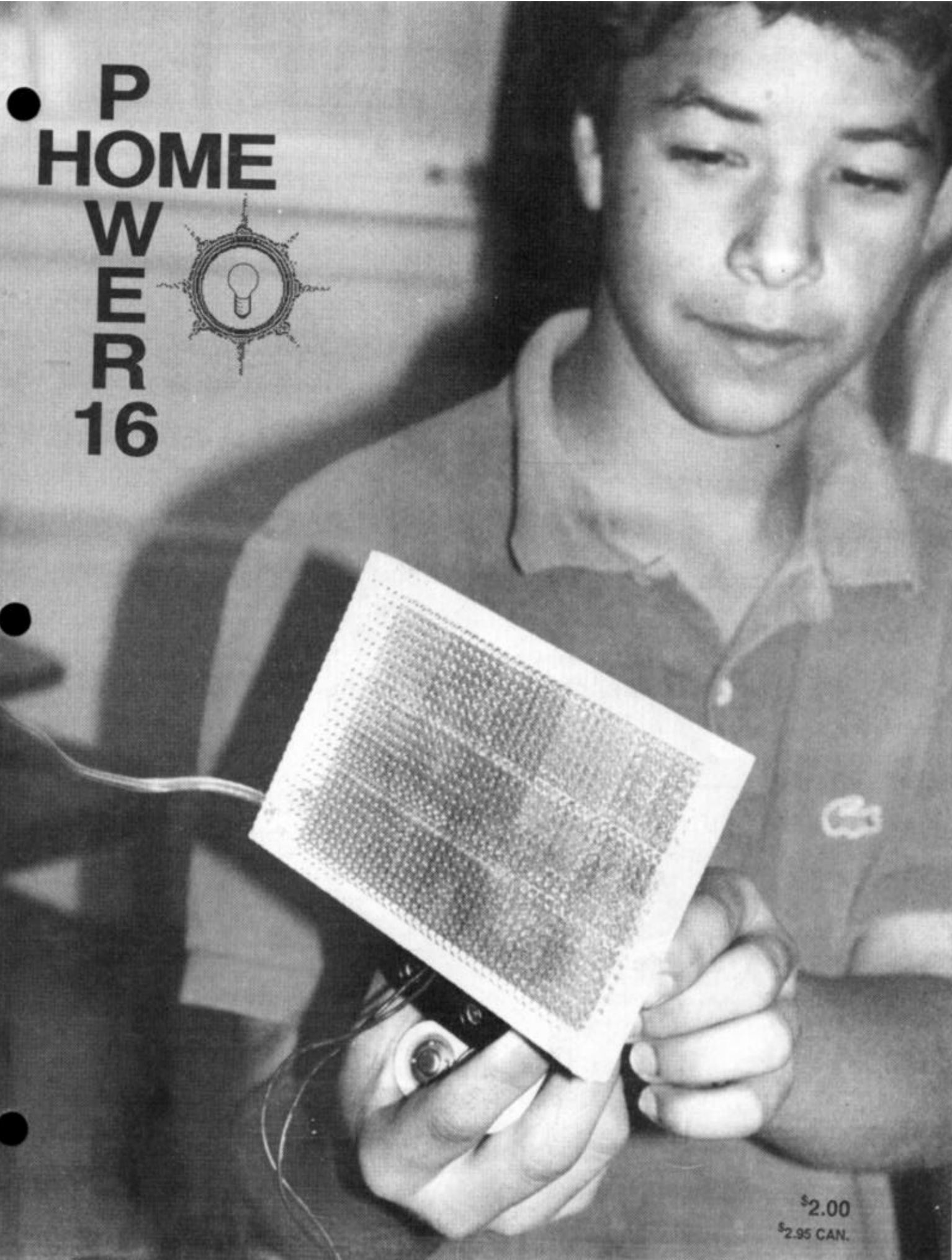
HOME POWER 16



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Home Power

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Think About It

"The worst mistake is to do nothing because you can only do a little."

Edmund Burke. 1729-1797

Cover

Stefan Barney holds his almost-finished solar charger for two C nicad cells.
Article on page 14.

Photo by Aubrey Evelyn

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From Us To YOU

Accept Our Thanks

When we realized a few months back that we'd have to start charging for subscriptions, we didn't know how many of you would come along, and how quickly.

The flow of mail since last issue has been a springlike torrent. Noble Karen, chief data entry being, has been kept nose to the Mac. This first paid-for issue goes out to over 5000 subscribers. Thanks.

* * *

A special thanks to all the good folks that not only subscribed, but also made donations, bought T-shirts, back issues, and did what they could. We salute you!

* * *

Advertisers have also been great. Thanks for sticking with us through thick and thin. With subscriptions and ads, this issue is solidly in the black. Hooray!

* * *

April 22 is Earth Day. The Home Power Crew will be celebrating Earth's renewal from Mt. Shasta, California. Participate in your local Earth Day festivities! Call Pauli at 916-938-3556 for info on the Mt. Shasta event.

* * *

I try to embrace all of experience. But I especially embrace spring. Great stuff happens in the spring.

* * *

Spring is quite a time, isn't it?

Spring is a time to give thanks for surviving the winter past.

Spring is a time for gardening.

Spring is a time for dreaming.

Spring is a time for building.

Spring is a time to marvel at the regenerative powers of life.

Spring. I love spring.

SK & the Home Power Crew

Selections from the "Spring" Section of Walden

Henry David Thoreau

One attraction in coming to the woods to live was that I should have leisure and opportunity to see the Spring come in. … Fogs and rains and warmer suns are gradually melting the snow; the days have grown sensibly longer; and I see how I shall get through the winter without adding to my woodpile, for large fires are no longer necessary.

At length the sun's rays have attained the right angle, and warm winds blow up mist and rain and melt the snow banks, and the sun dispersing the mist smiles on a checkered landscape of russet and white smoking with incense, through which the traveler picks his way from islet to islet, cheered by the music of a thousand tinkling rills and rivulets whose veins are filled with the blood of winter which they are bearing off.

The change from storm and winter to serene and mild weather, from dark and sluggish hours to bright and elastic ones, is a memorable crisis which all things proclaim. It is seemingly instantaneous at last. Suddenly an influx of light filled my house, though the evening was at hand, and the clouds of winter still overhung it, and the eaves were dripping with sleety rain.

A single gentle rain makes the grass many shades greener. So our prospects brighten on the influx of better thoughts. We should be blessed if we lived in the present always, and took advantage of every accident that befell us, like the grass which confesses the influence of the slightest dew that falls on it; … We loiter in winter while it is already spring.

Home Power Powers Home Power

Richard Perez

We've been publishing data for years now about renewable energy use in small systems. In almost every case the system was residential- a home. Many renewable energy systems also power businesses beyond the reach of the commercial electric grid. The electrical system that powers this magazine is a good example. These systems offer back-country business users the ability to make a living in their remote homes. No commuting time & expense, fixed power cost, and far cleaner and more reliable power than can be purchased from the commercial electric grid are all advantages that renewable energy offers the rural business.

Can a Business exist without the Power Company?

You bet it can. Home Power Magazine is living proof. In our case, the nearest grid electricity is over eight miles away. Our choices here were few: 1) pay the Power Co. over $300,000 to run in the lines, 2) commute at least 50 miles daily (16 miles of which is over some of the nastiest, muddiest, stickiest, roughest, truck-killing roads anywhere), OR 3) make our own power. We opted for the freedom and the business edge that home-made electricity gave us. We could work in our home, which was already paid for, and also avoid the high cost of commuting. Both rent and transportation are very real expenses for any backwoods business. A byproduct of working at home is time- time saved by not commuting, time saved in vehicle maintenance, and time saved because what was needed at the moment wasn't somewhere else.

Home Power Magazine is information. We deal with ideas, words, pictures and drawings. The tools of our trade are computers. We correspond with many other backwoods businesses that produce a fantastic variety of products and services. We know personally of renewable energy powered businesses that make wood products (everything from furniture to complete houses), run resorts in remote places, make audio/video equipment, build hydroelectric or wind turbines, manufacture electronic controls/instruments, run direct mail sales, do blacksmithing, provide investment counselling, write/sell computer programs, raise herbs, make soaps, manufacture toys, and many artists, handicrafters & writers. The point is that American small business is thriving in the back country, and doing so without the pollution and expense of commercial electricity. The renewable energy systems powering these backwoods businesses have one major advantage- they put bread on the table and beans in the pot!

We moved to the Oregon outback in 1970 and immediately went into economic catharsis. All our skills were city skills. Karen took odd jobs punching cows for the neighboring ranchers (she loves horses) and worked short order cookin' at the local bistro. I made/sold fancy knives, pimped electrons for the neighborhood CBS network television station, and planted trees. We grew a garden and got by as best we could. Over the years, we learned to adapt our skills and were able to survive without leaving our beloved mountains. Our neighbors saw what we were doing for electricity, and before we knew it, we were in business providing power systems for others. Our turnkey renewable energy business, Electron Connection, and Home Power Magazine now keep us in grits. We don't have to leave the mountains to join in the feeding frenzy of corporate weaseldom.

Many folks making the transition to the back-country have one major question- where do you find a job? Well, this article seeks to encourage us all to follow our noses, look deep within ourselves, find out what we REALLY want to do, then DO IT! The miles of back country between ourselves and the rest of America are not an insurmountable barrier to creating our livelihoods in beautiful and natural places. Running one's own business from a remote location offers many advantages and three common problems: 1) no electricity, 2) no communications, and 3) difficult transportation. This article offers solutions to no power and no telephone, and sadly, no real solution for the difficulties of backwoods transport.

