for America's PUCs is, "I'm ready for a solar future and I'm willing to pay what this energy is worth." Whether you own your own PV array, or rent your solar electricity from the utility's PV array, it is going to be solar either way. When you own the sun, you don't need to rent rainbows.

Richard Perez

People

Sam Coleman
Gerry Cunningham
Windy Dankoff
Otmar Ebenhoech
Larry Elliott
Joe M. Flake
Chris Greacen
Michael Hackleman
Joe Hoar
Kathleen Jarschke-Schultze
Don Loweburg
Stan Krute
Therese Peffer
Karen Perez
Richard Perez
Shari Prange
Mick Sagrillo
John Schaefer
Byron Stafford
Bob-O Schultze
Michael Welch
John Wiles
Lafayette Young

" Think about it…"

"The first day or so we all pointed to our countries. The third or fourth day we were pointing to our continents. By the fifth day we were aware of only one Earth."

Discovery 5 Space Mission.

Introducing the *LINK 2000*

Integrated Battery Monitoring and Inverter Control

"In the future, we will see highly integrated systems which provide battery monitoring, inverter/charger control, PV regulation, and advanced load management. The benefits are just too obvious: increased battery life and capacity through superior management"   Rick Proctor from *Power Predictions for 1994*

Control

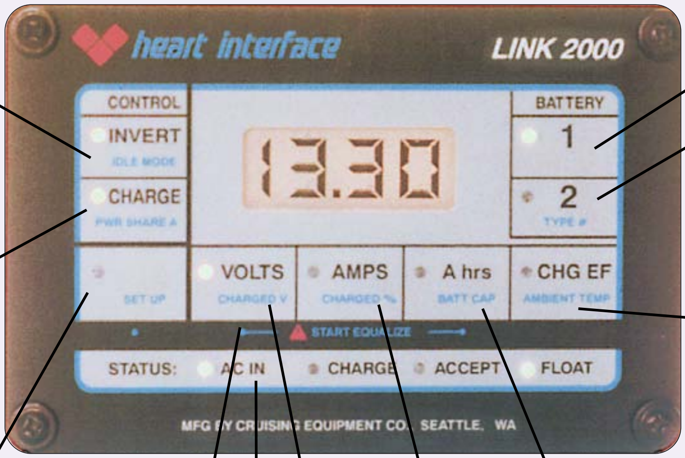
Green LED indicates on.

INVERTER may be turned On or Off independently from charger.

IDLE MODE sets load sensitivity while idling, expressed in Watts. Range = 0W, 4W, 6W, 15W.

CHARGER may be turned On or Off independently from inverter.

PWR SHARE sets the AC current limit at which the battery charge rate is reduced to avoid overloading limited AC sources. Expressed in Amps. Range = 10A, 15A, 20A, 30A, 50A



Monitoring

Green LED indicates selection

Selects BATTERY #1.

RESET A hrs to zero.

Selects BATTERY #2.

TYPE # sets battery chemistry: 1=Liquid, 2=Gel

Green LED indicates parameter displayed.

CHARGE EFFICIENCY FACTOR of selected battery displayed as percentage.

AMBIENT TEMP sets default Charging Voltage for selected temperature range. Default value = 70°F. Range 30–120°F in 10° increments

***SET UP** allows the selection of various functions and values.*

Press for 5 seconds to enable Set Up. The Green LED will flash at 1 second intervals. Then press the function to be set up. The present value will be displayed. After 3 seconds, with the button pressed, the display will began scrolling. When the desired value appears, release the button.

Flashing Green LED indicates Set Up mode. The LED of the function being set up also flashes.

AMP-HOURS consumed from selected battery displayed as a negative number. Over-charge A hrs displayed as positive number.

BATT CAP sets battery capacity. Default value = 200 Ahrs. Range 20–2000 Ahrs in 20 Ahr increments.

AMPS charging into the selected battery are displayed as a positive number. Discharge Amps displayed as a negative number. Range ± 250 Amps with 0.1A resolution below 27A and 1.0A resolution above 27A.

CHARGED % sets the current that the charge rate must fall below for the battery to be considered full. Default value = 2% of battery capacity, (Ex: 4 Amps = 200 X 2%). Range 1–7% in 1% increments.

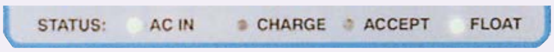
START EQUALIZE function of charger by pressing SET UP button for 5 seconds followed by simultaneously pressing the VOLTS and A hrs buttons.

Red CHARGE LED flashes when in equalize mode.

VOLTAGE of selected battery is displayed. Range 7–50 Volts with 0.05V resolution.

CHARGED V sets the Voltage the battery must be above to be considered full. Default value = 13.2V or 26.4V Sets default automatically for 12V or 24V systems. Range 13–40V in 0.1V increments.

STATUS indicators for AC power and charge cycle state.



AC IN: Green LED on when AC is present.
CHARGE: Red LED on when charger is in bulk charge mode.
Flashes Red when charger is in Equalize mode.
ACCEPT: Orange LED on when charger is in Acceptance mode.
FLOAT: Green LED on when charger is in Float mode.

Compatible with
Heart Interface Inverter models:
Freedom 10
Freedom 20
Freedom 25

The LINK 2000 is a joint venture of two Valley Forge companies:

heart interface **811 1st Ave. S. Kent, WA 98032 (206) 859-0640**

Mfg. by Cruising Equipment Co. **6315 Seaview Ave. NW Seattle, WA 98107 (206) 782-8100**

Living in an Energy Independent Sculpture

Gerry Cunningham

My wife Ann and I live in a 1500 square foot, earth-sheltered, free-form, concrete dome. We have not paid a utility bill since 1981. We have no back-up generator or water pump. Our power comes from 560 Watts of photovoltaic (PV) panels. Water is supplied by a Bowjon Homesteader windmill, and heated by the sun. Our fossil fuel use is about 40 gallons of propane a year for our kitchen stoves. We have many appliances: two refrigerators, computers, stereos, TV, VCR, washing machine, a machine shop, and woodworking power tools.

Earth shelter means easy energy conservation

Energy conservation is not that unusual this day and age. But when Ann and I started out over 50 years ago, declaring our intention to live in the mountains and be independent, the idea was not received with any enthusiasm by our parents. We romanticized the "pioneer life" but fortunately, we never did have to live like pioneers.

We built our first house, a conventional type, after World War II in the Colorado Rockies at 8600 feet. It was the most energy efficient I could design at the time. Our utility bill was less than any of our urban friends living down in Boulder. The house was thoroughly insulated. It looked like a Swiss chalet, but was essentially a cube for a minimum of surface area. The fireplace, furnace and water heaters were all in the center surrounded by living space. We didn't even have to pipe the furnace to the upstairs bedrooms. This served us well for 25 years, then we were introduced to concrete free-form domes.

Free-form domes have ambiance
Our 17 year old daughter Penny came back to Colorado to build a dome bedroom for herself after she dropped out of Verde Valley School, a prep school near Sedona, Arizona. She learned about domes through the visionary architect Paolo Soleri, who had shown the students at Verde Valley how to build a dome. They never finished it, but Penny liked the ambiance of its curves. She would study up there, sitting on sacks of hardened cement and gazing out the triangular window at Cathedral Rock.

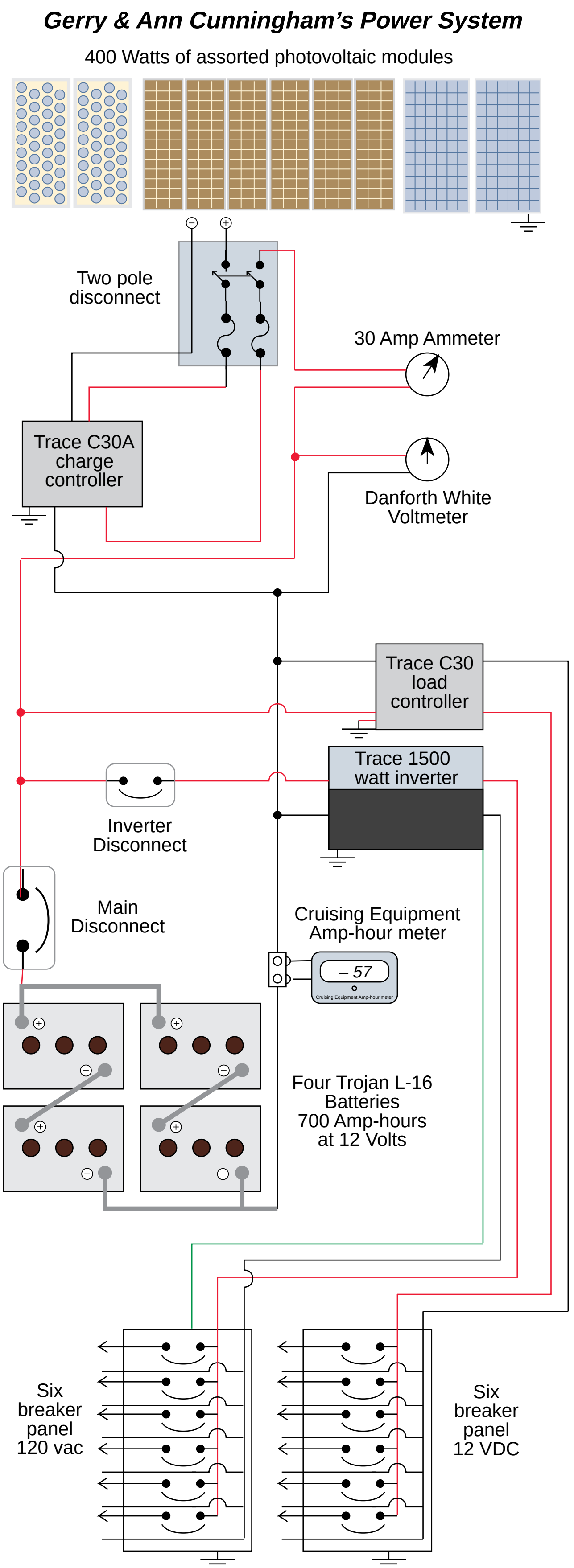
Penny thought she found better solutions to some of the dome building problems than the other students had used. So Penny built herself a small 175 square foot dome with electricity but no plumbing. Her mother and I thought it was quite an accomplishment for a young girl with no help. Then we slept in it for a month while my parents visited us. After that we said, “No more flat walls and square corners for us. We must have a dome.” We too had been caught by the pleasant ambiance of a free-form dome.

The dome we now live in is the sixth one with which we have been involved. First was Penny’s. When I became headmaster of Verde Valley School, we finished the dome the students had started and lived in it. We had the new students, under Penny’s supervision, build a small guest room dome for us. The original Soleri domes had been built on a dirt mold with the dirt dug out after the concrete hardened. I was familiar with ferro-cement boat construction. Starting with the Verde Valley guest room, all of my domes have had the steel erected first, the inside plastered, and finally four inches of concrete applied from the outside. The earth sheltering was an after-thought and was added to the school domes. Subsequent domes have been designed to be covered with earth.

Some locations are easier than others
After I left Verde Valley School, I did a stint as Arizona’s Director of Energy under Governor Bruce Babbitt. He had been on the Verde Valley Board of Directors, and was interested in our energy conservation theories. While we were in Arizona we had been looking for land. We sought a climate where we could relatively easily be completely-energy independent. We found our piece 26 miles north of the Mexican border at 4700 feet on the flanks of Mount Wrightson. Since 1981, the outside temperature here has only once been below 20°F and rarely reaches 100°F. The inside temperature, even with the dome closed up while we are traveling, has ranged from 54°F to 89°F. The surrounding wall temperatures of 65°F to 70°F are more important to our comfort than air temperature. During the monsoon season when humidity is high, we rely on ceiling fans and a small oscillating fan (and lots of iced coffee).

Above: The soft curves add a peaceful ambiance for Ann’s kitchen.
Below: PVs on the roof. Note skylight on lower right.

A small dome is a do-it-yourself project
We’ve actually built two domes here. We built the first 500 square foot studio apartment during our first two years entirely by hand. We dug the emplacement, mixed the concrete, and back-filled it all without



using any fossil fuels. We used 64 Watts of PVs with a 100 Amp hour RV battery, a 500 watt inverter for lights, a tape deck, drill, and saber saw. You have to cut lots of curves to fit the woodwork into a dome. It's like building a boat. Our cost was about $20,000 for the small dome which included the water and sewage systems for both domes.

We lived in the studio apartment for six years while we leisurely built our present 1500 square foot, 2 bedroom, 1½ bath dome. We built as the money became available because of our retirement arrangements. The studio is now fulfilling its proper function as a studio, plus complete living accommodations for guests when we have them.

The big dome was built with the help of contractors who obviously used a lot of fossil fuel. I put up the steel rebar and 6x6 highway mesh frame with the help of a couple of friends. This frame is what gives the final shape to the dome. The excavation, back fill, floor slab, facade stucco, and the concrete dome itself were all done professionally with heavy equipment. Total cost for the big dome was about $80,000.

Solar Electric Systems

The guest dome is powered by an 160 Watt PV array with 350 Amp-hours of Trojan L-16 lead acid batteries for storage. The PVs are on an azimuth turntable that was operated by hand while we were living there. But now with only the refrigerator going and occasional use of lights, the array works fine oriented just east of south to allow for the afternoon thunderstorms.

The two domes are connected by a 120 volt ac line. I plan to have an independent 500 watt inverter in the guest dome. I am a bit apprehensive about depending entirely on my 1500 watt Trace inverter as the sole source of ac power. My wife's computer has its own dedicated system since I crashed her data once by starting my ½ hp synchronous drill-press motor. She has 20 Watts of photovoltaic panels, a 100 Amp-hour battery and a small 100 watt PowerStar inverter. I know I should get more efficient motors for my lathe and drill-press but can't bring myself to spend the money.

The array for the big dome consists of 400 Watts of fixed mount PV panels. I hope to add a tracker for half of the array to help us through the summer. The power from the array for the big dome is collected on the roof in a junction box and then comes down to the battery compartment on #4 wire to a Trace C30A charge controller. The battery bank is four Trojan L-16 batteries for 700 Amp-hours of storage. Input and output run through a Cruising Equipment Amp Hour Meter. I have a 30 Amp ammeter in the input and a Danforth White marine battery condition voltmeter for monitoring.

Distribution

Both the 120 vac from the inverter and 12 VDC from the batteries feed into separate six breaker panels. The 12 Volt DC travels through a Trace C30 load controller. Batteries and inverter are centrally located. Busses as heavy as #4 for the longer 12 Volt runs feed out in the floor slab to six distribution boxes around the dome. The distribution boxes feed the lighting and outlet circuits. We use fluorescent lighting for the often-used fixtures, and use regular 12 Volt globes in conventional sockets for closets, wine cellar, etc. For converting light fixtures to 12 Volt fluorescents, I use Iota ballasts which are available from Real Goods. Appliances and tools used intermittently are conventional 120 vac.

Energy Use

We don't use much electricity. Two reasons that we can get by using this small an array of PVs are our use habits and the fact that I built our refrigerators and freezers to be quite efficient. The freezer is about three cubic feet and the two refrigerators are nine cubic feet each (see sidebar). We are old backpackers and

Home-made Refrigeration

To make our refrigerators, I first frame in the exterior with 2x4 studs and plaster board. Then we see how far my wife Ann can reach over the front edge to the rear lower corner. This determines the height of the chest bottom above the kitchen floor, and the distance from the outside front edge to the rear wall of the chest. The length of the chest depends on the space available, up to the maximum cubic feet recommended by the compressor manufacturer.

The insulation is rigid urethane foam. Roofing contractors, or those making walk-in commercial freezers, can usually supply four inch thick slabs of foam. One and two inch thick sheets can usually be obtained from ordinary building materials dealers. I use one 4 inch thick slab for the front and two 4 inch slabs for the floor and the sides. The rear wall of our present refrigerator is about seven inches thick from several slabs laminated together. The freezer, which has its own compressor, is adjacent to the refrigerator; there is a two inch thick partition there.

The underside of the top is insulated with three inches of soft urethane foam covered with plastic coated nylon to keep out moisture. I used 3M spray contact cement for both the fabric covering and to attach the insulation. Soft foam is used here to make an almost air-tight seal when the lids are closed.

After the insulation is in place, the entire chest is lined with sheets of 3⁄16 inch white ABS plastic with the shiny side out and the textured side against the insulation. Long stainless steel screws tie the centers of the larger panels through the insulation so they don't "oil-can". Clear ABS cement was used for the joints which were caulked with silicone. There is a sump and drain to the outside.

The refrigerators are extensions of our kitchen counters. The counter top is custom-made. I cut the high-density particle board to fit, and marked where I wanted the lids. The board was then returned to the

counter-top people who covered it with formica, cut out the three lids, relieved the front edges so they would have clearance to hinge, and edged the perimeters of both the lids and holes. The top is fastened from underneath, after applying the insulation. It can be removed in case the evaporators need working on, which has never been necessary in 10 years of service in our small guest dome.

The compressors are Adler Barbour 12 Volt Cold Machines made for marine use. The small Adler-Barbour unit will handle 9 cubic feet for a refrigerator and 3 cubic feet for a freezer, both well insulated.

Many might consider "chest type" refrigerators a nuisance, but you soon develop a technique for storing and retrieving. The slight disadvantage is more than offset by the efficiency. Such a refrigerator will hold its chill for two days without power if not opened often. When we have lots of cloudy weather and the batteries are down, we turn off the 'frig rather than sacrifice reading in bed at night.

sailors, both of which require you to get by on limited resources. We use a Bowjon wind-powered water pump (from Real Goods) that uses compressed air to pump water from our 220 foot deep well. When our Bowjon air line sprang a leak recently, we used less than 300 gallons of water in four weeks. We use Seiche Flush-matic toilets (manufactured in Canada).

The ac appliances that are phantom loads are connected to a switched outlet bar which we turn off when not in use. This means no electric clocks or automatic programming unless we leave the power on, but we don't seem to miss it. I equalize the batteries about once a month and rarely draw them down more than 100 Amp-hours. As I'm sure all PV users experience, I only have to drill a bunch of ½ inch holes in ¼ inch stainless steel plate, or saw some lumber to bring cloudy weather for the next three days. I could buy more storage, but, "An ounce of good management is worth a thousand dollars worth of L-16s."

Why?

We enjoy not paying utility bills, though to "buy" the amount of electricity we use would probably not even meet the power company's monthly minimum. The cost of our entire system is probably more than it would have cost to run underground cable the half mile to our house, but we aren't doing this for strictly economic reasons. We like to feel that we are draining the world's fossil fuel resources as little as possible. Next shot is an electric vehicle for our weekly trip to town!

Above: Ann and Gerry Cunningham.

Access

Gerry & Ann Cunningham, Box 976, Patagonia, AZ 85624 • 602-394-2393

Solec
Full Page
CAMERA READY
BLEED!

Above: Joe Flake and his solar-powered Shasta travel trailer.

Going Solar

Joe M. Flake

I love to go camping, but not in a public campground. So when I bought my 1959 Shasta travel trailer, I decided that it must be electrically independent and able to roam beyond the limit of extension cords.

How

In the beginning my only electrical load was lighting, and this was easily accomplished. I obtained some 12 VDC tail light adapters that had Edison bases. I installed the adapters into the existing fixtures. I switched the wires from the ac input jack to a 12 VDC deep cycle RV battery. Going a step farther, I bought a trickle charge panel from Real Goods to keep my battery topped off. I was totally satisfied!

What Happened?

What happened was that I became intrigued with solar technology. Intrigued to the point that I started a solar business and took off to Colorado for an education at Solar Energy International (SEI). After that it was apparent to me that the Shasta travel trailer must be transformed into the Solar Chariot — able to boldly go where extension cords don't.

Sizing the System

Taking a load-dominated approach towards sizing the system meant getting real about my electrical needs and wants. My absolute camping needs were taken care of by the trickle charge system. But I wanted to have a rolling demonstrator for my business and a portable office/hotel/power station for remote installations. The decision was obvious. I wanted the largest system that the Shasta travel trailer would accommodate.

BIG IDEA — LITTLE SPACE

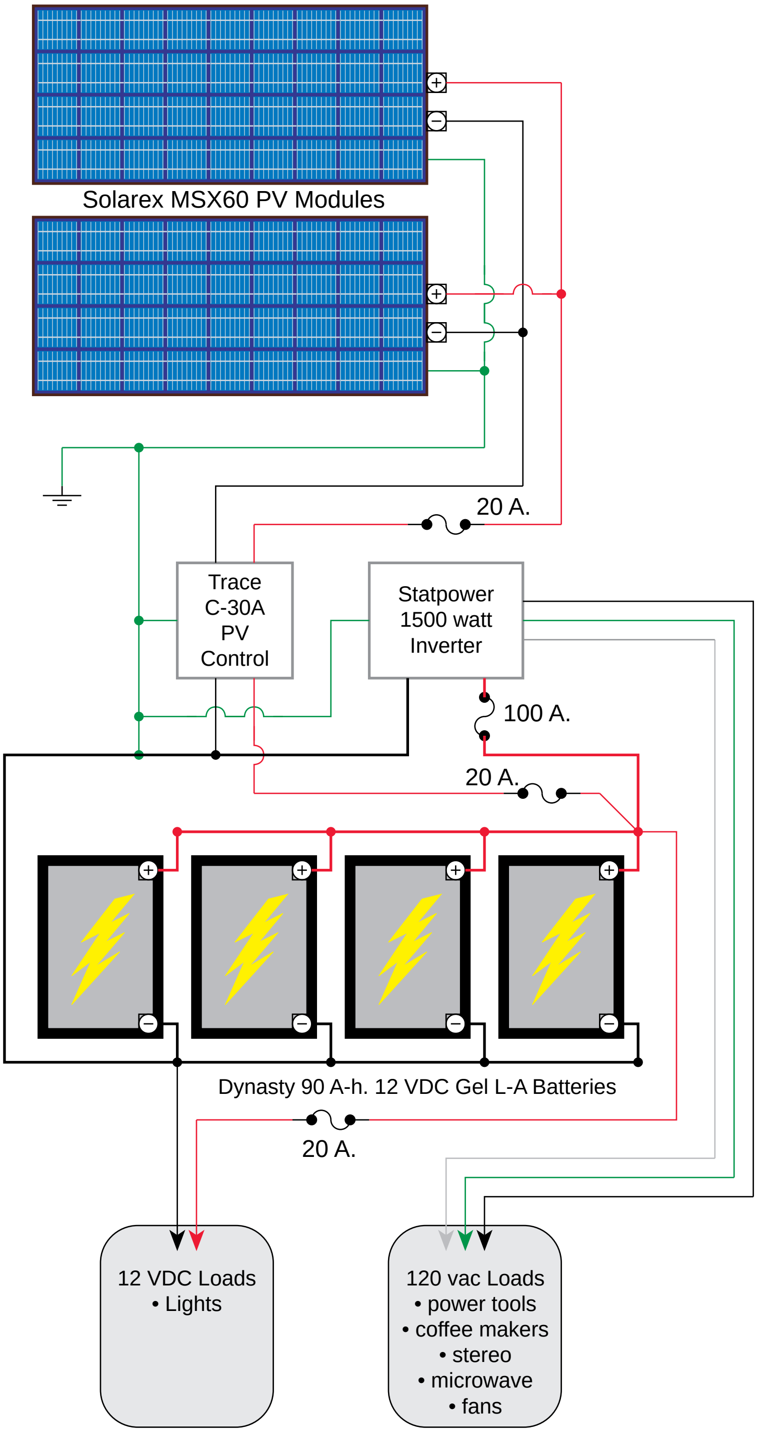
The Battery

I expected the system to be subjected to occasional heavy use with lots of time between uses for recovery. This meant that my battery bank should be disproportionately larger than my array. Extensive measurements revealed that the battery must be located under either the seat or the bed. Being concerned about electromagnetic fields in either location, I rationalized that there would be less electrical activity when in bed. So the battery went under the bed. The final choice was four 12 Volt Dynasty lead-acid, gel cell batteries (each 90 Ampere-hours at 12 VDC) wired in parallel to yield 360 Ampere-hours at 12 Volts DC.

The PV array
My array consists of two 60 Watt, Solarex MSX60 PV modules wired in parallel to provide 7 Amperes in peak sun. I thought that this was the minimum for my system, but the maximum for my budget. So far it has been adequate.

The Mount
I had two reasons for not putting the array on the camper's roof. I like to camp in the shade and I wanted the array where it would draw the most attention. A combination ground/truck mount suited both criteria. Camping on the north side of a tree with the array on the south side keeps me cool. Meanwhile the array and its umbilical cord attract curiosity seekers to the trailer. The mounting frame is made from channel aluminum with a steel tubing foundation. Hitch pins make for easy tilt angle adjustment. C-clamps are used to attach the mount to the truck. The umbilical is the 12/3 power supply cord that came with the camper. It is connected to the array and camper with polarized plugs for easy disconnect. The line voltage drop is less than 0.4%. If a stay is brief, instead of moving the mount to the ground I simply orient the truck and adjust the tilt angle.

Controls
For a charger controller I chose the Trace C30A; it allows for future expansion. It is wired to the old 120 vac input jack which is now the PV input jack. The circuit is protected with a 20 Ampere plug-in fuse. My inverter is the Pro Watt 1500 by Statpower. It has bar graphs for battery voltage and current along with overtemperature and overload indicators. The only thing I don't like about this inverter is that the lugs will only accommodate a #2 AWG cable with a rated ampacity of 115 Amps. Since a continuous load of 1500 watts at any battery voltage below 13 Volts draws more than 115 Amps, I'm a bit concerned. For now I carefully monitor the battery voltage and current draw to avoid subjecting the wire to overcurrent. I plan to make modifications that would accommodate a #2/0 AWG cable with a 200 Ampere fuse.



Outlets

Two UL-approved powerstrips, which are individually switched and internally fused, provide power to the ac loads. The lights remain on a fused DC circuit.

System grounding

All equipment is grounded to the camper chassis along with the negative battery terminal using #6 AWG bare copper. The neutral conductor of the inverter's ac output is connected to the chassis ground internally. When the array is to remain in one place for a long time, a ground rod is driven and attached at the array.

The Loads

This system powers these appliances from the inverter: a Skil™ saw, 3/8 inch drill (800 watts), soldering iron (125 watts), electric typewriter, Sharp™ microwave oven (600 watts), coffee grinder (130 watts), coffee maker (900 watts), Regal™ food processor (300 watts), two small fans, and Sony boom box. Lighting is supplied directly from the battery using car tail lamps which consume about 1.5 Amperes each at 12 VDC.

System Cost

Item	*Cost*	*%*
Two Solarex MSX60 PV Modules	$634	32%
Statpower Prowatt 1500 Inverter	$600	31%
Four Dynasty GC120V00 batteries	$507	26%
Mounting Hardware	$100	5%
Trace C30A PV Controller	$65	3%
Wiring & Misc.	$50	3%
Total	$1,956	

Now I'm totally satisfied...?

Access

Author: Joe M. Flake, GO Solar Enterprises, POB 422, Richfield, NC 28137 • 704-463-1405 • FAX 704-983-5466


Above: Wind and sun power Larry Elliott's home and business. Photo by Larry Elliott

From a Dream to Reality

Larry Elliott

Ever since I was a kid I've looked forward to the day when I could feel independent from utilities and the umbilical cords tying me to energy supplies beyond my own backyard.

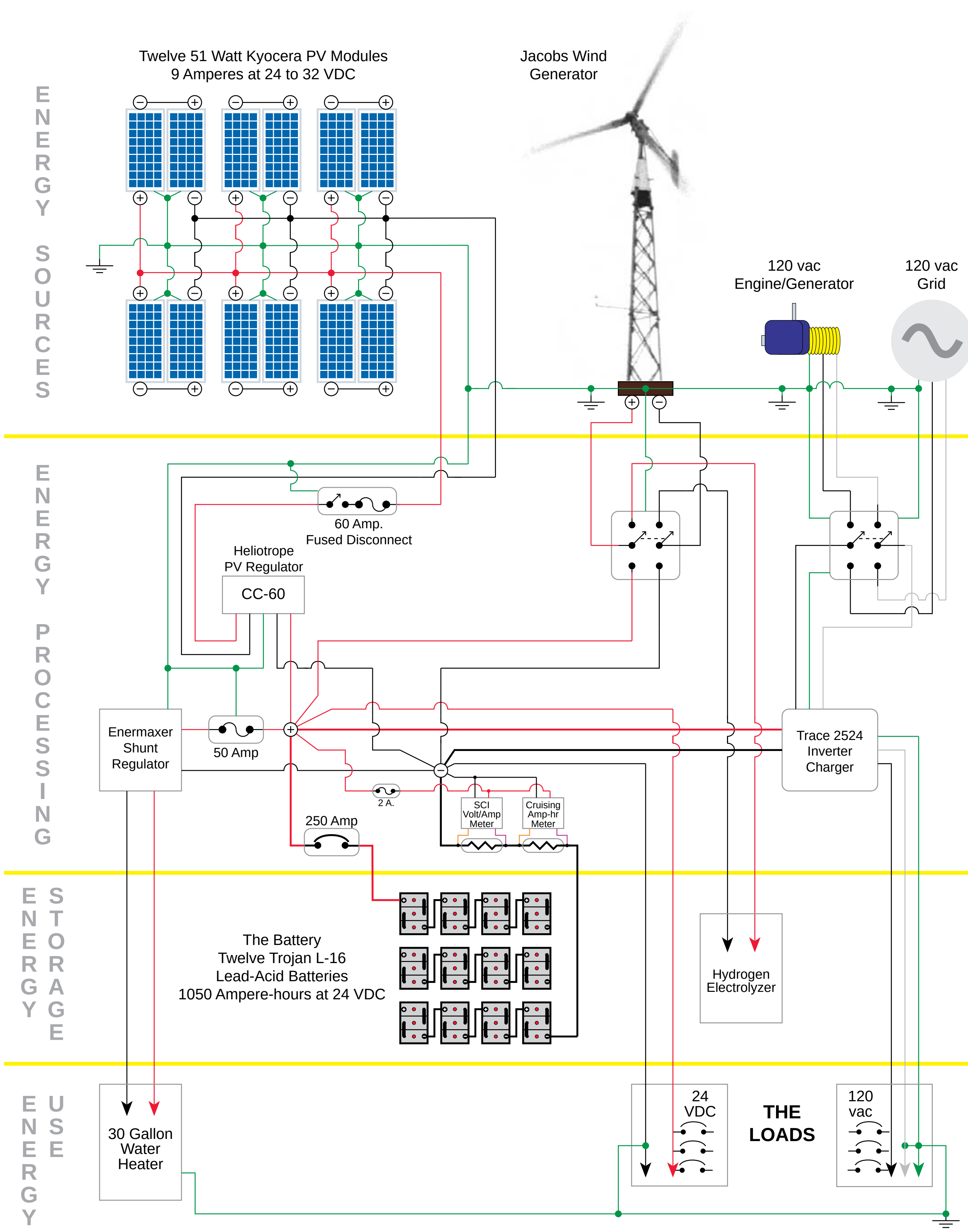
A little over seventeen years ago I erected my first wind generator (a Jacobs) and assembled a crude and marginally effective system. It powered ancient 32 Volt motors running a water pump, a converted fridge (certainly no SunFrost), some incandescent heaters (excuse me) lights, and a radio. The dream of having an inverter was just that — a dream. Inverters were available but they were expensive (a Trace even today is dirt cheap by comparison) and they had a bad habit of self destructing. After five years of struggling through the growing pains that accompany any new technology, I sold the Jacobs, the farm, and most everything else, and moved west to Oregon. For the next 10 years I dreamed of building my ideal renewable energy system while doing odd jobs and pursuing an engineering degree. In just the last two years, I think I've finally made my dream a reality.

My new home is located out in the puckerweeds on 40 acres of Central Oregon desert. With lots of sunshine my PV system feels right at home. Twelve Kyocera J51 PV modules mounted on a homemade tracker supply better than three kiloWatt-hours on a good sunny day. This power is stored in twelve Trojan L-16 lead-acid batteries wired for 1050 Ampere-hours at 24 VDC. Instrumentation and regulation are supplied by a Heliotrope CC-60, a Cruising Equipment Amp Hour meter, as well as an SCI digital Volt/Amp meter. An assortment of analog meters monitor individual loads and wind generator production. AC power comes from a Trace 2524 inverter (a true testament to just how far technology has come in 17 years) with standby battery charger option. The bulk of this equipment came from the good folks at Alternative Energy Engineering.

System Loads

My home power system is just a little different from most systems. I use most of the power to keep my "mad scientist's workshop" (at least that's what my friends call it) operating, and what is left I use for domestic purposes. A small 350 square foot apartment is built within the shop as temporary quarters until my house is built. (That's dream number two). That's about as domestic as I get or perhaps want to be.

My house loads consist of an RF-12 Sun Frost refrigerator/freezer, 700 watt microwave, coffee maker, toaster, automatic washer, 19 inch color TV, stereo, a VCR and a 386 IBM clone computer. I also have a 12 cubic foot home-built freezer that uses about 10% more


ENERGY SOURCES
Twelve 51 Watt Kyocera PV Modules
9 Amperes at 24 to 32 VDC
Jacobs Wind Generator
120 vac Engine/Generator
120 vac Grid
ENERGY PROCESSING
60 Amp. Fused Disconnect
Heliotrope PV Regulator
CC-60
Enermaxer Shunt Regulator
50 Amp
2 A.
SCI Volt/Amp Meter
Cruising Amp-hr Meter
250 Amp
Trace 2524 Inverter Charger
ENERGY STORAGE
The Battery
Twelve Trojan L-16
Lead-Acid Batteries
1050 Ampere-hours at 24 VDC
Hydrogen Electrolyzer
ENERGY USE
30 Gallon Water Heater
24 VDC
THE LOADS
120 vac

than a Sun Frost. Four Osram compact fluorescents supply the lighting. My Sun Frost is a little unique in that I bought it without a finish and built an oak cabinet around it to resemble an antique ice box. The oak came as used flooring from an old house. The Sun Frost has operated very well for over two years and I couldn't be more pleased. The automatic washer is a Whirlpool of 1970s vintage that I converted to 24 Volts. I compared the power consumption before and after conversion and the reduction was so dramatic (over 38%) that I ceremoniously destroyed the ac motor with a sledge hammer and took it to the scrap dealer. I didn't want anyone else to use it. No reduction in the washer's ability to do its job could be observed. My computer has a fax/modem board, a scanner and an Hewlett Packard DeskJet 500 printer that eats inverter power without indigestion. To date I have been able to run all of these loads without a problem.

Shop Loads

My shop loads consist of a 24 Volt Flowlight water pump, ½ hp belt sander, ¾ hp pedestal grinder, ⅓ hp metal cutting band saw, 1 hp milling machine, a 1947 vintage South Bend lathe with 1 hp motor, as well as assorted drills, sanders, a router, etc.

I can make ⅛ inch cuts in red oak using my 12 inch planer powered from my Trace inverter. The 2 hp air compressor and two welders are operated from the utility. A welder/generator is used as a backup welder. I plan to convert the compressor to 24 Volts and buy a 24 Volt MIG welder. The 900 square feet of shop is illuminated well by five 27 watt Panasonic compact fluorescents. Two incandescents and another 17 w compact are used for close work illumination. Originally I had four 8 foot so-called high efficiency fluorescents that drew well over 500 watts from the inverter. After I removed these and installed the compacts, my loads dropped to 135 watts with no appreciable drop in light. I had a problem finding appropriate fixtures for all of the compacts, so I made my own. Three switches control the five lights. I have replaced the electric motors in my bandsaw and wood heat blowers with about 33% power savings.