Electric Tools in the Outback

Our system uses computers as the primary tools. Other businesses will use other tools. And chances are that these tools will require electrical power. The differences between systems are only those of proportion, the basic approach to producing, storing and using the electrical power is the same. A wood working business will rely heavily on electric motors, and would require more energy hardware to supply the power. An electronics business would use smaller amounts of power for items like instruments, soldering irons, etc. and require less energy hardware.

Using computers to illustrate what is possible in a remote business is very representative. The computer is the greatest work amplifier ever created by man. Micro computers give any small business the edge it needs to gracefully survive. In fact, it was our need to computerize that finally led us to buy our first inverter.

Using Computers & Peripherals in Home Power Systems

Computer equipment is usually a very moderate electrical consumer. For example, all the equipment we use (and there's a pile of it) consumes less electricity than the average American deep freezer. Computer use is most of the work that we do here at Home Power (that and screwing PVs onto roofs). We use our computers for everything: our subscriber databases, word processing articles/letters, illustration, keeping the books, running mathematical electronic circuit simulations, specifying PV energy systems, keeping track of inventory, printing the mailing label on every copy of HP, composing/printing the page layout masters for an issue of HP, and myriad other information type tasks.

To Invert or not to Invert?

We have direct experience with many brands/types of computer gear, almost all powered via inverter. The sidebar gives specific data on computers that are known performers on the inverters used in renewable energy systems. Bottom line is that computer power supplies are much more rugged and carefully designed than the average piece of consumer electronics- a VCR for example. As such, computer hardware generally has no problems digesting the modified sine wave power produced by inverters. We considered

Karen edits articles and maintains our subscriber database on the Mac SE. Photo by Laura Flett.

Richard at work on the Mac IIcx doing writing, illustration, editing and page layout . Photo by Laura Flett.

modification of our equipment to direct 12 VDC operation, but this idea was too costly and offered many pitfalls in future compatibility and utility. The main problem area in 12 VDC conversion is the computer's display. In the case of our Mac SE, the display is a built-in Cathode Ray Tube (a CRT, just like the one in a TV). CRTs require high voltages (anywhere from 0.6kV. to >25kV.) for operation. A 12 Volt TV set contains a micro inverter which makes the required high voltages for the picture tube. Construction of such a micro inverter to retrofit the Mac SE is simply not practical. Some computers use external displays, and in many cases, a regular TV set. The digital electronics used in computers already run on low voltage DC and are easily adapted to 12 VDC operation. The same is true of most floppy and hard disk drives, and many printers. The downside of 12 Volt conversion is interconnection and incompatibly between the computer and peripherals like printers, modems, scanners & hard drives. While peripheral or computer may function fine individually on 12 Volts, the combination of devices may not function together. We also considered a variety of "portable" computer hardware. In most cases, the portable equipment offers less computing power/utility at a higher price. The most cost effective and versatile path for computer application in home power systems is to use an inverter. This allows wide compatibility with all hardware, especially third-party peripherals.

INVERTER COMPATIBLE COMPUTER EQUIPMENT

Manufacturer	Category	Model
Amdek	Monitor	B&W Video 300
Amdek	Monitor	Color I
Apple	Computer	Apple II+
Apple	Computer	Apple IIc
Apple	Computer	Apple IIe
Apple	Computer	Mac 129K
Apple	Computer	Mac 512K
Apple	Computer	Mac II
Apple	Computer	Mac IIcx
Apple	Computer	Mac SE
Apple	Computer	Mac+
Apple	Hard Drive	20 SC External
Apple	Hard Drive	20MB Internal
Apple	Hard Drive	80MB Internal
Apple	Monitor	TwoPage Display
Apple	Printer	ImageWriter I
Apple	Printer	ImageWriter II
Atari	Computer	Model 800
Atari	Computer	SC1224
Commodore	Computer	Amiga 1000
Commodore	Computer	C-128
Commodore	Computer	C-64
Commodore	Floppy Drive	1541 External
Commodore	Floppy Drive	1571 Internal
Compac	Computer	386 PC Clone Portable
Epson	Printer	MX80
Hayes	Modem	1200 External
Hewlett-Packard	Printer	DeskWriter
IBM	Computer	286 AT
IBM	Computer	Model 386
IBM	Computer	XT
Jade	Computer	286 PC Clone
Jade	Modem	2400 External
Kaypro	Computer	Model 10
Kaypro	Computer	Model 4
Leading Edge	Computer	8088 PC Clone
Seikosha	Printer	SP-1000AP
Tandy	Computer	128K
Toshiba	Computer	Model 1000
Xerox	Computer	Model 82011
Zenith	Computer	2f117142
Zenith	Computer	ZFL181-92

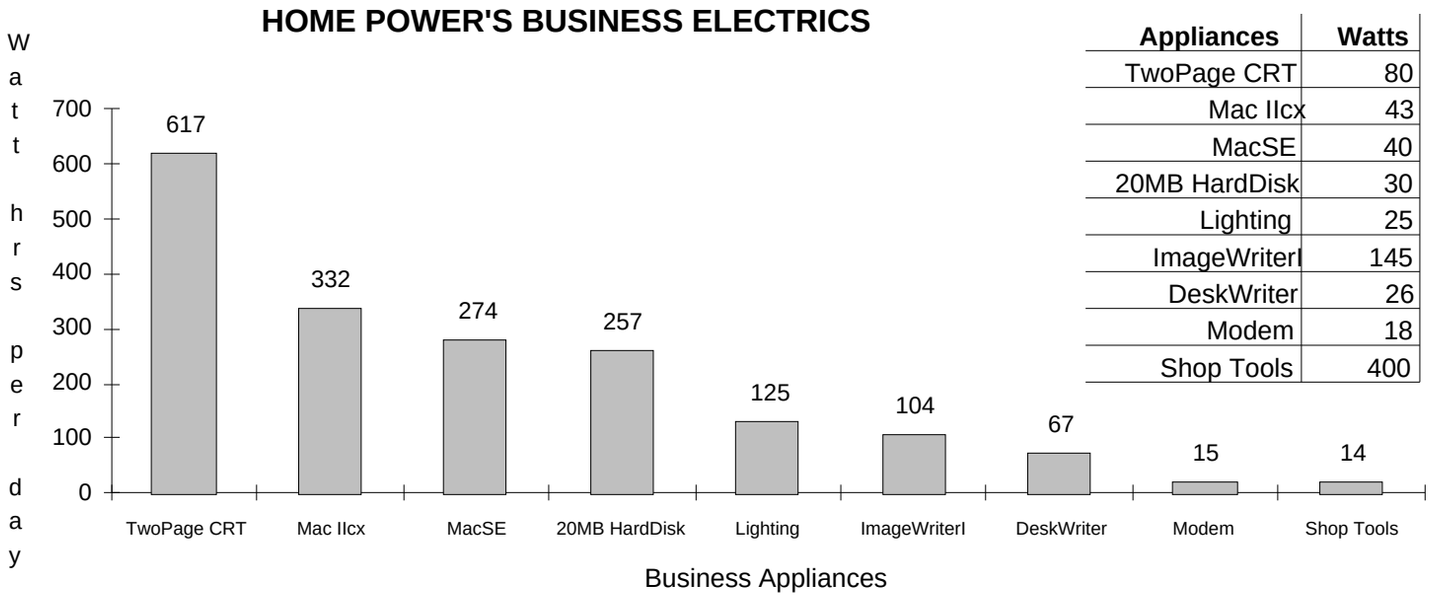
Home Power's Computers

The computer equipment we use is detailed in the chart to the right. This chart shows the average daily power consumption of each piece of computer gear. We are using Macintosh™ computer equipment made by Apple®. We're into desktop publishing and this equipment runs the hottest software currently available for our particular needs. Total power consumption of all this computer

hardware is about 2,000 Watt-hours daily. The computers listed here run an average of ten hours daily, six days a week. The major power consumer is the large "TwoPage" display for the Mac II. This Cathode Ray Tube (CRT) monitor is Black & White with a diagonal measurement of 21 inches. According to Apple it consumes 100 watts maximum. Our instrumentation shows the monitor consuming slightly less than 80 watts (measured as 12VDC input watts into the inverter by a Fluke 87 DMM & 0.001Ω shunt). Power consumption of CRT displays is directly proportional to the display's size. The bigger the picture tube, the more power it uses. We thought long and hard before getting the big screen. We balanced display cost, power consumption, and utility. Since we do a lot of desktop publishing, the large display has really increased the effective speed and utility of the Big Mac. In our case, the large display is worth its additional power consumption and cost. The Mac IIcx contains an internal 80 MegaByte (MB) hard disk drive and 8 MB of Random Access Memory (RAM-electronic memory). This is our main machine and has no trouble digesting Home Power's over 20,000 record (>2.8MB) database or producing the page layouts of this magazine (>1.8MB). The Mac SE contains a 20 MB hard disk and 2.5 MB of RAM. The SE is primary used for editing/writing articles, doing illustrations, and subscriber database entry. The additional 20MB outboard hard drive is used for quickly backing up critical files from the Mac IIcx, and as a "traveling" disk. The ImageWriter I, a dot-matrix, impact printer is the stock Apple model we purchased with our original Mac computer in 1984. This printer is rugged beyond belief. In the last six years we have run over 36,000 pages and well over 100,000 mailing labels through the ImageWriter I. We've religiously performed the required printer's maintenance and it still trucks on. The Hewlett-Packard DeskWriter™ is the high resolution printer (300 dpi, inkjet) we use to produce the masters for Home Power Magazine. These masters are then used to make lithographic plates for an enormous web press that prints the thousands of Home Power issues. The Hewlett-Packard DeskWriter is another amazing piece of computer hardware. It operates twice as fast as the ImageWriters, and at over three times the resolution, AND at about one quarter the power consumption. This printer (or its IBM compatible models) is a natural for renewable energy systems. It functions happily on inverters-- at 1/4 the cost (both initial and operating) and 1/30 the power consumption of a laser printer. We've run over 2,000 pages through the DeskWriter in the last six months- no problems. The Hayes 1200 SmartModem™ is powered via a 120 vac "wall cube" power supply and keeps our Macs in touch with other computers. The lighting is marked with a different pattern on the graph because it is powered by 12 VDC directly from the battery and not via the inverter as is all the computer gear and tools. This light (made by Solar Retrofit Consortium in New York City) is a single 40 Watt fluorescent that lights our entire work area. It spends five hours operating every day and consumes 29 Watts of DC input (2.3 Amperes at 12.3VDC). The shop tools on the graph are soldering irons, an electric drill, and a variety of digital multimeters, pulse generators, and an oscilloscope. And we are not done yet. In our future lies a FAX machine, a photocopier, and a digital scanner to capture graphics for our Macs. Whatever the business type, be sure to leave room in the system for growth- keep both the business hardware and the power system open-ended.