My backup is the grid, but I don't need to be using more than necessary. My shop has 6 inches of insulation in walls and ceilings, and only minimum window area, so heat loss is very small. I made up for lack of windows by installing skylights. On most days, I work with little or no electric lighting. Remember, heating and cooling are part of the whole energy package.

Wind Power

I use a 50 year old, 1800 watt, 32 Volt Jacobs wind generator on an 80 foot home-built guyed tower. The generator came from a fellow wind maniac and expert,

Left: The Jacobs wind generator atop its tower.
Above Left: The batteries and energy processing equipment.
Above Right: Larry Elliott in his shop.
Below: Larry's "mad scientist's workshop" powered by renewable energy.

Mick Sagrillo of Lake Michigan Wind and Sun. All other parts I made. I use the wind generator as a backup on cloudy, windy days, but most of the power goes to experimental electrolyzers for future hydrogen production. Fuel cells here we come! When winds really howl, I dump the excess power into a 30 gallon water heater that uses an Enermaxer for regulation and power shedding.

The Jacobs has worked without a problem for two years. My area is not thought to be a good wind site, but my Jacobs has performed well. I am using a 32 Volt generator on a 24 Volt battery bank. This has both an advantage as well as a disadvantage. The generator charges in lighter winds, but its power output is reduced to 1300 Watts.

PV Tracker

I use a hybrid active tracker. I designed and built the tracker itself, but purchased the electronic sensor module from WattSun. I spent months trying to perfect my circuit but the WattSun is better than anything I could make. If I had it to do again, I would buy a new tracker from the start. A note of caution: always build a good margin of safety into the strength of your design. High winds can damage the tracker and those expensive PVs. The weak link in my design was the pivot mechanism bearings. An 80 mph wind literally tore my bearings apart. Fortunately the linear actuator and some other attachments managed to keep my PVs from being blown into the next county. Damage was limited only to the bearings.

Conclusions and Observations

After two years of living on homebrewed power, I have concluded that the only limitations are your own imagination and a willingness to live within your system's energy budget. Conservation becomes as integral to your lifestyle as eating and sleeping. Former President Ronald Reagan once said, "Conservation is sitting in a cold, dark room with a sweater on." Nothing could be further from the truth. Warp drive couldn't catch up with some of Ronnie's statements.

I am glad that I never gave up the dream of a cordless home. I spent more money on my own renewable power than I would have spent on Mr. ReddiKilowatt. Nothing is like sitting snug as a bug, lights on, watching your favorite movie on the VCR, when ice storms shut your neighbors lights off. I invite them over….

Access

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Using a DC Submersible Pump in a Domestic Water System

Windy Dankoff

DC submersible pumps are a new technology, developed especially for solar power. In an alternative energy home, a low-powered DC pump can be more efficient and economical to use than a conventional 120 or 240 vac well pump.

Capabilities
DC submersible diaphragm pumps can lift water from wells as deep as 300 feet. They pump slowly, between ⅓ and 4 gallons per minute. Even such a low volume is enough water for a family's daily use if the pump runs a few hours per day and fills a storage tank.

Advantages
These low power pumps allow us to build a solar pumping system for a deep well at a modest cost. They are cheaper than windmills, and pump the most water during dry, sunny weather. They can be installed and pulled by hand. They work in wells of very low yield that conventional pumps may suck dry in minutes.

Pump Controllers
These solar pumps require a special controller if they are to be powered directly by PV modules (without batteries). The controller acts like an automatic transmission, allowing the pump to start and run in low light conditions. With a battery power source, the controller may not be required at all, or a special controller may convert 12 Volt battery power to 30 Volts to run the pump at top speed.

Installing a DC Submersible Pump
Carefully follow the instructions that come with your pump, and call your supplier if you have any questions. Also refer to "Installing a PV Powered Submersible Pump" in *Home Power* #31, and "Drilling a Well" in *Home Power* #33.

Drop Pipe
The pipe that drops from the well top down to the pump is called "drop pipe". We use flexible black *polyethylene pipe*. Get drinking water grade pipe, *not* utility grade pipe or irrigation tubing. It should have at least a 100 psi rating. This flexible pipe allows easy installation and removal by hand, without the need to disassemble joints every 20 feet.

In most cases, use ½ inch diameter pipe. If your pump is designed for 24 Volt use and has a ¾ inch outlet, and you are using it at 12 Volts, adapt it to ½ inch pipe size. We use minimal diameter drop pipe for two reasons. First, water is heavy. Small pipe holds a small enough weight of water that the pump may be pulled by hand. Secondly, small pipe allows the water to flow upward at a higher velocity, so that sand or sediment can be exhausted from the pipe. If you use larger pipe, the water will rise so slowly that the sand may settle within the pipe. When sand accumulates, it causes abrasion and pump problems.

Water well professionals are accustomed to larger 120/240 vac pumps and use one inch pipe or larger, of a thick, rigid variety. This type of pipe is *not* appropriate for these pumps. The low power pump will not "kick" when it starts, so it does not require heavy-wall pipe (or a torque arrestor) for support.

Installing Polyethylene Pipe
When you buy your fittings, get extra connectors in case you break one or strip threads. Get plastic fittings, not plated-steel ones. Get extra hose clamps in case you strip one by overtightening. Get some extra couplers in case you kink the pipe and cause a restriction (cut out the kinked part and install a coupler). Use two clamps side-by-side on every poly pipe connection. Tighten each clamp with a wrench, until the "tail" just begins to turn sideways. Now you can trust your connections not to leak. Do *not* use any type of sealant on poly pipe connections. Take sample parts with you to the store to match sizes. Pipe sizing does not always match what you will measure with a ruler!

Personpower Required
One person can handle lowering the pump to its limit, if pipe, safety rope, and power cable are carefully laid out on the ground. Removing the pump is a much heavier job because of water held in the pipe. One person can usually handle a 100 foot pull. Two or three people are needed for greater pull. In addition, someone is needed to tend the pipe so it does not kink.

PIPE FROM WELLHEAD TO TANK

Freeze Protection
Your pump's drop pipe must turn to horizontal where it exits the well casing. This can be done underground,

below frost line, by using a clever device called a "pitless adapter". This fitting slides together, allowing you to install and pull your pump from above, without digging. Have your driller install one for you when your well is drilled. The smallest pitless adapter is for one inch pipe. Use a reducer bushing to adapt to your smaller drop pipe.

Supply Pipe
The horizontal pipe from the wellhead to your tank should be PVC, or whatever you prefer. Do *not* use polyethylene pipe underground, as it may develop joint leakage after many years. Use at least one inch pipe since who knows, maybe you'll put a bigger pump in someday. Also, you may be using the same pipe to let water *out* of your tank. If it flows down by gravity, you'll want big pipe for a good flow. It cannot be too big, only too small. Check a pipe sizing chart to be sure.

Check Valve
These diaphragm pumps have internal check valves, without which they would not function. When the pump stops, water does not readily flow back down the drop pipe. However, the valves aren't perfect, and may allow a slow downward trickle when the pump stops. If you want this to occur, in order to drain above-ground pipe for freeze protection, then do not install a check valve. Otherwise, place one or more check valves at the pump and/or in the line to the tank.

POWER SOURCE: DEDICATED OR INTEGRATED?
A *dedicated* power system is one which supplies power only to the pump. An *integrated* system is one in which the pump is wired to the home power system. Let's examine these two methods.

Dedicated System
Wire for low voltage power transmission must be relatively large and expensive to minimize power loss. If the distance from your home's power center to the well and down to the pump is more than 200 feet, the expense may be high. A dedicated system may be cheaper, particularly if batteries are eliminated. This is called PV array-direct. Price both systems and compare. The dedicated system gives the water system its own power supply divorced from the consumptive vagaries of the main home power system. This means that the energy used to supply water is not shared with other appliances like TVs, lights and what-not.

Integrated System
Connecting the pump to the home power system has advantages. Wired in this way, it is simply one of the home's appliances. During the summer, a home with photovoltaic power tends to produce excess energy. This energy can be put to work watering your land. A controller may be set up to do this automatically when your battery bank approaches full charge. The home's battery system and backup generator also provide an energy reserve that can be applied to pumping. An integrated system is more versatile and cheaper than adding a dedicated system, if your well is not too far from your power source. Powering the pump from the main system's batteries also allows use of the well pump to pressurize the water system if necessary. More on this below.

Pump Voltage
The pumps discussed here are primarily intended for solar-direct use at 24 Volts rather than 12 Volts. Larger home power systems are often based on 24 Volts, but smaller systems are 12 Volts. These pumps will operate at half-flow on a 12 Volt system. There is no problem using the pump this way.

Boosting the Voltage
A step-up controller will convert 12 Volts to 30 Volts. Solarjack makes a Pump Controller model PB10-28H that can be used with any 24 VDC pump (5 Amps maximum).

Use in Domestic Water Systems
Because of the low flow capacity of these pumps, water must be accumulated in a tank so that it can be released on demand. There are three ways to do this. One, pumping directly to a pressure tank. Two, using storage tank with a booster pump and pressure tank. Three, using an elevated storage tank with gravity flow. The rest of this article deals with the first method.

Pumping Directly to a Pressure Tank
This is the simplest and least expensive setup. It is the same system used by most conventional AC submersible pumps run on utility grid power. However, the low capacity of these DC pumps poses two limitations.

The pump is doing two jobs, *lifting* and *pressurizing*. Pressurizing 1 psi = lifting 2.31 feet. Pressurizing to 43 psi (a typical pressure) is equivalent to lifting 100 feet. So, a pump that can lift 230 feet maximum can lift only 130 feet if it is also pressurizing to 43 PSI. Remember however, vertical lift is measured from the depth of the pump down the well, not the level of the water in the well. These DC sub pumps are the positive displacement type and gain little pressure advantage from the water above them. Such is not the case with conventional submersible pumps (multi-stage centrifugal) pumps made for 120 or 240 vac.

The pump's volume is low. It may be as little as ½ gpm, which is like a pencil-size stream from a faucet. A pressure tank is used to accumulate water so that it can be released quickly when you open a faucet. An 80 gallon pressure tank can store about 30 gallons of water (the rest of the volume is air). The limitation to this system is that once you deplete that stored water, it will take as long as one hour to “recharge” the tank.

If people wait in line to take long showers, or you irrigate with a sprinkler, the pressure tank will be quickly depleted. But, small families get along well with this system, using common water-conserving measures, providing they are aware of the limitation. Drip irrigation is practical with this system.

As your water needs and/or budget expand, you can expand this system by adding a storage tank (large, non-pressurized) and a pressurizing “booster pump” to fill your pressure tank quickly. Meanwhile….

OPTIMIZING THE PERFORMANCE

Pressure Tank

Get a *captive air* pressure tank, not a plain or galvanized tank. Get a large one, like the 80 gallon size. This can store over 30 gallons of water — enough water to fill a small bathtub before the pressure gives out. Go bigger if you have the space and the budget. It *can’t* be too big. You can plumb more than one tank together to add volume, if it fits your space better, or if you wish to add to an existing tank. The tanks need not be equal in size. You can buy a horizontal or vertical tank (vertical tanks are cheaper).

Pressure Adjustment

Install a pressure switch and a pressure gauge on your system. Purchase a pressure switch of the type used with conventional AC pumps. You might buy a switch that says “cut-in 30 psi / cut-out 50 psi”. This indicates the factory settings, but they are adjustable. The setting determines the pressures at which the pump turns on and off. The cut-out adjustment is also called “differential”, since it sets the difference between cut-in and cut-out. It is desirable to use the *lowest* pressure that will satisfy your flow requirements. The lower you can set the cut-out, the less power your pump will require *and* the more water your pressure tank will store. Read the instruction card that comes with the switch.

Many homes are plumbed using the minimum required sizes of ½ inch and ¾ inch pipe. In this case, use a 50 psi cut-out for good flow. If you have not yet plumbed your house, have it done with one size larger than minimum pipe sizing, all around. Your piping will have less resistance to flow, and you can use a lower cut-out pressure. Try 35 psi and see how it performs. You can try less. When you are satisfied with the flow you get, then go to the next step.

Cut-In Setting

Set this to a pressure that is not much lower than the cut-out. That is, set a low “differential”. This way, the pump will switch back on *before* much water is drawn from the tank. A typical setting might now be 30 psi cut-in, and 40 psi cut-out.

Pressure Tank Precharge

Inside your pressure tank is a big rubber balloon. It is filled, at the factory, with pressurized air from a valve on the tank that looks like a valve on your car’s tire. It is pressurized at a *higher* pressure than you need. Check it with a tire pressure gauge. With this high setting, the water cannot compress the air balloon, so the tank is not yet effective.

Once you have set your pressure switch as described above, you need to let some air out of the tank. To do this, turn off the power to your pump. Open a water outlet to relieve the pressure in the tank, then close it again. Now let air out of the tank until the tire gauge indicates 2 or 3 psi *lower than your cut-in* pressure. This is also described on instructions that come with your pressure tank. If you have more than one pressure tank, adjust them equally.

Turn your pump on, and time how long it takes to charge the tank to cut-off. As soon as the pump starts, the pressure should quickly rise to the pre-charge pressure. Then it will rise very slowly as it compresses the air in the tank. Fix yourself a sandwich or something. When it finally reaches cut-out pressure and shuts off, note how long it took, and write down “cycle time…” on the wall near the tank. Also record your cut-in and cut-out pressure settings. If you have an ammeter measure the current (Amperes) that your pump draws at the beginning and at the end of the pumping cycle. If you have trouble in the future, changes in these readings will indicate where the problem lies.

Determining the Energy Requirement

These little pumps use less power than a 100 Watt light bulb. To estimate, look at the data sheet for the pump you intend to use. Calculate your *total* lift by adding your vertical lift plus the pressure (1 psi = 2.3 feet). A chart will indicate the current draw (Amps) and the flow rate. Calculate how many hours the pump will need to run to supply your daily needs.

Energy Required (Amp-Hours per Day) = Amps x Hours of pumping per day

You may need less than the output of one 50 Watt PV module to handle the energy requirement. Energy storage for one cloudy week may be less than the capacity of one battery. Or the water system could consume more. Energy consumption depends on the physical configuration of your water system and the volume of your water consumption.

Determining Optimum Pump Depth
Drillers and pump installers are in the habit of placing pumps down near the bottom of the well. Conventional pumps (centrifugal impeller mechanism) are not adversely affected by great submergence, so it doesn't hurt. Also, they cannot tolerate dry running if the water level should drop, so it is safer to place them low.

Diaphragm submersibles are fundamentally different. Diaphragm stress increases with pressure, so life expectancy decreases. They have good tolerance for running dry. Low voltage pumps require larger, more expensive wire, so length should be minimized to reduce cost. So, it is most advantageous to set the solar-powered pump *high* in the well, under just 5 or 10 feet of water, unless the water level is expected to vary. See manufacturer's ratings for maximum submergence. Do *not* approach the maximum unless you must.

The water level in your well may vary, and its long-term characteristics can only be speculated. In case of uncertainty, obtain the "Driller's Log" for your well. Most states require drillers to keep a log of their drilling results. The log will note locations of water-bearing strata, water yields, and possible variations in water quality. It will also indicate where the casing is perforated to allow ground water to enter. Collect any known information about neighbors' wells, including seasonal variations. In a mountain valley for instance, groundwater may rise with spring snowmelt and drop in winter. Or, it may vary from year to year according to rainfall. Large commercial irrigation can also lower the water table around nearby wells. You can have your well tested by a driller.

If the well yield is *more* than double the pumping rate, set the pump only 5–10 feet under the static water level.

If well yeld is *less* than double the pumping rate, anticipate the draw-down level of the well (take a guess or talk to the driller) and set the pump below that level.

If well yield is low, or water level is uncertain, purchase extra length of pump cable and pipe. Coil up the extra cable rather than cutting it. You can easily couple in the extra length of pipe if you need to drop the pump lower.

Measure the water level using a string with a weight. Run the pump a full day, and measure the level again. Also, listen. If the pump begins sucking air, you will hear it.

If your well yield is very low or uncertain, use a pump controller with level sensors. Place the sensor probes in the well to shut the pump off if water drops too low. Long-term dry running may damage the pump, especially if there is sand in it.

If Well Water Is Sandy
Ask your driller to bale or pump the well until it runs clear. Drillers don't always do this. Let him know that your pump is not only slow, but is not very tolerant of sand, which wears the rubber parts.

Keep the pump higher than casing perforations that may be introducing sand. If this is not possible, obtain a "sand shroud" from your supplier, or make one from a plastic soda bottle and a hose clamp. This fits over the pump like a skirt, so that if sand falls from above the pump, it will pass around the pump and continue to fall. If you have a four inch well casing, then you will not have enough room to fit a sand shroud.

Grounding And Lightning Protection
A long wire run, even buried, may act as an antenna receiving power surges from nearby lightning. Electrical grounding is essential for lightning protection. If you live in a dry climate, get a good earth contact for your grounding system. When you have a trench open for piping or wiring, lay in bare copper wire (#6 gauge, minimum). Connect it to the ground rods and/or to your grounding system. The wire buried and exposed to the earth will help drain off accumulated electrical charge during lightning conditions.

Access
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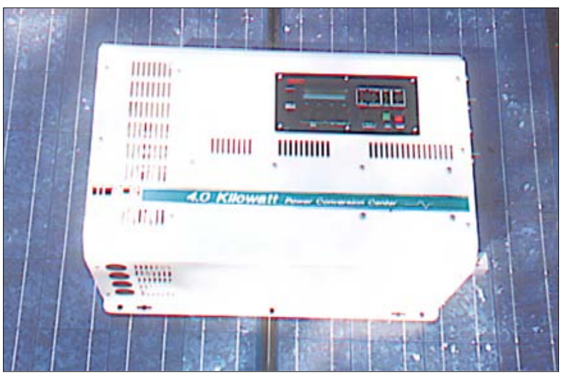

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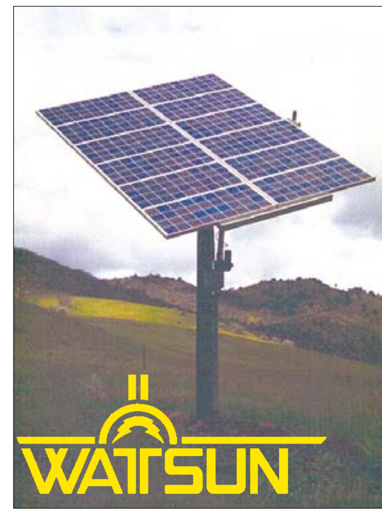

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Tower Economics 102

Mick Sagrillo

Turbulence and ground drag are the enemies of any wind generator, robbing it of its precious fuel, the wind. As we move away from the surface of the earth, the effect of turbulence and ground drag are reduced. The higher up we go, the stronger the wind speed. The lesson is that tall towers are a must for wind generators. But how high is high enough? What is cost effective?

Recap

In the last issue of *Home Power* (*HP*#37), we examined why turbulence and ground drag are detrimental to the production of wind generated electricity. We looked at the relationship of height above ground and wind speed, and how the power available to a wind generator increases with wind speed. Finally, we analyzed the economics of a simple wind installation at two different tower heights.

The conclusion we reached is that a taller tower is always cost effective. Now, being essentially terrestrial animals, most folks don't like to hear this. After all, if we were meant to service wind generators on 100 foot towers, we would have been given 95 foot legs!

Try to put your fear of heights aside for a little while as we examine the economics of increasing tower height cost versus additional power output.

Shear Factor

How much wind speed increases with height is fairly well documented. The major variable of wind speed versus height is the terrain over which the wind is blowing. Land forms, vegetation, and buildings all impact the speed of the wind in their own way.

The increase in wind speed with height over various ground obstacles is known as "wind shear". Wind shear is less pronounced over relatively flat open ground and considerably greater over hilly terrain with many buildings and trees. Wind shear can be represented as a percentage of increased wind speed as height increases over the ground or over vegetation and buildings. The above chart depicts wind shear for us.

Thirty feet is the baseline used to determine wind shear at higher levels. It is a typical adjusted height for measuring wind speed at weather bureaus and airports.

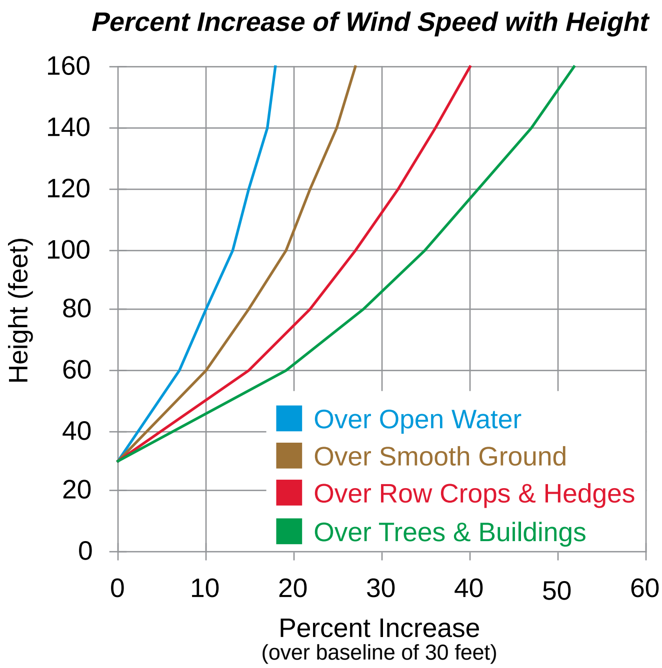


Chart 1

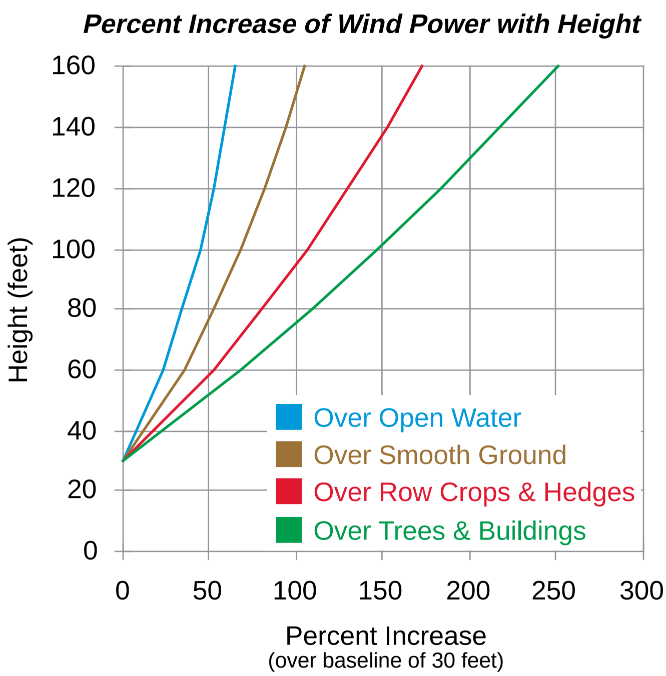


Chart 2

Remember (back to *HP*#37) the wind power equation states that: P = ½d x A x V^3. The power in the wind is a function of (among other things) the cube of the wind speed. Therefore, the easiest way to increase the power available to a wind generator is to increase the wind speed. We can increase wind speed by either installing a taller tower (as depicted in Chart 1) or by moving to a windier location.

Tower Height (ft)	*BWC 1500 w/controller*	*Rohn 25G Tower*	*Tower Wiring*	*Concrete*	*Backhoe*	***Total***
40	$4,290	$1,275	$40	$75	$120	$5,800
60	$4,290	$1,725	$60	$75	$120	$6,270
80	$4,290	$2,195	$80	$100	$120	$6,785
100	$4,290	$2,625	$100	$100	$120	$7,235

Table 1

Note that as a percentage, wind speed increases much faster over terrain cluttered with trees and buildings than over flat open ground. The lesson here is that, with the exception of the middle of a lake or desert, wind speed increases significantly with height.

From Chart 1, we can now determine how power to a wind generator increases with height by cubing the values represented (but not the actual numbers) in Chart 1. Our percentages would look somewhat different (see Chart 2, previous page).

This chart dramatically illustrates the beneficial relationship of greater height above ground obstructions. The numbers represent the percent increase in power (and therefore watts) produced by the same wind generator at the same point in time that the wind is blowing over a given piece of ground, but at different heights. While the wind is blowing, the wind speed and therefore wind power, is obviously not the same at increasing heights.

For example, compare the power available at 30 feet, our baseline, to that at 100 feet above row crops and hedges. There is 106% more power available at 100 feet as compared to 30 feet. Said another way, two wind generators on two 30 foot towers will produce as much power as one wind generator on a 100 foot tower. And the system with the 100 foot tower will be cheaper to install than the "twin" systems at 30 feet (see *HP*#37).

It's time to apply what we've learned so far to some real life installations to determine the cost effectiveness of increasing tower heights.

DIY System

Our first system will be a small (by wind standards) do-it-yourself installation. We are going to install a 1500 watt Bergey wind generator on a Rohn 25G guyed tower. The cost of the 24 VDC wind generator is $3395, and Bergey's automatic controller is an additional $895. Since we already have the batteries, inverter, various disconnects, and all the house wiring, we will not include these costs.

We also need to make a few other assumptions. Since I don't know where you live, shipping costs for the wind generator and tower have not been included. We'll need a backhoe for half a day to dig the holes for the tower base and guy anchors at a cost of $120. Since the anchor specs for all of the towers options we are considering are nearly the same, we'll use the same backhoe cost for all towers. We'll also need some Redi-mix concrete at about $50 per yard.

Finally, we will be doing the installation ourselves with the help of a few friends on a labor trade, so there are no costs for the installation. Here are the four tower height options we will consider with their cost breakdowns (see Table 1 above).

The system is to be installed on a homestead that was once a working farm. The usual farm buildings, barn, short silo, and a few fruit trees fill the yard along with the house. In other words, we have lots of ground obstructions. Because this is a low voltage system (i.e., 24 VDC), the wind generator needs to be near the battery bank, which is in the shop in the center of the yard. The rule of thumb for siting (see *HP*#37) is that the wind generator must be at least 30 feet above any obstacle within 500 feet. The 40 foot tower is too short for this site, so it cannot be considered.

We need a way of comparing the different costs of taller towers with the additional power output at higher levels. Table 2 (below) does this for us.

An explanation is in order. Our base tower height, against which we will compare taller options, is 60 feet. "System Cost" comes from the column labeled "Total" in

Tower Height (ft)	*System Cost*	*Incremental Cost*	*Percent Increase*	*Percent Over Base*	*Wind Power*	*Incremental Power*	*Percent Over Base*
60	$6,270	—	—	—	68%	—	—
80	$6,785	$515	8.2%	8.2%	109%	41%	41%
100	$7,235	$450	6.6%	14.8%	147%	38%	79%

Table 2

Tower Height (ft)	System Cost	Incremental Cost	Percent Increase	Percent Over Base	Wind Power	Incremental Power	Percent Over Base
60	$25,530	—	—	—	52%	—	—
80	$26,790	$1,260	4.9%	4.9%	80%	32%	54%
100	$28,220	$1,430	5.3%	10.5%	106%	26%	104%
120	$29,880	$1,660	5.9%	17.0%	130%	24%	150%

Table 4

Table 1. "Incremental Cost" refers to the difference in price between the tower height considered and the next lower height option. "Percent Increase" refers to this cost increase as a percentage. "Wind Power" refers to the power increase given in "Over Trees & Buildings" for various tower heights in Chart 2. "Incremental Power" is the increase in power as a percent over the next lower tower height.

In the scenario we have developed, going from a 60 foot to an 80 foot tower will cost us an additional 8.2% giving us 41% more power. Going from an 80 foot to a 100 foot tower will cost an additional 6.6% and yield 38% more power. And going from a 60 foot tower to a 100 foot tower costs 14.8% more but gives us a 79% power increase!

UTI System

Our next example will feature a much larger system with a different form of storage. We are going to install a 10 kiloWatt Bergey EXCEL utility-tie-in (UTI) wind generator with its own grid intertie inverter. Excess electricity will be stored on the grid in the form of a credit to our monthly electric bill. The wind generator will sit atop a Rohn SSV freestanding tower. This is a real "cadillac" installation that will be the envy of the neighborhood.

The cost of the Bergey EXCEL with the UTI inverter is $17,495. This installation is going to help power a working farm. Since it is a high voltage system, it can be placed a considerable distance away from the farmyard, thereby eliminating most of the problems of turbulence associated with buildings and trees. The best place for it is determined to be a low fence row between two corn fields.

Since this is a major project, we are going to contract out all of the labor for the installation. This includes digging the holes for footings with a backhoe, pouring the concrete for the footings, assembling the tower, running the wire down the tower and over to our house, erecting the tower and wind generator with a crane, and installing the inverter and disconnect switches in our house. The cost for the wire and concrete have been broken down because they change depending on the installation. Again, shipping has not been included in the calculations.

Tower Height (ft)	EXCEL w/inverter	SSV Tower	Wire Kit	Concrete	Installation	**Total**
60	$17,495	$4,435	$800	$300	$2,500	$25,530
80	$17,495	$4,980	$890	$425	$3,000	$26,790
100	$17,495	$5,750	$975	$500	$3,500	$28,220
120	$17,495	$6,735	$1,050	$600	$4,000	$29,880

Table 3

This is a complete "turn-key" installation, meaning we pay the bill but don't have to lift a finger! We're going to consider four different tower heights for this installation (see Table 3 below).

As with the previous system, we'll now compare the incremental cost differences with the different tower options listed above against the incremental power increases for those tower heights in Chart 2. Since this system is to be placed in a fence row surrounded by row crops, we'll use "Over Row Crops and Hedges" from Chart 2. Table 4 (above) summarizes the results.

The explanation of what the columns are telling us is the same as for Table 2.

Conclusions

So, how high is high enough? And what is cost effective? The numbers don't lie! Although people don't like to hear the message, the truth is that the cheapest way to increase the power output of a wind generator is to increase tower height.

For example, a 10 kW Bergey wind system on a 100 foot tower will produce slightly more than twice the power of the same wind generator at 60 feet, for a little better than 10% increase in total price. In other words, two 10 kW Bergeys on 60 foot towers will produce about the same amount of power as only one of the same wind generators on a 100 foot tower, but at nearly twice the cost.

The investment in the system with a 100 foot tower will pay for itself in half the time of the system with the 60 foot tower. In simple economic terms, increasing tower height cuts the payback time in half in this example.

You now have the tools to determine the economics of various tower height options when planning for a wind system. All you need to do is compare the incremental cost of the taller tower you are considering to the increased power output at the additional height as we just did in Table 2 and Table 4. If you wish, you can even extrapolate the numbers for the two scenarios we developed to even taller heights.

Access

Although he doesn't like it either, Mick Sagrillo dangles from very tall towers at Lake MIchigan Wind & Sun, E 3971 Bluebird Rd, Forestville, WI 54713 • 414-837-2267.

Above: A portable solar-powered system runs computers and communications equipment. The system recharges from the sun, an automobile, or from the electric grid wherever you are. Photo by Richard Perez

Photovoltaic Power for the Permanently Portable

Richard Perez

I really missed my computer on our trip to Colombia last year. So much of what I learned ended up on scribbled notebook pages. So much of what I had to teach was stuck inside a computer four thousand miles away. I decided then and there that a portable computer was for me. Here's a small PV system that tucks away in a large briefcase and frees your computer, radios, printer, or what-not, from the tyranny of the extension cord.

Enter the Portable Computers

Our small Macintosh PowerBook is a delightful and fast tool. This small computer allows us to take Home Power's databases and renewable energy information anywhere. The problem is that the built-in battery only lasts about two hours before requiring recharging. This is scarcely enough time to work through a long aircraft flight, much less a few weeks in the Andes. At Energy Fairs and events, folks have often asked us for a small PV system design that would allow the new generation of portable computers to go where the power lines don't. I remember one gentleman in particular. He was employed by the USGS doing mapping in Alaska. He lived out of a backpack and his range was limited by how many PowerBook batteries he could carry. He would spend all day gathering survey data and feed this data to his PowerBook at night. Every few days he returned to his base camp and ran a small generator to refill his regiment of PowerBook battery packs.

Over the years I have wanted to take a variety of electric tools into the outback. But when it really comes down to it, there are really only two tools that justify this degree of expense and effort — computers and communications. Communications turns out to be an easier to solve solar problem than is the computer. Radios and small TVs consume only small amounts of power, usually 10 to 40% of the power required for a portable computer. The system described here will not only support intense use of a portable computer, but will also run a radio or small TV receiver. This system will support CB and Amateur transceivers. I can run my two meter handytalkie (ICOM IC-2SRA), charge an extra HT battery, and run the computer at the same time!

Space — the final frontier

Two things I've learned about traveling in the outback — go compact and go rugged. This portable PV system had to be small enough to hump up mountain trails and rugged enough to survive a moose attack under four feet of water. These two design criteria constantly clashed during the fabrication of this system. When it came to a hard choice between lightweight and ruggedness, I chose ruggedness.

Power Sources

The successful traveler is an opportunist. When the food is good, it's time to eat. When the bed is soft, it's time to sleep. The happy traveller stores his energies for times when the living isn't so easy. I wanted this PV system to be just the same — an opportunist. This system will feed from virtually any electrical power source — a PV module, a car (12 VDC), and/or the local electric grid (either 120 vac, 60 Hz. or 240 vac, 50 Hz.).

Travelers with special feeding requirements often go hungry. I decided to base this portable system on the most common form of power in the world — 12 Volts DC. Every country in the world uses automobiles and they are all 12 VDC systems. Twelve Volt PV modules, batteries, and inverters are readily available and inexpensive.

The PV Modules

The PV modules used in this portable system must have a high power to weight ratio. I used a Solarex MSX-10, 10 Watt PV module (650 mA at 15.5 VDC) that weighs about 1 pound. This module uses no glass and is rugged enough to survive on the decks of sailboats. I also put an old Sovonics 6 Watt fold-up PV module in the case and can power the system with both modules if needed. Ideally two of the Solarex MSX-10 Lite PV modules would be better for this system. Since I already owned the trusty Sovonics fold-up module, I used it instead.

Recharging from a Car

This system is designed to plug directly into any car's cigarette lighter socket. An automotive battery/alternator is a very effective recharging source for this portable system. The system will both recharge its internal battery and operate the loads from a resting car battery (no alternator running). The regulator provides overcharge protection if the car's alternator is operating.

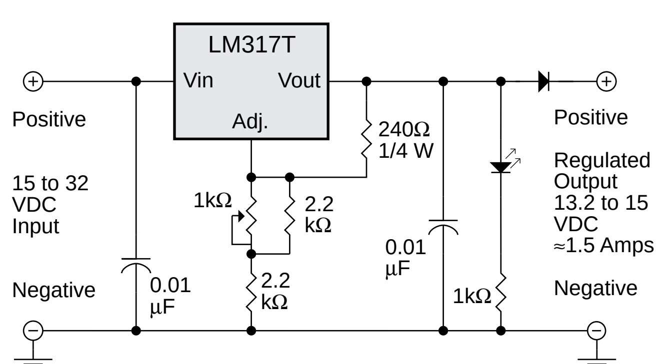
Recharging using 120 vac

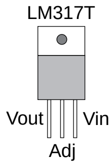
A small 120 or 240 vac "wall cube" type power supply recharges the system when the grid or a generator is available. I used a supply rated at 500 milliAmperes 14 Volts DC. Actually this supply has an open circuit voltage of 16.8 VDC and very nearly replicates the MSX-10 Lite PV module as a power source. This wall cube is about 3 inches on a side and weighs 8 ounces.

The Regulator

I had to design and build the regulator because no commercial model was available. The system is tiny with maximum recharge currents in the neighborhood of 1.2 Amps. The regulator should be able to feed on a variety of power sources and not ever damage the battery.