Start Small, Work Hard, & Grow Strong!

The computer equipment we now use reflects our extensive and long-term involvement with information. When we started Home Power, we published and mailed our first five issues (HP#1 through HP#5) on a single, 0.5 MB RAM, NO hard drive at all, Macintosh we bought in 1984. It was time consuming, breaking down the various files until they would fit on the small capacity floppy disks (0.4 MB). I could only lay out four pages of the issue's master at a time. We had to break down our subscriber's database into tiny bite sized chunks (California alone occupied three disks). Now the Big Mac handles the page layouts for an entire 64 page issue in a single file, and our subscriber's database is also used as a single, gigantic file. The point is: you don't need a high powered (and expensive) computer system to start and/or run your home business. But, regardless of your business, you do need a computer of some sort. Without it you are wasting time. As time passes and your business grows, there will be money for a faster and more extensive computer system. Choose a system than grows with you- don't get trapped into dead-end, close-out, hardware. Choose your computers using their software as prime criteria. The computer hardware available now is about ten years ahead of the software



Appliances	Watts
TwoPage CRT	80
Mac IIcx	43
MacSE	40
20MB HardDisk	30
Lighting	25
ImageWriterI	145
DeskWriter	26
Modem	18
Shop Tools	400

needed to effectively use that hardware. Look for the software that most suits your needs, and then buy the hardware that best runs that particular software. Our picks for some effective software are: Microsoft Excel Version 2.2 (the best spreadsheet and charting program ever), Ready, Set, Go! Version 4.5 (fast and intuitive page layout), SuperPaint Version 2.0 (great for both bit mapped and object graphics). Selecting computer software and hardware is difficult enough for any business. Add the additional requirements of operation from a battery based, inverter powered system and you have a real puzzle. The information here will help with general decisions. If you have more specific questions, call me, Richard Perez, at 916-475-3179, or call our resident computer pinhead, Stan Krute at 916-475-3428. We stand ready to do what we can.

What powers all these high-tech computers?

Sunshine powers all the computer hardware we use to make Home Power Magazine. We use eight Kyocera 48 Watt photovoltaic modules to produce the electrical power. This power is regulated by a Heliotrope CC60 controller, and fed to a pack of four Trojan L-16W batteries for storage. The power is converted from 12 VDC into 120 vac by a Heliotrope PSTT, 2.3kW. inverter.

The Power Sources

Eight Kyocera 48 Watt PV panels provide Home Power's electricity. Photo by Laura Flett.

The eight Kyocera PV panels produce slightly more than 2,000 Watt-hours on our average sunny day. According to the Thomson & Howe recording Ampere-hour meter we have measuring this array, we average about 160 Ampere-hours daily. This means that as long as the sun shines daily, we produce as much power as we consume (actually about 5% more than we consume). Under full sun, the array produces 360 Watts (≈24 Amperes at 15 VDC). The highest amperage peak we've ever seen from this array is 34 Amperes on a very cold, clear Winter day with deep snow everywhere. The array is ground mounted and connected to the charge controller via 85 feet of 00 aluminum cable. We are testing this aluminum cable as an experiment. Since soldering to aluminum is not possible, all connections must be made mechanically. I am highly suspicious about the longevity of mechanical connections involving aluminum which is easily oxidized. We took all the textbook steps to insure a good connection: thoroughly cleaning the wire to make it bright and shiny, applying the antioxidizing compound (No-Ox, in this case) and using the special aluminum connectors which we torqued to the max. We'll let you know how this experiment turns out by this Summer, after the connections age a while. We provided a water tight box at the array for the mechanical connection between the 10 gauge copper wire used on the PVs and the 00 aluminum cable delivering the current to the controller.

The PV controller is the CC60 model made by Heliotrope. It features user adjustable voltage limit, which we have set to 15.2 VDC. Since our system is constantly in use, this high voltage setpoint is fine. If we are ever able to take a vacation, then I would set the CC60 at about 14.3 VDC to prevent overcharging the batteries. The CC60 is capable of handling 60 Amperes, so we've plenty of room to expand the array without replacing the controller. The CC60 doesn't use electromechanical devices like relays, but instead uses power field effect transistors (FETs) as switches. The exclusive use of semiconductors rather than relays greatly increases the reliability of the controller. The Heliotrope CC60 PV controller was written up as "Things that Work!" in Home Power #8, page 31.

When it is cloudy for more than three days in a row, we fall back on our home-made Mark VI engine/generator. This powerplant uses a single cylinder Honda 5 hp. gasoline engine driving a 100 Ampere Chrysler automotive alternator. We're still using one of the first prototypes of the Mark VI regulator, built in 1981, as the control. For a complete description of this engine/generator, with schematic for the Mark VI control, please see Home Power #2, page 23. We wind up using our Mark VI system about 400 hours a year. Almost all of this generator operating time is during the winter. During the summer, we go for four or five months without running the generator at all. The Honda engine has been in service since 1984 accumulating over 10,000 hours, mostly before we installed the larger PV array in 1988.

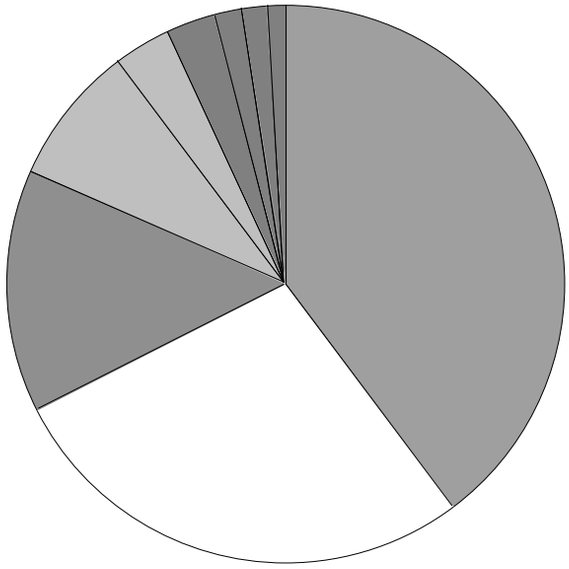
Power Conversion

The Heliotrope PSTT inverter converts the PV produced, battery stored, DC power into 120 vac for all the computer equipment and other tools. We choose the Heliotrope inverter because of its two transformer design. After testing many inverters, we found that the Heliotrope powered inductive loads (like computers and electric motors) very well. This inverter will produce 2,300 watts, with surge power over 6,000 watts. It functions so well that it has totally replaced our 120 vac engine/generator, we haven't started it once in the last 18 months. We use the Heliotrope inverter for everything: computers, printers, bench grinder, drills, a wormdrive Skil saw, and

Home Power's Biz System Cost

No.	Item Description	Item Total	% of Cost
8	Kyocera Photovoltaic Panels	$2,800.	40.0%
1	Heliotrope PSTT 2.3kW. Inverter	$1,933.	27.6%
4	Trojan L-16W Batteries	$1,000.	14.3%
1	Engine/Generator 12VDC	$550.	7.9%
1	Cruising Equip. Amp-hr. Meter	$233.	3.3%
1	Heliotrope Controller CC60	$208.	3.0%
2	PV Mounting Racks	$120.	1.7%
1	Wiring	$85.	1.2%
12	Hydrocaps	$72.	1.0%

System Cost $7,001.



all our nonbusiness appliances (like the coffee grinder and microwave). For a complete review of the Heliotrope inverter see Home Power #3, page 29.

The inverter we use is large (Heliotrope also makes bigger models that produce 5kW., 7.5kW. and 10kW.). In fact, a smaller inverter would run all our computer gear. For example, the Trace 612, with 600 watts output, would be able suitable for powering up a computer system like ours. We, however, also run large motors in our bench grinder, vacuum cleaner, and saws from the PV produced power. We like being able to use PV power for the big jobs and hence, a big inverter.