This regulator is simple, versatile, and bullet-proof. It is capable of controlling the voltage of the PV module, the incoming car battery power, or the wall cube ac/DC power supply. I used the LM 317T regulator (Radio Shack # 276-1778 for $1.99) not because it is efficient, but because it is virtually indestructible. The LM 317T contains internal current limiting (1.5 Amps), overtemperature shutdown, and short circuit shutdown. Since the regulator is inefficient, a manual switch is provided so the the bulk of the recharging can bypass the regulator. The system uses a sealed battery, so I set the regulation point at 14.2 VDC. At this voltage, less than 10 mA is flowing into the battery.





I provided the regulator with a blocking diode to prevent discharge into the regulator when a power source is not present. This blocking diode also isolates the portable power system's battery from charging sources when the regulator is defeated by switch S1. All resistors in the regulator were ¼ watt. I used a 5 Amp blocking diode even though it only handles 1 Amp. The additional mass of this heavy diode acts as its heatsink with the regulator's sealed enclosure. Use a clip on heatsink on the LM 317T. I used a plastic enclosure with a sheet metal face, 6 inches long by 3.75 inches wide and 2 inches deep (Radio Shack #270-627 for $2.79). The circuit went together on a small two inch by three inch piece of perf board mounted inside the enclosure.

The Case

When I first got the PowerBook, I went shopping for a case and didn't buy one. All the cases I could find were modeled on Yuppie luggage concepts. I wasn't going to pay over $150 for a cloth case that wouldn't protect the PowerBook against water, dust, or impact.

Then I remembered the Pelican plastic case that Juan Livingstone used to house the video gear on our trip to Colombia. This case was so air tight that we'd have to activate the air vent in order to open the case when we lost altitude. These cases are unbreakable, watertight, and dustproof. They carry a lifetime guarantee that only specifically excludes shark bite, bear attack, and children under five.

I used the Pelican Pro Case model 1550. It measures 20.5 inches long by 16.75 inches wide by 8.5 inches deep — about the size of a large briefcase. These cases are available at most big camera stores and this one cost $115. I looked long and hard at the next smaller size, but it was too small to contain all the power system equipment and the PowerBook. The 1550 case is heavy (about 12 pounds), but after seeing the routine abuse heaped on our equipment in Colombia, I figured that the case was the last place to save weight.

I had originally planned to attach the Solarex MSX-10 Lite to the outside of the case. After some thought I decided to stow the PV module inside the case instead. If the module is mounted on the outside of the case, then the case and its contents must be placed in the sun. I more fancied sitting under a tree with the case, the computer and everything else, and placing just the module out in the sun. I am loathe to drill holes in this wonderfully watertight case. I also wonder about PV module damage if it is permanently attached to the case's exterior.

As I finally set up this system, everything stows within the case and is capable of the most extreme travel imaginable. The Pelican case came with two "pluck & chuck" foam inserts that allowed me to nestle each component in its own snug foam pocket. The degree of protection offered to both the system components and the appliances in the case is excellent. This system will bounce down a rutted road in the back of a truck. It can take being dunked in a mountain stream. No matter how rough the going gets, this system and its loads will arrive undamaged and ready to go to work.

The Inverter

The inverter allows use of an appliance's stock power supply. In order to recharge the PowerBook, or Amateur radios, I simply plug their standard power supplies into the inverter's 120 vac power. I tried three different inverters in this system, a PowerStar POW200, a Statpower 100, and the new PowerStar Pocket Socket (100 watt). All performed equally well when powering the loads. The new PowerStar Pocket Socket smallest 100 watt inverter I have ever seen and is perfectly sized for this system. The larger Statpower model while heavier had a lower idle current (50 mA for the Statpower versus 175 mA for the Pocket Socket).

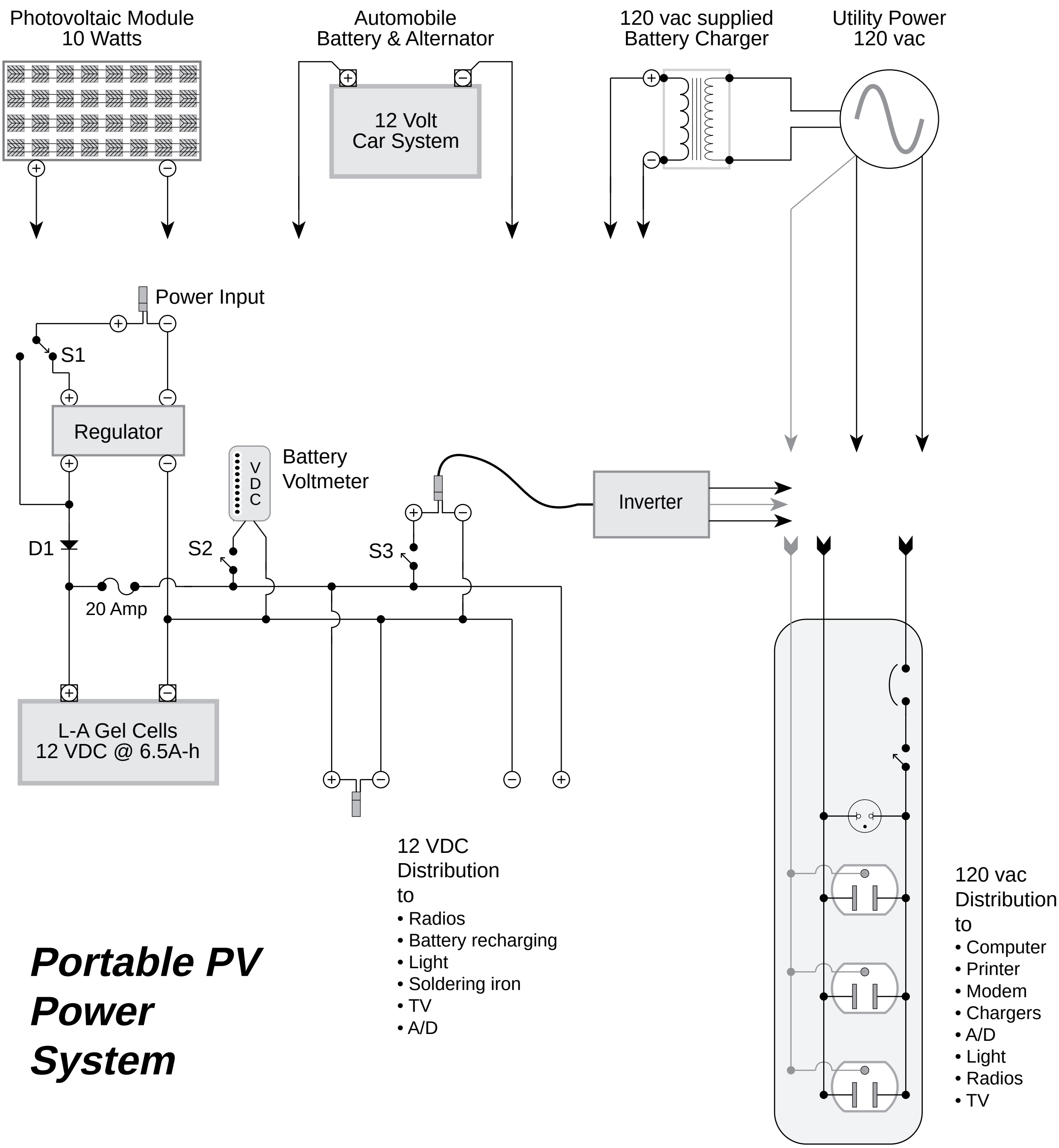
While operating the PowerBook on the system, the inverter consumes about 1.1 Amperes of current. With the PowerBook sleeping and recharging its battery, the inverter consumes about 400 milliAmps of current. Any of the inverters mentioned above still has lots of snort leftover to recharge radio batteries, run a small printer (like a 26 watt Hewlett Packard DeskWriter/Jet), or even power some compact fluorescent lights. While the inverter may seem oversized for this tiny system, there is a method in my madness.

The inverter allows this portable system to be more opportunistic. In my experience, much back country travel is by car or truck. The 100 watt inverter allows this miniPV system to mooch power from a vehicle. Loads being powered by the system's tiny internal battery can be transferred to the vehicle's battery while it is available.

The Battery

I used a Panasonic model LCR12V6.5P sealed lead-acid, "gel cell" battery. It has a rated capacity of 6.5 Ampere-hours at 12 VDC. It weighs in at 4.8 pounds and is the heaviest component of the system, except the PowerBook. Its dimensions are 5.95 inches long by 2.54 inches wide by 3.70 inches high. This battery cost $32 from Digi-Key (800-344-4539), and is widely available.

I would have liked to carry more battery capacity in this system, but its size and weight had reached the limits of



Portable PV Power System

portability. If the system were any larger, it would not be carry-on luggage on an airliner. Considering its value, this system rides in the cabin with me.

Increasing the battery's capacity without increasing its size or weight is a problem. I looked at many battery technologies for use in this system. I settled for what I described. In the future either rechargeable lithium or nickel-metal hydride cells may offer more energy for the weight, but they were simply too expensive for me to use. I look forward to upgrading the battery and thereby the entire system's performance in the future.

Instrumentation
I included a SunAmp LED bar graph voltmeter in the system. It is small, lightweight, and very rugged. Current consumption is a low 20 mA, but I still turn off the meter when I don't need it. The range of this LED voltmeter exactly suits the lead-acid gel cell battery. I cannot conceive of operating a portable system without knowing at least the system's voltage.

Plugs, Connectors, and Cords
While problems of weight and size plagued me, the real battle was connectors and plugs. Originally I planned to

assassinate all the plugs and connectors and solder all the connections. Then I realized that this vastly limited the system's possible configurations. In the end I succumbed to standard 120 vac plugs and cigar lighter plugs and sockets for the 12 VDC gear. Here are the reasons why.

I am no lover of the cigar lighter plugs. The are bulky, and for their size offer tenuous high resistance connections. But I wanted the system to be flexible, and most cars come with a cigar lighter, so when in Rome….

I fitted the Solarex PV module with a male cigar lighter plug (the Sovonics module already was so equipped). I attached a male cigar lighter plug to my 120 vac wall cube battery recharger's output. I made a cigar male to cigar male fused jumper cable to interface with a vehicle's system. The power input to and output from the system is via cigar lighter female plugs. Two cigar lighter "Y" cables (one male into two females) are included in the case. These cigar "Y"s allow use of two charge sources or two DC loads.

Portable PV System Cost

Component	*Type*	*Cost*	*%*
PV Module	Solarex MSX-10	$130	28.1%
Case	Pelican 1550	$115	24.9%
Inverter	Modified Sine ≈100 watt	$100	21.6%
Battery	Panasonic LCR12V6.5P	$33	7.1%
Voltmeter	SunAmp BCM	$30	6.5%
Plugs	Cigar M/F	$16	3.5%
Battery Charger	120 vac/16 VDC	$15	3.2%
Regulator	Homebrew 1.5 Amp.	$8	1.7%
Plugstrip	any ole' type	$7	1.5%
Extension Cords	16/2 lightweight 120 vac	$6	1.3%
Wire	14 ga. and 22 ga.	$2	0.4%
	Total	$462	

The use of cigar lighter receptacles allows high flexibility. For example, in a vehicle I can plug the inverter directly into the car battery, run the powerbook from the inverter, and use the 120 vac power supply to recharge the portable system's gel cell battery. The use of standard connectors everywhere allows system components to serve outside of the system. For example, the PV module can easily recharge a dead car battery.

The system also stows several cords inside the case. Both PV modules have 12 foot extension cords that allow them good access to the sun. There are two 12 foot, 120 vac extension cords to bring in grid power and distribute inverter produced 120 vac.

System Cost
Well, it cost more than I thought when I began this project. Considering the portability, and utility of the system and its loads, I think the cost is justified. The damages are detailed here.

System Performance and Operation
While the internal PowerBook battery allows two hours of operation, this system extends that time to seven hours with no energy input. If a the Solarex MSX-10 Lite PV module is in the sun, then operating time is increased to twelve hours. If the Sovonics module is also deployed, then operating time is about 15 hours.

Since the PV modules are portable, they can be repositioned during the day to capture the maximum amount of sunlight. Using such manual tracking, this system will recharge in a single day with both modules deployed. Recharging via the 120 vac supply is accomplished in about 14 hours. I have recharged the system from a vehicle battery in as little as six hours.

Conclusions
The only true advantage of portable computers and communications devices like the ICOM handytalkie is in the freedom of movement they offer. A system like this one allows us to transport and use these electric tools in very remote places. And we can remain in places without power and still have the use of these electric tools.

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

Case Maker: Pelican Products, Inc., 2255 Jefferson St., Torrance, CA 90501 • 310-328-9910

Above: A bit of electronics, computer, and datalogger gather together to record data on six makes of AA cells.

AA Nicad Battery Testing

Therese Peffer

Have you ever noticed how many batteries you use? I counted seven batteries in my life: in my truck, power system for the trailer, flashlight, camera, calculator, two-meter handheld radio, and even a portable pencil sharpener. Since some of the batteries — the AA cells in my flashlight and handheld — need frequent replacement, I became interested in rechargeable nickel cadmium (nicad) AA cells. But how do you know which brands of AA cells are a good buy? After all, not all cells are alike! I bought six different brands of AA nicad cells and tested them.

Shopping around for batteries can be more difficult than shopping for a new car! With a car, you can usually get information on the size of the engine and gas mileage, and you can review consumer reports for reliable makes and models. With rechargeable batteries, you're lucky if you can find out the capacity of the cell! And the best way to find out about the reputation of certain manufacturer's AA cells is just by word of mouth.

Introducing the Players

I have AA cells from Panasonic, Saft, Golden Power, Radio Shack, Gold Peak, and Millennium. The nicads range in capacity from 500 milliAmp-hours (Saft) to 850 milliAmp-hours (Radio Shack and Gold Peak). Three can be rapid-charged in one hour, the other three require a 14 hour charge at a C/10 rate. (This means the charging current is equal to ⅒ the cell capacity). The chart below describes each cell. I bought them all from various companies (addresses are listed at the end.)

When buying a car, some look for low gas mileage or special performance, like four wheel drive. What about a battery?

I had five considerations for the AA cell shootout. First was the capacity of the cells: would the cells last as long as they were supposed to? That is, would I really get 850 milliAmp-hours from the high capacity Radio Shack AA cells? Second is reliability or "quality control": I have four of each type of cell except the Radio Shack cells (just two). How much does one Panasonic cell differ from another? My third consideration is compatibility: will these cells fit in my appliances? Fourth consideration is the price. Are inexpensive cells cheap in quality? How much am I paying per milliAmp-hour? The final consideration will take years to test: longevity. Will these cells really last 1000 cycles? Tune in about *Home Power* #99….

Testing capacity is fairly straightforward. I just discharge the cells and measure the current over a period of time to get Ampere-hours. I'll compare the capacity of different cells to check quality control. Checking for fit is simple.

The Test Procedure

Each cell was marked to tell them apart. For example, the four Millennium AA cells were labeled M1, M2, M3, and M4. The first step was to charge and discharge these brand new uncharged cells to get them warmed up for the test. The first two charge/discharge cycles used a Kyocera Jetski 50 milliamp photovoltaic module for charging and a 10 Ω power resistor for discharging. Cells were charged and discharged in series. The four- and eight- cell holders for AAs that I bought from Radio Shack work great here.

For the first two cycles, I used a Fluke 87 digital multimeter to follow the discharge of the cells. The voltage of a charged nicad cell measures about 1.3 Volts. This voltage drops gradually as the cell is discharged and falls rapidly once it reaches one volt. But using the Fluke, I could only measure the total voltage of all four cells, not the voltage of the individual cells. Our Remote Measurement Systems datalogger and Macintosh PowerBook 160 computer solved this problem.

I got out the tools and scrap plywood and developed a test jig (see schematic next page). This test jig consists of four AA cell holders wired in series. Positive and negative leads from each cell feed a voltage divider. This allows the datalogger to read in its ±400 mV range. The negative lead from the last cell has a shunt for measuring current into or out of the cells. The total voltage was also recorded. I used an alligator clip on the negative lead so I could charge/discharge one to four cells. The datalogger plugged into the PowerBook and the data was imported to an Excel spreadsheet and tallied. The voltage of each cell and the current was recorded every nine seconds.

AA Nicad Cells

Name	*Capacity*	*Type**	*Recommended Charge*	Cost	*bought from*
SAFT industrial nicad (Mexico)	500 mAh	S	50 mA for 14 hours	$2.25 each for 4 plus $4 S&H	Sunelco Inc
Panasonic P272 nicad (Japan)	600 mAh	R	60 mA for 15 hours 600 mA for 1.5 hours	$2.16 each for 10 plus S&H	DigiKey Corp.
Golden Power nicad KR700AA	700 mAh	R	70 mA for 14–16 hours 210 mA for 4–5 hours 700 mA for 1–1.5 hours	$2.75 each for 4 plus S&H	Real Goods
Millennium nicad (Gates Energy Products)	750 mAh	R	can be charged in one hour, no information	$2.74 each for 4 $3H	Crutchfield (also 7th Generation)
Radio Shack Hi-capacity nicad (China)	850 mAh	S	85 mA for 14 hours	$2.98 each for 2	local Radio Shack
Gold Peak Sylva Charge nicad (China)	850 mAh	S	85 mA for 14 hours	$2.75 each for 4	C. Crane Company

*S = Standard charge, R = Rapid charge

The RMS datalogger runs on DC; we hooked it up to a small battery. Since the PowerBook has an internal battery, my setup was completely independent of "power outages" (inverter changes), which are fairly common around here.

For the next five cycles, I used the test jig to charge and discharge the cells. Since these were still preliminary cycles, I experimented with a variety of battery chargers. The cells that could be rapid-charged were rotated among the different chargers. The standard charge cells were charged with Richard's homebrew nicad pulsar charger (HP #30).

Each set of cells were placed in the cell holders in the test rig and discharged using a variety of power resistors. I used a 0–25 Ω rheostat (variable power resistor) and 22.5 Ω power resistor for accurate discharges. A cell was considered discharged when it reached one volt. For the first few cycles, I used a C/1 rate — cell were discharged in about an hour.

Preliminary Notes

Now, watching batteries discharge is about as exciting as watching grass grow, but I learned a lot.

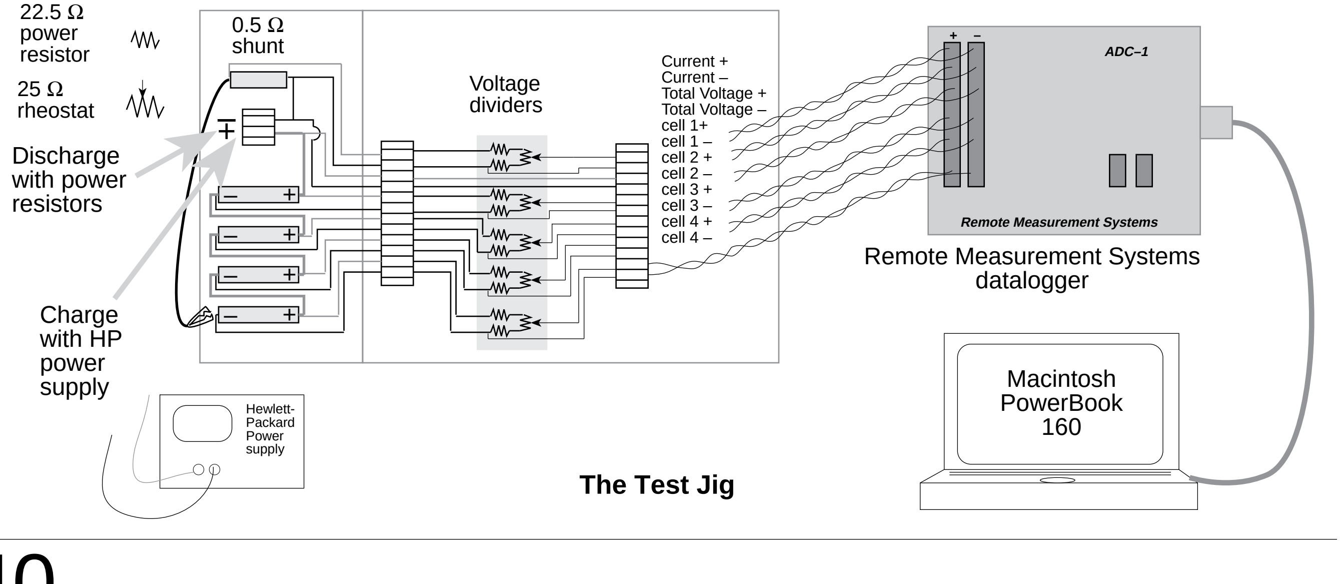
I knew that each set of cells, even though from the same manufacturer, would differ from each other. I was surprised at how much! The difference was fairly consistent throughout the cycles. That is, the cells developed a predictable order: the cell with the highest capacity in the first discharge generally came up tops in all the discharges. For example, over the six recorded discharges of the Saft cells, S4 consistently had the lowest capacity of the four cells regardless of the rate of discharge.

The difference between cells was evident in each cell's voltage under charge and discharge. Nicads under charge show a characteristic peak in voltage at the end of the charge when they are full. The peak increases with charge rate. That is, at a slower charge rate (say C/10), the voltage might peak at 1.45 Volts. Under a C/1 charge rate, the same cells might show peaks in the 1.6 Volt range.

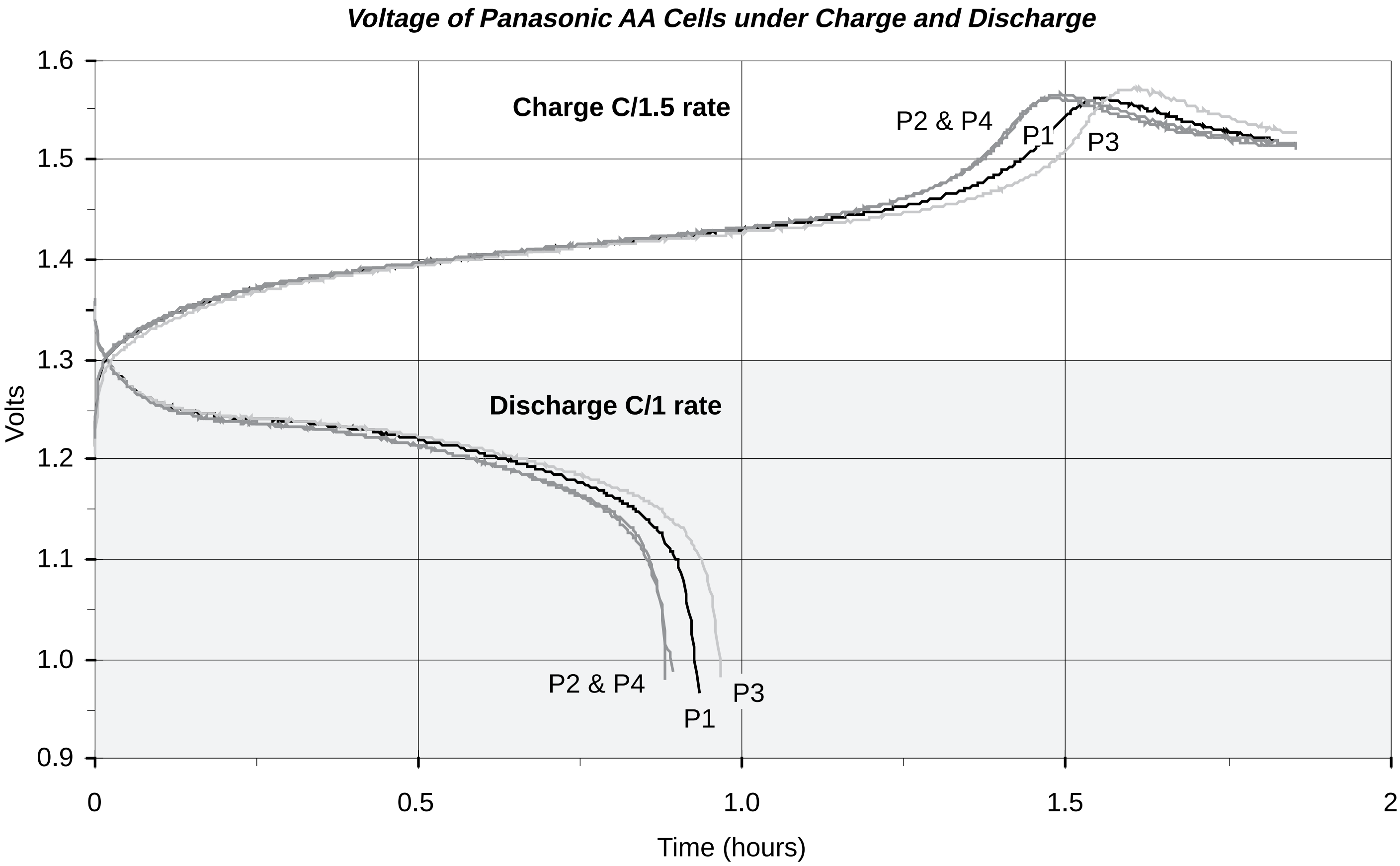
The datalogger and computer made this "peak" voltage easy to see. For example, see the graph on page 41. The four Panasonic cells were charged in 1.5 hours and discharged in about an hour. Each cell reaches its peak at a different time. But although they are marching to the beat of their own drummer, they march in order. The voltages of P2 and P4 are about even under both charge and discharge. Both reached the end of the charge earlier than P1 or P3, and both also reach "empty" earlier.

Watching the cells at the tail end of the discharge, I learned why quality control — the difference between the cells of a particular manufacturer — is so important. I understand why the charging instructions for some cells mention not to mix and match cells: don't use old cells with new cells or two different brands in the same appliance. Why? In a real life situation, cells are used in series or series-parallel. My flashlight takes two AAs in series, my handheld takes six. The appliance sees the total voltage: the sum of the individual cell voltages in series.

What happens if one cell has less capacity than the others? Towards the end of the discharge cycle, the cell's voltage starts to drop off rapidly. The flashlight starts growing dim. If the cell has slightly less capacity, this is not a problem. Soon the other cells' voltages drop, and the flashlight needs freshly charged cells. But if the "bad" cell had much less capacity than the others, the voltage could drop below zero.



The Test Jig



Imagine four strong people carrying a rack full of PVs. One person is slightly weaker than the others and slows down. The rack slows down slightly, because the weight shifts to the other three. But soon all four people are tired and have to stop. No problem. But say that one person is much weaker than the other three. He (or she) gets tired much faster than the others. He slows down, and the weight shifts to the other three. But they are not tired, so they trudge on. The rack slows (flashlight dims), but does not stop. The weak one could fall down before the other three stop. That is, the flashlight would grow slightly dim because the other cells still have some juice. Because the flashlight still gives off light, you don't replace the cells. The voltage of the bad cell could even fall negative. Here is another reason not to overdischarge cells! The voltage of the cell with the lowest capacity might become reversed. The more similar the cells are, however, the less chance of overdischarging them. While a cell that has its voltage reversed for a few minutes is not ruined, you may see a decrease in capacity.

Let the Tests Begin

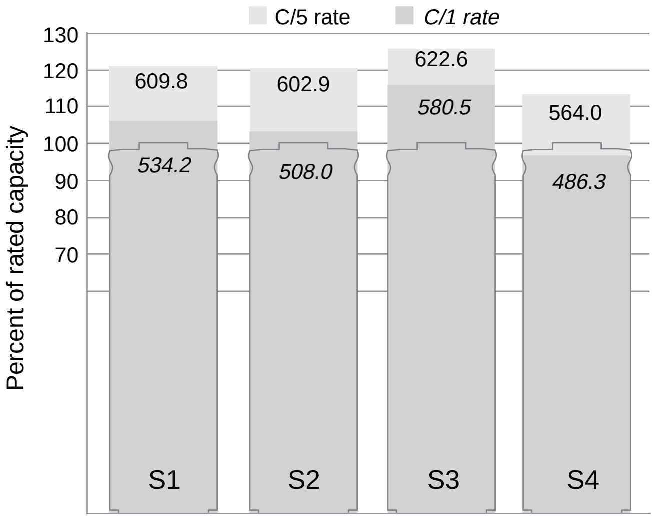
For the final data record, I wanted the cells to be treated as equally as possible. I charged each set of cells with the pulsar charger. Each cell was charged for 13 hours at a C/10 rate. Then I turned to the test jig and topped off the cells using the Hewlett-Packard power supply. I waited fifteen minutes after the last cell had reached its peak to stop charging. The topped-off cells sat around for a few hours to cool off before discharging.

I had discharged the cells in about 1 hour using a C/1 rate (the discharge current equalled the capacity). But I decided to also discharge using a C/5 rate. Why C/5? All the technical information I have on nicads lists the capacity of the cells rated at a C/5 rate. So the cells were discharged using a 25 Ω rheostat in series with a 22.5 Ω power resistor to achieve a C/5 rate. I removed discharged cells as they reached 1.0 Volt — each was thus allowed to fully discharge.

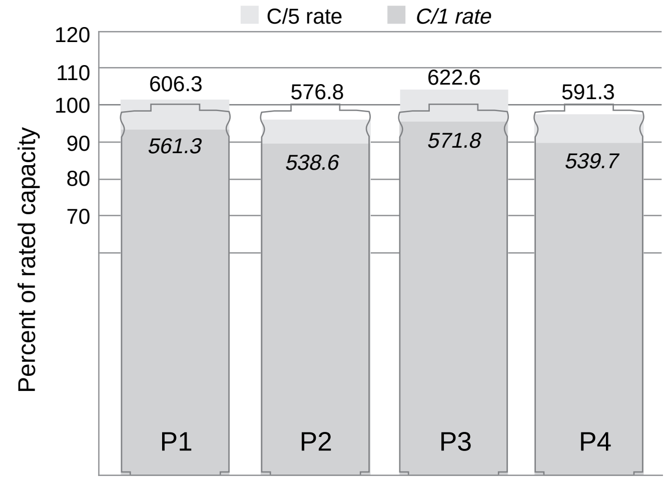
Test Results

The next page shows the actual capacity measured from the discharges. I took this data after each cell had seen six charge/discharge cycles. I'll let the results speak for themselves. The graphics show how the contesting cells did under discharge, at both C/1 and C/5 rates. The outline of the cell shows the rated capacity. Shaded areas reflect the capacity measured.

These results raised more questions! Typically the cell with the highest capacity under the fast discharge (C/1 rate) had the highest capacity under the more moderate



Saft industrial AA cells
Rated capacity: 500 milliAmp-hours



Panasonic P272 AA cells
Rated capacity: 600 milliAmp-hours

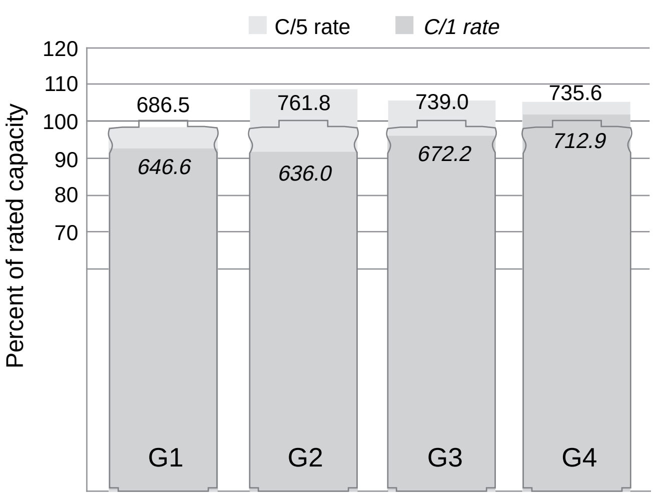
discharge (C/5 rate). The rate of discharge affected the capacity of some brands more than others. Check out the Panasonic cells. The difference in capacity between the C/5 rate and C/1 rate in each cell is not that great. Now take a look at the Gold Peak cells. Much greater difference. Why? I don't know. Perhaps it has to do with capacity. Most of the cells improved with time. For example, the Radio Shack cells showed increased capacity with each cycle.

What about fitting in my appliances? Most of the cells fit my appliances. The tightest fit — my Mini-Mag Lite flashlight — proved too tight for the Millennium cells.

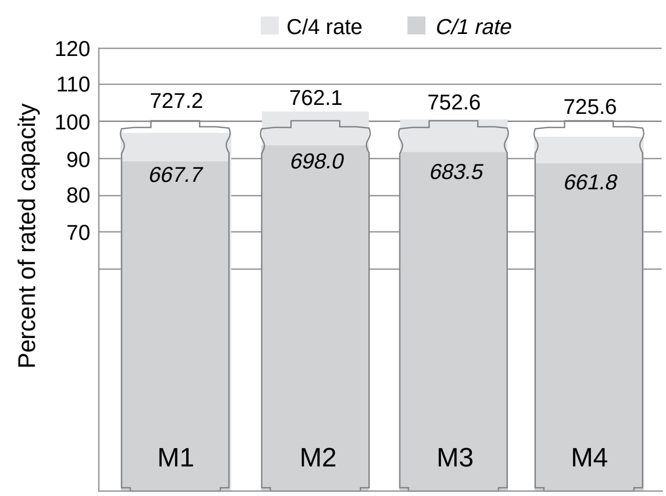
Conclusion

So what does this all mean in real life? I tried to treat all the cells equally — the datalogger and computer were a great help — but there was still human error involved. A quick glance across the charts shows that most cells met the specifications set by the manufacturers. Will this information affect future battery buys? Somewhat. My personal bias is towards the rapid charge AA cells. I like having the option of charging the cells rapidly or at my leisure. Just like a car, the performance depends somewhat on the make and model and somewhat how it is treated and maintained. I learned more about caring for these cells.

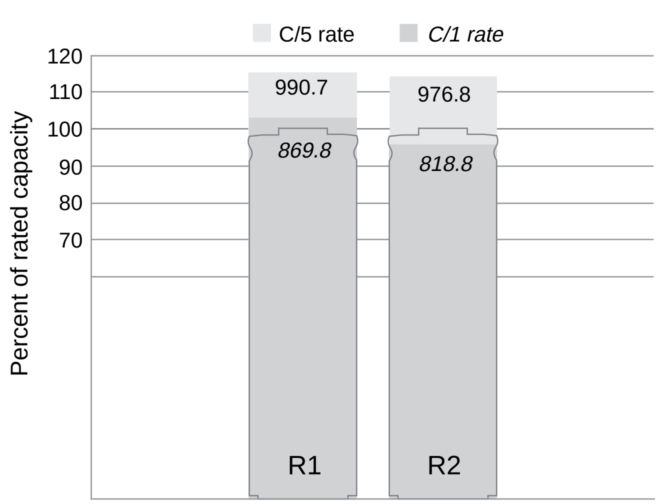
I saw that how the cell is charged makes a difference. I kept track of how the cells were charged during the warm up cycles. When the capacity of one cycle looked lower than expected, I could usually trace it to how the cells were charged. For the test results above I made sure the cells were completely charged. But I had



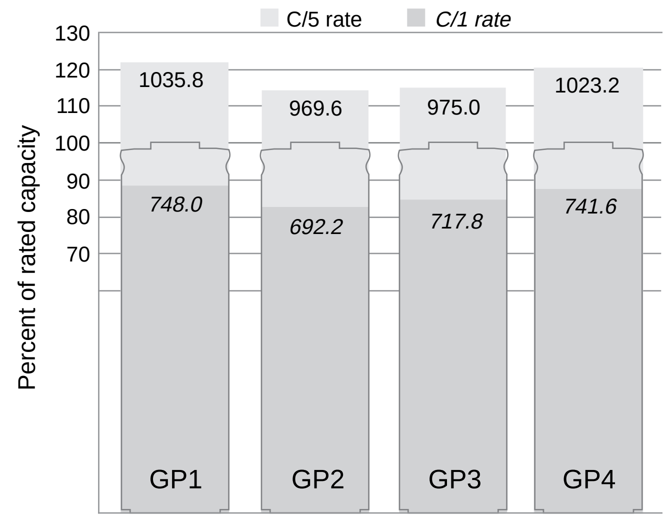
Golden Power KR700AA AA cells
Rated capacity: 700 milliAmp-hours



Millennium AA cells
Rated capacity: 750 milliAmp-hours



Radio Shack Hi-capacity AA cells
Rated capacity: 850 milliAmp-hours



Gold Peak Sylva Charge AA cells
Rated capacity: 850 milliAmp-hours

meters to help me. How do commercial chargers charge the cells and how do they decide when the cell s are full? With some commercial chargers, the cells grow very warm, as if they are overcharged. I wonder how well the cells will last in this service.

I still believe charging these cells with a small solar module is viable. But I'd like a backup. I like using the nicad pulsar charger, but I'd like an automatic shutoff. I've heard about new integrated circuits for controlling fast charges for nicads and Nickel Metal Hydrides (NiMH). I've heard about great nicad chargers for model aircraft hobbyists. I'm searching now for the perfect battery charger.

Oops

Speaking of charging, David Yoder, a reader and avid nicad user, called to point out an error in the graph in HP#36 page 79. I goofed. The charge curves are incorrect — the relationship is *not* linear. The correct graph appears right. My apologies.

Side Notes

No, I'm not really done with testing yet. I'd still like to put some Nickel Metal Hydrides through their paces. Also, my boyfriend Bill discovered rechargeable alkaline cells, called Renewal by Rayovac. While these only last 25 cycles (and with diminishing capacity), these alkaline cells might be a cheaper option than nicads in some applications. Stay tuned.

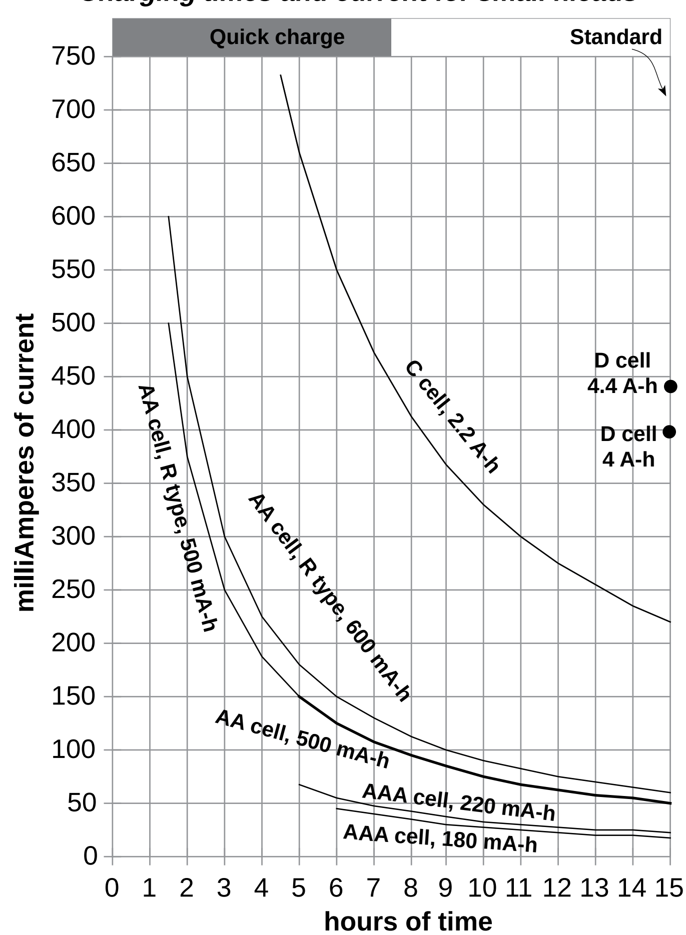
Access

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

Saft cells, industrial: Sunelco Inc., POB 1499, 100 Skeels St., Hamilton, MT 59840 • 406-363-6924 • 800-338-6844

Below: Correct graph on charging times and current to replace incorrect graph in Back to the Basics, HP #36

Charging times and current for small nicads



Panasonic cells, rapid charge P272: DigiKey Corp., 701 Brooks Ave. S., POB 677, Thief River Falls, MN 56701 • 218-681-6674 • 800-344-4539

Golden Powercells, KR700AA: Real Goods, 966 Mazzoni St., Ukiah, CA 95482 • 707-468-9292 • 800-762-7325

Millenium cells (Gates Energy Products): Crutchfield, 1 Crutchfield Park, Charlottesville, VA 22906 • 800-955-9009

Radio Shack Hi-capacity cells: local Radio Shack in Ashland, Oregon

Gold Peak Sylva Charge cells: C. Crane Co., 558 Tenth St., Fortuna, CA 95540 • 707-725-5940

My Lai Hospital Solar Project

Joe Hoar

When my neighbor Danny Cunningham returned from building a medical clinic in Xuan Hiep, Vietnam in spring 1992, all he could talk about was going back. Danny had gone as a Team IV member of the Veterans Vietnam Restoration Project (VVRP), and soon talked me into returning with him.

I have been designing solar powered water systems and water filters with the architect Michael Reynolds and Solar Survival Architecture. So I suggested that we get pumps and filter Vietnamese water.

Danny got in touch with Mr. Nguyen Ngoc Dinh, the 3rd Secretary of the Vietnamese mission of the United Nations in New York; I started looking for equipment. Peggy French, a Taos, New Mexico political activist, joined our effort and began getting tickets and visas.

Donations and Plans

A Vietnam veteran and sales representative for ShurFlo Pumps, Greg Bowles, donated two 24 Volt DC pumps. Michael Reynolds got two 63 Watt Kyocera photovoltaic panels from Photocomm for half the dealer's price. Katadyn U.S.A. provided a water filter for half price.

Meanwhile Steven Stratford, a Team IV Member and Executive Director of the VVRP, and Danny made the arrangements. We would provide solar power to the My Lai Hospital. The hospital was built by Cherie Clark and the International Mission of Hope several years ago, but had not been provided with electricity or running water.

The VVRP contacted David Katz, a former VVRP Board Member, and owner of Alternative Energy Engineering (AEE). David agreed to donate eleven 50 Watt Solec photovoltaic (PV) modules, four 80 Watt DC fluorescent light fixtures, an SCI charge controller, and lots of wire.

On the way to My Lai

Jim Belisle, a Team IV Member and Treasurer of the VVRP Board of Directors, met us with the AEE equipment and $1200. The money had been donated to the VVRP by friends in New Mexico. We had a direct flight with Korean Airlines, who allowed us to carry all nine boxes of equipment free to Ho Chi Minh City.

At Tan Son Nhut Airport in Ho Chi Minh City, we were assessed a modest $25 duty for our $5000 of solar equipment. We were met at the airport by two young Vietnamese women whom Danny had met in Hue last spring. They were our guides and interpreters in Ho Chi Minh City. One of them, Phan Nhat Thanh, agreed to accompany us to My Lai and be our Team interpreter.

Kathy's Ceramic Shop and Travel Agency in Ho Chi Minh City prepared our travel papers and arranged for a van to take us and our equipment to Quang Nhai. In Quang Ngai we were graciously welcomed by the Quang Ngai Peoples Committee.

Arrival at My Lai Hospital

Dr. Chau Linh Ky, who is the director of three province hospitals including the My Lai Hospital, became our host and project coordinator. We took our equipment out to the clinic, which Dr. Ky told us serves 50,000 people. On the way to the clinic, through six miles of beautiful irrigated farmland and trees, I asked Dr. Ky what it had looked like 20 years ago. He said in those days you could stand on the highway and look at the South China Sea eight miles to the east. It had been totally destroyed during the war.

The My Lai Hospital is a large two story building with about 40 rooms, most unused. It was completely wired and equipped with fans, lighting, and plumbing, but the power line ended five miles back toward Quang Ngai. The plumbing system was supplied by a 650 gallon tank on the roof, but they had no way to get the water from the well to the roof.

The hospital would need about six kiloWatts of electricity to run all its lights and fans, and we had less than half a kiloWatt to offer. I suspected that our hosts might prefer a generator to these "strange panels" we had brought. But Danny was adamant about avoiding the generator option.

The Perks of PVs

We then composed a letter to the Peoples Committee, apologizing for the limits of our equipment, but explaining the advantages. The letter explained that not only was it possible to power the hospital with solar energy, but solar had advantages over a generator. The solar equipment was durable and relatively maintenance free, whereas a generator required fuel, lubrication and maintenance which increased the cost. The generator would pollute the community which the hospital served. We also explained that the geopolitics of oil were a contradiction to the politics of peace and healing, which the hospital and memorial represented. Finally we added that many people in the U.S. interested in helping Vietnam also wanted to see alternative energy in the developing world.

At our next meeting with Dr. Ky and the Chairman of the province, Dr. Ky proposed that we give them our battery budget of $900 so they could buy a generator and a pump. Our interpreter Thanh translated our letter to them. In a profound act of trust and idealism, they accepted our analysis. They told us to proceed with our project and offered to provide food, shelter, and transportation during the two-week project.

Starting the Project

The committee arranged for an electrical engineer named Mr. Touy to help us obtain the best batteries and the other things we needed. The batteries were 100 Amp-hour Japanese dry charged automotive batteries — no deep cycle batteries are available yet. Mr. Touy also helped explain the design of a ten panel rack to a local welding shop.

Dr. Ky designated which rooms would receive lights: a large ward room with about six beds, the doctor's examining room, the delivery room and a large postpartum room next to it.

After hours spent in the market counting money (there are 10,000 Vietnamese Dong to one U.S. dollar), we had wire and pipe and were ready to start building. Another engineer and jack-of-all-trades, Mr. Bong, began running wires from a second floor room (chosen to be the power center), to a designated room on the first floor. We had to run heavy gauge stranded wire since existing lines were all very thin 220 volt wires.

The Electric System

Mr. Bong put together a control board which could hold our SCI charge controller. This 30 Amp controller was also a 30 Amp low voltage disconnect, which would protect our fragile automotive batteries from overdischarge and overcharge. Our control board also held a voltmeter to monitor the charge of the batteries, an ammeter to monitor the current from our array, and a two breaker box donated by Nick Stallard, an electrician in Taos, New Mexico.

Mr. Touy and Dr. Ky fastened the ten Solec panels to the rack. The rack stood 25 feet up on a section of 4 inch pipe that was fastened to the front of the hospital. The location was chosen to avoid shadows and to preserve the panels from stones, which Dr. Ky told us the children throw at birds. Dr. Ky and Mr. Touy wired the panels, and when I swung the rack to face the sun, we had 25+ Amps of current.

Above: Dr. Ky and Mr. Touy install the photovoltaic modules that will provide power to My Lai Hospital.

The Water System

Peggy French and I began building a small pump house, which the resident bricklayer finished very quickly. The water line from the pumps to the roof tank was buried and covered with bricks (brought on heavily laden bicycle to the site) to protect the ¾ inch polyethylene tubing.

Below: (left to right) Phan Nhat Thanh, Danny Cunningham, Peggy French, and Joe Hoar at the power center for the hospital.

After Dr. Ky climbed off the hospital roof, he climbed onto the kitchen roof out by the well to mount the two 63 Watt Kyocera PV panels. We connected both panels to a duplex receptacle in the pump house, so that in full sun both pumps could be plugged in and pump together in parallel. When there is not enough sun to drive both pumps, one can be unplugged, leaving both panels driving one pump. This setup worked great. We soon had the roof tank overflowing and everyone smiling.

Dr. Ky decided that the Katadyn filter should be in the delivery room. He and Mr. Bong devised the plumbing and mounting for it while Peggy, Danny and I began hooking up and testing the lighting system.

Celebrating Completion

By Wednesday, 11 days after our arrival in Quang Ngai, the project was basically complete. We'd educated Dr. Ky and Mr. Bong in the ways of this "alien technology." Our interpreter Thanh prepared a written translation of the manuals we brought with us, for them to keep. Finally, we put up bilingual No Smoking signs in the battery room and called it quits. We were taken to a feast in our honor.

On Thursday we disconnected one battery from the other nine and ran all the lights off it while we ate lunch. After more than an hour the low voltage disconnect shut off the lights leaving our test battery at 12.15 Volts. We reconnected the test battery and headed to the guest house to yet another feast.

Dr. Ky told us he planned to use the eleventh Solec solar panel to charge a battery for a light at one of his other hospitals where he does obstetrical surgery. Although that hospital has electricity, they often have power failures. This initiative by Dr. Ky showed how well our "alien technology" had been accepted.

And Still Growing...

The My Lai Hospital system needs support. Since the Team VI effort, the VVRP with help from AEE has added a lightning arrestor and 100 Amp fuse to the system. ShurFlo has donated a spare water pump. The VVRP is obtaining a 12 VDC, 240 vac inverter to power some of the lights and fans. We are seeking donations for panels and charge control equipment to accompany this inverter. A Team has formed to return to Vietnam in February 1994. Any of you who would like to help are invited to help us make it happen!

Access

Joe Hoar, Team VI Member, Taos Construction, Box 635, El Prado, NM 87529 • 505-758-1381

Veterans Vietnam Restoration Project, POB 369, Garberville, CA 95542 • 707-923-3357

Above: This is one of 100 City-el's that will be tested by the general public for the Sacramento Municipal Utility District (SMUD). Photo by Tom Whitney

Stuck In Gear

Michael Hackleman

A milestone is looming five years off. By 1998, 2% of cars sales in California must be ZEV (zero emission vehicles). So, a manufacturer must sell two EVs out of every hundred vehicles sold. There is a $5,000 penalty for each non-ZEV car sold beyond this ratio. These must be sales. So, a trick like making something that nobody wants or can afford won't work.

General Motors, Ford Motor Company, and Chrysler Corporation are balking. The 1998 mandate, they claim, isn't a milestone. It's a wall. Influence peddling is in high gear to get it killed, delayed, or weakened. The magic year is 1994. It takes four years for a product to go from an auto company drawing board to the showroom floor. If they can't kill the mandate, auto companies must commit to do the work by 1994.

A gutsy WGBH production on Frontline (PBS) in mid-October put the issue in perspective. First, there were highlights of a little-known press conference where the Big Three adopted a can-do attitude over a Clinton-Gore challenge (and the tens of billions of dollars behind it) to build "clean cars" with 80 mpg fuel economies in the next decade. I wonder how many cars they will build for the money. If this was Vegas, I'd bet three.

Meanwhile, the Big Three have turned up the heat, much of it directed at CARB (California Air Resources Board), the agency charged with enforcing the 1998 ZEV mandate. At first, one of the giants in the auto industry suggested that they were "counting on the flexibility of CARB in this matter". CARB spokesperson

Jananne Sharpless' response was a suggestion that they "step outside in the real world and take a look around." Will CARB back off? "Any car company that can't deliver ZEVs in 1998," replied Sharpless, "won't be selling cars in California!"

Among others, the documentary interviewed Alan Cocconi of AC Propulsion. Cocconi was a key figure in the revolutionary design of the motor and controller found in GM's Impact, a production prototype that was built from the ground up to run on electricity. The Impact's performance *is* impressive, demonstrating sports car acceleration, range, and cruising efficiency (100+ mpg equivalent). This speaks well for EV propulsion and validates thinking "light and aerodynamic". For a comparable size of car, the Impact has chopped by 50 percent *both* drag and weight without sacrificing crashworthiness.

Cocconi left the joint GM-Aerovironment project because he felt that GM was going to sit on the technology. He's put thousands of miles on "a next generation ac drive" that he has built and installed in a Honda CRX. With a *tiny* generator pod in tow, he drove his electric non-stop from Los Angeles to the Phoenix electric car races earlier this year. He has systems for sale.

I called the CARB office after the show aired on PBS. (In this morning's paper, there was a short article that described GM's reaction to the documentary. They were going to look closer at funding PBS shows in the future. See, I told you it was a gutsy show!) I asked CARB's Jerry Martin how did *they* know that GM could build an affordable ZEV? I liked the answer: "ZEV's are already being produced in California by smaller companies that meet our expectations and are comparably priced," he said. "We already certify conversions (cars converted from engines to electric drive) from ElectroAutomotive, Solectria, Solar Car Corporation, and others. This includes Geo Metros, Volkswagen Rabbits, some trucks, and imports like the Kewet (Green Motor Works)."

Meanwhile, GM has killed production of the revolutionary Impact. They do plan to build fifty Impact look-alike's. Supposedly, there are now a dozen duplicates of the Impact driving about. I wonder what kind of mileage they get on the Impact with the engine in it? With only one-fourth the propulsive load of a standard car, it must be pushing 100 mpg.

I tried to get on the list of people who get to drive an Impact for a two-week test period beginning next year. "No way," a GM representative told me. "You live outside the city. You won't be close enough to one of our support centers." Oh, do I need one of those? I've been driving nothing *but* an electric car for the past 18 months. It's content to sip power from a wall socket.

I changed tactics. I explained the good public relations I could give GM with the environmental crowd through a *Home Power* article. I was told rather bluntly that environmentalists will *not* be the target market. Too small a group. The Big Three make their money on big cars. That's partly right, I think. Most environmentalists I know don't buy big or flashy.

The conversation wasn't over. I was told it will cost more to buy an electric car. And operate it, too. How much more operating cost over a gas car?, I asked. $1,000 per year average, came the reply. That's funny. My experience has been just the opposite. Some EV owners have been documenting their use and costs over very long time periods. *Why Wait For Detroit* (Steve McCrea, editor) has printed this information. Can this data be ignored?

I have to ask this question. Do we really want to give these people any more money to develop a good EV?

We don't lack the technology for EVs. A lack of integration, yes. Even that's changing. I am ecstatic to offer Otmar Ebenhoech's "Regenerative Braking for the Series DC Motor" in this issue. Safe, reliable, and affordable REGEN for DC Propulsion Systems has been an elusive Holy Grail. Now, here's something designed to work with the stock, off the shelf components found in most conversions. This trailblazing R&D didn't cost government or industry a dime. At least, I hope a manufacturer will include it (or an interface) with their own package. EV owners need an option to voiding their controller's warranty in order to use it! Good job, Otmar!

When it comes to EVs, the U.S. lags behind other countries in design and implementation. Visiting Geneva soon? Why not rent an electric? John Schaefer's experience, detailed in "Electric Cars In Switzerland", was a pleasant one.

Incidentally, there's a *new* official world record distance for Electrathon class racing. It was set at the San Jose, California Velodrome on August 26th by Otmar Ebenhoech, driver of the Cloud #40 car. Gaining an eight-lap lead on the field before the race was over, Otmar chalked up over 35 miles in one hour. Not bad for only 64 pounds of stock lead acid batteries!

If 35 mph doesn't sound so fast, try this. Sit on a skateboard. Lean back until you're almost reclined. Get over the hill where you can achieve and maintain a 35 mph speed. Add seven more machines doing the same thing in your immediate vicinity. Now, tell me you want to go faster!

I recently scanned a consumer survey conducted by an auto company. Where is the non-gas car an option? A few wild questions like “Would you like a car that doesn’t use gasoline or any other petroleum-based fuel?” and “Would you prefer a car that had no tailpipe emmissions?” and “To make your car run, would prefer to plug your car into your house or at work or are you happy to operate a gas pump at a service station?”. Answers are ever so much more informative when you can’t predict the answer. It lets you know if you’re playing the same game — or even in the right ballpark!

Suggesting that electric vehicles will cost more, be limited in range etc. achieves little more than biasing the answers. Car ads don’t say “Burning gasoline creates smog!” This is an unequal application of truth in marketing. When GM unveiled the Impact, it was stunned by positive response, despite its statement of increased costs. That’s about as good a vote of confidence (and endorsement) any company should need to advance a product! Time to shift gears. It’s a race. The prize is a happy, clean place to live, work, move about in, and play.

Access

Michael Hackleman, POB 63, Ben Lomond, CA 95005

Above: This electric Suzuki Samurai uses regnenerative braking to extend its range and increase its performance.
Photo by Otmar Ebenhoech

Regenerative Braking a DC Series Motor

Otmar Ebenhoech

It takes energy to accelerate a vehicle. Any vehicle moving down the road stores kinetic energy in its motion. Applying the brakes in your car, whether it is electric or engine-powered, converts that kinetic energy of motion into heat. This heat energy is lost.

What if we could convert some of that kinetic energy back into electricity instead of heat? In an electric car, couldn't we put some of the energy used to accelerate our car back into the batteries when we slow down? The answer is yes! It's known as regenerative braking, or REGEN for short.

In a vehicle equipped with REGEN, the motor works as a generator, trading the motion of the vehicle (momentum) for a charge in the battery (electricity). Where the vehicle normally experiences a lot of braking in its driving cycle, REGEN helps to increase overall vehicle range. As well, it conserves the brakes.

Electric vehicles equipped with ac motor drive systems all have this feature built in. Unfortunately, ac drive systems are still very expensive. Those that are only triple the price of a DC system are quite under-powered for the average conversion.

My interest has been to build a REGEN system to work with the components that most people have in their EVs. This involves series-wound motors and Curtis PMC MOSFET controllers.

Hooked on REGEN

I got the REGEN bug from the first EV I worked on. It was a 1981 Ford Fairmont station wagon with a noisy SCR controller and a series wound motor. We called it the Lead Sled. It was heavy, slow and a bit power hungry — but it did have REGEN. There is something so satisfying about coming up to a stop knowing you are not totally wasting all the energy that was consumed to get up to speed in the first place. I didn't even mind those ridiculous Los Angeles stop signs as much as I used to.

My next EV was a nice new Honda CRX with brand new components but — no REGEN. Something was wrong. Every time I was forced to a stop, I thought of all the energy I had just wasted. This car could have rolled three quarters of a mile for every city stop I made from 35 mph! The search for REGEN was on!

What's Real?

Everywhere I went I asked about REGEN. Everyone had different ideas. "It can't be done ... it requires a shunt motor ... you can do it but it's likely to ruin your motor, controller, or batteries ... it isn't worth the trouble." Rarely could anyone tell me why.

Many people told me of experiments that had ended in fried motors. It seems that the motors would experience commutator meltdown. It was time to talk to a manufacturer. I called Eric Dieroff at Advanced DC Motors for some help.

Eric educated me on characteristics of series DC motors and REGEN issues. It was important to maintain equal currents in the armature and field windings of the motor. There is an area on the commutator where adjoining commutator bars have very little voltage potential between them. The motor's brushes are located here, to minimize arcing and heating, and meltdown or brush failure. Failure to keep equal currents in the two windings causes this critical dead zone to move. The brushes now short out bars with a higher differential voltage. Sparking results. Excessive arcing can extend all the way to the opposite polarity brush, creating a fireball effect. Since all the REGEN circuits I had seen so far separately excited the field with a high current, I thought I could see the cause of meltdowns and short-lived brushes.

By comparison, shunt wound motors have a separate miniature field winding called a compensation winding that creates a dead spot for good commutation. This mitigates the need for equal current balance.

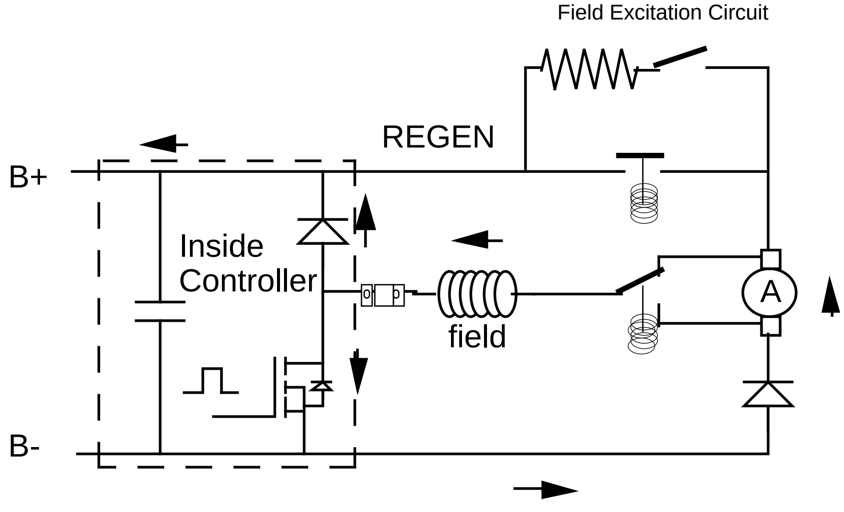
Discovery!

I eventually found a circuit design that used a boost/flyback converter. Although it was intended for a PM (permanent magnet) motor, I thought that it might be the right way to go. Shortly thereafter I read a *Design News* article describing REGEN on an old Cableform SCR controller. This system, which was similar to the old station wagon system that I never had traced out, was also the boost converter type.

Boost converters can easily develop enough voltage to ensure that charging current can flow. Older designs had to switch the batteries into a parallel configuration so that battery pack voltage was lower than the generator voltage. Without such complexities, current wouldn't flow. The circuit designed around the boost converter was simpler, eliminating three contactors and a bunch of wiring! Its main feature was that it kept the field and armature in series, assuring equal currents in the field and armature except for a short period during field excitation. I found that I could eliminate half of one of the field-reversing contactors by connecting the REGEN diode directly to the motor. This eliminated one contact on the reversing contactors. It also eliminated the possibility of a faulty circuit forcing the vehicle to take off in reverse! I felt my confidence growing. I was ready to risk a test.

In a boost converter, a high current at low voltage is fed through an inductor. This builds up a large magnetic field (see "Using Magnetic Field to Change Voltages", *HP* #37 for basics on buck/boost circuits). My circuit does this by shunting the motor/generator through the controller and the REGEN diode (Figure 1a and b). The motor itself is the inductor. When the controller reaches its current limit, it turns off. This causes the magnetic field to collapse, in turn creating a large voltage spike. Current flows in the same direction as the original current build up. This surge of a high voltage and proportionately lower average current flows through the controller's freewheel diode and — back into the batteries.

Figure 1a



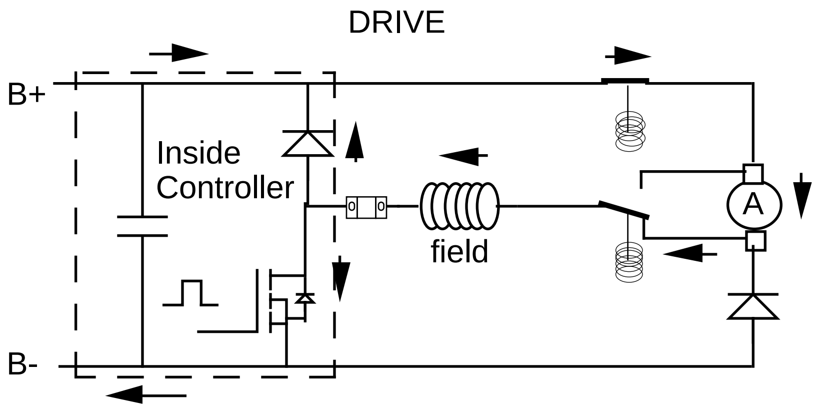


Figure 1b

Crude Testing
The first test was rather crude but served well as a proof of concept. The vehicle was a lightweight EV called a Freeway with a 72 Volt system, a compound wound Prestolite motor with a manual field reversing switch, and a Curtis PMC 1221B controller. A paint stick wrapped with heating wire served as a field excitement resistor that was controlled by a dash switch.

The system worked! It did lack control, though. Motor current was limited by the controller at 400 Amps. By the time I pulled back the sticky accelerator pedal, toggled the field switch on the motor behind me, waited for the controller to ramp up, and switched on the field excitation circuit, the Stop sign had gone by!

Refinements
Some automation was needed. I modified the circuit to include a changeover contactor on the field reversal. I also added a “delay” relay on the excitation circuit.

I also needed to reduce the level of the current limiting feature of the Curtis controller when I was in REGEN mode. This unit is pretty well sealed. I wanted to avoid breaking the seal (and the warranty) on the controller. I worked around this dilemma by contacting the wiper terminal on the current-limit potentiometer through the hole in the case provided for this adjustment. I connected a wire from this point to ground through a signal diode and a 10 kΩ potentiometer. The amount of current limiting was now under my control.

You don’t want REGEN to work when the vehicle is fully charged, or it will overcharge the batteries. For this reason, I added a “comparator” to the circuit. When it sensed full battery voltage, it reduced the level of current limit, and regulated overcharging.

A road test confirmed a working circuit. The ability to vary the current limit allowed quick or gentle slowing almost to a full stop without downshifting (gears). But the controller’s delay circuitry was very annoying. You see, for REGEN to work, it requires that the controller be full on. However, it takes about two seconds to ramp up and half that to come down (or turn off) again. For this reason, I had to install a one-second delay in the main contactor just to give the controller time to ramp down before driving again.

Aside from the controller delays, I was happy with the improvements to the circuit. The vehicle was a pleasure to drive. As planned, REGEN was limited for the first couple of blocks on a full charge until the batteries could accept a charge without exceeding 14 Volts per 12 Volt block. Nighttime tests at 400 motor Amps of charge current showed no unusual arcing of the commutator and brushes. The motor and controller did get hotter than during normal driving. This was to be expected. After all, they were now working hard in both acceleration *and* braking modes.

Into the Samurai
The system was now ready for full sized tests on a more normal vehicle. The test bed was an electric conversion on a 4WD (four wheel drive) Suzuki Samurai that I was building with some Lopez High School students in Washington.

At this point, to circumvent the annoying delays built into the controller itself, I decided to void the warranty on the controller by opening it up. In addition to bypassing the internal delays, I also mounted some of the REGEN circuit’s control electronics inside the controller housing. The result was a cleaner installation!

Standard Disclaimer
The Curtis PMC controller is the standard in the industry today. It is very reliable and simple to use. The electronic guts of these controllers are *very* complex. High currents and their related magnetic fields can cause unexpected problems. Curtis does not supply circuit diagrams. They don’t want anyone to mess with it. They are generally not interested in what an experimenter might want to do with their product. And they don’t want to be liable for anything that happens to you. Hence, opening the box voids the warranty. We are on our own when we start modifying things. At best, it’s a high risk adventure — even if you do consider yourself an electronic engineer.

The REGEN circuit itself introduces an element of danger into an EV’s circuitry. What happens if both contactors were to get stuck in the ON position when the controller was in REGEN mode? The EV would accelerate on the application of REGEN, with the rate of acceleration proportional to the REGEN current. The addition of lock-out microswitches on both contactors can reduce the chance of this happening.

Getting Into the Controller

The first step in modifying my controller was to remove the potting compound from the end and the screws on the bottom. To do this, I put the controller in a large pot of boiling water until it was hot. This softens the potting compound. I used a nail (any sharp object will do) to remove the potting material from the location of the six screws in the bottom and removed these screws. The potting compound on the terminal end can be broken free from the case with a punch and a hammer. By tapping the potting carefully around the edge where it sticks to the aluminum, I broke this seal. I removed the electronics from the case by putting a screwdriver through the M- and A2 terminals and pulling. The heat sink and mounted electronics slid out. I removed the rest of the potting compound from the terminals with pliers. I saved the foam piece for the re-potting process.

The Modification

The control board comes off the power board by desoldering the seven interconnects. After extensive analysis and testing, I identified the function of the components and took the following actions:

• C9 controls the acceleration delay. It's below the base terminal of the large heat sunk transistor. I removed it completely.

• D7 affects acceleration input scaling, making the controller more sensitive at low speeds. D7 is the second diode from the large transistor toward the current limit pot. I removed D7 to disable it.

• R72 and R73 control the over-voltage shutdown and they are factory set for 155 volts. I wanted it set at 140 volts (to avoid overcharging the batteries). To do this, I replaced the 10 kΩ value of R72 with a metal film 10 kΩ (for more temperature stability) and replaced R73 with a metal 86.6 kΩ resistor. (Note: The Samurai conversion uses a 120 V battery pack. R73 would have to be a smaller value for a lower voltage system. A variac with a bridge rectifier works well to test and adjust this. Be sure to bypass the ground lead on any test equipment to avoid ground loops through the non-isolated variac.)

External connections are needed to reduce the current limit and to hold the controller in full throttle state during REGEN (Figure 2).

• The current limit can be reduced by tapping into the current limit adj. pot wiper through a diode, a 1.5 kΩ resistor and a 4 kΩ Pot to terminal B-. This gives a motor current range of about 100 to 200 Amps. (These resistors may need to be adjusted to obtain reasonable motor currents.)

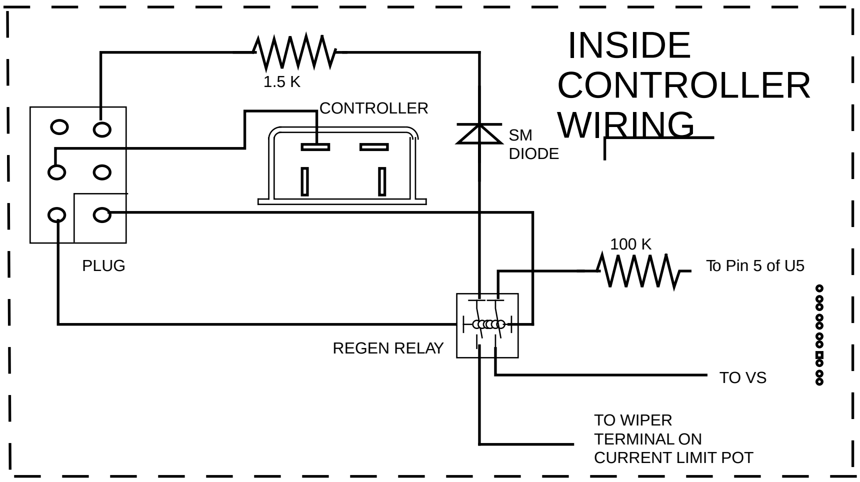


Figure 2

• The controller can be held at full throttle (during REGEN) by pulling pin 5 of IC 5 high to VS through a 100 kΩ resistor. Older models (board 98627C) needed a 47 kΩ resistor. The pull-up resistor should be the same value as R62. IC 5 is the fifth IC from the end with KSI and pot terminals on it. VS is the only square pad on the test terminals on the top of the board. I connected both the current limit adj. and the pull-up resistor through a DPST relay with shielded wire inside the controller. The DPST relay needs a small delay (two/tenths of a second) to prevent the REGEN from turning on before the contactors have finished switching (Figure 3a, next page). Switching the contactors under load will cause them to melt down and could ruin the controller with high voltage spikes.

The field excitation circuit, also known as a tickler, is necessary to ensure that there is enough field strength available to start the motor generating (Figure 3b and c). I found that 10 Amps at a ½ second delay was plenty. Next time, I'll try less current for ¼ second to reduce arcing of the brushes during REGEN initiation.

After testing, I re-potted the controller with about 100 grams of potting compound. It doesn't take much corrosion to cause problems at these voltages, so don't skip this step.

Not Finished Yet

Testing was performed around Lopez Island which has many small hills. The system seemed to work very well. I showed a 10% increase in range with REGEN. Motor current was set at 230 Amps maximum and battery current would go as high as 90 Amps usually sitting around 60 Amps.