Power Storage

We use a venerable pack of four Trojan L-16W batteries. Each battery contains three lead-acid cells, in series, each with a capacity of 350 Ampere-hours. Our battery pack is configured as 700 Ampere-hours at 12 VDC. These batteries have been in service since 1980 and have seen many deep cycles during the years before we could afford a substantial PV array. Our battery now stores enough power to run our system for about 3.5 days of continuously cloudy weather. We are planning on replacing these aged lead-acid cells with a pocket-plate, NiCad pack within the next year. We will size this nicad pack at about 1,200 Ampere-hours, giving us the ability to store seven days worth of power. Since we rarely see more than five cloudy days in a row, this will store more PV produced power and reduce our engine/generator operation.

Our battery pack is equipped with two extras that should really be standard equipment on any system. The first is the Hydrocap battery caps. Hydrocaps take the hydrogen and oxygen gas produced by the cells under charge and recombine these gasses into pure water which is returned to the cell. Hydrocaps decrease the water consumption of our cells by over six times and keep the cells cleaner (see HP#11, page 37). The second accessory is the Cruising Equipment digital Ampere-hour meter. This meter is a "gas gauge" for all types of batteries and is the prime instrument we use to operate our system. This Ampere-hour meter is detailed in a "Things that Work!" article in this issue, see page 40.

Power System Cost

Our entire power system can be bought for less money than a good used car (and it's certainly much cheaper to run). Over the years, we've invested slightly more than $7,000 in power system hardware. We did all the installation and fabrication ourselves. Our bottom line power cost is around $1.20 per kiloWatt-hour, some 20 times what the local electrical grid charges. But then the grid wants over $300,000 to plug us in. In our experience, PV based, renewable energy systems cost less than 1/2 mile of commercial power line installation, and have no or minuscule monthly bills. Since we are digital nerds, the advantages of uninterruptable and very stable power are icing on our computerized cake. The advantage of waking in the morning, drinking coffee while watching 14,360 foot Mount Shasta "smoke its pipe", and then go to work without having to deal with either the roads or the truck, is utterly priceless.

Home Power's RadioTelephone System

Our telephone is our business's lifeline. We do the vast majority of our business via telephone. The nearest telephone landline is over six miles away. Over the years, we've tried a number of communication modes: CB radio, RCC simplex radiotelephone, and IMTS duplex radiotelephone from the phone company. All the radiotelephone services came with severe warts attached. The simplex RCC service was unsuitable for business purposes because our customers couldn't understand that only one of us could talk at a time (simplex). At about a buck a minute (for both incoming and outgoing calls, not including long-distance, monthly charges, local message units, and federal surtaxes), the IMTS phone co. service was soooo expensive that we couldn't afford to do business via phone. It's easy to run up over $800 monthly bills on IMTS with very minimal usage. We finally settled upon buying and running our own radiotelephone (R/T) system.

Our system works as follows. The phone company wired us up as a business line at our associate's, Stan Krute's, house. Here we are billed by the phone company as any other business telephone. At Stan's place, Carlson Communications installed one end of our VHF, R/T system. This end rebroadcasts the telephone signal to us, located on Agate Flat some six miles away (and with two large hills in the way- no line of sight here). The "base" end located at Stan's place is an electrical parasite on his 3,000+ Watt-hour per day PV system. Stan's mega-system uses 12 Kyocera 48 Watt PV modules and 8 Trojan L-16Ws to store the power. Stan's power system doesn't even notice the some 200 Watt-hours of

electricity that our R/T system consumes daily. The radiotelephone system uses two Uniden ARH 351 commercial VHF repeaters, especially modified by Carlson Communications for telephone service.

At Agate Flat, we have the second Uniden ARH351, connected to a four element beam antenna up about 36 feet on a steel antenna mast. This "remote" end of the R/T system is powered by a single Kyocera 59 Watt PV module and a battery of 10 Edison ED-160 nicad cells. The battery contains over ten days of storage and the single PV panel produces about 70 Watt-hours a day more than the R/T consumes. Net result is a stand alone PV system powering the remote end of the R/T system. We isolated the R/T on its own separate electrical power system because communications is very important to us. We wanted to be sure of power for the phone regardless of the state-of-charge of the main system's batteries. The remote end of the R/T system provides power for the telephones. This system will run virtually any standard telephone equipment: speakerphones, cordless phones, demon dialers, answering machines, mickey mouse phones, computer modems and FAX machines. We have run 2400 BAUD modem traffic on the R/T system with NO errors and NO sending of any block of information twice.

Cost of the radiotelephone hardware was just about $6,000 including both modified Uniden R/T units, two telephones, masts, feedlines and antennas. Since we use Stan's power at the base end, we spent nothing for power there. At Agate Flat, the stand alone PV power system for the R/T, nicads and PV panel, cost $860. We want to thank Jim Carlson and Jim Longnecker at Carlson Communications for solving our phone problems. I recommend that anyone considering a radiotelephone consult someone in the business. The technology is changing very rapidly, as is the vast quantity of redtape required by the FCC to operate a R/T system. If the system is done right, then you'll have trouble free communications. Our phone system allows us to run our business many miles from the regular telephone lines. We consider it a bargain. Compared with the phone company's IMTS bills, it completely paid for itself in less than a year.

Some suggestions for Backwoods Business operation…

We've been operating Electron Connection since 1982. In 1987, we started Home Power Magazine. When we started out, I visited the Small Business Administration folks. They told me that we need about $200,000 startup capital to begin business. Obviously they were wrong, since we started out with less than $6,000 in 1982 and are still alive and growing. Here are a few backwoods business lessons we've learned over the years.

- Use your heart for guidance. Do what you know is right and you will prosper.
- Create a product or service that you yourself would be proud to use.
- Plan on working at least 70 hours a week, every week.
- Plan on eating many beans in the beginning.
- Don't call it quits for at least two years. Anything worth having takes time.
- Don't listen to experts. If they knew what they were saying, they would be doing it.
- Get a computer & learn to use it in your business. It's your best business buddy.
- Keep overhead to a minimum. Monthly bills can eat a small business alive.

We get by with a little help for our friends…

Home Power has been the loving work of many. Friends, relatives, neighbors, and folks we'd never even met have all contributed their energies to make this magazine work. We are indebted to all of you. If we can help any of you starting your own backwoods businesses, we stand ready to do whatever we can.

OSBORNE
AD

CARLSON
COMMUNICATIONS
AD

Teaching Kids to Build and Use a Solar Battery Charger

George Hagerman

Over the lifetime of these students, the Earth's population will double. At current rates of consumption, fossil oil and natural gas will disappear even sooner. These trends suggest that anyone who is too young to remember the "energy crisis" of the 1970's will experience one far more severe, unless serious changes are made in the ways we produce and consume energy. Here is one way to open their minds to renewable alternatives.

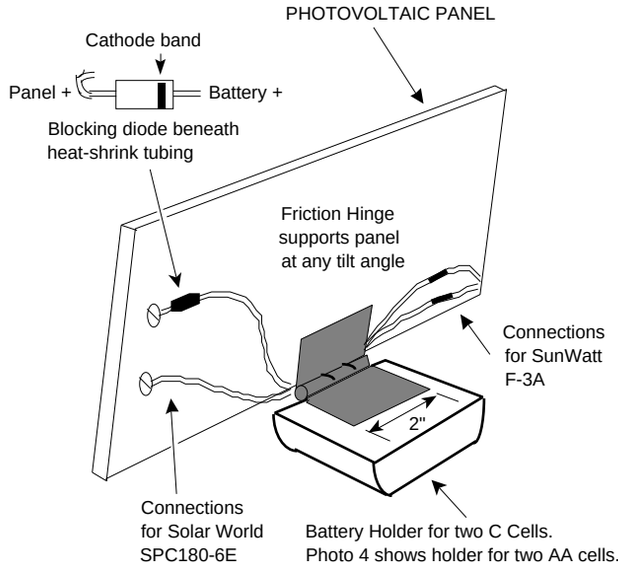


Figure1. Basic solar battery charger design.

Xenox Garavito, Hermes Borges, and George Hagerman help another El Ingeniero 89 student troubleshoot a solar battery charger problem.

Photo by Aubrey Evelyn.

This article is the second of two about a "short-course" approach to teaching junior high school (and older) students the basics of photovoltaic electricity and battery storage. The first article (in HP #15) described various lectures and experiments, conducted as group activities in the classroom and outside. This article describes the solar battery chargers built by the students of El Ingeniero'89, custom designed for their favorite portable gadgets.

Building the charger can be a course by itself. It also may be combined with the lectures and experiments described in the first article. Table 1 shows how both activities can be paralleled.

Charger construction can also be undertaken as an individual student's project for either a regular school class or a science fair. It is described here, however, assuming that it will take place in a class, supervised by a teacher.

Ordering the Necessary Materials

The basic charger design is sketched in Figure 1. The key components are a solar panel, a blocking diode, a battery holder, and rechargeable batteries. Component access information is given at the end of this article.

The parts to be ordered for each student depend on the battery configuration of the student's favorite gadget. Specifically, one must know the size (AA, C, D, etc) and number of batteries required, which can be determined simply by looking at the battery compartment.

The students should be asked to provide this information on some sort of questionnaire or registration form circulated 4 to 6 weeks before the class meets. This way, the component parts can be ordered and will be on hand when work starts on the charger. The students should also be asked to bring their gadgets to the first class session.

Session A - Measure Current Drain of Portable Gadget

So why build a battery charger? One demonstration is worth a thousand words. Hold up a portable tape recorder and pull the batteries out. Place them in series with a large-display multi-meter (Photo 3). Put on a tape that the kids know. My favorite is Paula Abdul's Forever Your Girl (copyright 1988, Virgin Records America, Inc.). It really makes the class come alive. Show how current drain increases when you crank up the volume. They'll love it!

Now pull the cells out of circuit. No energy, no tunes. What's the price of hearing Paula play? Put a chart on the board, which the students should copy, that shows the capacities and prices of Ni-Cad and alkaline cells (Table 2). Explain the relationship between battery capacity, current drain, and time to discharge.

Weather	Lectures & Experiments (see HP15)	Activities Related to Building Battery Charger
	1. Lecture on batteries & loads	none
	2. Experiments with batteries & loads	A. Measure current drain of portable gadget
	3. Lecture on Photovoltaics	none
	4. Experiments with Photovoltaics	B. Glue hinge to solar panel
	5. Quiz	C. Glue hinge to battery holder
	none	D. Make wiring connections & test charger
	6. Wrap-up	E. Wrap-up
	Rain, overcast, or night conditions OK since these sessions are indoors	
	Outside and requiring sunshine- distinct shadows at least 5 out of every 10 minutes	

Table 1. Outline of Course Sessions

CELL SIZE	NI-CAD CELLS			ALKALINE CELLS		
	Capacity in Ah at Continuous "C" Rate	Capacity in Ah at Continuous "C/5" Rate	Retail Price per Cell	Capacity in Ah Radio/Cassette Service	Capacity in Ah Flashlight Service	Retail Price per Cell
AAA	0.15	0.19	$2.70	0.75	0.55	$0.80
AA	0.45	0.56	$2.35	1.80	1.40	$0.72
C-STD.	1.10	1.35	$3.40	5.10	4.40	$1.30
D-HC	3.50	4.00	$7.95	11.00	9.60	$1.30

Table 2. Capacities and Prices of Radio Shack Ni-Cad and Alkaline Batteries

Photo 1. Demonstrating the current drain of a portable cassette recorder. Photo by George Hagerman

Give some simple examples, and then compare the cost of disposable vs. rechargeable batteries for the demonstration tape recorder. Talk the class through the calculations, explaining that they'll be doing a similar exercise for their own gadgets.

Notes on Table 2: 1) Capacities based on data in Enercell™ Battery Guidebook, copyright 1985 by Radio Shack. Prices based on the 1990 Radio Shack Catalog. 2) The more economical C-sized Ni-Cad is Radio Shack's standard (Std.) version. The more economical D-sized Ni-Cad is Radio Shack's high-capacity (HC) version. 3) For alkaline cells, "Radio/Cassette Service" assumes between 37.5 mA. to 187.5 mA. drain, two to four hours daily. "Flashlight Service" assumes a 375 mA. drain (for AAA, AA, and C cells) or 667 mA. drain (for D cells) for 4 min./hour for 8 hours daily.

To begin with, we've seen (and heard) that at maximum undistorted volume, the tape recorder draws 150 mA. With alkaline cells, I'll get 34 hours of total listening time for only $5.20 (such a deal!). On the other hand I'd have to pay a whopping $13.60 for four Ni-Cad C cells, and they'd be fully discharged in just 9 hours. Not much of a bargain until you consider that these guys are rechargeable. If they last 500 cycles (and an expected life of 1000 cycles is not unreasonable; see HP #4), then I'll get 4500 hours of total listening time from a single set of batteries! To get the same total listening time with alkaline cells would require the purchase of 133 sets of four, at a total cost of $691.60 plus sales tax. That's no small piece of change. An effective demonstration at this point would be to pile 532 discarded C-cells on a table in front of the class, so that the students can see the solid waste problem that's involved.

NOTE: Although dwarfed in number by their disposable cousins, Ni-Cad cells represent a solid waste problem because cadmium is a highly toxic heavy metal.

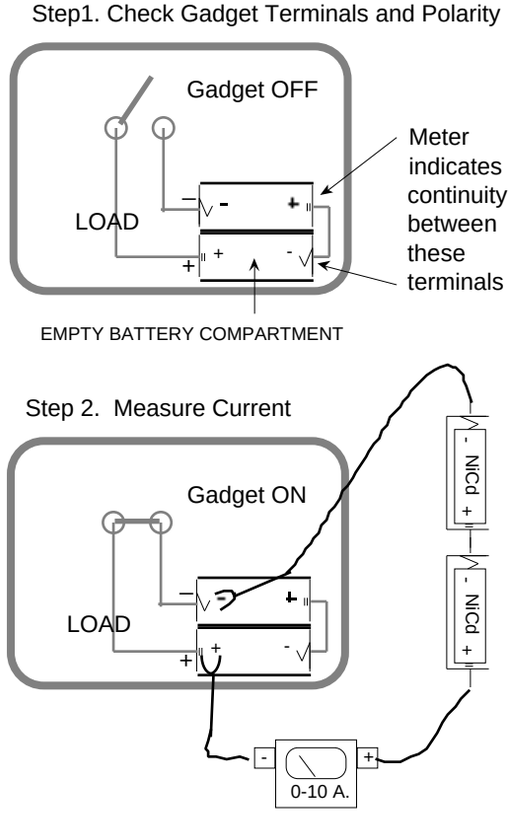


Figure 2. Use multi-meter continuity function to be sure that batteries are connected across the load rather than short circuited.

As described in the last issue of HP, Ovonic Battery Company has developed a rechargeable cell that contains no such toxins. Their nickel-hydride cell has nearly twice the capacity of the same size Ni-Cad, yet is expected to cost only half again as much. This will further improve the economic comparison made above. Production C cells are available now, and AA cells will be soon.

Each student should now measure the current drain of their portable gadget. The connections are best made by the teacher or by assistants who know their stuff. BE SURE to run a continuity check on the battery compartment terminals of each device, before hooking up (Figure 2). I blew a lot of meter fuses by shorting batteries across the wrong terminals until I figured this out.

As a homework assignment, the students should use the information in Table 2, together with the measurements they've made, to compare the cost of using disposable vs. rechargeable batteries in their gadgets.

Session B - Glue Hinge to Solar Panel

Find a chalkboard that won't be erased overnight, and write down the entire sequence of steps for building the charger. The students should copy the instructions in their notebooks, but it helps to have them on the board, so the kids can look up at a glance to be sure they're on the right track.

BEFORE ANYONE GLUES ANYTHING, they should outline the "footprint" that the short plate of the hinge makes on the solar panel, and that the long plate of the hinge makes on the battery holder. Set up a "sanding station", with many small pieces of coarse (40-weight) sandpaper. The students should thoroughly roughen both hinge plates, as well as the "footprints" marked on the battery holder and solar panel (Photo 2).

After everything has been sanded, the student should move on to the "gluing station", where several sets of two-part, quick-setting epoxy have been laid out. The glue that has worked best for me is "Duro"™ brand "Depend II"™ Industrial Strength Adhesive (part number MTB-1, distributed by Loctite Corporation, Cleveland, Ohio). It requires no mixing (Part A goes on one surface, Part B on the other), and the parts only have to be pressed together for a minute or so (Photo 3). It achieves full strength within 45 minutes, which is an advantage if you have only one day to build the charger.

Key ingredients at the "gluing station" are paper towels and isopropyl rubbing alcohol to wipe up spills and clean hands. The students should be encouraged to USE BOTH HANDS when working the plunger to dispense the glue. That way the amount of glue that comes out the tip can be carefully controlled.

Photo 3. Malibea Burguillo and Peggy Cabrera, El Ingeniero '89 student, hold hinge plates against the back sides of their SunWatt solar panels, while the glue sets. They put the panels down after about a minute, leaving them undisturbed for an hour and they were ready to glue on the battery holders after lunch.

Photo by Aubrey Evelyn.

Photo 2. Solar panels for battery chargers. Left-to-right: SunWatt F-3A, with cover removed to show blocking diode; Solar World SPE50-6; Solar World SPC180-6E, front and back. The back view shows where the blocking diode goes, and where the "footprint" of the hinge plate has been roughened. Photo by George Hagerman.

Photo 4. Lorena Nieto carefully glues the battery holder to the long hinge plate of her charger. Note the proper positioning of wire leads to minimize the length of wiring connections between the solar panel and the batteries.

Photo by Aubrey Evelyn.

Session C - Glue Hinge to Battery Holder

It is important that the end of the battery holder which has the wire leads coming out of it be placed next to the hinge pin (Photo 4). This minimizes the length of the wiring connections. Occasionally, a student's gadget will take only one battery. In order for the charger to sit level in such cases, a block of wood or spare battery holder should also be glued to the hinge.

Once the battery holder is glued in place, the hinge should be fully folded and the panel placed face down on a table. This way, the battery holder is in a horizontal position, and won't "creep" off the hinge while the glue dries.

Because all the instructions were given during Session C, and there is no sanding to be done, there should be time to give a brief lecture

after all the students have finished their gluing. This should cover such topics as the care and feeding of Ni-Cads and the adjustment of panel tilt to receive maximum solar energy from month to month.

The use of the charger is explained. Fully charged batteries are placed in the gadget, while discharged ones are placed in the charger. The use of the gadget should be such that its batteries are discharged no faster than the other batteries are charged by the sun. This means that the students can use their gadgets more hours per day in the summer than in the winter. As a homework problem, the students should calculate how many hours of gadget use they should limit themselves to on an average December day (with their charger panels tilted at latitude + 15 degrees) and how many hours on an average June day (with a tilt angle of latitude - 15 degrees). The solar energy data for this exercise should be available from your local solar equipment supplier, or the Solar Energy Research Institute in Golden, Colorado, 303-231-1000).