Delay 1
power delay unit for field energizing relay

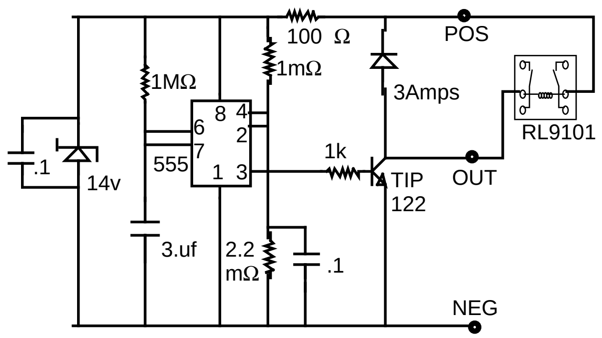


Figure 3a

Delay 2
Low power turn on delay
.2 sec. for controller REGEN on relay

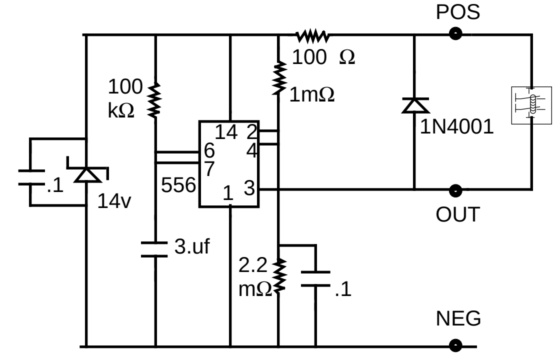


Figure 3b

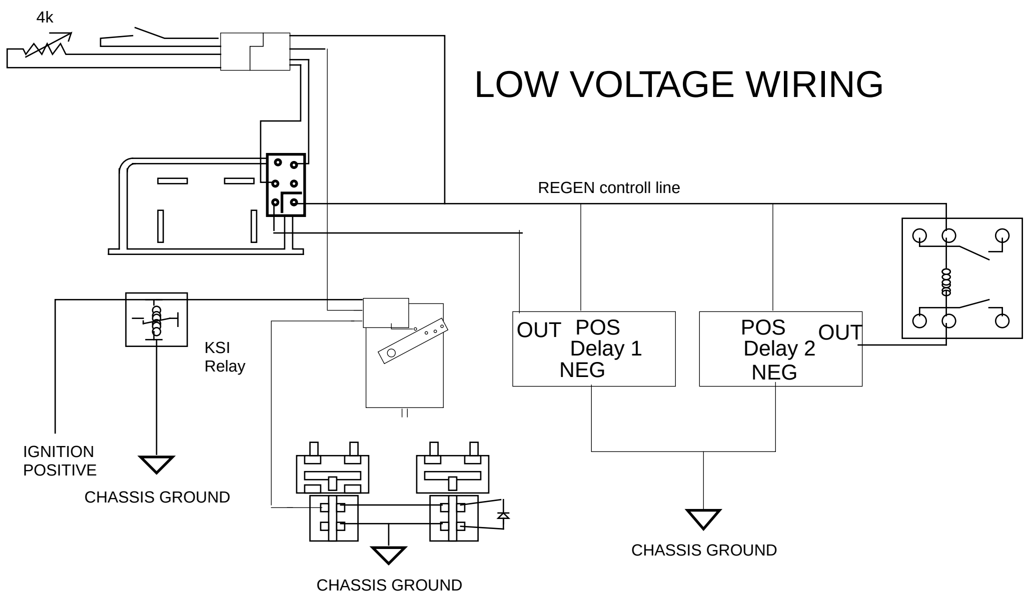


Figure 3c

Unfortunately, all was not well at the brushes. The motor brush temperatures were getting much too hot. 180°C is normal. During REGEN, we would exceed the 230°C maximum (measured from a thermocouple inserted ½ inch into a positive brush). With the vehicle on a lift, we could watch the motor during REGEN. Sparks flew 6 inches off the brushes! We tried zeroing the advance on the brushes, as suggested by the folks at Advanced DC. There was no perceived benefit. The project was shelved for a couple months while I worked on other projects and thought about possible solutions.

Too Conservative

One night, as I reviewed the wiring diagrams for possible clues, I noticed that I had hooked up the A2 terminal on the controller (diode to B+) to the S2 motor terminal. This had not been shown in the *Design News*-Cableform article. Instead, I had copied this connection from the Lead Sled's controller circuit. Up to this point, I had assumed it was there to protect the controller from high voltage spikes that might be caused by "contact bounce" at the contactors. It had also worked on my original test vehicle with no problems. With the higher voltages of the Samurai's system, I wondered if the diode was turning on and diverting current past the field during flyback. This would result in a weaker field and, hence, extreme arcing at the brushes. I decided to test this hypothesis by removing the diode and reverting back to the simpler Cableform circuit. The final circuit high-voltage circuit layout is shown in Figure 4 (p.57).

More Testing

Back in Washington, I hooked up the oscilloscope and brush temperature meter, removed the A2 connection, and tried it out. The Samurai EV's owner lives on a smaller island than the original testing area, so I was limited to alternating between full throttle and full REGEN around the three mile main road. This kind of

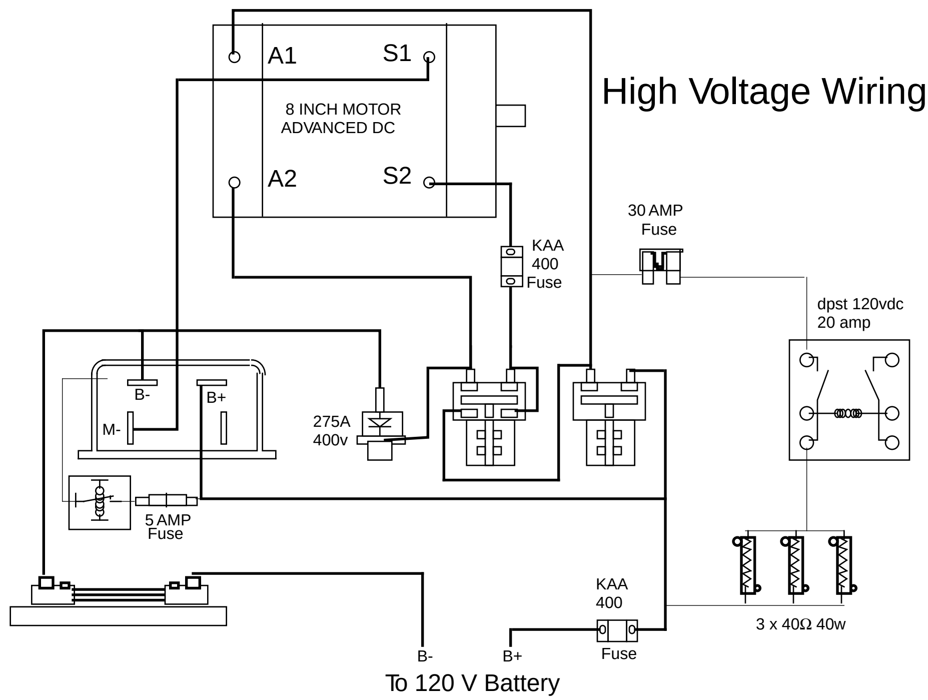


Figure 4

"testing" maximizes the current through the motor and controller. After one loop around the island, the controller was overheating despite its cooling fan. It had worked! The commutator no longer turned into a fireball. The highest brush temperatures I could obtain were 200°C. The brush block was still set at zero advance but I suspect that even this is not necessary. After the excitation circuit turned off, I noticed no sign of unusual arcing.

Still To Do

REGEN on the Samurai works well now. Still, I feel that the circuit is not finished. The inherent roughness of the controller's current limit causes the vehicle to stutter during the transition from a large pulse width to continuous operation at very low speeds. For this reason, I have been activating REGEN with a pull trigger on the shift lever. Eventually, I would like the system to work "transparently". That is, there should be no odd little quirks or special procedures to do. The circuit could be designed to work off the accelerator pedal or brake pedals. This might be smoothed out inside the controller itself. If that doesn't prove easy, I'm thinking of building a dedicated REGEN current limit with a shunt outside the controller.

I'm guessing that conversion efficiencies are about 50%. This gets worse at high motor amps. I suspect the inductor component of the motor is too small and may require another inductor in series. Higher switching frequencies are another avenue of research. I'll need a better oscilloscope for this.

Costs

The system described adds about $350 in parts to the price of an EV. The SPDT contactor, at $150, is the largest expense. At $50, the diode comes in second. Labor is difficult to judge because the system is still experimental and requires adjustment. I estimate that the cost to convert an EV to include REGEN should be under $1500 parts and labor.

Summary

REGEN is possible with series motors. Range increases from 8 to 15 percent have been reported. Savings in brake work alone could pay for the cost of adding it to a conversion, especially if you regularly drive in hilly terrain. At this time the system is still somewhat experimental. The next step is more testing on a variety of vehicles to verify its reliability. It would help to look at the motor current waveforms during these tests. Please contact me with any experiences you have on this subject.

Thanks

Many people helped to make this project possible. Bob Schneevies, for the use of his Freeway EV for initial tests. Marilyn Anderson and Rachel Adams, for sponsoring the further research on their Samurai. The students and staff at Lopez High School, for the great experience of doing the electric conversion with them. The folks at Advanced DC for their excellent support and for making a great motor. And all the other people who taught me so much about controllers and REGEN along the way.

Access

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Potting compound, Part # 2419: Call For local distributor. Techform Laboratories Inc., 2021 N. Glassell St., Orange, CA 92665 • 714-921-9054

SPDT Contactors: Use half of a reversing set or special order a single one. KTA Services, Ken Koch, 944 W 21st St., Upland, CA 91786 • 909-949-7914

DPST relay with magnetic blowout for field excitement. Also good for heater switching. Contacts: 125 VDC at 20 amps. 12 VDC coil #RL9101 $7.95 each. C&H sales company 800-325-9465

REGEN Diode 1N4052 275 amps 600 volts. I bought the last surplus one at HDB. They may be able to special order a new one or try other surplus houses. HDB, 2860 Spring St., Redwood City, CA 94063 • 415-368-1388

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Electric Vehicle Safety Disconnects

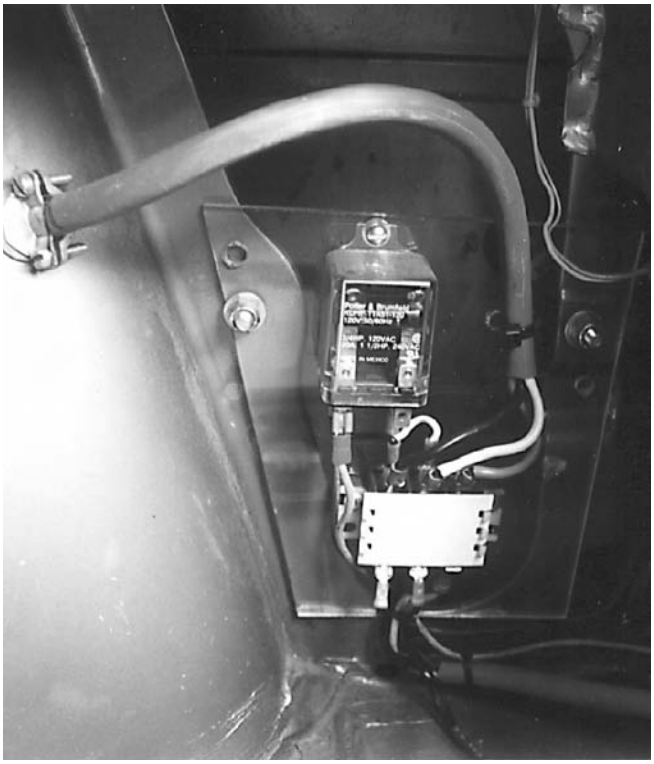
Shari Prange

Some of the most important parts of your electric car are the ones that make it *not* go. These are safety features that will shut down the system in case of problems or potential problems. Gasoline cars have similar features, such as the "neutral lockout" that prevents the driver from starting the car in gear. This type of safety feature is one of the distinguishing marks of a professional-level production-quality conversion. Fortunately, all these safety disconnects are readily available to the amateur mechanic.

Safety disconnects interrupt the power at some point between the batteries and the wheels. Different kinds of disconnects function at different points in the system, and protect against different kinds of problems. Some overlap in their functions. Where safety is concerned, too much is better than too little. Some of the disconnects operate automatically, some can be operated manually by the driver, and some can function both ways.

Charger Interlock

When you get into your car to drive it, the first safety disconnect you should encounter is the charger interlock relay. The exact wiring of this may vary from one car to another, and from one kind of charger to another. The underlying principle, however, is the same: the interlock disables the ignition whenever the car is plugged into the charger. This makes it impossible to accidentally drive away while still plugged in, which could damage your charger and your sense of humor.



Above: The ac input to the battery charger connects to a relay which disables the vehicle while under recharging. Photo by Shari Prange

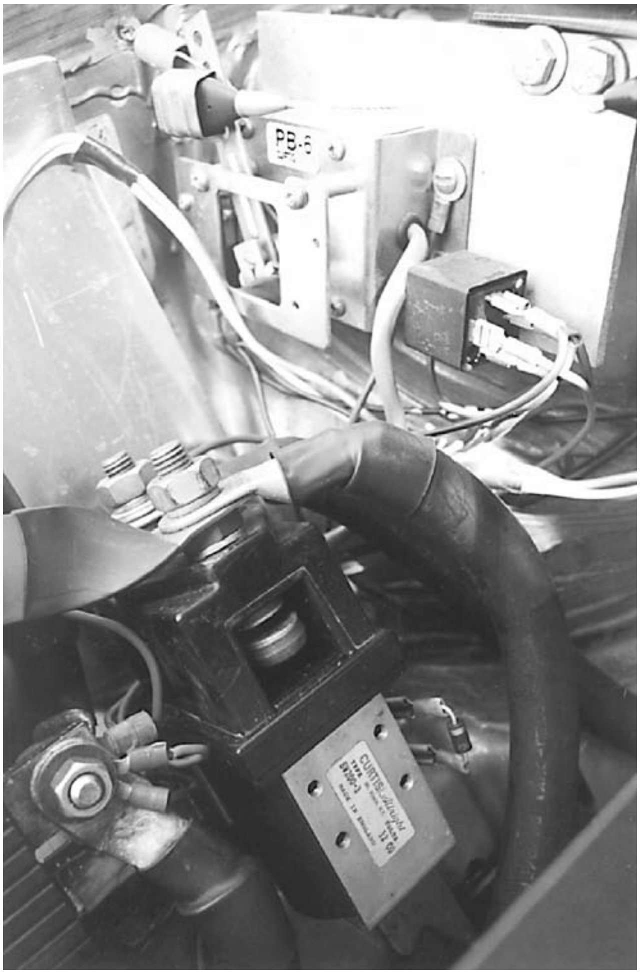
Most conversions today have onboard chargers. Typically, the interlock is a normally closed relay that opens when it receives ac current. When the charger is plugged in, this relay automatically opens and interrupts the 12 Volt circuit of the car between the ignition key and the main contactor.

Main Contactor

The next safety disconnect is one of the same ones we use in our gas cars: the ignition key. In an EV, this key operates a main contactor. Even though there is no electricity flowing when an EV is standing still, safety requires a way to turn the car off. This could be done with a toggle switch or knob, but the ignition key is the method we all know from our gas cars, and it allows us to lock the ignition off.

Eliminating the main contactor from the system would interfere with the charger interlock, and leave components such as the controller vulnerable to damage and fire hazard during charging.

Cheap contactors can fail, and may fail in a closed (full on) position. Install a contactor that is intended for use in an electric vehicle. The Albright seems to be the most widely used. It will withstand repeated openings and closings under load. It includes a magnetic blow-out feature to suppress arcing.



Above: A main contactor is one of the most important safety disconnects. The PB-6 potbox includes a deadman microswitch. Photo by Shari Prange

Another feature is the potbox microswitch, which functions as a "deadman switch". Whenever the throttle is completely released, this microswitch opens the main contractor and cuts off power to the key switch input terminal of the controller. This would allow the car to be stopped if the controller should fail in a "full-on" condition.

The controller will also reduce its power output if the car is drawing too many Amperes for too long. It will cut off power completely if the battery pack voltage is too low. Both of these are designed to protect the controller (and motor) from damage.

Circuit Breaker
The next safety disconnect is the circuit breaker. It is installed in the high voltage system, either between the battery pack and the main contactor, or between two of the batteries in the pack. It will operate automatically, or it can be flipped manually. It's a handy way to open the high voltage circuit for safety when you are working on the car.

It does not, however, take the place of a main contactor as an on/off switch. It can't be locked with a key, the way the ignition switch can be locked to keep the main contactor open. Also, the battery layout in most cars requires the circuit breaker to be closed during charging.

For manual operation, the circuit breaker must be mounted where the driver can reach it easily, but where

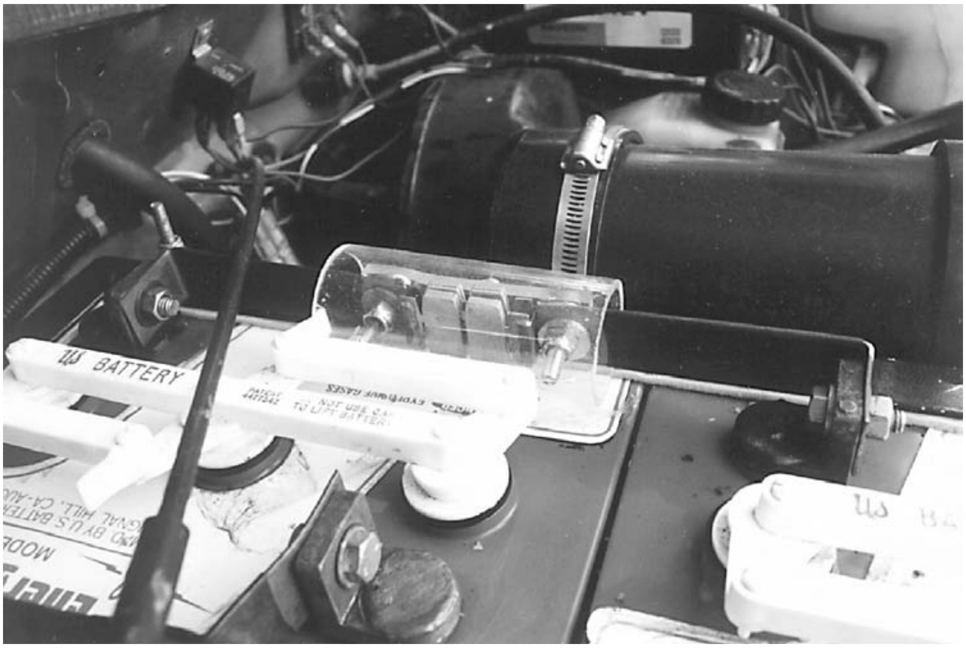
Below: A DC circuit breaker mounted where the driver can reach it quickly. Photo by Shari Prange

Since the contactor can produce a spark, it should be mounted below the level of the battery tops. That way, any potentially explosive hydrogen will rise away from the contactor.

Controller & Potboxes
The most popular speed control system for conversions today is the Curtis PMC controller and potbox. These pieces incorporate several safety disconnect features. One is a "high-pedal lockout". This prevents the car from being started with the throttle even slightly depressed, which could cause an abrupt and unexpected lurch into motion.

it won't be accidentally bumped or kicked. If it is mounted out of reach, it is necessary to have some kind of pull-cable for the driver to use to open the breaker. This is less desirable, because it requires the driver to get out of the car (and possibly under it, or under the hood) to reset the breaker.

Although the car will pull several hundred Amperes of current momentarily under acceleration, the breaker need not be rated that high. A 250 Ampere breaker with a built-in delay curve will withstand 400 Amperes of current for five minutes, which is more than adequate. This delay prevents nuisance trips due to non-harmful momentary surges.



Above: Each battery pack should have a fusible link mounted between battery elements. Photo by Shari Prange

The breaker *must* be a DC breaker, not an ac unit. The performance characteristics are different, and an ac breaker will not give you the same kind of protection.

Fusible Link
The next emergency disconnect in the system is the fusible link. One of these should be mounted in each battery pack. The link mounts between any two batteries and serves as an interconnect for those two batteries. In case of a short across the pack caused by a dropped tool or (in the case of a serious collision) chassis sheet metal, the fusible link will blow and open the circuit, disarming the high voltage system.

The link blows by melting apart. It can't be reset like a circuit breaker, but must be replaced. Fusible links are also available with a delay, similar to the circuit breaker, to prevent nuisance blows from momentary surges.

Clutch
The clutch is also an emergency disconnect. In case of a throttle stuck open or a seized wheel or a similar failure, a simple movement of the foot disconnects the motor from the wheels.

Last Resort
The final safety disconnect (at least when the car is stationary) is a pair of cable shears. If all else fails, cut a cable.

You may never have to call on any of these features to avert disaster, but if you do, you'll be glad they are there. If your car won't start because a safety disconnect did its job, you may be on the phone to your parts supplier for advice. If the safety disconnect isn't there to protect you, you may be on the phone to 911.

Access
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Electric Cars in Switzerland

John Schaefer

While not known as a giant in the auto industry, Switzerland has a variety of developmental activities under way. During a visit in the summer of 1993, I found I could rent a well built, commercial grade electric Fiat for 50 Swiss francs (about $33 U.S.) a day in Geneva. Sponsored by Hertz, Avis, SixtAlsa, and the Geneva Cantonal Energy Office, this program offers a day's test drive for a price far lower than that of a conventional car rental.

Above: Fiat Panda Elettras like this one can be rented in Geneva. Photo by John Schaefer

The Car I Rented

The rental cars are Fiat's own conversion of their two door Panda subcompact, smaller and boxier than a VW Rabbit. No major structural changes are apparent in the Panda Elettra, so that the ten 6 Volt batteries occupy the back seat passenger compartment, rather than extend through the floor. Instead of the back seat, a deck behind the front seat provides space for luggage or delivery items. Steel bars separate the front seat and rear battery/luggage compartment. The car is essentially a two-seater, although for a short trip I squeezed three people in the front seat without any discomfort. The space below the rear seat (outside the body) is still utilized for a fuel tank to supply the combustion-type water heater for passenger comfort.

Two more batteries are mounted in the engine compartment, making a total of 12 for 72 Volts. A Danish DC motor is coupled with a conventional clutch to the four speed transmission. First gear is rarely needed. The controller shows a Fiat nameplate, and no details are available on its operation; regenerative braking is activated by slight pedal pressure and as would be expected, the regenerative charging current depends on motor speed.

At a rather heavy 1150 kliogram (2500 pounds), the car performs a bit sluggishly. The top speed with two passengers on level ground reached 72 km/h (45 mph), matching performance specifications published in the operating manual. The manual specifies the car's range as 70 kilometers (43 miles). An excellent and very instructive manual is supplied with each vehicle. It is, however, in Italian.

The Batteries

The car operates on Italian, lead acid gel batteries rated at 140 Amp-hours. An electronic LCD indicator on the dashboard where the radio ought to be shows state of charge in Ampere-hours, or percentage of full charge, or battery current out (under normal travel) or in (when braking or charging). Push buttons select which measure is displayed. A conventional speedometer displays speed.

Battery Charging

Battery charging is available at ten service stations around Geneva, plus two specially reserved spaces in the parking garage below the railroad station. European electric supply is 240 volts, 50 Hz, and the cord supplied with the car can be plugged into any conventional Swiss outlet. The public battery charger in the parking garage is convenient to use. The driver opens an access cover with a key coded to his account, plugs in the cord, shuts the cover, and removes the key. After charging for the period desired, the same key opens the cover, the cord is unplugged, the cover is closed and the key is removed.

Electric car rentals are apparently possible in Zurich as well. Box Mobil's address can be found listed with others at the end of this article.

Top: Fiat Panda Elettra batteries take up most of the space in the rear compartment.

Center: Fiat Panda Elettra motor compartment contains a 12 Volt battery, 72 Volt battery charger, motor controller, two 6 Volt traction batteries and the combustion space heater.

Bottom: Rental Pandas in Geneva come with charging cord.

Photos by John Schaefer

Swiss EV Manufacturers

Fiat Pandas or Panda look-alikes dominate other Swiss electric car programs. LARAG, a Mercedes and IVECO truck agency in Wil, has built and sold about 150 such cars over a period of two years, the most recent more than a year ago. In 1990 they determined that their selling price had to be about 35,000 Swiss francs (about $20,000 US). They concluded that they couldn't sell enough at that price. LARAG is no company-come-lately in the electric vehicle business. They have had a number of winning entries in European electric car races, and they built 12 electric buses and trucks for the 1992 Olympics in Barcelona. They have also tested sodium-sulfur batteries, which require insulation to keep them hot at all times. They still use lead-acid batteries for most of their cars. Bruno Jager of LARAG noted that although their interest continues, the company must foresee a better business climate before beginning large scale production.

I drove one of their recent developmental models called a LAREL, powered with one 20 kilogram permanent magnet motor direct coupled to each front wheel. The car performed well in an urban setting, which is due in part to its lighter weight. Although it looks like a Panda, the body is of fiberglass construction and has no gearbox. Motor and electronic design details are proprietary, but the car operates on a 168 Volt battery pack.

The LAREL's color graphic display includes state of charge, battery current, and vehicle speed simultaneously. All are readily visible — a nice feature compared with button pushing required in the rental Pandas.

Another widely publicized corporate interest in Switzerland is Swatch. It has evidently suspended its arrangement with Volkswagen. However, Swatch says it has not lost interest in the electric vehicle market and may have cars available in 1996 or 1997. No further details on Swatch's plans are available.

Swiss electric drives manufactured by Scoll Sun Power in Vernier, Switzerland, power French cars built by Ligier in Vichy, France. I have not driven one. According to *Lightweight EV News*, Ligier is manufacturing them on a continual basis along with their gasoline powered models. They are smaller than Pandas, probably about the same size as the Danish Kewets imported by Green Motor Works in North Hollywood, California and are not intended for freeway operation.

Above: This LAREL is a Panda look-alike built by LARAG. It offers direct drive permanent magnet motors.
Photo courtesy of LARAG

Scholl's electric drive is based on an induction motor (12 kW nominal, 16.8 kW peak) and includes regenerative braking. Batteries total 156 Volts. No transmission is necessary, although the car does have a differential.

Technical progress in vehicle design is apparent in a car built by Jurg Tschepen of Wetzikon. Mr. Tschepen's Calypso is also similar to a Panda in appearance, except that the batteries are housed in a tunnel down the middle of the car rather than in the front and rear. The Calypso also runs with an ac drive, switching the motor from a wye to a delta connection to provide the appropriate low-speed and high-speed performance. His car also includes regenerative braking. Mr. Tschepen holds an interest in a South African fiberglass manufacturing firm, where he feels car bodies could be manufactured economically.

Much electric car activity is under way in Europe, and this article does not even cover all of the recent developments in Switzerland, Germany, France, the U.K., Italy, and Austria. For example, none of the Swiss developments at Horlacher, Bucher, Fridez, EMC Elektromobil, or Calonder are covered here. Readers are referred to the two publications listed below for greater detail.

Conclusions

A few conclusions can be drawn from these observations. Alternating current or permanent magnet motors are more common than in the U.S., and battery voltages are generally higher. This suggests that ac drives may become more common here. It would be prudent to set up charging stations with 240 volts rather than committing now to 120 volts. The other major difference is that all the cars I drove in Europe are equipped with regenerative braking and controllers that operated smoothly with no lurching. Yet another societal difference is that in Europe there are many railway stations to which they can drive their electric cars. Wouldn't that be convenient?

Access

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Scholl Sun Power, 135 Rue de Peney, CH1214 Vernier, Switzerland; phone 022 341 0874.

Mr. Tossin, Swatch, Zentrum fur Neue Produkte Entwicklung, Biel; phone 032 28 6811.

Fiat Auto Suisse SA, Rue de Lyon 108, CH1203, Geneve, Switzerland.

Mr. Jurg Tschepen, Flurystrasse 9, CH8620, Wetzikon; FAX 01 932 4370.

Mr. Sella, Office Cantonal de l'Energie, 4 rue du Puits Sainte-Pierre, CH1204, Geneve, Switzerland; phone 022 319 2323

Lightweight EV News (in German or English), Mr. Urs Muntwyler, PO Box 512, CH3052 Zollikofen; phone 031 911 5061.

Mobile (magazine in French), Association Suisse des Vehicules Eletriques Routiers, rue du Maupas 2, CH1000 Lausanne 9, Switzerland; phone 021 312 9067 or in German, Schweizerischer Verbund fur elektrische Strassenfahrzuege, Bahnhofplatz 3, CH8023 Zurich, Switzerland; 01 211 5191.

Telephone Note: Use the leading zero only if calling from within Switzerland. Otherwise dial or touch your international access code (AT&T is 011), then the country code (41), and then the number listed without the leading zero.

Energy Trends, Global Warming Action Plan, NAFTA, & Gridman Politics

Michael Welch

This year marks the twentieth anniversary of the Arab Nations' Oil Embargo. It is interesting to see what energy-related things happened around that time and since. I recall that in the 1960's my dad purchased gasoline for around 25 cents a gallon during the "gas wars" common among service stations in California's central valley.

The 1973 Oil Embargo put an end to that forever. Oil prices skyrocketed because demand outstripped embargoed supplies. The price for a barrel of crude quadrupled as a result of the embargo. The collusion among mid-Eastern oil suppliers taught American oil companies and local distributors a lesson: if they stuck together to jointly make fuel prices stay artificially high, the end of the embargo would mean remarkably increased profits.

A new report, by a coalition of environmental and business groups, is called "U.S. Energy Trends and Policies: Past, Present and Future". It points out the successes and failures of our nation's energy choices since the 1973 Embargo. Here's some of the interesting elements of the report.

Until 1973, energy usage was increasing by 4% annually. Had that trend continued, as was projected, the U.S. would consume 110 quadrillion BTUs (quads) this year. Instead, consumption is at about 85 quads, which represents a savings of over 25 quads and about $170 billion each year from early projections. This strengthens the popular axiom that conservation and efficiency are the largest and most economical "energy resources."

The 1973 Embargo had negative effects, too. Coal became the fuel of choice as an alternative to petroleum based electricity. Since 1973, coal consumption increased by 50%. But, because of concerns over pollution, coal use is projected to decrease, allowing the nuclear industry to think they can fill the void. Richard "I am not a crook!" Nixon called for and got an increase in coal and nuclear subsidies as the mainstay of American energy independence.

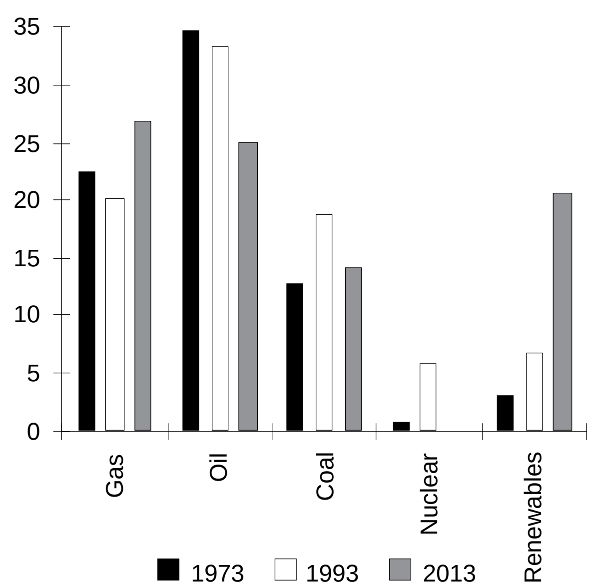
The nuclear power industry is in trouble because of rapidly rising costs, the unsolvable nuclear waste issue, and serious reactor safety issues, all of which contribute to poor public opinion. But, the industry hopes for a comeback fueled by efforts to sway public opinion with multi-million dollar ad campaigns. In spite of the money being spent by the industry, the energy trends report predicts that nuclear power will no longer contribute to our nation's energy mix by the year 2010.

The report states that renewable sources are the only steadily increasing energy technology. Because of dramatic declines in the cost of renewables and the prediction of further substantial declines, it is predicted

Actual & Projected Energy Use (Quads)

source: "U.S. Energy Trends and Policies: Past, Present and Future"

Year	*1973*	*1993*	*2013*
Gas	22.5	20.3	27.1
Oil	34.8	33.5	25.2
Coal	13.0	18.9	14.3
Nuclear	0.9	5.9	0.0
Renewables	3.1	6.9	20.7
Totals	74.3	85.5	77.3



that renewables will triple their contribution to our nation's energy mix from about 7 quads this year to about 20 quads in 2013.

This increase will be in spite of the lopsided subsidies that the non-renewable industries receive. Renewable energy is overcoming amazing odds. Let's just hope that it comes in time… that is, before we have done fatal harm to our planet's ecosystem.

New Nukes Funding

Despite these predictions, nuclear energy seems to be winning some battles in Congress. In the Appropriations Bill signed by President Clinton in October, the only thing that made national news was the cut in the multi-billion dollar Supercollider project. What we didn't hear about was that funding for both the Advanced Liquid Metal (fast breeder) Reactor and the Modular High-Temperature Gas-Cooled Reactor, both unnecessary and dangerous pork-barrel projects, got put back in the bill. It is amazing how powerful the pro-nuclear advocates are.

Those projects were nixed by Congress, with the Senate striking one and the House the other. But when the different Appropriations Bills went to a joint Conference Committee, influential pro-nuke minions Bennett Johnston and Tom Bevill got their way and the projects wormed into the final version. The good news is that R&D for renewables increased over what the Bush and Reagan years offered us but not to the point of what the Carter years had offered.

To show how powerful the pro-nukers are, a report was recently released by the U.S. Public Interest Research Group and the Nuclear Information & Resource Service called "License to Spend, An Analysis of Nuclear Power Industry PAC Contributions and 1992 Congressional Votes on Nuclear Issues." The report found an apparent correlation between the amount of money a Congressperson received from nuclear PACs and their vote on the nuke industry's most important legislative issue, one-step licensing. Legislators voting for this particular issue received an average of about twice as much nuke-bucks as those voting against this issue.

Clinton Global Warming Inaction Plan

As a candidate, Clinton chastised the Bush administration for not paying enough attention to global warming. President Bush resisted attending the 1992 Earth Summit in Rio De Janeiro until public outcry forced him to attend. Bush then refused to sign a 150-nation plan to reduce greenhouse gases, and even went one step further by bullying other countries into accepting a much weakened agreement. This really ticked off the environmental and renewable energy communities. It didn't take long for Clinton to seize the opportunity and use this as a example of the differences between the candidates.

On Earth Day 1993, President Clinton pledged the first step in controlling global warming: a plan to stabilize U.S. greenhouse gases at 1990 levels by 2000 and begin decreasing them thereafter. In an October press conference, the President announced his plan. It is a disappointment to many. His speech appropriately outlined and acknowledged the problem and stated a deep commitment to make the needed changes, but the substance of his plan tells a different story.

Rather than regulating industries into meeting the much-needed goals, Clinton's plan bowed to the influence of the polluters. He used economic problems as an excuse to avoid needed regulation and called for "personal responsibility" and voluntary effort to be used as the tools for reaching the goals. Fact is, if personal responsibility was a workable solution, things would have turned around a long time ago as the issue became prominent.

What his plan should have included is a commitment to legislate better automotive fuel efficiency, improved mass transportation, and a halt to subsidies and incentives for the consumption of fossil fuel. We can only hope that his motives are pure, and that when he sees that his plan is not workable, he will take strong action to force the polluting industries to comply.

North American Free Trade Agreement = Bad News for Renewable Energy

According to an open letter from Greenpeace, President Clinton is pushing hard to implement the NAFTA agreement negotiated by the Bush administration. A recent court ruling demonstrated that NAFTA's environmental implications could be disastrous. Of major concern is its devastating impact on efforts to reorient energy policy in favor of renewables and efficiency as well as increasing pollution in the U.S. and Mexico. Negative impacts would far outweigh any trade benefits. There are three main dangers to watch out for:

NAFTA attacks gov't. support for clean energy

Tax breaks, subsidies, environmental reviews, collaborative agreements, PUC least cost planning mandates and any other regulatory measures supporting energy efficiency and renewables may be attacked as "barriers to trade". Trade agreements are already being used to attack U.S. energy regulations. For example, the European Community attacked U.S. automobile mileage standards using GATT. On the other hand, NAFTA explicitly acknowledges and promotes subsidies for fossil fuel projects.