In talking about Ni-Cads, be sure to mention that they will self-discharge in 60 days (at room temperature). This is particularly important for gadgets that are used infrequently, such as flashlights and camera flash units. To be safe, the Ni-Cads in such gadgets should be swapped with those in the charger once a month, if unused, and after every period of heavy use.

Also, it should be pointed out that the rate of battery charging behind a sunny window is much less than its outside value. Typically, a single pane of south-facing window glass transmits only 80% of the direct beam energy falling on it during the middle of a clear winter day. Due to reflection, it will transmit even less at other times of day or when the sun is high in the sky during the summer. Transmission of diffuse energy (such as on overcast days) is even more reduced. Put a window screen in front of the glass, and the charger will receive only 50-60% of what gets through the plain glass.

Therefore, leave your charger outside if you want to charge up a set of dead batteries as quickly as possible. Bring it indoors once they're fully charged (and again, the students can calculate how long this should take), and the smaller amount of energy coming through the window can be used to offset any self-discharge, keeping the batteries fresh and ready to go.

Session D - Make Wiring Connections and Test Charger

Among other things, this session involves soldering and the application of heat shrink tubing. The actual "hot work" should be done ONLY by the teacher and/or a thoroughly checked-out assistant. The directions that follow are for these "hot workers". The students should watch while their particular chargers are being worked on. This situation is far from ideal, but made necessary by the mini-panel designs now available on the market.

For the SunWatt panel, which comes with a blocking diode and speaker-wire lead, the speaker wire should be cut to a 2-inch length, the two wires peeled apart about an inch, and a half-inch of insulation stripped away from the individual wires. Solar World panels come with screw terminals, so no wire preparation is necessary for them. The battery holder leads should be cut so that when connected to the panel, there is about one inch of slack. For Solar World panel SPC180-6E, which comes without a blocking diode, an additional inch should be cut off the battery holder's positive lead, to make room for the diode. Once cut, a half-inch of insulation should be stripped away from the battery holder leads, and the leads should be tinned.

The connections are made somewhat differently for each panel type. With the SunWatt panel, two one-inch pieces of 3/32-inch (unshrunk diameter) heat-shrink tubing should be cut, and slipped over the battery holder leads. Slide these as close to the battery holder as possible, so that your soldering work doesn't inadvertently shrink the tubing! Twist the leads together and slip the heat-shrink tubing over the twisted connections. Hold the panel vertically and use a cigarette lighter to shrink the tubing. Do not hold the flame too close to the tubing or it will melt. Also be sure to pull the wires away from the panel surface first, so that you don't scorch it.

Solar World panel SPE50-6 comes with a diode, and screw terminals on the front face of the panel. Once the battery holder leads have been cut and tinned, the students can make their own connections, using a standard screwdriver.

Solar World panel SPC180-6E requires a 1N4001 blocking diode. The leads from this diode should be clipped one-inch from the barrel, and the anode lead should be bent into a fishhook shape (see Figure 1). A one-inch length of 3/32-inch heat-shrink tubing should be slipped over the positive wire from the battery holder. Remember to slide it away from your soldering work! The red wire

CONFIGURATION		SOLAR PANEL			BATTERY HOLDER		NI-CAD CELLS	
Cell Size	Number of Cells	Vendor & Part #	Charge mA.	Price	Vendor & Part #	Price	Vendor & Part #	Price
AAA	2	SolarWorld SPE50-6	50	$17.50	Digi-Key BH2AAA-W-ND	$1.71	AEE Standard 0.12 ah Capacity	$1.62
	3		45		Digi-Key BH3AAA-W-ND	$2.69		
	4		40		Digi-Key BH4AAA-W-ND	$2.86		
AA	1	SunWatt F-3A 10 cell model	150	$15.30	Radio Shack 270-401	$0.59	Plainview Batteries Rapid Charge 0.50 Ah Capacity	$2.00
	2		140		Digi-Key BH2AA-W-D	$1.76		
	3	SolarWorld SPC180-6E	190	$22.00	Digi-Key BH3AA-W-ND	$2.77		
	4		175		Digi-Key BH4AA-W-ND	$2.97		
C	1	SunWatt F-3A 10 cell model	150	$15.30	Radio Shack 270-402	$0.69	AEE Standard 1.8 Ah Capacity	$4.68
	2		140		Radio Shack 270-385	$1.19		
	4	SolarWorld SPC180-6E	175	$22.00	Radio Shack 270-390	$1.39		
D	2	SunWatt F-3A, 10	140	$15.30	Radio Shack 270-386	$1.39	AEE Standard 4.0 Ah Capacity	$6.85
	4	SolarWorld SPC180-6E	175	$22.00	Radio Shack 270-396	$1.49		

Table 3. Parts List for Common Battery Configurations

should then be twisted around the diode's cathode lead, and the diode screwed in place as shown in Photo 2. This will hold it securely while you solder the diode-wire connection. Then slip the heat-shrink tubing up over the diode barrel (it'll be snug!), and shrink it down as described above. The negative wire from the battery holder can be screwed in place by the student.

The use of a butane (lighter fluid) soldering iron is STRONGLY RECOMMENDED. This avoids a multitude of safety hazards and heats quickly. Radio Shack sells one for $29.95 (catalog number 64-2161), and you can often find them on sale at electronic parts outlets.

The next step is to test the charger, which the students can do on their own. First, they should put their new rechargeable batteries into their gadgets, to convince themselves that the batteries are "out of juice". Then, they should pop the batteries into their chargers and go outside. They should orient the panel so that the sun's rays are striking it squarely, and wait ten minutes on a clear day, longer on a partly cloudy or bright overcast day. Finally, they should put these batteries back into their gadgets. Voila! Sunshine at work!

Having verified that the connections are correct, the students should tack down the wires on the back surface of the panel. Last summer, we used dabs of "Krazy Glue"™ for this job. Any sort of instant glue will work, but I found this particular brand to be well packaged for student use.

Session E - Wrap-Up

The homework problems assigned in Sessions A and C should be returned to the students and reviewed in class. A table should be put on the chalkboard, showing the cost comparison between disposables and rechargeables for each student. How much money will the entire class save?

The disposable ethic is pervasive in suburban America. Using time and energy to drive to the store for a set of batteries once or twice a month is viewed as "less trouble" than fussing with a charger. It is easier to buy alkaline cells and toss them when they're dead. Most kids have never seen a landfill or incinerator, so it's no big deal. I have this lingering fear that the chargers may end up collecting dust instead of rays.

One way to help prevent such a fate is to impress the students with the environmental consequences of not using their chargers. Here's an idea. Go through the homework assignment from Session A and have each student read out loud the number of disposable batteries that would have to be used and discarded for each set of rechargeables. Then pull out a box containing that many used batteries (of the correct size), walk over to the student's desk, and dump them. Repeat this for everyone. Finally, tell the students that they must pick up "their" batteries and put them back into the boxes labelled with their names, before anyone can leave the room.

You'll hear some complaints (pity the owner of a six-D-cell boom box!), but maybe the kids will now think twice before putting their chargers on the shelf. This also is a way to put literally thousands of used batteries to good use, rather than in the air or groundwater. I've started setting up collection bins at various places around town, and it'll be interesting to see how long it takes to collect enough for a class of twenty.

Access

Table 3 and the accompanying vendor list provide all the information you need to order materials for a class, with one very important exception, and that's the hinge. While I was fortunate enough to obtain some prototype material that was already in stock, it was of limited quantity. Although the hinges would cost very little individually ($1.00 or less), an order must be placed that would utilize one whole coil of steel, which would be enough for about 12,000 hinges! The solar energy education business is not yet sure enough for me to justify an investment in that kind of inventory. Possibly a couple of education groups could get together for a collective order, which I'd be happy to help coordinate. Any suggestions out there? Contact me at SEASUN Power Systems, 124 East Roasemont Ave., Alexandria, VA 22301 • 703-549-8067.

The hinge is not necessary for the charger to work, but it really helps improve its performance, as well as teaching some basic solar astronomy concepts. If you don't want to use the hinge, then Sessions B and C can be combined, and the students would simply glue the battery holder directly to the solar panel.

A word about matching cells, panels, and loads. AA cells are the most common size that a teacher will encounter. AA cells are ideally charged at 50 mA. This is too low for many gadgets. For example, if a panel delivers 50 mA under one full sun, three sun-hours would be required for a student to listen to only one hour of cassette tape. In overcast weather, that could take over a week

of charging! That's why I've specified rapid-charge AA cells, and panels that deliver 150-200 mA under one full sun. This also happens to be a good charging rate for standard C cells, another common battery size.

Notes on Table 3: 1) Charging current is average expected under one full sun (1kW/m^2) incident radiation. 2) Solar World panel SPC180-6E requires a 1N4001 blocking diode available for Radio Shack at two for 49¢. 3) Three-cell holders (AAA, AA from Digi-Key) have wires running beneath them, and require a thick application of glue. 4) Purchase two sets of batteries for each student, which are to be rotated between the charger and the gadget. 5) Price breaks vary from item to item. The prices given are for ten chargers.

No experience has been had with charging 9-volt rectangular transistor batteries. These are frequently found in radios and remote-controlled vehicles. A six-cell Ni-Cad is underpowered for the job, but Plainview Batteries has an eight-cell version with enough voltage to replace its disposable cousin. A suitable panel would have an open-circuit voltage of ≈15VDC and ≈10 mA.short-circuit current.