A flood of cheap fossil fuels will undermine clean energy

NAFTA essentially removes control of the export of oil and gas from Canada and Mexico. This could increase the amount of cheap fuel available, thus further squeezing competitive wind and other renewable projects as well as demand-side management programs out of utility bidding processes.

Undemocratic process will remove public accountability

In all cases, disputes would be settled by a handful of appointed bureaucrats sitting on international trade boards, without any avenue for public input. It is likely that industry representatives will make up the majority on these boards.

The good news is that NAFTA is not yet a done deal. You can help by writing your Congresspersons as well as Clinton and Gore, and let them know that you want a clean environment and renewable energy to be the top priority for any future trade agreements, including NAFTA. As of this writing, there appeared to be enough votes in Congress to pass this treaty, but many representatives are showing signs of wavering on this issue, so your input could really count. Another problem the agreement has is that the recently elected Canadian government has taken a new look at the treaty and may turn against it.

Gridman Politics

For those of you who are following or are involved with Southern California Edison's efforts to grab the off-the-grid market (see *HP*#37), beware the politics of these kinds of situations. Those that could be considered or are acting like allies now could at a moment's notice drop you like a used disease prevention device. An example is in order here.

In 1988, a big fight was brewing over how much California ratepayers should pay for the construction of Diablo Canyon Nuclear Power Plant. The California PUC's Division of Ratepayer Advocates (DRA) had decided to fight PG&E's application to get ratepayers to pay for over $4 billion in mistakes and construction cost overruns at the nuke plant. Toward that end they had lined up California's Attorney General and several citizen advocacy groups to help with their efforts. The DRA's case was well-developed and poised for success.

Suddenly, and without warning, the DRA and Attorney General dropped their case and announced a settlement with PG&E that left ratepayers with their empty pockets hanging out. The settlement changed PG&E's rates from better than the national average to among the highest in the nation.

It was never discovered exactly what political pressures were brought to bear on the DRA and the Attorney General (both are supposed to represent us), but it was apparent that something had happened. Maybe a backroom deal had been negotiated for PG&E by now Secretary of State Warren Christopher. The job they did was thorough, even to the point of getting the Administrative Law Judge to deny significant participation by the involved citizen advocacy groups. It was a rude awakening for us all. So beware, SCE may not be as powerful as PG&E (the largest investor-owned utility in the nation, and the top political contributor in the State), but they are very strong nonetheless.

Access

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Array-Direct Power Point Regulator

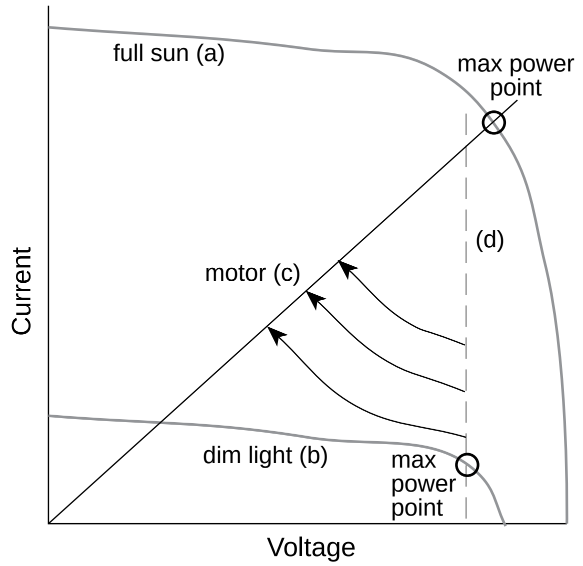
Chris Greacen

If there's no battery in a solar electric system, then the system is called "array-direct". Array-direct systems are great for water pumping and operating cooling fans. When it's sunny the motors spin. When it's dark they don't. Divorced from the failure-prone voodoo electrochemical mysteries of batteries, array-direct systems are efficient and reliable. Removing the battery presents a challenge though: how to start the motor turning when the first faint rays of dawn hit the photovoltaic (PV) panel, and keep it turning until dusk.

There are brand-name circuits for this job: LCB™ and Solar Jack™ pump controllers. This homebrew is a lightweight cousin of these circuits, able to deliver 3 Amperes continuously to a load. This makes it suitable for motors powered by a typical 50 Watt panel. Electronics techies call these circuits "buck converters", or "switchmode step-down DC to DC converters".

What is a DC to DC Buck Converter?
The transmission in your car takes the fast spinning motion from the motor and changes it to slower spinning, higher torque motion for the wheels. An ac step-down transformer does a similar thing for ac electricity. In comes high voltage, low current ac electricity, and out goes lower voltage, higher current ac electricity. DC to DC buck converters do the same thing — but for DC electricity. See *HP*#37 for an explanation of how these critters work, "Using Magnetic Fields to Change Voltages", and the homebrew DC to DC step down (output) voltage regulator using the LM2576 chip.

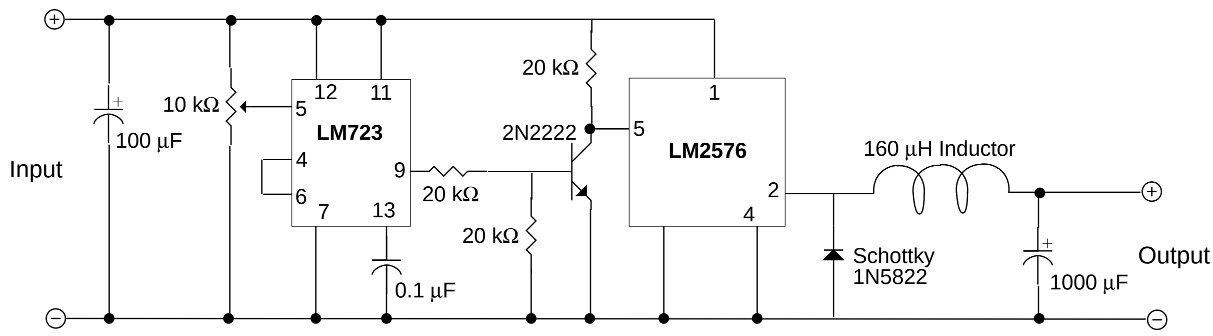
Motors — PV Direct



In bright constant sunlight, if you measure the current that a panel puts out as a function of panel voltage, you'll get a graph which looks like (a). At the "knee" of the curve is the maximum power point — the point at which current times voltage is a maximum. In dim light, the same panel might give a curve which looks like (b). Notice this curve has much less power, but the voltage of the maximum power point doesn't decrease very much. (Vpmax will decrease with decreasing sunlight and increasing temperature).

Unfortunately the curve of an electric motor's needs (c) doesn't match very well what the panel can deliver in varying light. In this case, the motor is matched to the panel's output in full sun: the motor's curve (c) intersects near the maximum power point during full sun (a). But look where it intersects the dim light curve (b). The panel could give the motor more power if only the motor weren't so demanding.

Here's where the necessity of regulating the panel's voltage comes in. In effect the circuit's job is to say to the motor, "Nope — you're not going to get any until the panel's voltage is high enough". When the panel's voltage is high enough, only then does the motor get current, and this fix of current might last only a fraction of a second, because when the voltage falls too low again, the circuit shuts off the current. As long as the sun is shining, the circuit tries to keep the panel's voltage at or above the dotted line (d). The DC to DC converter part of the circuit then converts this power (curved arrows) to feed the motor.



Custom Mods for Array-Direct

Let's take a close look at the task at hand here. I want to keep the PV panel putting out as much power as it can even in low light. Can't I just hook it to the + and - leads of the motor I want to run, and point the panel at the sun? No... When I look at the back of my panel, it says V_{pmax} = 16.7 Volts. This means the panel will put out the most power if I can keep its voltage at 16.7 Volts. But the voltage of a sunlit panel is mostly determined by the load it's powering. And the voltage across a permanent magnet motor is roughly proportional to the current going through it. In dim light this isn't much current, so the voltage across the motor is small — a volt or so. Result? A stalemate of sorts: the motor is stalled in one place, and because of the low voltage across the motor, the panel is forced to operate at a voltage where it makes a fraction of the power it could (see sidebar previous page).

To solve the problem I need to regulate the solar panel's voltage at the optimum 16.7 Volts. Unfortunately, when engineers design switching DC to DC power supplies they are almost always concerned with a regulated output voltage. They want the circuit to take, say, anything from 90 to 220 Volts in, and make nice, clean 5 Volt DC to run computer chips. For powering an array-direct motor I don't really care what the output voltage is — I certainly don't need it regulated at precisely at 5.00 Volts. I just want to feed the motor as much current as I can. And to maximize the current I need to keep the panel's voltage at V_{pmax}, and then convert this power to higher current/lower voltage for the motor. The circuit above does all these things, running motors which refuse to run hooked directly to a solar panel. The circuit also has built-in overcurrent protection and thermal shut-down. Efficiency depends on light level, but reaches 90% in full sun.

Building and Using the Circuit

When you build the circuit, try keep the leads short to minimize unwanted feedback from stray electromagnetic fields from the inductor. Heat sinking the LM2576 will increase the amount of power it can handle. To set the potentiometer, attach the completed circuit to your solar panel and motor and turn the knob until the motor runs fastest. The voltage across the motor at this point should be highest, and the panel voltage should be at V_{pmax} or a little lower. It would be best to do this in sunlight conditions similar to those you built the circuit for: morning, evening, cloudy.

How the Circuit Works

National Semiconductor's LM2576-XX series are "buck regulators on a chip". They are designed for small computer power supplies and such. You just provide an inductor, a Schottky diode, and a couple of capacitors. Put in anywhere from 14 to 40 Volts (60 Volts on the high voltage LM2576HV-XX), and you get more current out (up to three Amperes) at a regulated lower voltage. Inside the chip is an oscillator which allows pulses of current to flow from pin 1 (the solar panel +) to pin 2. When the current is flowing (oscillator "high"), it builds up the inductor's magnetic field. When the oscillator is "low", the inductor's collapsing magnetic field induces current through the Schottky diode.

In most applications of this chip, feedback to pin 4 from the output voltage enables or disables the oscillator, keeping the output voltage regulated to within ±3%. But in this circuit I've grounded pin four. As I said, I don't care about the output voltage — I want to maximize output current to the motor. But I do care about the input voltage (the panel's voltage), because if this is set right, then the panel will make the most power, and the motor will get the most current. This is where the LM723 comes in. It watches the panel's voltage through the 10 kΩ voltage divider. When the panel's voltage rises above V_{pmax}, pin 5 rises above the LM723's internal threshold, and pin 9 goes high, saturating the transistor and enabling the LM2576. This gives power to the motor until the panel voltage falls below the threshold. This enable/disable cycle goes on thousands of times a second, keeping the panel at the voltage you choose with the potentiometer.

A small modification to the circuit could make it regulate both input and output voltages. More precisely, the output voltage won't go above a certain level. But it will fall below that level if there's not enough power coming in. Possible uses: a 24 Volt array (regulated so that it operated at, say, 33 Volts) charging a 12 Volt battery (regulated at, say, 15 Volts). Or running voltage sensitive equipment (9 Volts, 12 Volts, etc) efficiently off a 12 Volt or 24 Volt array. If you want a circuit with this regulated output voltage feature, put a second potentiometer (50 kΩ is fine) across the output. Instead of grounding pin 4, connect pin 4 to the wiper of this potentiometer. For a schematic, see pins 2 and 4 of last issue's Homebrew circuit.

Interesting Nerd Issues

Question #1: Do you really need the inductor in the circuit? Judging from the small physical size of some brand-name circuits that do this, it seems likely that they use the motor itself as an inductor. This may be true. But when I tried it, my circuit ran motors much more smoothly with the inductor in place. Experiment!

Question #2: So, why did I need the LM723? Couldn't I just use the LM2576's feedback pin 4 with a voltage divider to the panel to keep the panel voltage regulated? No, because pin 4 is a noninverting input, and the inverting "input" is internally tied to an internal reference. When pin 4 falls below the LM2576's internal threshold, the oscillator is enabled, pushing current through the inductor and raising the output voltage. Hooked to the panel, it would have behaved exactly backwards from what I need: turning on the load when the panel's voltage was below V_{pmax}, and turning it off if (an unlikely "if") the panel rose above V_{pmax}.

Question #3: You might wonder why I used the transistor to couple the 723 with the 2576. Early versions of the circuit tied the panel's voltage to the LM723's inverting input (pin 4). Then pin 9 (with a bleeder resistor) was tied to pin 5 (the on/off pin) of the LM2576. The problem comes because the LM2576 interprets zero volts as "on" and because the LM723 doesn't really start working until 8 Volts or so. In dim light, the LM2576 would see zero volts on pin 5, start to operate, keeping the voltage low so that the LM723 never had a chance to come to life. With the transistor in there, the LM2576 is off until the LM723 is on.

Access

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Parts: Finding components for these circuits isn't easy. DigiKey has the LM2575T-5.0 which is a 1 Ampere, 5 Volt version of the chip. It sells for $6.55. For most folks this won't do. National Semiconductor was not able to recommend any other retailer of these chips on a piece by piece basis, and big distributors sell in lots of 45. But National Semiconductor says they will accommodate individual customers building prototype circuits. What this means is they'll send you one if you ask nicely and use words like "sample", "engineer" and "prototype". Their support center is 1-800-272-9959. If you're interested in this stuff, their "1993 Power IC's Databook" is excellent.

I'm going to take the risk and order a bunch of these. If you think it's more moral to buy a chip (I do), I'll sell one to you for $15 (they cost me $8.50 in quantity). I'll send you all the other parts (not including the LM2576), but including a generic PC board, instructions, and a box for $45. Allow six weeks for delivery.

Schottky diodes (1N5822 3 Amps, 40 PIV) are available from All Electronics • 800-826-5432. If you plan a high voltage version, use a diode with a PIV at least as high as the maximum input voltage. "Fast Recovery" diodes will also work, but will be less efficient because of their higher forward bias voltage drop.

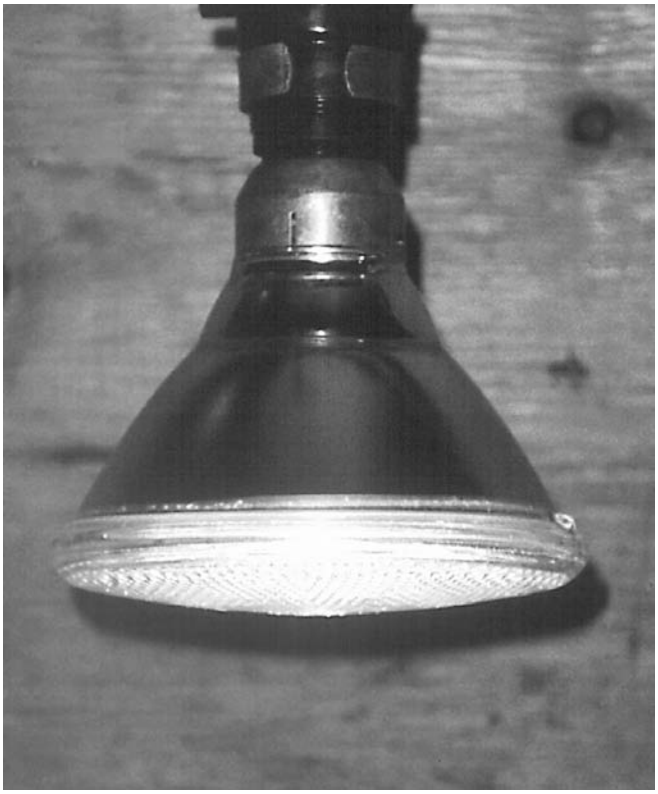
Hosfelt Electronics, 2700 Sunset Boulevard, Steubenville, OH 43952 • 614-264-6464 has a 160 µH inductor for a buck, part number 18-123.

Things that Work!

GE's Halogen IR Lamp

Richard Perez

Here is a 60 watt incandescent flood lamp that delivers the same useful light as 150 watt models. This lamp survives where compact fluorescents die early and expensive deaths.



Above: the GE Halogen-IR™ PAR 38 lamp in action four feet above our kitchen stove. Photo by Richard Perez

Incandescent vs. Fluorescent

If you've been reading *Home Power* for a while, then you know that we are big fans of compact fluorescent lights. Well, please know that we put our money where our mouths are, and we have been running the Osram EL series compacts for over three years in all our fixtures. Our lighting power consumption was cut to about ⅓ by these fluorescents. I thought the lighting job was done. I was wrong.

There are several lighting jobs around the home that will kill the expensive compact fluorescents in short order. A compact fluorescent will last about 10,000 hours of operation. There are two locations in our home where the compact fluorescents were lasting less than 1,000 hours. The first location was in the battery/inverter room. The second location was in the kitchen directly over the stove top.

I am in the habit of visiting the battery/inverter room between five and ten times daily. The principal attractions are the instruments in the inverter room which monitor our system's performance. I switch on the lights upon entering the windowless room (after all batteries don't mind sitting in the dark). I only remain in the room for a few seconds, and then I shut off the lights and leave. This type of short duty cycle, intermittent operation causes the starter circuits in compact fluorescents to fail long before their time. Places like our inverter/battery room, closets, hallways, and staircases are all examples of locations where lighting is used intermittently for short periods of time. Incandescent lamps like the GE Halogen-IR™ are ideally suited for these locations.

The fluorescents over the kitchen stove top were lasting less than 500 hours. I was using Osram EL-15R compact fluorescents which are very bright and have their own built-in reflectors. We like to cook, and having a bright light right over the stove top makes it easier and more fun to turn chow into cuisine. After the second Osram died an early death, I realized that high temperatures over the stove top and intermittent operation were killing these fluorescents. Incandescent lamps love to run hot. Over the kitchen stove, or in any hot location, an incandescent lamp is more cost effective than a compact fluorescent.

Enter the GE Halogen-IR™ PAR 38 Lamp

While at the Midwest Renewable Energy Fair, Mike Mangan of Ecology Services & Products showed us this new incandescent lamp. Mike gave us one and suggested that we give it a test. I installed it in the fixture above our kitchen stove top on June 23, 1993.

This 117 vac incandescent lamp is a halogen type with a built-in reflector and flood diffusing lens. I measured the power consumption of the GE Halogen-IR™ PAR 38 at 445 milliAmperes at 117 vac with a Fluke 87 digital multimeter. This is about 52 watts and beats the GE's power specification of 60 watts (at a rated 130 vac). This lamp produces the same amount of useable light as ordinary 150 watt PAR lamps, but only consumes ⅓ as much power. According to GE, this lamp uses an infrared coating that reflects wasted heat back into the lamp where it produces more visible, useful, light.

The GE Halogen-IR™ PAR 38 is very bright. While I don't have the instruments to measure the light intensity, I estimate that it is at least three times as bright as the Osram EL-15R it replaced. The color rendition of the GE Halogen-IR™ PAR 38 is excellent, with a crisp, white halogen light. Foods cooking on the stove have brilliant and natural colors. The built-in reflector and flood lens create an intense pool of light that fills the stove top. The GE Halogen-IR™ PAR 38 is also available in spot and wide flood models.

GE rates the lifetime of this lamp at 2,500 hours. This is over two times longer life than non-halogen incandescents. While the GE Halogen-IR™ PAR 38's rated lifetime may be only a quarter of a compact fluorescent's rated lifetime, there are places where the incandescent will actually outlive the fluorescent.

One nice feature about the GE Halogen-IR™ PAR 38 lamp is that it is encased in glass. After a rousing round of stir-fry, the lamp over the stove always gets a good coating of grease and cooking funk. The compact fluorescents were a nightmare to clean, while the glass surface of the PAR 38 is easily cleaned.

Bottom Line
The GE Halogen-IR™ PAR 38 retails for $16. If you are grid-connected, then this lamp will save you about $18 over the lamp's lifetime when compared to a regular 150 watt PAR lamp. If you are powered by renewable energy and have given your house a total compact fluorescent job, then this is the lamp to replace those fluorescents that fail early because of intermittent use and/or high temperature.

Conclusions
I still like my compact fluorescents, but I'll be dipped if I'll use them in locations where they are obviously unsuited. This GE Halogen-IR™ PAR 38 lamp is just the ticket for locations that are too tough for the fluorescents to handle.

Access
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Lamp Supplier: Michael Mangan, Ecology Services & Products, POB 176, Delafield, WI 53018 • 414-646-4664. Mike sells a single GE Halogen-IR™ PAR 38 lamp for $16 each plus postage. Cases of 12 lamps for $180 plus shipping.

Lamp Maker: General Electric Co., Nela Park, Cleveland, OH 44112. Product order code: 18628 and Product description: 60PAR/FL/HIR

Tech Notes

Buzz Free Telephones on Inverter Power

Lafayette Young

A common complaint shared by almost all families living off-grid with an inverter is the audible buzz heard on the telephone lines, in the AM band of the radio, and in some entertainment devices, like boom box type portable stereos.

Unlike a utility company which derives its sine wave power from rotating machinery, an inverter creates alternating current by switching, 60 times a second, direct current with solid state devices. This inverter must also cope with a variety of electrical loads. The 120 volt ac current provided by the inverter has a "noise or buzz" component that can be heard in the AM portion of the radio band. This radio frequency interference (RFI) is an inherent component of today's high efficiency inverter technology. It is not my intent to solve the inverter's RFI problem, but to offer solutions primarily for buzz free telephone conversation. Some of these solutions will also yield cleaner stereo, radio, and TV reception.

Not all phones are alike when it comes to filtering out line noise. If you want to attempt the solutions offered in this article, then start by surveying how each of your phones "sound" at each of the various jacks in your home. Experience has shown that some phones will still buzz softly, while others are buzz free.

Many *Home Power* readers have probably heard changes in the buzz on the telephone earpiece as loads around the home are switched on and off. The noise heard on the telephone can be radiated from a variety of sources and picked up by the phone lines. Knowing what the sources are and what can be done to minimize or eliminate their invasion of your telephone is the intent of this article.

Sources of RF Radiation

Although it appears that the source of the offending RFI is the inverter, this is not entirely true. The inverter draws current from the battery through the battery cables. The product of current and voltage passing through cables is power. The inverter delivers most of this power to the load once it has been inverted into alternating current. The flow of current through the battery cables can be imagined as similar to the power sent to a transmitting radio antenna, particularly if the cables are running parallel to one another. If for example, an inverter was delivering 2,000 watts to the load, the draw through the cables would be 2,350 watts (85% efficiency).

If the cables are laid out parallel to one another they can act as a 2.3 kW broadcasting antenna. If for example, your telephone service entrance, or any of your telephone wires are in close proximity to the battery/inverter location, your phone quality could be jeopardized by RFI from the battery cables.

Fortunately, it is easy to correct this problem in most instances. The very act of twisting the battery cables into a "twisted pair" will cause the offending radiation to cancel out. If the inverter cables are separate from the battery cables they too should be braided into a "twisted pair". Don't overlook twisting battery charger cables as well. Since they may radiate during charging sessions.

If you attempt these tasks it is advisable to listen to the noise on the telephone lines after each attempt to determine its effectiveness.

The next, simple but often overlooked, solution is to make sure that battery negative is grounded. Ask your solar equipment dealer to help you if you are unfamiliar with battery grounding procedures.

The next solution involves confirming that all metal enclosures used in your system are grounded at one common point. This is also governed by the National Electric Code (NEC). All metal disconnects, load centers, transfer switches, junction boxes, gutters, etc., can leak RFI the same way the battery cables do. Connect them together via a bare copper conductor or a green insulated conductor and terminating them at one common grounding point, as required by Code (NEC). This will serve to shunt spurious RFI to ground and thereby keep electrical noise out of the telephone system.

From here the detective work moves to the ac system. The RFI can be radiated just as easily from the ac wiring as from the DC wiring. And in my experience it is far more likely for the telephone buzz to originate with the ac wiring than from the DC wiring.

The next steps are:
1. Relocate the offending loads. This is a possibility for appliances but seldom easy for telephones since the wiring is hidden inside the walls.

2. Listen carefully to determine if phone devices like answering machines, fax machine, and computers with modems are coupling the noise through their power supplies. This is easily done by listening to the buzz on an affected phone while an assistant unplugs the power supply on the devices listed above. Any change in the buzz may indicate that the power supply is contributing to the buzz.

3. Replace or substitute the phone wiring with shielded telephone cable.

4. Collect the shields at one location only and ground them.

Shielded Wire
The simplest example of shielded wire is a "twisted pair" wrapped within a foil (metal) shield and then enclosed in an insulted plastic jacket. Shielded wire is used extensively in the telecommunications industry. It is usually available from retail outlets like Radio Shack, electrical supply houses, and from your local telephone company.

Each phone line requires a pair of wires. Multi line phones require multiconductor cable. I have found shielded wire, suitable for replacement of the "pink" unshielded wire found in the home, to be readily available. It is usually at or near the same diameter as the "pink" wire. A home can either be restrung or have the existing wire replaced. This may be difficult for some homes. Consult an electrician, phone service technician or a representative from your telephone company.

A quick trip to the attic or underneath your house will reveal that the "pink" wire criss-crosses the 120 vac Romex wiring throughout your house. Phone jacks are frequently adjacent to existing ac outlets and switches. Since the standard telephone cable is not shielded, it picks up the RFI and introduces it as a buzz in the telephone. Phone lines that cross Romex at right angles are less apt to pick up the signal than phone lines that run parallel to Romex.

The most offending location is usually where the telephone service enters the building. At this service entrance point, the phone lines form a network extending outward to all of the phone jacks. If there is any Romex wiring in this area, and there usually is, your phone quality is likely compromised.

Starting with the service entrance point you need to shield the phone lines. If ac wiring is present at this point of distribution, then invite local phone company to replace the telephone service entrance cable with a shielded cable. Telephone company underground (direct burial) wire is already shielded and is usually not affected. Aerial wiring is not shielded. You may choose to replace an aerial telephone service entrance cable with shielded wire if, say on a building's exterior, it is adjacent to ac wiring.

The phone company grounds the telephone service at the service entrance point. This done for electrical noise suppression, lightning protection, and your safety. You can visually confirm that your phone system ground connection is intact. Look for a solid copper wire, either bare or with a pink or green insulation that terminates to a cold water pipe, (metal), or other grounding point. If in doubt, ask your phone company to check the phone service ground.

The phone company ground is the location at which all of the shields from the shielded cable will be joined and terminated. You should only ground one end of each shielded phone cable.

With these tasks accomplished you will enjoy buzz free telephone communication. It will also enhance the performance of answering machines, fax machines, and computer modems.

Case Study A
I recently completed a new home. Because it happened to be available, at no cost, the home was wired for phone service with telephone company type direct burial wire. It was a three pair cable with an aluminum foil shield wrapped around the twisted line pairs. The whole assembly is encapsulated in a tough PVC type insulated jacket. Cable diameter is about ⅜ inch. Wire size is #22 AWG.

The off grid power system is installed to Article 690 standards and met the County of Maui electrical requirements. The inverter is a pair of Heart 24-2500 XCP inverters delivering 120/240 vac to the loads. Telephone quality is excellent. This was a new home wired to Article 690 of the NEC. We were not certain if the noise free line was a result of the wiring or the use of shielded phone cable, so a second investigation was undertaken.

Retrofit project Case B
A client complained frequently about the buzz in her phone. It was so annoying that she would start her back-up propane generator, which would pick up the load through the automatic transfer switch, and drop out the inverter, so that she could make long distance calls. Her inverter is a Trace 2012. The installation is several years old. The grounding was adequate throughout the DC and ac wiring. The battery and inverter cables were

laid out in the usual parallel fashion. However I discounted their impact because the entire off grid power system is located in an out building 50–75 feet away from the nearest phone lines.

A quick examination under the house revealed the problem. The direct burial telephone service entrance wire was shielded. The shield was grounded at the telephone company's termination enclosure. From this point the network of phone jack wiring was run helter-skelter under the house and through the walls with “pink” unshielded wire. Multiple splices were evident. The “pink” unshielded wire criss-crossed the Romex numerous times. There were parallel runs with the “pink” wire stapled adjacent to Romex.

The single level home had three phone jack. Replacing the “pink” wire required 100 feet of new wire. Since the home only had one phone line we choose to replace the old wire with Belden # 8451. This is a #22 AWG twisted pair, in a foil sheath, and a black PVC jacket. It is the same diameter as the two pair “pink” wire it replaced. Cost on Maui was $32 for 100 feet.

We made a conscientious effort to staple the new wire along girders and joists so that close parallel runs with Romex were avoided. We maintained at least four inch separation. The run from each jack was a “home run”. This allowed me to terminate the shield — that is, foil — at the same point that the phone company terminated the shield on the direct burial service entrance cable. Plan your work so that each cable run has its shield terminated at the service entrance ground.

Although this may appear as difficult field work it only took two people 2.5 hours to restring the new phone cable and remove the original wire. Conventional electrician’s tools were required plus plenty of patience when fishing wire through a wall and into an existing phone jack.

The net result was excellent audio quality on the principle telephone and a faint buzz remaining on an inexpensive phone used in one of the bedrooms. Telephone instrument quality has a lot of impact on the final outcome.

One remaining untried approach to cleaning up the buzz on low quality phones would be replacing the cord that connects the phone to the jack with shielded cable. This is a task best left to a telephone company technician because of the specialized tools required to strip and terminate the ultrafine wires.

If we get around to it, you will read about in *Home Power Magazine*!

Access

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Sir Thomas Lipton — 1870

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Magazine Mechanics

Home Power readers are inquisitive folks. A lot of you ask about the mechanics of putting together the information — basically, how we get it to you in the form of a *Home Power* issue. So here is an occasional column answering some of the most asked questions about how and why we do what we do.

For Paper Nerds

The demand for recycled paper has grown so much that the paper mills are finally responding, and at affordable prices. We're trying a new paper for the interior pages of this issue of *Home Power*. It's called Pentair PC 30 Gloss from Niagara of Wisconsin Paper Corp. This paper contains a minimum of 30% post-consumer fiber. Niagara bleaches its paper using hydrogen peroxide, not chlorine. This paper is not considered totally chlorine-free because virtually all available recycled pulp contains chlorine from its previous manufacture, but it comes very close to being chlorine-free.

Mailing Lists

Home Power never sells or rents its mailing list. On three occasions, we have donated our list to non-profit groups for a single use only. When we do this, the non-profit organization is required to sign a contract stating that the use of the list is for a single, specified mailing only. The mailing list can not be used for any other purpose. We seed the database so we'll know if the list is ever used again for any other purpose. We have only donated the mailing list to non-profit RE Fairs and educational institutions.

When a subscriber asks not to be placed on any other mailing list, we have a code for the database so that these folks won't be included in the donated mailings. So if you don't want to be included on these donated mailings, please note this on your subscription form.

Power System Stuff

Home Power Magazine is located eight miles from commercial electricity. We live and work in a place called Agate Flat, Oregon. Our cordinates are 42° 01' 02" North and 122° 23' 19" West. All the electricity that goes into our production is generated on-site by renewable energy sources. We use an array of 42 photovoltaic (PV) modules producing 1,800 watts of peak power. A 1,000 watt wind generator provides power during stormy periods. This renewable power is stored in a battery holding 18 kiloWatt-hours of energy. Most of the energy is inverted to 120 vac, 60 Hz. for use by the computers. Our system routinely cycles 12 kilowatt-hours daily.

Writing for *Home Power Magazine*

Want to share your story? *Home Power* specializes in hands-on, practical information about small scale renewable energy production and use. We try to present technical material in an easy to understand and easy to use format.

Informational Content

Please include all the details! Be specific! Write from your direct experience — *Home Power* is hands-on! We like articles to be detailed enough so that a reader can actually apply the information. Please include full access data for equipment mentioned in your article.

Article Style and Length

Home Power articles can be between 500 and 6,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short and to the point. Use sub-headings generously to organize your information. We highly recommend writing from within an outline. Check out articles printed in *Home Power*.

Editing

We reserve the right to edit all articles for accuracy, length, and basic English. We will do the minimum editing possible. We get over two times more articles submitted than we can print. The most useful, specific, and organized get printed first.

Photographs

The photos you see in *Home Power* are processed digitally. We use a 35 mm slide scanner and a 8.5 inch by 14 inch flatbed scanner. We can work best from a color slide (color positive transparency). We can also work with virtually all 35 mm film formats (color and B/W negatives) and color or B/W prints.

Line Art

We can redraw your rough sketches via computer. We can generate tables and graphs from your rough data.

Article Form

We would love your article on a 3.5 inch computer diskette. Or put it on the *Home Power* Bulletin Board (707-822-8640), addressed as E-mail to Richard Perez.

We can, and often do, work from typewritten doubled spaced manuscripts. If you don't have access to either a computer or typewriter or other fancy hardware, then please print in ink. The quality of your info and experience counts, not the cost of your equipment.

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Hardware Stuff
OK Nerds, you asked for it, so here it comes. *Home Power Magazine* is virtually an all-digital production. Only camera-ready advertising is carried via conventional film technology. We use a motley assortment of five networked Macintosh computers from an ancient SE to a full race Big Mac IIci with 50 MHz accelerator and 20 MB of RAM. Two of the large Macs are equipped with 21 inch monitors, one of which carries 24 bit color and the other 8 bit gray scale. The Mac network here on Agate Flat uses a modem and two analog-to-digital data acquisition systems.

Since we began digitizing color photographs, we have developed an insatiable appetite for storage. The Big Mac runs with both 660 MB and 1.2 GB fast hard drives. Last issue of *Home Power* (#37) occupied over 450 MB in art and page layouts; the cover alone was over 45 MB. Our digital storage salvation are the 128 MB magneto-optical disks. Our issue travels from our computers on Agate Flat to our printer, St. Croix Press, in Wisconsin on four of these 128 MB magneto-optical disks.

Image acquisition is via a 2700 dpi 35 mm color slide scanner and a 600 dpi color flatbed scanner. We do our page proofing on a 600 dpi laser printer. The final printing plates are made by St. Croix's computers on an AGFA 9800 Raster Image Processor. These plates are then printed on computer-controlled, Harris heat-set web presses.

Software Stuff
We do most of our word processing in Write Now 3.0. Page layout is done in Quark XPress 3.1. Photography is processed and separated in Photoshop 2.5. We use Freehand 3.1 for line art, tables, charts, and diagrams. Business chores are handled by Excel (spreadsheets) and 4th Dimension (all databases). Our new color logo was drawn in Fractal Painter X2 (thank you, Stan Krute). We are using Mac System 7.1 and only crash a couple of times daily….

Humans
Home Power Magazine is the work of many people. First are the folks who graciously share their hard-won information within our pages, the reader. This magazine exists because most of you have made the choice to use renewable, home-sized energy systems. We are here to help share and expand the world of home powered systems. Second are the advertisers who make it possible to put this copy in your hand at so little expense to you. And third, is the crew of four full time people who have let *Home Power* take over their lives — Kathleen Jarschke-Schultze, Therese Peffer, Karen & Richard Perez.

Hopes
The same sun that provides power for this magazine shines on us all. It is our hope and goal that we may all use the sun's energy to build a better world. Our New Year's resolution is to become a clearer and quicker highway transmitting *your* renewable energy information worldwide. — *the Home Power Crew.*

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Each 2 Volt cell is 29 inches tall, 14 in. in dia. and weighs 330 pounds. Six cells make a 12 Volt battery.

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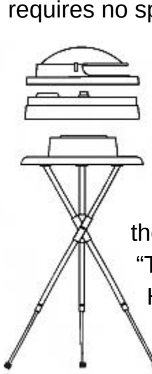

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Shorts and Stuff

John Wiles

Electrical cables, conductors, and wires, no matter how large, have some inherent internal resistance. If the level of current through these conductors exceeds the current for which they are rated, the internal heating (Power = Heat = I^2 x R) will cause the insulation to fail (soften, melt, or burn) which in turn can cause fire or shock hazards. All cables used in electrical power systems are designed to operate 30 years or more when used within their rated values of temperature and current.

In the last Code Corner (*HP*#37), the appropriate sizing of conductors was discussed. This article is about protecting those conductors from accidental overloads and short circuits.

Overcurrent Devices

Any overcurrent device (fuse or circuit breaker) used in the direct current (DC) portions of a PV system must be rated for use with direct current. Independent testing organizations such as Underwriters Laboratories (UL) establish performance standards for DC-rated overcurrent devices and test them to those standards. To keep electrical inspectors happy, the overcurrent device should bear the UL mark and the DC ratings in volts, amps, and interrupt rating (more next issue). In some cases, the manufacturer will not mark the device with the DC ratings, but will provide a written copy of the UL-Listing. Factory certifications are sometimes not acceptable to the inspector.

There are two primary types of overcurrent devices: supplemental and branch-circuit. The UL-Listed, branch-circuit overcurrent device is a robust unit that has undergone extensive testing and is required in all branch circuits. In the renewable energy system, branch-circuit listed devices are required in the circuits from the battery to any loads — either alternating current (ac) or DC. This would include DC inverter circuits, DC load circuits, and ac load circuits.

The UL-Listed supplemental overcurrent device is tested to less stringent standards. They are generally smaller than branch-circuit devices and are normally located inside pieces of electronic equipment. While they are not allowed in branch circuit locations, the National Electrical Code (NEC) does allow them to be used in PV source circuits. These are the circuits between the PV modules and the batteries.

Overcurrent is the most common problem that causes cables to fail. It is not the power that flows through the cable nor the voltage applied to the cable, but the current through the cable acting on the internal resistance of the cable, which causes the cable to heat. The power equation, $P = I^2R$, shows the relationship between the cable resistance and the current flowing through the cable. Overcurrent problems are not directly related to the power that the cable is transmitting, only to the power that is being lost due to the internal resistance. For example, a 1200 watt electric heater operating at 120 volts draws 10 amps and can safely be operated with number 18 AWG cable. A 1200 watt electric heater operating at 12 Volts draws 100 Amps, and this level of current would rapidly cause a number 18 AWG cord to fail. Current, not voltage or power, is the culprit.

Module Conductor Protection

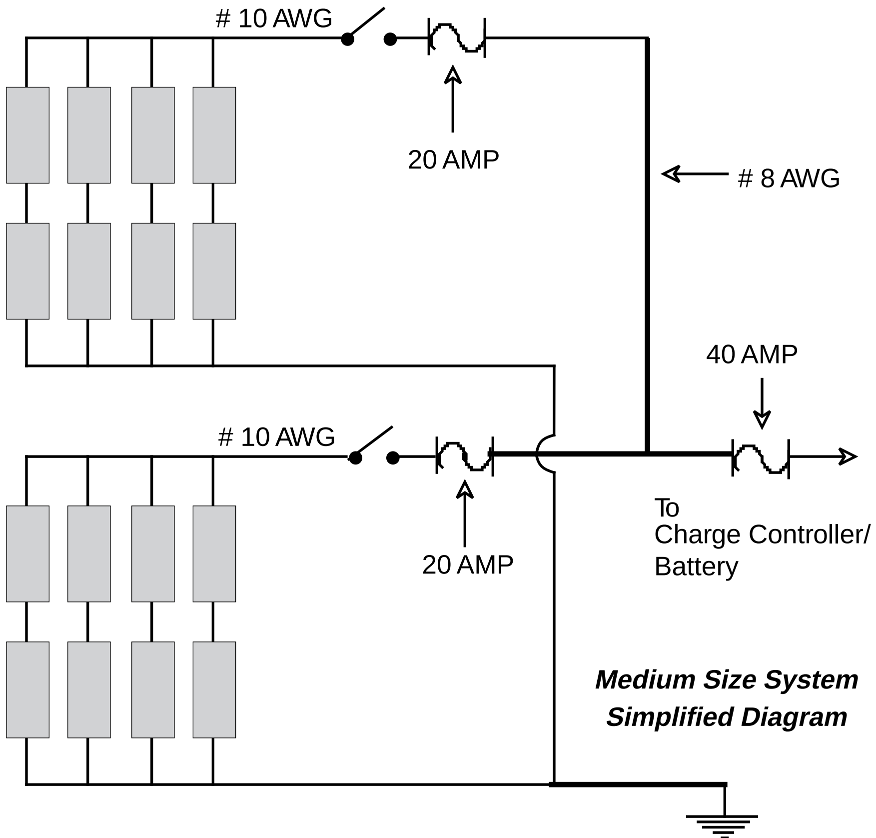
PV modules are current-limited producers of power. They can be safely operated with the terminals short-circuited. In fact, some types of charge controllers do just that — they short the modules as part of the charge control process. The module output current will not exceed the short-circuit value — unless the sun gets brighter, or clouds or snow increase the solar irradiance reaching the module. The conductors used for module interconnections are sized to carry 125% of the short-circuit current of the module, string, subarray, or PV array.

The question frequently arises: Why use overcurrent protection on module wiring if it is designed to handle 125% of the maximum short-circuit module current? There are two reasons. The first is that in the module conductors, short circuits can draw power from not only the connected module, but the battery and other modules connected in parallel subarrays or strings.

Blocking diodes, used to prevent reverse current flow into the PV array at night from the batteries, can and do fail in a shorted mode (they act like a piece of wire, not like a one-way diode). When this happens, a short circuit in the module wiring can draw very large currents from the batteries with resulting damage to the conductors, charge relays, and switches in the circuit. Even when a battery fuse (rated at several hundred amps) is installed near the battery, a partial short circuit in the module wiring can draw 40 or 50 Amps, which exceeds the rating of that wiring but is insufficient to blow the battery fuse.

The second reason is that in a medium-to-large array, there are usually several modules or strings of modules connected in parallel. If a short circuit were to occur in one of the strings, then current (possibly several times the short-circuit current of a single string) could flow from the other strings into the shorted string wiring.

For these reasons, the relatively small gauge conductors used to connect the PV modules must have overcurrent protection by fuses or circuit breakers related to their ampacity. The size or rating of the overcurrent device is calculated the same way as the conductor ampacity. It is 125% of the short-circuit current from the module(s), string, or subarray feeding that particular conductor.



Medium Size System Simplified Diagram

Examples

Small System — Three Siemens M55 modules are connected in parallel in a 12 Volt system with number 10 AWG USE-2 cable. Number 10 AWG UF 10-2 with ground cable is used from a junction box near the modules to the disconnect switch located at the charge controller. Since all of the conductors are the same size, they can all be protected with one overcurrent device in the ungrounded conductor (usually the positive). If the system is not grounded (neither of the current carrying conductors are connected to ground), a fuse (and disconnect) must be used in both the positive and negative conductors. In this case, the fuse or circuit breaker should have a rating of about 12.75 Amps, which is the short circuit current (3.4 Amps) times 125% times 3 (for the 3 modules). A 15 Amp fuse or circuit breaker would be acceptable, because the cable has a temperature derated ampacity of over 20 Amps in this example.

The overcurrent device will normally have a rating equal to or below the ampacity of the cable, and both must be rated at greater than 125% of the short-circuit current.

If number 10 AWG conductors were used all the way to the battery, then the overcurrent device could be located near the battery and provide protection for all of the wiring from the battery to the modules. Additional information about battery fuses will be presented in the next Code Corner.

Medium System — In this 24 Volt system, sixteen Solarex MSX-60 modules are connected in two subarrays. Each of the subarrays has eight modules consisting of sets of two connected in series with the four series-connected sets then connected in parallel. The short-circuit current of each module is about 3.8 Amps, and the four strings in parallel would require cable with an ampacity of about 19 Amps (3.8 x 1.25 x 4). Number 10 AWG USE-2 cable with a temperature derated ampacity of about 23.2 Amps (in conduit) is acceptable for the subarray cable; number 10 AWG cable could also be used down to a subarray combiner box. At this point, the two subarrays would be connected in parallel, and the required ampacity for the cable would be 38 Amps (3.8 x 8 x 125%). A number 8 AWG cable could carry this current.

Since there is a requirement to protect all conductors from overcurrents and short-circuits, fuses of different sizes must be used. A 20 Amp fuse would be used to protect the number 10 AWG conductors from each subarray. Then, near the battery, a 40 Amp fuse would be used to protect the number 8 AWG cable. A simplified diagram of the system is shown here.

This branching out of cables, with large fuses protecting large cables and smaller fuses protecting smaller cables, is similar in principle to what we see in ac load centers where there is a large main breaker and several smaller branch circuit breakers.

In the next Code Corner (*Home Power* #39), overcurrent protection of the higher current circuits associated with the battery will be addressed. Following that, the art of disconnects will be revealed.

Access

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National Electrical Code – 1993, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

ask NREL

The National Renewable Energy Laboratory (NREL, formerly known as SERI, Solar Energy Research Institute) is one of ten federally funded national laboratories. NREL has offered to provide answers to technical questions Home Power readers have regarding renewable energy.

Question: *Why are PV modules blue?*

Answer: Of course not all PV modules look blue. Some look black, some have rainbow colors, and some are brown. The answer lies in "ROY G BIV". The human eye sees colors from red, orange, yellow, green, blue, indigo, and violet (hence ROY G BIV). White light is a combination of all the colors. The reflected light from an object determines the color we see of that object. A black object reflects no light, while a white object reflects all the light.

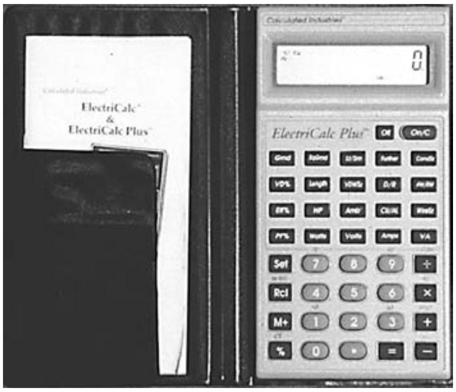
PV modules work by using the energy of light to free electrons in the solar cell. A solar cell "sees" visible light plus some invisible infrared light. As the name implies, infrared light is light that is beyond the color red. If light is reflected, then the solar cell can't use it to free electrons. To maximize the light into the solar cells, the manufacturers use anti-reflection (AR) coatings. A perfect AR coating would make the solar cells appear black, as there would be no reflected light. Also, a perfect AR coating is expensive. When a manufacturer evaluates the cost of different AR coatings with the performance gains, a single-layer AR coating is usually chosen. The type and thickness of the AR coating determines whether the solar cell absorbs or reflects the light. If a solar cell looks blue then all the other colors except blue, indigo, and violet are absorbed by the solar cell. The human eye can't tell if the invisible infrared light is reflected or absorbed. Rainbow colors appear when the AR coating has minor thickness variations. Don't judge the performance of a PV module by the color of its AR coating. It's the electrons out that count, not the light into the module.

Access

Author: Byron Stafford, NREL

Send your technical renewable energy questions to: NREL, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179 voice or FAX • 707-822-8640 Computer BBS (send Email to the name: Richard Perez)

Tech Notes



The ElectriCalc Plus™ Electrical Code Calculator

Bob-O Schultze KG6MM

Once in a while, a tool comes along that makes your work just a little easier. Imagine an early auto mechanic when he first laid his eyes on a ratchet wrench and a set of sockets. That's kinda the way I felt when I saw the ElectrCalc Plus™. I gotta have it.

"It" is a compact and easy to use calculator made for electrical designers, contractors, electricians, and others who work in the electrical power biz. It's designed to utilize Tables 250-94, 250-95, 310-16, 310-17, 3B, and 8 of the National Electric Code®. The darn thing figures Volts, Amps, V-A, Watts, Power Factor, Horsepower, and Efficiency. It solves for ampacities, wire size, voltage drop, and conduit size. It'll toggle between copper and aluminium wire, 75°/90° Wire Insulation, 1ø and 3ø systems. You enter the ambient temperature in either Fahrenheit and Celsius and it will figure wire size derating. The ElectriCalc Plus™ will also convert Fahrenheit to Celsius and vice-versa (a handy little calculation that used to drive me nuts!). It's also a plain vanilla calculator with a memory key. Fits in yer shirt pocket. Whew!

All very neat, you say, but how does that apply to the average RE system designer/installer? Check this out. Based on your customer's needs, you've designed a 24 VDC system that uses, say... twelve 50 W photovoltaic modules. The PVs you are using put out three Amps each. The array will be located about 80 feet from the house and there will be 110 feet (one-way) of wire between the modules and the controller / disconnect / batteries. The wire needs to be buried in conduit. You need to size the wire (you'll accept a 5% wire loss at peak) and the conduit. Sound like a pretty typical setup? It is. OK, grab your NEC®, pencil and paper, and figure it out. We'll just sit here and wait... think I'll get a cuppa while I'm waiting...

Here's how it'll go with the ElectriCalc Plus™. Turn it on. Its default values are 1ø, Cu wire, 75°C Insulation and 30°C ambient temperature. Change them if you like, but they'll all work for our scenario. Punch in 24 and hit the Volts key. Multiply 12 (modules) by 3 (Amps per module) and divide by 2 (takes two modules in series to provide 24 volts), punch "=" and hit the Amps key. Punch in 110 and hit the Length key. Punch in 5 and hit the VD% (Voltage Drop %) key. Done. Pressing the VDWSz (Voltage Drop Wire Size) key displays 4 CU (#4AWG copper wire). Pressing the VD% key twice displays 4.3% — the actual % of voltage loss at peak output of 18 Amps. Punch in 4 and hit the WireSz (Wire Size) key. Punch in 2 and hit the #W/RW (# of Wires/ Wires in Raceway) key. Pressing the CondSz (Conduit Size) key displays .75 CONDUIT SIZE IN. Is this easy or what? Want to see what size you need if you use aluminium wire? Press the CU/AL key once and then the VDWSz key. The display shows 2 AL (#2 aluminium wire). Pressing VD% key twice shows an actual 4.5% wire loss. Change the WireSz key input to 2 (#2 Wire) and the CondSz changes to 1.00. Where has this thing been all my life?

The ElectriCalc Plus™ isn't going to replace your copy of the NEC®, but it will give you an accurate, simple way to solve many of the problems electrical workers come across every day without having to wade thru its 900+ pages. Is that worth $79.95 to you? It is to me.

Access

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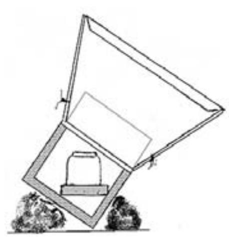

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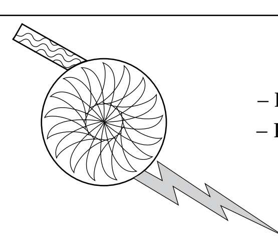

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HAPPENINGS

INTERNATIONAL
AUSTRALIA
A Centre for Applications of Solar Energy (CASE) in Perth Australia has been proposed under the auspices of the United Nations Industrial Development Organization (UNIDO). An invitation to participate has been offered for research, manufacturing, marketing, financing, aid, government, and policy organizations. For more information contact UNIDO, Technology Promotion Development Division, POB 300, A-1400 Vienna Austria, FAX Int+43 1 230-7355 or The Executive Officer, Perth CASE, POB 7234 Cloisters Square, Perth, Western Australia Fax Int + 619-327-5481

CANADA
SW Alberta Renewable Energy Initiative Information Centre–This group 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

NATIONAL
Electric Vehicle Safety Survey: In order to establish meaningful standards, the Electric Vehicle Industry Assoc. is seeking data on the safety of EVs already in actual 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 95018-1113 • 408-429-1989

Elfin Permaculture is holding a number of workshops ranging from one day to three weeks in locations around the U.S. and Canada. Contact Cynthia Hemenway, 7781 Lenox Ave., Jacksonville, FL 32221

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, or call 800-523-2929

HOME ENERGY MAGAZINE is offering a free Directory of Energy-Related Graduate Programs in US Universities. 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 him an SASE: 12531 Breezy Way, Orange, CA 92669

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 or 1-800-452-5901 (AL only) or 205-348-4523

ARIZONA
Solar Energy International (SEI) will present workshops in Tucson, AZ. “Solar Home Design Principles” is offered February 28 to March 10. The second workshop on “Solar Electricity for Homes and Water Pumping” will be held March 14 to 24. The two week workshops provide participants with practical how-to knowledge in passive solar and solar electric technologies. Contact SEI, POB 715, Carbondale, CO 81623-0715 • 303-963-8855.

ARKANSAS/MISSOURI
OZARK RENEWABLE ENERGY ASSOC. (OREA) is dedicated to providing RE enthusiasts regional connections and promoting the use of alternative energy in the Ozarks. OREA is working on a Networking Directory which is meant to be a vehicle for getting interested folks in touch with each other. For more info about OREA and a Directory Questionaire send SASE to Julie Courtney at RT3 Box 4305, Reed Spring, MO 65737, 417-338-8688

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 (OTRCs), 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

THE Solar Prosperity Exhibition will be held on June 25-26, 1994, in the San Jose Civic Auditorium Complex in downtown San Jose California. The Northern California Solar Energy

Association (NCSEA) sponsored exhibition will provide an opportunity to showcase products, systems, and services to the general public as well as the Solar ‘94 Conference. The exhibition is designed for companies, organizations, non-profit groups and educational organizations involved in solar, and renewable energy, energy conservation, and related environmental issues. The event will also feature solar and electric cars. Indoor and outdoor booth space is available. For more information or to receive the exhibitors registration packet contact NCSEA, POB 3008, Berkeley, CA 94703 or call 505-869-2759.

Solar Energy International (SEI) will present workshops in Willits, CA in cooperation with Mendocino Community College. “Solar Home Design Principles” is offered February 10 to 13. The second workshop on “renewable Energy for Remote Homes” will be held February 17 to 20. The four day workshops provide participants with practical how-to knowledge in solar, wind and water power. Contact SEI, POB 715, Carbondale, CO 81623-0715 • 303-963-8855.

CONNECTICUT

On April 10-12, 1994, a broad coalition of industry, environmental and trade organizations will convene RENEW’94, a watershed conference focused on bringing the production and use of renewable energy into the mainstream for the northeastern USA and accelerating the development of the renewable energy industry within this region. The Northeast Sustainable Energy Association, organizer of RENEW’94 invites exhibitors of products and services to participate. For more information contact, NESEA, 23 Ames St, Greenfield, MA 01301, 413-774-6051, Fax 413-774-6053

FLORIDA

Sun Day Challenge ‘94 is scheduled for Feb. 12 & 13 1994. The Alternative Vehicle Event will be a one day road rally and a one day track event. Solar, electric, hybrid, and other types of vehicles will be competing in 4 classes. For information contact Bill Young, S/EV Committee, Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, FL 32920

HAWAII

The Electric Vehicle Association of Hawaii and the Hawaiian Electric Company are hosting Hawaii EV ‘93, an international electric and hybrid vehicle conference and trade show. Held at the Hilton Hawaiian Village, the event , which is co-sponsored by Hawaii Dept. of Business Economic Development and Tourism, will be held December 9-12, 1993. The event is designed to meet the needs of major manufacturers, the general public and everyone in between. Preliminary sessions on Thursday and Friday cater to industry interests, providing valuable information on vehicle and infrastructure development. Paul MacCready, Aerovironment will be keynote speaker at Thursday’s luncheon. Saturdays activities are for the general public, including training sessions for the maintenance and repair of EVs. Concurrent for these three days is a vehicle and component trade show . Sunday closes the event by bringing industry and the public together for the Pali Challenge, a road rally and exhibition to show-off commercially available vehicles with the “right stuff”. Detailed information is available by contacting Hawaii EV’93, 2800 Woodlawn Dr Ste 248, Honolulu, HI 96822 or phone 808-539-3770, FAX 808-539-3767.

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 immensely 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

NEVADA

Solar Electric Classes in Nevada taught at remote solar home site. Maximum of four students for more personal attention. Two day classes on weekdays & 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

OREGON

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

The Utilities, the Offgrid Market and IPPP

Don Loweburg and Bob-O Schultze

The offgrid market of photovoltaic systems (PVs installed beyond the utility lines) is now being served by a growing and healthy PV industry. Recently, utilities have taken an interest in PVs used off the utility grid. Our concern here is not whether utilities should be involved with PVs. The utilities should be encouraged to serve their customers by putting PV on the grid. The big question concerns utility involvement in the offgrid PV market and representation from those businesses currently serving this market.

The Electric Utility Grid

First a little background. The electric utilities are natural monopolies. A natural monopoly occurs where one economic entity can function more efficiently than several. In this case, electric utilities have tremendous distribution networks (the grid), requiring huge amounts of capital. In order to attract this capital, the utilities are allowed to be monopolies (inherently anti-competitive) They are regulated by the state so that their anti-competitive advantage is limited — limited to the arena that is "natural" to their particular enterprise. The generation of electric power itself is not protected. The distribution network that forms the basis of this natural monopoly allows the electric monopolies to function as state regulated monopolies.

Two groups have been working on ways to promote and develop PV applications involving utilities. UPVG (Utility Photovoltaic Group) is a national group of utilities with DOE and EPRI (Electric Power Research Institute) backing. In California, PV4U (Photovoltaics for Utilities), a group of PV manufacturers, distributors, utilities and, just recently, PV installer-dealers, has been working on a commercialization plan.

As part of this plan, offgrid applications have been targeted as the first market for utilities to enter. Why? A quote from the May 1991 Battery and EV Technology: "According to EPRI's Taylor Moore and John Brigger (Generation and Storage Division), two dozen U.S. utilities of various sizes and ownership types are using photovoltaics for low-power loads in their own operations, having found the technology to be more economical than frequent battery replacement or extending a utility service line....Many such applications involve maintaining charged batteries for remote lighting, monitoring, and communications equipment. Some utilities are also exploring the cost-effective use of photovoltaics in customer service applications, including livestock water pumping, remote residences, and outdoor lighting. Small, remote loads of industrial and institutional customers represent a virtually untapped utility market for photovoltaics."

Now consider the pending proposal for electric utilities to enter the off-grid market. Off-grid is by definition outside the arena that is "natural" to these companies. The quiescent feature that identifies these companies is the grid itself. By entering the off-grid market they are leaving the domain for which they were allowed to be a natural monopoly and entering a new market in which they have no "natural" rights. The off-grid PV market needs no transmission lines, substations or other identifiable attributes of the electric power utilities. Monopolies functioning in this domain would be intrinsically anti-competitive. There is no way to counteract or mitigate the anti-competitive potential they bring to this market.

In 1976 the California State Legislature passed PUC statute 2775.5, ordering the PUC to "regulate the involvement of privately owned public entities in solar energy development, and to ensure that the solar energy industry develops in a manner which is competitive and free from the *potential* dominance of regulated electrical and gas corporations." (my emphasis on potential) The demonstration of potential dominance should be enough to keep the utilities out of the offgrid market.

Fair Play

During the last month we have attended two meetings, the purpose of which was to address and mitigate the anti-competitive elements of utility entry into the off-grid market. These meetings lacked full industry representation and presumed to answer a question that had not yet been asked openly. Should or should not the solar industry encourage the utilities to enter the off-grid market? To date, an incomplete formulation of procedures has been drawn up, the purpose of which is to allow utility entry into the off-grid market while not violating 2775.5.

Not one of the proposed measures can eliminate the potential of utility dominance mentioned in 2775.5.

One proposal would have all purchasing, installation and maintenance of utility off-grid systems involve a local PV contractor. The process would allow qualified contractors to bid for the job. Since the contractors are local and the bidding would be fair, there should be no complaints about the utilities monopolizing the PV business. There's "something in it for everybody". But wait. Let's take another look. What's different about the picture now? Before, my client was John Q. Homeowner. Now I'm working for the utility as a contract worker. Since we presume this will be a successful program, in the near future I may be working primarily for the utility. My business is now dominated by the utility.

With 10,000 grid-connected homes to every one off-grid, why are the utilities looking to enter such a small market while virtually ignoring the on-grid possibilities? Why aren't the utilities encouraging more individually owned on-grid PV installations by offering inducements like net billing for on-peak PV power production?

Meet the Bolts and Volts Folks

The Independent Photovoltaic Power Providers (IPPP) started a few months ago as an ad hoc committee of California Mom 'n Pop PV businessfolks who feel they are not being fairly represented by the existing solar energy organizations. These establishment organizations are heavily dominated by manufacturers and large distributors. Whether as a result of the utilities stepping into the off-grid market, Home Power's editorial in the last issue, or just an idea whose time has come, the concept of IPPP is now a national movement toward free, independent ownership of the sun as an electrical power source.

Who We Are

IPPP (or I3P to save a mouthful) is a group of independent solar electric contractors, dealers, and system designers. Members of this group have pioneered the design and installation of *most* of the residential and commercial off-grid photovoltaic systems existing today.

Statement of Purpose

IPPP is dedicated to furthering the growth of independent solar energy installations and applications in the USA and the world.

We believe that a healthy and prospering network of independent photovoltaic power providers is vital to the continued growth of the solar energy industry.

Utility entrance into the remote and off-grid market will serve to restrict the growth of our industry, interfere with competition in the market for solar energy systems, and increase the cost of PV produced power to ratepayers everywhere.

Why We Need To Organize

As a group, we have been unrepresented during PV For Utilities (PV4U) discussions of the Utilities Commercialization Plan which recommends utility entrance into the off-grid business. IPPP has been formed to give independent providers, the backbone of our industry, a voice in the future of the solar energy industry.

We oppose utility involvement with remote or off-grid applications of photovoltaics. The utilities have huge advertising, marketing, and legal departments in place. They have "name" recognition and ratepayer loyalty — after all, they've held a legal monopoly for decades. This publicly-granted monopoly confers an unfair marketing advantage to the utilities over the independents. The utilities hold no natural rights to the off-grid portions of their service areas. Utilities have never serviced the remote or off-grid markets.

What We Can Do

Join together. Organize on state and national levels to assert our voices as legitimate stakeholders in the renewable energy industry. If your utilities have restrictive policies toward acceptance of independently-produced on-grid power, use the media to inform the public about it. If their policies are encouraging, support them. If they haven't got a clue, *teach* them. Ratepayer-financed, on-peak power produced by renewables should be encouraged with net billing. If the utilities consider *all* the factors, including environmental and long term generation replacement costs, PVs on the grid look pretty good right now.

Networking

IPPP is limited only by our imagination, energy, and sweat — three qualities with which all small solar businesses are familiar. It can act as a clearinghouse for information exchange. We need each other's help and input on where to go from here. We need volunteer lawyers' help in forming a legal organization.

The one thing that all IPPP folks have in common is our solid knowledge that renewable energy is the present *and* the future. Who owns the sun? We all do — let's keep it that way.

Access

National: IPPP, c/o Home Power, POB 520, Ashland, OR 97520 • Phone/Fax 916-475-3401

California: IPPP c/o Don Loweburg, Offline, POB 231, North Fork, CA 93643 • Phone/Fax 209-877-7080

Authors: Don Loweburg, (see address above) & Bob-O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044 • Phone/Fax 916-475-3401

Home & Heart

Kathleen Jarschke-Schultze

Living with a septic tank has changed the way I wash clothes. I use only biodegradable laundry soap. I quit using a chlorine bleach. I don't use anything containing phosphates. I quit using scouring powder that has chlorine in it. Last year, when we lost our spring and were hauling water for everything, I began using dishwater to keep my perennials alive.

Beyond Biodegradable

I thought I was doing the best I could with the system I had. Then we received some samples of Oasis laundry and dish soap from Art Ludwig. I read the literature and realized there was much more I could do.

Oasis in a Drought

Art Ludwig did his thesis in Conservation and Resource Studies at UC Berkeley in 1988–89. As a consequence of this research he developed Oasis Biocompatible Laundry Detergent. This coincided with the decision of Santa Barbara County in California to legalize greywater reuse because of continued drought conditions. Since that time other counties have followed suit. In March of 1991 the California Department of Health Services endorsed the use of greywater during drought.

Biocompatible Laundry Detergent

I began using the laundry detergent. It is superconcentrated so I only used ⅕ to ⅛ of a cup per load of clothes. I found that it was very important to shake the bottle before you pour as the liquid separates. I only use cold water to wash in. I had been using liquid "ALL® Free & Clear". Oasis detergent cleaned as well as what I had been using. That was the first test.

Greywater and Plants

Oasis detergent claims that it is highly effective (it worked for me), contains no plant toxins, is cruelty free, and biodegrades into plant nutrients. To test whether it was OK for plants I saved some greywater from the washing machine and watered a tomato plant in a pot with it. Because the rain is supposed to naturally leach the greywater in a large area every year I watered every other time with creek water. I know this wasn't really very scientific but the results were that the tomato plant watered with greywater grew just the same as my other potted tomato plants.

Oasis detergent biodegrades into carbon dioxide, water, and plant nutrients (3% phosphorus, 6% potassium and 1% sulfur). It is non-toxic for plants and does not make the soil alkaline.

It contains ionic, non-ionic surfactants, a water softening agent, an anti-redeposition agent and a fabric brightener. It does not contain any fillers, perfumes or coloring. There are no animal testing or ingredients. And it comes in a recyclable container. One gallon sells for about $23. There is also a No Phosphate Biocompatible Laundry Detergent available for phosphate free states.

Now the Dishes

Washing the dishes is another of those thankless tasks that need to be done again as soon as you are through. I have a cartoon of Mr. Natural doing the dishes over my sink to inspire me. I tried out the Oasis dishwash/all purpose cleaner. I found that it did not suds up like I was used to. The water seemed to wear out (lose its cleaning ability) quickly. Here I would say it would be a choice of whether you wanted to use more dishwash than usual. Karen had the same experience at her house where her water is very soft.

It worked fine for me for my fine washables (a cool blouse with wooden beads handsewn all over it). I also used it as a shampoo (diluted 1:5) and that worked OK. This would be great stuff to take camping in the woods as you would only have to carry one plastic bottle of soap and just dilute as necessary for the job at hand. Again the great benefit is that it is biocompatible and actually feeds plant life.

Cleaning Conclusion

I liked the laundry detergent and plan to use it in the future. I think the dishwash/general purpose cleaner is OK. I can see where it has its place. You can also send to Oasis for a Greywater Information booklet that explains greywater systems. It includes System Design and Plumbing, The Official Word, Health Considerations and Basic Biocompatibility Issues and more.

Bathroom Cleanser

I bought some Citra-Solv™ natural citrus solvent. I wanted something I could scrub the toilet, sink and tub with that would be the equivalent of my usual scouring powder. Well, this stuff is strong. Yeah, it cleans well, but when I read that it shouldn't come in contact with skin, some material and some plastics in its undiluted state, and that it is combustible, I had second thoughts. I have been diluting it and using it in a spray bottle for an all-around bathroom cleaner. It works quite well. I particularly like the smell of oranges that it leaves. It also works well for spot cleaning of greasy stains.

Sink Scrubbing

So what do I use for a scouring powder? Bon Ami® kitchen and bath cleanser. Yep, the formula hasn't changed in over one hundred years. Its abrasives are made of feldspar and calcite. No phosphate, no chlorine, no perfume and no dyes. It works where I need it and works well. You can find it in any grocery store and it is usually cheaper than other brands.

Natural Wax

When I bought some unfinished wooden dining room chairs my neighbor, Jim Flett, turned me on to a great natural wood wax, Howard Feed-N-Wax. It is made of orange oil, beeswax, and carnauba wax. It is thick like a salve in the bottle so you have to warm it up to liquify it for use. My chairs just drank it up at first. Now they are just the mellow wood grain I wanted. I like that orange smell too. I have used Howards on all the wood furniture. It's great.

Conclusion

So now after this you probably think my house is clean all the time. All I can say is, call at least an hour before you show up. I just like anything that makes housekeeping easier or more fulfilling in any way.

Access

Author: Kathleen Jarschke-Schultze is probably washing more dishes right now, c/o Home Power Magazine, POB 520, Ashland, OR 97520

Oasis Biocompatible Products™, 1020 Veronica Springs Rd., Santa Barbara, CA 93105-4532 • 805-682-3449 FAX: 682-1540

Citra-Solv™, Chempoint Products, Inc., POB 2597, Danbury, CT 06813-2597 • 800-343-6588

Howard Feed-N-Wax®, Howard Products, Inc., Monrovia, CA 91016 • 818-357-9545

the Wizard speaks…
A Theoretical Breakthrough

Many people today do not believe in the concept of free energy because they think that it violates the Second Law of Thermodynamics. This law states that the energy available from a closed system is always less than the energy put into that system. I believe I can present a viewpoint of free energy that is consistent with the Second Law.

Normally energy is thought of as being produced by transforming it from one state to another. Since there is always some loss of energy in this process, it is consistent with the Second Law. Consider this concept: a latent pool of potential or virtual energy coexistent with the continuum itself. If we now use a certain amount of energy to create a system which allows this latent pool to flow in a useable form, we have free energy if there is more flow than input. This still does not violate the Second Law. The flow output is still less than the sum of the flow input plus the energy necessary to sustain the system. However, for all practical considerations, after initial startup, we are obtaining a net energy equal to the flow minus the sustaining energy. This is free energy.

I believe this is an important conceptual breakthrough. Free energy has long labored under the misconception that it violates the Second Law of Thermodynamics. I have shown that this is not necessarily so. One of the major arguments against free energy has been countered. Also, a generalized direction for research has been discovered which is consistent with the Second Law. Free energy may not be just around the corner, but it may only be a few blocks away.

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Wet Success

Have you ever wondered what it would be like to teach a workshop in a tent standing in three inches of mud and water? Have you ever wondered how much free heat a group of fair attendees can generate to stay warm in the pouring rain? In the continuing saga of wet weather during 1993 in the Midwest, the Iowa Renewable Energy Association's (IRENEW) second annual energy fair had a typical wet weekend with almost three inches of rain on the first day. As every Home Power reader knows, the Midwest Renewable Energy Fair (MREF) in Amherst, Wisconsin is the energy fair to use as a basis of comparison, but copying the weather is a bit too much!

This year's fair was a two day event with 36 workshops on Saturday and 32 workshops on Sunday, with a total of 102 hours of information. For two years in a row, IRENEW has been fortunate to have PV expert Chad Lampkin of Michigan Energy Works available for workshops and use of his state-of-the-art equipment for PV and IRENEW's Whisper 3000, installed especially for the fair. Other workshops on residential wind systems by Lake Michigan Wind & Sun and commercial wind farms in Iowa by Ty McNeil of Windway Technologies, Des Moines rounded out the wind section. (This was not an orchestra, folks, but considering the weather all acts went on as scheduled.)

Other workshops consisted of an electric car conversion by Rolland Strauss, active and passive solar design, and methane by Al Rutan, who just recently built a new working display and has moved near Des Moines, Iowa. One workshop was on Electromagnetic ecology which has a tremendous impact concerning farmers: stray voltage. Besides causing a decrease in milk production, this also affects the utility bill.

The booths and displays covered the gamut of equipment available: green goods, light bulbs, PV panels, solar panels that produced 80 degree water all day long (remember, the sun doesn't shine when three inches of rain are falling), a solar powered boat, Solar Pathfinder, a patented solar panel design that will reduce Radon in the home, Phil Manke with his display of sterling engine technology, and our own version of the Energy Cycle donated by CIPCO (Central Iowa Power Co.).