Acknowledgements

Richard Perez planted the seeds of the battery charger project and encouraged me to write up the results. He also answered a zillion technical questions when I had only a couple of weeks to work out the design. Richard Komp of SunWatt Corporation, and Brad Thompson of Solar World, agreed to modify their standard panel designs, and offer these at very reasonable prices. Thanks also to Geri Walker, of Wagner Products Corporation, who ended my quest for the perfect hinge, and kindly supplied the prototype material.

As mentioned in my last article, the students of El Ingeniero '89 were terrific. They did all their gluing (Sessions B and C) in just a few hours and were then given the Session D lecture. This was a lot of heavy-duty material at the end of a full day, and I was really impressed with how attentive these kids were.

It was this kind of response that inspired me to document what we did last summer. Much credit, then, goes to the students of El Ingeniero '89: Olga Aquino, Stefan Barney, Carla Bernal, Vanessa Bernal, Hermes Borges, Malibea Burguillo, Peggy Cabrera, David Ferragut, Erik Ferragut, Edgar Garay, Jr., Richard Giles, Xenox Garavito, Rodrigo Gutierrez, Monique Mauge, Gerardo Molina, Lorena Nieto, Lupe Nieto, Ruben Pena, Yirla Portobanco, Emeline Tirado, and Louisette Vega. Thanks again to Lucy Negron-Evelyn (and Ivan Vera), who brought us all together.

SUPPLIER ACCESS

AEE
Alternative Energy Engineering
POB 339
Redway, CA 95560
707-923-2277 • 800-777-6609

Digi-Key Corp.
POB 677
Thief River Falls, MN 56701
800-344-4539

Plainview Batteries
23 Newtown Road
Plainview, NY 11803
516-249-2873

Radio Shack
500 One Tandy Center
Fort Worth, TX 76102
817-390-3011

Solar World
2807 North Prospect
Colorado Springs, CO 80907
719-635-5125

SunWatt Corp.
RFD Box 751
Addison, ME 04606
207-497-2204

SIZING YOUR NICAD BATTERY BANK

Before ordering please be ready to answer the following questions.

1. Primary charging system. ❑PV ❑Hydro ❑Generator ❑Grid ❑Other_____
2. Secondary charging system. ❑PV ❑Hydro ❑Generator ❑Grid ❑Other_____
3. Average daily load of system (Amp-hours)._____ System Voltage_____
4. Number of days autonomy (storage) desired._____
5. What are batteries being used in? ❑ Home ❑ Boat ❑ Vehicle ❑ Other_____

Name_____

Address_____

City_____ State_____ Zip _____

Phone Number _____

Hidden Energy Costs

Richard Perez

Commercial electric power costs about 7.75¢ per kiloWatt-hour, and gasoline costs around $1.10 per gallon at the pump. These are the prices we pay for energy, or are they? I always figured that the true cost of energy was higher than this because the societal and environmental consequences of energy use are not included in these costs. The American Solar Energy Society (ASES), in its publication "1989 ASES Roundtable: Societal Costs of Energy", has quantified many of the hidden costs in our energy bill. This information is very revealing- it shows we are paying far more than we might think.

What is a "Hidden Cost"

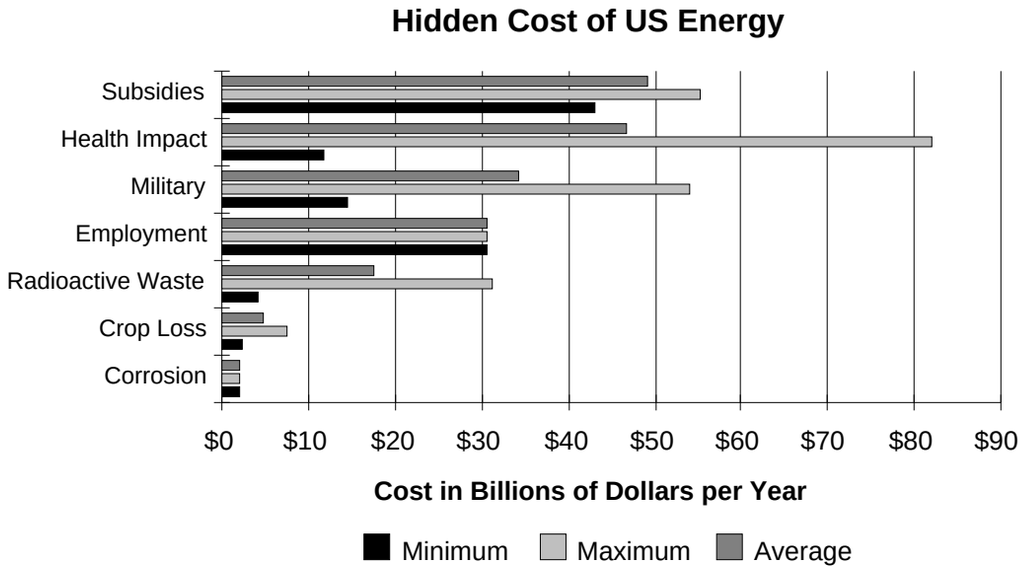
When we pay the power company's electric bill or fill up our car's tank, we pay a specific price for the energy we directly consume. What we also pay, sooner or later, are many hidden costs associated with our energy usage. For example, I quote Michael Nicklas in the ASES report.

"Our free market economy operates best when both the buyer and the seller have complete knowledge of which choice will benefit them the most. With energy , this is obviously not the case. How many people know that sulfur dioxide from just our coal burning plants is costing Americans $82 billion per year in additional health costs? How many farmers are aware that they are annually losing $7.5 billion per year due to reduced crop yields caused by air pollution? And, how many people are really aware that nuclear waste and decommissioning costs (which, for the most part, we have not seen yet) are the equivalent of $31 billion per year?"

Quantifying Hidden Costs

Michael Nicklas and the ASES has done a well documented study of the hidden costs of energy. This table was compiled from their data.

Hidden Cost Classification	Minimum Hidden Cost in $ per Year	Maximum Hidden Cost in $ per Year	Average Hidden Cost in $ per Year	Hidden Cost per US resident in $ per Year
Subsidies	$43.3 Billion	$55.2 Billion	$49.3 Billion	$197.00
Health Impact	$11.8 Billion	$82.0 Billion	$46.9 Billion	$187.60
Military	$14.6 Billion	$54.0 Billion	$34.3 Billion	$137.20
Employment	$30.6 Billion	$30.6 Billion	$30.6 Billion	$122.40
Radioactive Waste	$4.3 Billion	$31.2 Billion	$17.8 Billion	$71.00
Crop Loss	$2.5 Billion	$7.5 Billion	$5.0 Billion	$20.00
Corrosion	$2.0 Billion	$2.0 Billion	$2.0 Billion	$8.00
TOTALS	$109.1 Billion	$262.5 Billion	$185.8 Billion	$743.20



This table shows each hidden cost classification, its estimated minimum cost, its estimated maximum cost, its estimated average cost (the average of the preceding two categories), and the estimated average cost per person living in America. This last amount is figured by dividing the average cost by the 250 million folks living in the US. The estimated average hidden cost per classification is presented graphically in the chart to the right.

What is really shocking is that we are actually paying between 109 billion and 260 billion dollars yearly in hidden energy costs. In terms of an individual, each of us is paying over $740 yearly in hidden energy costs. Let's look at each hidden cost classification, starting with the potentially most expensive- our health.

Health Impact

The major health impacts are caused by our combustion of fossil fuels. Here the information is far from complete and the maximum estimate is, in my opinion, most certainly low. This estimate is based on the combustion of low sulfur coal and the resultant sulfur dioxide pollution (which eventually winds up as acid rain). Ron White of the American Lung Association estimates that if the new Environmental Protection Agency (EPA) standards regarding sulfur dioxide emissions are adopted, Americans would save 82 billion dollars in health cost yearly. And this is just from cleaning up coal burning plants. The health costs of automobile emissions and nuclear waste/accidents are **not** included in this total. The problem is really much greater. Who can really put a price on disease and

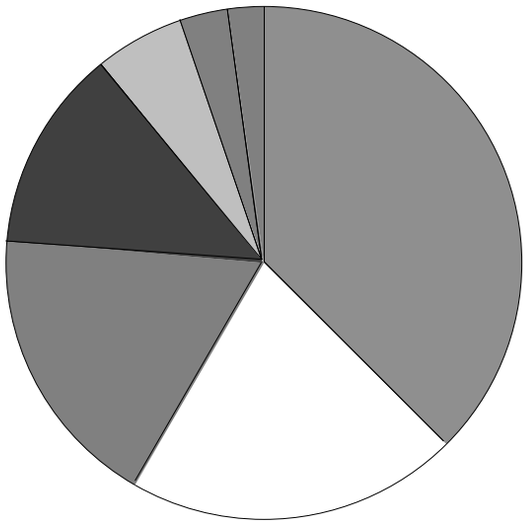
pain?