The true inspiration was that as the rain came pouring down and we started taking bets of where and when the next tent would start floating, the people came! In spite of the weather we had a bigger attendance than last year. IRENEW withstood the elements, had a bigger attendance than last year, and proved the Field of Dreams statement: "If you build it, they will come". IRENEW promises a truly unique third annual energy fair in 1994.

I would like to editorialize about Home Power, IRENEW, and energy fairs in general. Just before our energy fair, *HP*#36 arrived. I sat down to what I thought would be some serious reading, but was truly impressed with the article by Richard concerning MREF. After reading the last section (Heroes and Heroines), I remembered our purpose in life is to leave it a better place than when we arrived. Roy Rogers happens to be one of my heroes because in real life he has taught the value of a man's word and the meaning of a handshake. With nothing more than a handshake, the Cedar Rapids Convention and Visitors Bureau helped us organize our first fair. This year (1993) I feel IRENEW truly learned a lot about laws concerning wind turbines, towers, and electrical generation by RE. Our organization also did a lot of teaching to convince local inspectors that what we proposed to do was legal and safe. I feel that the city of Cedar Rapids, the state of Iowa, and IRENEW all learned a lot even before the 1993 energy fair. May other states and energy fairs prosper and learn together about the value of renewable energy. Tom Snyder c/o IRENEW, 611 Second St. SE, Dyersville, IA 52040 • 319-875-8772

Thanks, Tom. The weather just can't stop hardy, hearty, heroic Midwesterners! We can always hope for sun next year, but not rain nor sleet nor hail will stay the energy of the fair. — Therese Peffer

Not so bright idea

Regarding Kurt Nelson's Bright Idea, *HP*#36, page 99: Having scavenged a box of GV auto bulbs, I tried an 1154 on 12 Volts with the filaments in series (the bulb socket must be insulated from ground). It was real bright, for about three hours, then one filament burned out. I used it for a reading lamp — maybe Kurt's intermittent use builds up less heat and lasts longer. Now I put two GV bulbs of equal current draw in series using two sockets with no problems on 12 V — two tail or two stop/turn filaments wired in series.

Along the same line, two or three miniature clear Christmas tree bulbs in series makes a good room background light. At 3.5 V a bulb, three are OK for 12 V but dim. I like two in series for more brightness. Yes, they burn out sooner than later, but at 2¢ each who cares? Ernie Soya, KA7VIR, 44 Nota Rd, Wauconda, WA 98859

Sounds like an easy cheap solution for 12 Volt lighting, Ernie. I have a 12 Volt halogen light I am testing right now in my trailer. Not as cheap, but it's a nice light and it lasts.... — Therese Peffer, KB7WRP

Battery Research

Two chemists at Clark University in Worcerster, Massachusetts have improved the chances of having a better battery to power the electric car (EV) of the future. The latest issue of *Science* magazine, reports the finds.

The battery they are working on has a sulfur-aluminum combination, where the sulfur is the negative (cathode) side, and the aluminum (anode) the positive side. They have discovered that sulfur, an insulator at room temperature, can be transformed into a conductor by immersing it into a polysulfide solution. This is a terrific breakthrough, as batteries using sodium-sulfur have to operate at high temperature (600–700°F) to melt it, and make it into a conductor.

The battery is still in the experimental stage, but is a very promising approach to the "ideal" battery. The use of aluminum decreases the weight and both the sulfur and the aluminum are environmentally benign materials. The energy capacity could be as high as 200 Watt-hours per kilogram. The lead-acid currently in use reaches 35 Watt-hour per kilogram. The close to 6:1 improvement is an excellent one. With the lead-acid battery an EV has a range of 60 to 100 miles per charge. This means that the sulfur-aluminum battery might make it possible to extend the range of an EV to 300 miles. Hector L Gasquet, El Paso Solar Energy Association, 10909 Bill Collins, El Paso, TX 79935

Thanks for the info, Hector. All EVs need to make them everyone's favorite ride is better batteries. If this Al/S cell functions as promised, it may be the technology to set free the EV. — Richard Perez

Efficiency versus RE

Having just completed the RE "circuit" of energy fairs this past summer I stumbled upon a gem of a publication called "America's Energy Choices, investing in a strong economy and a clean environment" published by the Union of Concerned Scientists (UCS), Nat'l Resource of Defense Council (NRDC), American Council for an Energy-Efficient Economy and the Alliance of Save Energy.

This 25 page Executive Summary (a full report is available from UCS for $18, UCS Publications Dept., 26 Church St., Cambridge, MA 02238) has given me a crystal clear focus of what the next 40 or so years will look like with regard to RE and energy efficiency. If anyone has seen UCS, Donald Aitken's excellent slide presentation (I have seen it thrice and still get supercharged at all the info) on the future of RE and EE in the U.S., you'll want to get this publication.

Not to downsize the role that renewables will play in the next 40 years, I would like to stress that demand-side (the energy we use) savings potential are estimated to be 55 quads (quadrillion BTUs) versus the best RE supply side production of 32 quads. Demand-side energy efficiency will give us a bigger bang for our limited buck. After we've squeezed the last drop out of the energy rock, then spending money on renewables will be much more cost effective and practical.

I'm not raining on the RE parade, just putting into perspective where the greatest good can be found with limited funds. I would like to suggest a column in future *HP*s dealing with demand-side projects that work or good quality items to reduce the power we now consume. The sooner we can turn off the nuclear power plants through efficient use of electricity, the sooner we'll have PV panels replacing them. Mike Mangan, POB 776, Delafield, WI 53018

*Good idea for a column, Mike. We've already heard response from Richard's article on eliminating phantom loads (*HP*#37, page 46). A gentleman called and told us he'd saved $32 a year on his utility bill from installing plug strips on those appliances that draw power when not in use. How 'bout it, readers? Send HP your energy savings tips (c/o me)! A small tip: fill up your kettles at night before you go to bed. The water will be at house temperature (warmer than that coming from your tank or well) before you boil it in the morning. Every tip adds up the energy savings. — Therese Peffer*

Human Power

I became a subscriber from Michael Hackleman's Alternative Transportation News. HP looks good, keep up the good work. I am also a member of the International Human Powered Vehicle Association (IHPVA). Some of their members want to tinker with ultra-low powered gas and electric machines. IHPVA's address is POB 51255, Indianapolis, IN 46251-0255, phone/fax 317-876-9478, Mark Hack, Longview, WA

Where's Amanda

What has become of Amanda Potter? Her name does not appear on the "People" list. If one of you goes on to bigger and better things, it would be nice to read a sentence or two about them.

I am delighted that you plan to include an electric vehicle section but feel somewhat cheated that you have deliberately avoided transportation issues in the past (re Michael Hackleman) the three years that I have been a subscriber. John J. Kelly, 373 O'Connor St., Menlo Park, CA 94025

Dear John, thanks for your input. Amanda is currently working towards her teaching credential at Humboldt State University in Arcata, California. She'd like to teach physics (including PVs!) to high school students. We miss her energy — those lucky high school students! Chris Greacen still writes between classes from Bellingham, Washington, and is considering graduate school. Someday, we'll read about his research in the best science magazines, explained in ducks for the layman. Last we heard of Mark Newell, he was headed for Mexico — for some solar research, no doubt. — Therese Peffer

The Real Cost of Energy

In the long run, it would seem that the relative costs of various energy strategies ought to use the following considerations. (1) Depleteable fuels such as oil, coal, and uranium, ought to be priced at the source (as a world resource) by an amortization process using known reserve numbers and some time span less than infinity. (2) All external costs, such as pollution, transportation, transportation system hazards, societal costs, ought to be factored in at the consumption level or at some point higher. Daniel Baright, 281 North Jackson Apt #9, Lebanon, MO 65536.

Daniel, I agree. Everyone in alternative energy dreams of the day when we have a level playing field. Subsidies are OK to help something good happen faster. Continuing them as long as they have been for the non-sustainable energy sources you've mentioned pushes out good alternatives. Bruce Rawles sent me the percentages a few years ago: nuclear (38%), oil (21%), coal (18%), gas (13%), large-scale hydro-electric (5%), solar (3%), and conservation (2%). The word "shameful" comes to mind.

Despite these handicaps, solar, wind, small-scale hydro, and hydrogen are gaining. When *we give each of these sources the same subsidies the non-renewables have enjoyed for three-quarters of a century. In only 10 years time, we will have leaped into a future we can all live with! I believe this with all my heart. — Michael Hackleman*

Alaskan Power

I recently returned from my brother's cabin in southeast Alaska. I am an electrician and one of the chores I accomplished for him was wiring his house/cabin for both 110 v and 12 V operation. The next step in his energy path will be to improve his battery storage and probably invest in some kind of passive generation system. At the moment he recharges off a diesel generator, which is his only 110 v power supply.

I am a recent subscriber to your fine journal and short on experience so I hope it is all right to ask you for advice on the general direction he and the people in his region should take, and for references to more detailed explanations.

His uses fall into two ranges: those operable off his battery supply including lights, radios, and phone (a battery operated radio transmitter phone) and heavy users including washing machine and power tools.

In the winter he is reduced to only four hours of daylight so his lighting needs may be low wattage but lengthy in duration, while during the summer he receives as much as 21 hours of daylight. There is nearly continuous water supply. It is low volume but high head. He could install a wind generator next to the inlet. Winds up to 20 mph are not uncommon and a day without a wind over 10 mph is rare. Please advise. Neil McLean, 830 Treat, San Francisco, CA 94110

OK, Neil. Your brother needs a complete site survey to quantify his renewable resources. Consult the index in HP*#36 for site survey specifics. From your description, it sounds like hydro may be the way to go. Even a few gallons per minute at high head can produce substantial amounts of energy. Hydro is also on or under the the ground and has high survivability in bad weather. With 21 hours of sun, tracked PVs could certainly handle his summer time load. The problem in Alaska has always been the dark stormy winters. Wind generators must be of the heaviest type and the tower must be first class to survive the Alaskan winters. The best advice is to start slow, get some PVs up and running for the summer. Start making long term plans for hydroelectricity. — Richard Perez*

Revolutionary

Home Power is almost certainly the Dr. Dobb's Journal of a coming revolution in home & small business design. Currently, the pioneers are literally forging the first trails; soon, the nation may be following these trails to a decentralized America of small-scale towns running on small-scale, renewable power & economy. *Home Power* journal literally is "power to the people" from the only source that cannot be embargoed, rationed or used to hold a nation hostage. S R Staton, 5104 Quail Creek Dr., McKinney, TX 75070

Impact

The new magazine looks great! Thanks for all the human energy you use to make sure your production has the least negative environmental impact. I also highly approve of the "more marketable" look given *Home Power*. This info needs to be in the hands of as many people as possible. Keep up the good work. You're doing something truly worthwhile. Steve Shewmake, 10607 Bragg Ave, Grass Valley, CA 95945

Thanks Steve, This issue's interior paper uses 30% postconsumer (and here's the real plus) non-chlorine paper, finally! If you're interested in the nitty gritty details check out Magazine Mechanics on page 82. — Karen Perez

Wind Energy in Scotland

I have been reading your magazine for over a year now, and I find it very interesting. My big obsession is wind energy, which is rather a marginal area in your pages, unfortunately. I have been building and servicing wind systems since 1978, so I have a few ideas of my own to share with you.

I started out using generators (we call them "dynamos" here) from army jeeps, and many of these are still going strong, using a simple two bladed wooden propeller fixed on the pulley. Obviously, it was not easy to find slow enough dynamos, (and to make fast enough propellers). But there is a trick where you take a 24 Volt dynamo and run it at 12 Volts, halving the speed (almost). The only modification required is the wiring of the field coils, which need to be re-grouped in parallel to run at 12 V.

We get some problems with the brushes every couple of years, but basically these are low maintenance machines, ruggedly built in a by-gone age of engineering. Though hard to find these days, they cost very little, being obsolete technology. Where I find fault with my old dynamo machines now is that they are just not efficient in low winds, and here is why: to produce electrical power in any generator, you first need to provide an electromagnetic field. In the old dynamos, this is supplied by field coils, which kick up a good strong flux, as electromagnets. This requires a current flowing into your batteries. In light winds, the available power from your propeller may be only 30 watts or so. The old jeep dynamos use all that power to energise their own field, so you get nothing out. I find this frustrating.

People who have lived with wind turbines will know that there are often times when the wind is not very strong, and the batteries are getting low, and we want every ounce of power we can get. To me, this means that for stand-alone systems (not so much for utility inter-tie) the efficiency in low winds is the most critical factor of all.

The solution to the problem? Permanent magnet alternators. Permanent magnets eat no current, they just *are* magnets, full stop. Admittedly, there will be other losses in the generator at low speeds — friction mostly, some magnetic drag maybe, if there is iron in the stator. Losses in the main windings are minimal because at low windspeeds, the current is also low, and these losses go with the square of current. So, permanent magnet alternators are very good converters of wind energy when it is at its most scarce (and precious).

I reject the idea that there is more magnetic drag in permanent magnet alternators than there needs to be. Marlec machines have none at all since they have no iron in the stator. Bergey and Whisper machines have some drag, but this is only a problem in very light winds, when no wind turbine can produce power. There is no gain from a propeller spinning freely because there is no magnetic drag: without magnetism, you get no output either! Once started up, it doesn't make any difference whether your magnetism comes from coils or ceramic magnets, you need magnetism, and this will result in some small amount of drag.

My big problem with permanent magnet alternators has been finding affordable ones. For a while it seemed like the only way was to get secondhand windmills and re-use their alternators! Now I have finally produced a design for building one from scrap vehicle parts (notably) brake-drums), which work very well. I am getting this design down on paper so others can use it, if they send me a few pounds.

Not everyone wants to build their own wind machine. There are plenty on the market, but it is important to find one which can survive on your site. Here on the Scottish coast, we get some fairly heavy winds, and not all wind turbines pass the test. Like Mick Sagrillo, I believe that plenty of tower top weight on a wind machine is a sign of quality. Heavy components are stronger, vibrate less violently, and last longer. A good weight of copper in the windings will carry the output power with less losses. A good weight of magnets in the rotor will allow power production at low rpm, keeping wear, noise and vibration to a minimum. The only parts which need to be light are the blades, since their weight creates all sorts of centrifugal and gyroscopic loads, which tend to tear the machine apart.

We are very lucky here in Scotland, that we now have our own windmill manufacturer, Proven Wind Turbines, who build a 2.2 kW machine as rugged as a locomotive. The wind turbine weighs 450 pounds, but the blades are lightweight polypropylene. They regulate their own speed to a smooth, quiet 300 rpm, using a simple pitch governor which has stood the test of ten Scottish winters. The Proven WT2200 is not yet available in the USA, but when it is, I believe it will make a big name for survival and efficiency. Keep up the good work! Fair winds to you all, Hugh Piggott, Scoraig Wind Electric, Scoraig, Dundonnell, Ross Shire, Scotland IV23 2RE

Hugh, You are obviously a guy who's been at it for a while. You've done your homework!

I don't completely agree with you on permanent magnets (PMs). While PMs are not cheap, they are considerable less expensive than winding the field with copper wire. The problem with PMs is that the magnetic field, or flux density of the magnets, is always the same, no matter what the wind speed or blade rpm. PMs have the nasty habit of stalling the wind generator's blades at low wind speeds. It is not unusual for a PM alternator to require as high as an 11 mph (5 m/s or meters per second) wind to start the blades running. Once moving, the blades will usually continue running down to a 7 or 9 mph (3.5 m/s) wind, and produce a little power. But it is very little power.

It is true that a dynamo with a copper wire wound field wired in parallel with the armature is parasitic. That is, it is drawing off some of the power that is being produced by the wind generator. This is taken into consideration by the designer. A wind generator that peaks at 4000 watts that has a field draw of 200 watts is actually producing a total of 4200 watts.

However, because a wound field draws very little at low wind speeds, a generator will actually produce more at those low wind speeds than a PM generator, with its fixed maximum flux density. If you take a look at the power drawn, and therefore the flux density, of a copper wire wound field that is run in parallel with the armature and the corresponding power curve of the dynamo, it very closely corresponds to the curve of power available in increasing wind speeds. This can't be said of PM alternators.

I very much like the idea of building a wind generator around an automotive brake drum. It's a great use of materials that everyone has at hand. Fifteen or so years ago, there were actually several manufacturers that offered wind generators built around a brake drum and axle spindle, using PMs. Unfortunately, they are all long gone. I have never seen plans detailing such a wind generator. I would strongly encourage you to experiment and share your results with readers. After all, that's what home power and Home Power are all about. By the way, be sure to convert pounds to dollars. — Mick Sagrillo

RE in Europe

On my recent trip to Europe, I was delighted to see many new solar electric and hot water installations in use everywhere. I've enclosed for you a picture of a large photovoltaic installation I spotted in the Austrian Alps. The solar-powered souvenir shop and restaurant is located at an elevation of 8000 feet atop the Edelweiss Mountain, the high point of the spectacular Grass Glockner Alpine Highway. I also saw many unique electric cars being used in various towns in Austria and Switzerland. It is exciting to see the progress being made in solar technology! Jay Wilson, 7323 20th Ave NE, Seattle, WA 98115

LEDs

One note on your article about using red LEDs in flashlights. Hosfelt Electronics (1-800-524-6464) part#25-239 is a 10 mm red LED rated 1.8 VDC, 20 mA, 7000 mcd. I just refitted two flashlights using this LED and it seems to be the same brightness as you described in your article. The price is $2.99 without the requirement of buying a case of 10 as your source requires. Chris Soler, 368 Colony Rd, Bow, WA 98232

Good deal, Chris. It's great to see more sources for these flashlight bulb replacements. My LED replacement is still on the same set of batteries after over six months! — Richard Perez

First Time

First time I saw your mag was two weeks ago at a bookstore. Where have you been? Would like to see diagrams of complete PV systems for home power use from solar panels and trackers up to inverter to what type of switch and plugs to use. Who offers the best package deal with room to expand as funds permit? I have recently paid $5290 to Tucson Electric Power (our local power bandit) for a line extension of less than 700 feet. I don't meet the requirements for 500 feet free as there's no house or septic, etc! I am also interested in any way of recouping some of my funds somehow. Would like to stay and shoot the shot but have to go to work so I can pay my electric bill! Rick Hannamn, POB 243, Vail, AZ 85641

Hi, Rick. There are three complete wiring diagrams in this issue. Look at your new line extension this way — as soon as you have enough PVs up, then you can sell power back to Tucson Electric! — Richard Perez

Quadlams

In *HP*#37 "PV in the City", a PV array using QuadLams was observed to provide about twice the maximum current in the winter than the summer. This was true with my three sets of QuadLams. But what was increased was the charging voltage (up to 22 Volts) not the charging amperage available to the batteries. Remember when TriLams were causing voltage drop problems in hot climates? A set of TriLams in the northeast didn't have a significant decrease in power since our summers are cool. To take advantage of this, and avoid oversizing my PV array to compensate for our decreased solar exposure in winter, I have my three QuadLams wired as four TriLams. They provide extra amps in winter when it is needed; and during those two or three hot months in summer, the decrease in power doesn't matter since we have more sun time available to make up the difference. Chris Ryan, Murtagh Hill RD, West Cazy, NY

You're right Chris. If your climate is cool, then the voltage at the TriLam's maximum power point may be high enough to effectively recharge your batteries. If however the Lams are hot (ambient air temperature above 80°F), then the voltage of the maximum power point drops radically. Then four series modules are needed to do the job that was done by three Lams on a cold day. — Richard Perez

Dear Home Power:

More than a dozen people have called, faxed, or written me, and asked me to challenge a pullquote used in an article by Paul Hawken, A Declaration of Sustainability in the *Utne Reader*, Sept/Oct 93. It read: "Gas guzzlers are harder on the environment that electric cars. Right? Wrong! A conventional car creates 26 tons of hazardous waste for every ton the vehicle weights. A battery-powered automobile produces twice as much — 52 tons, including a witches' brew of lead and toxic acids." I drafted the following letter and sent it to the editor of the *Utne Reader*:

Dear Editor, Utne Reader*: Paul Hawken's A Declaration of Sustainability (Sept/Oct 93) is a remarkable work. However, the comparison of the relative proportions of hazardous waste generated by gas guzzlers (26 tons) and electric cars (52 tons), emphasized by a pullquote (pg 57), is myopic and misleading. This examines only the* production *of a car, whereas it is the merit of the total* life cycle *of a product — produce, use, and recycle — that allows us to make good choices.*

The bottom line is: A 30 mpg vehicle with ICE (internal combustion engine) propulsion consumes three times the resource (same BTUs of oil and coal) and produces 15–20 times the air pollution of the same vehicle equipped with electric propulsion to go the same mile. This is the reason that California has mandated that 2% of all vehicles sold in California in 1998 by any auto manufacturer must be ZEV (zero emission vehicles). Only the electric vehicle qualifies as a ZEV.

Lead is *toxic. In the lead-acid EV battery, the lead is totally contained and is not consumed. The "acid" is so weak it takes 24 hours to eat cotton clothes. Finally, there is already a recycled industry for lead, which is strictly regulated. The only "opening" in the cycle is when people dump batteries into landfills, a habit unlikely to occur with a larger and more expensive EV pack.*

The manufacturers of high-performance, lightweight EVs rarely mix as many materials or produce the kind of waste a major car company generates. Ninety-five percent of the EVs in the USA were built by individuals. These EV enthusiasts know that most ICE-cars make poor EVs. They're grossly overweight and hardly aerodynamic.

Many of us await a sustainable solar-hydrogen future. On this planet, solar energy and water are abundant everywhere. There is more power in one day's sunlight falling on the earth than humankind has consumed in its entire existence. Hydrogen and oxygen extracted from water by solar energy and fed to a turbine or fuel cell "makes" water again, extracting electricity in the process.

If the U.S. government subsidized the evolution of this technology at a fraction of the rate it aids nuclear power, we'd be there tomorrow. Lack of political will and ignorance are the only roadblocks. In the meanwhile, the pure electric car and electric rail — both able and ready to receive fuel cell technology — are the clear winners in the transition to clean transportation. — Michael Hackleman

An open letter to Home Power Magazine and Independent PV Power Producers:

As many of you know, my family lives in an off-grid home powered by PV. I have talked and worked with many of you over the years on how to solve your and my PV problems. We here at SWTDI test and evaluate many PV products including modules, charge controllers, and inverters. We also work with the PV Design Assistance Center at Sandia National Laboratories, U.S. Department of Energy, the Electric Power Research Institute (EPRI) in Palo Alto, CA, Underwriters Laboratories, and several utility companies around the country. We are members of the American Solar Energy Society, International Solar Energy Society, Solar Energy Industries Association, Institute of Electrical and Electronic Engineers, and the International Association of Electrical Inspectors. I hope this background gives me some insight into all areas of the PV industry.

These are my feelings on the issue of utility involvement in off-grid PV not only in California, but across the country. Remember, feelings are neither right nor wrong, nor good nor bad — they just are.

Literally, all areas of off-grid PV power are being examined and used by electric utility companies throughout the country — with and without the participation of the Independent PV Power Producer (IPPP). I feel that continuing delay on the part of the IPPP will cause their greatest fears to be realized. They may indeed be left out of the off-grid market that they have so carefully nourished over the last 12 years or so.

Off-grid PV power systems are being installed all over the country by utilities, and the pace is increasing. EPRI has had an ongoing “Niche Market” PV program for several years and it has been presented to nearly every utility in the country. It shows, and has demonstrated with actual PV installations, that PV power is cheaper than extending or maintaining the grid for small power customers. Numerous utility companies are installing off-grid stock watering ponds, bill board lighting systems, traffic counters, remote communications systems, solar resource monitoring systems, water metering systems, etc., etc., etc. Many of these systems are being installed by the local PV dealer or “expert”, while some are being installed by the power companies themselves.

Off-grid residential power systems are being investigated and installed by utility companies and the number is growing. In addition to PG&E, several power companies are building and demonstrating off-grid residential power systems. The most active utilities in this area are Idaho Power and the New York Power Authority, but others are getting ready including Southern California Edison. Several utility companies have state-of-the-art designs on file for off-grid residential systems that can be custom tailored to virtually any requirement. In some cases local IPPP have designed, developed, and installed these systems for the utilities; in other cases, the utilities have used in-house talent.

The utility companies can look to the IPPP for expertise or look elsewhere. Since the IPPP has far more experience in designing and installing off-grid residential PV power systems than any utility, it appears reasonable that the IPPP could team with the utility to provide that expertise. However if the IPPP continues to delay the decision to participate with the utility, the utility has other options. There are a number of System Integration Houses in the country that have considerable experience in off-grid residential systems. They include, Solar Engineering in Washington, Remote Power in Colorado, PhotoComm in Arizona, Integrated Power in Maryland, Ascension Technology in Massachusetts, and Northern Power in Vermont, among others. These PV installers have installed numerous residential and non-residential PV systems all over the country and all over the world.

The PV module and manufacturers realize that the utility companies are their ultimate market. PV modules are being manufactured and sold at near break-even prices or at a loss. Little of the years of research and development costs have been recovered or are being amortized in the current cost of PV modules at the factory. The PV module manufacturers are, for the most part, being subsidized by large oil companies, international conglomerates, or expectant stock holders. These backers are hanging in there, with year after year of red ink, not because of the IPPP market (which after all pays the salaries of the employees), but with the expectation that any day the utilities will move into the market to buy gigaWatts of PV modules for bulk-power generation.

The utility presence and expertise may provide a boost to the PV market and the IPPP. The utility companies, with marketing and education departments, line and equipment maintenance, appliance sales and service, and a long-long history of working with the consumer are a visible and familiar presence throughout the country. They are even known in off-grid areas through appliance sales and advertising. It has been said that the utility van goes up the road every day while the Sears service truck is seen only once a month. Who even knows what the IPPP vehicle looks like?

An IPPP/Utility Team may yield financial benefits. Although the sun represents a free power source, there are costs associated with converting that power into a usable form. While the typical IPPP may enjoy a highly desirable "quality of life", the profits in the IPPP arena do not allow for the same "standard of living" realized by utility employees in similar jobs. Utility companies will maintain their normal profit margins in dealing with PV. The IPPP teaming with the utility can share in this higher profit margin and begin to put our PV industry on a firmer financial footing.

Yes, I also want to be in control of my future and I want to make my own power. This country has been built through the efforts of the small independent Capitalist and even the small independent idealist. However, I feel that the PV industry and the IPPP will both benefit in very substantial ways with a merging of talents. Certainly, an IPPP can choose to remain truly independent from all utility involvement and serve a few likewise minded customers. But, I feel that neither the PV industry nor the IPPP will benefit in these sorts of activities on a long-term basis. The IPPP who wants to progress and see the PV industry advance, can no longer delay in this almost certain process. He or she who hesitates is lost. Sincerely, John C. Wiles, Research Engineer, Photovoltaics, SWTDI, Box 30001, Dept 3SOL, Las Cruces, NM 88003 • 505-646-1846

John, IPPP folks have been providing PV service for years to folks the utilities have totally ignored. Why do the utilities absolutely have to jump into off-grid with its miniscule market rather than encouraging on-grid, customer-financed applications? Once you eliminate the obvious factors of greed and consolidation of power, it makes no sense. Idaho Power, which you state is the "most active" utility providing off-grid PV, installed a total of THREE residential systems in the past year. IPPP folks in Idaho alone do far more than that every month. I can't even FIND anyone at New York PA who knows what they are doing off-grid. This kind of involvement is going to stimulate PV manufacturers to the gigaWatt level? I don't think so.

IPPP folks have brought the solar electric industry to the point of viability and reliability that it enjoys today. You have been a part of that process. Without our purchases and inputs, there would be darn few PVs and components. — Bob-O

Q&A

Phantom Loads

I enjoyed your article on phantom loads (HP#37). I, too, have never understood why a clock has to come with every appliance. And I can't stand the idea of unseen, unknown electronic "creatures" gobbling up electrical power at my expense!

My question is this, can turning off and on the power supply to some appliances damage them? I am concerned primarily with satellite equipment. As you know, this equipment is expensive, and my serviceman says that he has experienced problems if the equipment is shut down intermittently. Is this true or is his reasoning incorrect? What about cordless telephones?

PS: Am I an oddity here in Kansas? How many other subscribers here? Steve Wingerson, RR1 Box 58, Gaylord, KS 67638

Satellite TV gear generally doesn't mind being powered down when not in use. Most satellite systems use a heater in the LNA or LNB (located out on the dish). If the system is powered down, then it may take up to 30 minutes to warm up a deliver a perfect picture. There are many types of systems, so be sure to inquire about your specific make and model. Ask the equipment's maker. If you are using encrypted services, then you may have to leave your system powered up all the time. Consult with the provider of the service and the maker of your decryption "black box". On cordless telephones, no problem with powering them down. No damage will result, but the cordless phone is inoperative and not recharging the handset's battery. — Richard Perez

Looks like about 40 current subscribers out there in Kansas, Steve. Bookstores in Topeka, Hutchinson, Overland Park, and Wichita carry HP*, so perhaps we'll see more in the future! — Therese Peffer*

State of Charge vs Voltage

First, *Home Power* is the greatest. I have to admit that some of the stuff is not for me, but in general you guys do a great job. I was looking back through old back issues for more information on the battery charge vs. voltage problem, and realized what a slick and fancy magazine you have become. I hope success does not spoil a good thing.

I am writing to be sure that I really understand the charts on page 67 (*HP*#36) regarding batteries under charge. I have 24 cells of 2 V each and 500 Amp-hour rating. They are wired 12 in series and then those two sets in parallel for a 24 V system.

We have a Harris Hydro that will just about maintain us for most of the year, but when I charge I use a 4500 watt gasoline generator via my Trace 2524 with a built in charger. It shows a charge rate of 25 Amps, am I correct to use the C/20 line on your chart? Does this mean that if I hold my batteries at 28.4 V that I have 100% charge? Once I get to this level, is there any advantage to charge them further? Thanks for taking the time to answer this for me. Chuck Carelton, POB 75, Mosca, CO 81146

Hello, Chuck. You should be using the C/40 line on that chart. Your battery has a total capacity of 1,000 Ampere-hours at 24 VDC (you have two strings of 500 A-h. in parallel). A C/40 rate is then 1000 Ampere-hours divided by 40 hours, or 25 Amperes. Your battery is full when they reach about 28.5 VDC at the C/40 rate. It is a good idea to give the battery a 10 to 15% overcharge on a routine basis (every second or third cycle). All the cells within the battery must be routinely restored to the same state of charge. The only way to do this is by overcharging and equalizing charges. — Richard Perez

Power in the Wind

I have a question for the electric car people. One day I was driving down the road and I put the propeller section of an electric fan out the window and it spun like crazy! Why couldn't an electric car have a lightweight fan out in front that was hooked to a generator in order to recharge the battery as you drive along! Seems that you are creating wind while you drive anyway. Thanx, Dan Price, Box 109, Joseph, Oregon

Dan, I'm so glad that you asked this question! It is asked of me everytime I do workshops on windpower or electric vehicles. It has several other "faces", such as putting alternators on the wheels of the car, or a generator on the rear axles with a motor on the front axles.

The answer to these questions is very simple: it takes power to make power*. This was one of the* first *mistakes I made when I started doing windpower, and I embarrassed myself considerably in an article in* The Mother Earth News *as a result. What I didn't understand was that as soon as you try to take power from that spinning propeller (as mechanical motion or electricity), the propeller will slow down* and *so will the car! The wind moving quickly by a car is a* result *of its motion and speed. Power was consumed to achieve this motion. A windmachine, then, would represent considerable drag, which would take even more power to overcome.*

Attaching a generator to the unpowered wheels in a car has the same effect. An electric vehicle equipped with regenerative braking (see article this issue), for instance, turns its motor into a generator when activated. This puts some electricity back into the batteries but more importantly, it slows *and* stops *the car, too. What has happened? The process has extracted useful energy from the car's momentum. Because of mechanical and electrical losses that occur when energy is converted or transferred, the energy recovered is only a fraction of the amount originally consumed. So, if you could get 30 watts from your little windmachine, the car's battery pack would have to deliver 100 watts to maintain the same speed for the car, or the car will slow down.*

Does this make sense? It's the reason that perpetual motion doesn't work. Energy can't be created or destroyed, but it can be diverted as heat, or sound, or vibration — all less useful forms than the one we might want to achieve. — Michael Hackleman

All Terrain Electric

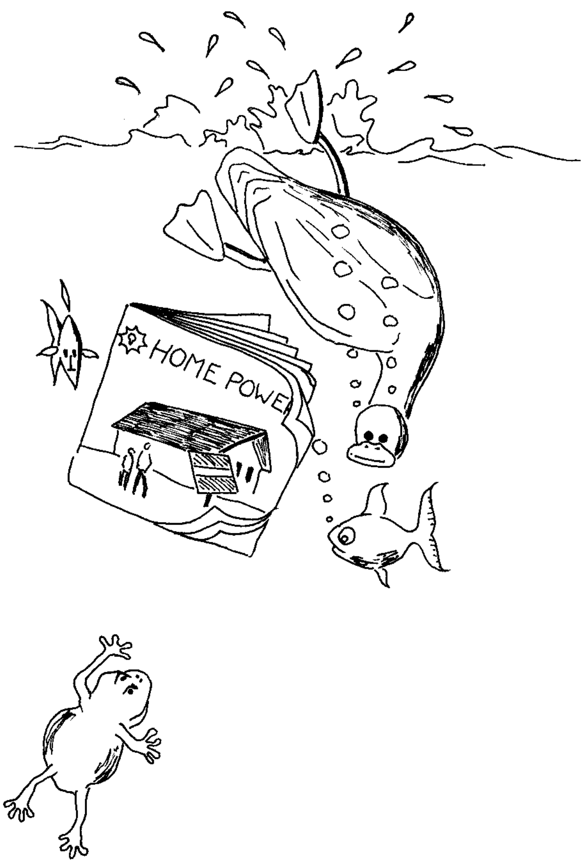
I am interested in adapting an All Terrain Vehicle to use as a small tractor and general yard and garden helper. Do you think it is feasible? I am considering trying to locate a G.E. electric tractor but I thought I might be able to find an older ATV easier. For my application, the ability to carry tools and tow a small trailer would be the majority of the work load. William Peyton, #57882-065PO Box 5002, Unit 5, Sheridan, OR 97378

Dear William, An electric "mule" for garden, yard, and farm work is an ideal application for a farm, house, or business. Electric motors have considerable torque, available at low rpm, eliminating the need for a clutch. I have seen many such vehicles. Jonathan Tennyson (Hawaii) and Phil Jergenson (Willits, CA) have built them. Some are scratchbuilts, and others are modified vehicles, like golf carts, tractors, and even ATVs. If there's no place onboard to put batteries, put them in a little trailer and attach them to the rear.

Incidententally, my first electric vehicle was just such a critter. We called it OX. A major discovery was that it was, first and foremost, a mobile battery pack! At the time, my farm used 32 VDC (power from our pre-REA windmachines) and I could plug my 32 V tools drill or Skilsaw directly into OX. Or use my old vibrator-type 32 V, 200 Watt inverter to power my electric typewriter. I wrote part of several of my books in some peaceful meadow in the mountains. Wherever I could drive OX, I had power.

Scout around for the G.E. tractors. Run ads in papers and check out garden equipment stores for them. Expect to install your own motor. The 1½ horsepower stock electric motor found in most golf vehicles, carts or cars, are ample. Put some knobbies on for more ground clearance, shave off half the weight, increase the voltage a bit and, presto — you're quietly off the road. — Michael Hackleman

Contact Fran-Mar Alternative Energy and Kansas Wind Power for information on electric tractors (see ad index on page 112 of this issue). — Therese Peffer



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