State and Federal Energy Subsidies

Government heavily subsidies the energy industries. The table and chart below show the depth of government financial involvement in energy. It is interesting to note that the energy technologies with the worst health and environmental impacts receive the most government money. The worst polluters, nuclear and combustion technologies, receive 90% of the government money. The renewable energy technologies, which offer little or no side effects, receive the least government support. Solar technologies (both PV and thermal together) receive only 3% of the government money. At the bottom of the list is conservation with 2% of the subsidy dollars. This is amazing since conservation offers immediate relief from our energy problems, is easily implemented, and has no environmental side effects. Something is radically wrong here…

State and Federal Energy Subsidies

Fuel Source	Subsidies in Billion $ per Year	%
Nuclear	$19.07	38%
Oil	$10.53	21%
Coal	$9.28	18%
Gas	$6.44	13%
Hydro	$2.77	5%
Solar	$1.61	3%
Conservation	$1.02	2%



Military

Our dependence on imported oil requires that our military keep the international supply lines open. The U.S. military is spending between 14.6 and 54 billion dollars yearly just defending the oil supplies coming from the Persian Gulf. On the low side, the National Defense Council places the Persian Gulf military cost at 14.6 billion. On the high side, the estimate of 54 billion is made by the Rocky Mtn. Institute. Retired Secretary of the Navy, John Lehman was quoted in Newsweek magazine as estimating the Persian Gulf military cost at 40 billion dollars yearly. And these cost estimates **only** concern the Persian Gulf. There are also other hidden national security costs. One of these is military aid to oil producing nations. Another is diplomatic and foreign policy decisions made on the basis of imported oil.

Employment

The National Defense Council Foundation estimates the annual cost of lost U.S. employment at 30.6 billion dollars yearly in their report "The Hidden Cost of Imported Oil".

Radioactive Waste

The major problem associated with nuclear fission power is, "What do we do with the leftovers?" To date, no one has a viable disposal solution for the thousands of pounds of radioactive waste nuclear power plants generate. This problem is made more severe because it is a long term problem. For example, plutonium (Pu239) has a radioactive half-life of 24,400 years and is environmentally dangerous for over 100,000 years. We are making nuclear decisions **now** that will affect our planet, and all lifeforms on it, for millennia in the future. The Electric Power Research Institute (EPRI Journal, July/August 1985) estimates that it will cost 195 million dollars to decommission a nuclear powerplant. The World Watch Institute estimates the disposal costs of nuclear waste at between 1.44 and 8.61 billion dollars per year. Radioactive waste disposal isn't actually disposal, but containment. We have to responsibly ride herd on high level waste for thousands of years. We now have no method of actually disposing of high level waste. We simply store it and hope our children can figure out a safe way to deal with it. This estimate doesn't include the cost of nuclear accidents. What does a "Three Mile Island" cost to clean up?

Crop Loss

The EPA reported in 1988 that ozone pollution alone is reducing crop yields by up to 12% yearly, and that's about 3 billion dollars annually. Boyce Thompson of the Institute for Plant Research at Cornell University has revised this estimate to a 30% crop loss yearly with an annual price tag of 7 billion dollars. And these estimates do **not** include crop losses due to global warming, acid rain, and other energy related forms of air/water pollution.

Corrosion

The primary component involved in corrosion is acid rain. Acid rain is caused by the sulfur dioxide produced by coal burning powerplants. It is estimated that the damage to metal buildings alone amounts to about 2 billion dollars yearly.

Global Warming

Global warming, resulting from our mania for combustion, will not be plainly apparent for at least a decade. And this is the really scary part- it can damage our planet before we know that it is happening. By the time global warming becomes a hard, measurable scientific fact, it will be very difficult to do anything about it. Once again, how we produce and use energy today determines the kind of world our children will inhabit.

The Problem

The main problem isn't that we use power, but how we make it. As long as we continue to produce our power primarily by combustion or nuclear reactions, we are going to have the problems, the environmental effects, and the costs detailed here. What we need are energy sources that are renewable and non-polluting. Forty years ago, this was a dream. Now renewable energy is a reality.

Do something about it!

Write your elected representatives and let them know how you feel about energy issues. This is the long, slow path. Our government agencies have access to the information presented here- they know what's going on. What they don't know is how YOU feel about it. Let your elected officials know that you consider energy a political issue. Ask them what they are doing to help solve our energy related problems. Let them know that when you cast your vote, you will have energy on your mind.

Conservation can be practiced by everyone. Whether you make your own power or buy it from the grid, conservation saves energy. Implement conservation techniques in your home. Install efficient lighting. Turn off unused appliances. Find and isolate those "phantom loads". When you buy an appliance, make efficiency your prime criteria. If all of us practice conservation, then I estimate we could reduce America's electric bill by half. And this means half the environmental damage. Conservation offers immediate, short term, relief until we can mass implement non-polluting renewable energy sources.

Perhaps the best thing any of us can do as individuals is to actually use renewable energy sources. And the best place to start is at home. Every time any one of us puts up a PV panel, a hydro turbine or a wind generator we are directly helping solve America's energy problems. Every time a renewable energy source is used, power that would have been produced by combustion or nuclear reaction is instead made by clean renewable methods. It's not often we get a real chance to change this world and stay at home at the same time. Put up a PV panel, develop that creek, put that wind machine up! Show the world that there are alternatives to life in a polluted greenhouse!

Access

Copies of the entire "1989 ASES Roundtable: Societal Costs of Energy" can be purchased for $20. from the American Solar Energy Society, 2400 Central Ave., B-1, Boulder, CO 80301. I want to thank the American Solar Energy Society for letting me use the data they have collected. This report contains much more data than I have discussed here. The opinions expressed here are mine and do not necessarily represent the views of the American Solar Energy Society.

Cost Comparisons between Nickel-Cadmium & Lead-Acid Batteries

Richard Perez

Nicads are happening in home power systems. We are getting calls and letters from many folks who are replacing their lead-acid batteries with nicads. This article addresses two specific questions asked by many HP readers. "Are nicads cost effective?" "How do I maintain my nicads over the years?"

Are Nicads Cost Effective?

The purchase price of a nickel-cadmium battery pack is indeed much higher than any lead-acid technology. But purchase price is only part of the story. Other factors that directly effect overall cost are longevity and operating costs.

In order to accurately compare different battery technologies, let's consider a typical, medium-sized, home power system. Such a system uses a battery that will deliver about 10 kiloWatt-hours (kWh) of electricity (≈800 Ampere-hours at 12 VDC). This is about four days of storage at a daily consumption of ≈2.5 kWh. There are many home powered households and business that operate quite nicely with this amount of daily power use. See the article in this issue starting on page 7, or HP#13, page 7, for examples.

A lead-acid battery for such a system would have to be sized at ≈1,100 Ampere-hours eventhough only 800 Ampere-hours are regularly used. This is because the last 25% of a lead-acid battery should not be used. If a lead-acid battery is regularly emptied, then its lifetime is greatly reduced. As such, a lead-acid battery must be sized larger than a nicad battery which will take regular and repeated total discharge without suffering.

In this comparison, I am considering four types of batteries: 1) Brand new nicad cells, 2) Reconditioned used nicads, 3) Best quality lead-acid, and 4) Medium quality lead-acid. As examples of nicads, I used the cost and performance of the ED-160 nickel-cadmium cells. For best quality lead -acid, I used the Chloride cells. For medium quality lead-acid, I used the Trojan L-16W. These batteries are used in the overall cost comparisons below.

Lead-Acid Battery Lifetime

Lead-acid cells will last around ten years **if** they are properly maintained. Maintenance with lead-acid cells is far more than just adding distilled water. All lead-acid cells require regular periodic equalizing charges if they are to last ten years. Lead-acids require total recharging on every cycle. If they are not totally refilled everytime, then they gradually and certainly lose capacity. If a lead-acid cell is repeatedly deep cycled, then longevity drops radically to less than five years. If the cells are not equalized, then lifetime is reduced to five to seven years. The point here is that in order to get ten years service from a lead-acid battery, it must be religiously maintained. I personally have seen brand new lead-acids ruined within two years through overdischarge and no equalization. The lead-acid cell is not very forgiving. It only takes a few energy disasters (like leaving the pack discharged for a few weeks) to permanently damage the cells. The calculations here are based on a lead-acid lifetime of ten years. A careful user will get this. A careless user is lucky to get five years before the lead-acid pack fails.

Pocket Plate Nickel-Cadmium Battery Lifetime

Brand new nicads are warranteed for twenty years service. We have tested a 57 year old nicad cell that is storing more than its rated capacity (see HP#15, page 23 for the details). The only inherent failure mechanism that we have identified is carbonation of electrolyte, which is easily solved by periodic (every ≈10 years) electrolyte replacement. The longevity of the nicad is further guaranteed by its operational characteristics. Nicad longevity is not reduced by regular and total discharging. Nicads also do not require equalizing charges, so if the user doesn't fully recharge them, the nicads don't care. I'm going to stick my neck out and say flat out, "Careful users of pocket plate nicad batteries will get 40 years service." Careful use means that the electrolyte is maintained. The rules are simple: 1) use **only distilled water** to refill the cells, 2) maintain the oil layer floating on top of the electrolyte, and 3) replace the electrolyte on an average of every ten years. That's it. No warnings about cycling, equalization, or total recharging. I know from direct experience in over 100 battery based systems in the last 20 years, that every once in a while, the battery inevitably gets totally discharged. Nicads will cheerfully accept this, but lead-acids will never forgive total discharge. Calculations here are based on a nicad lifetime of forty years in home power systems.

Operational Costs

Lead-acid batteries require equalizing charges. An equalizing charge is by definition a controlled overcharge of an already full battery. As such, the power is not stored within the battery. Equalizing charges are really energy we must waste in order to keep the lead-acid cells at the same state of charge. The lead-acid battery I am using in this example (1,100 Ampere-hours at 12 VDC) will cost about $250 in equalizing charges over its ten year lifetime. This is based on six equalization charges per year and a power cost of $1.00 per kiloWatt-hour, which is typical of home power systems. The equalization cost is included in the comparisons that follow.

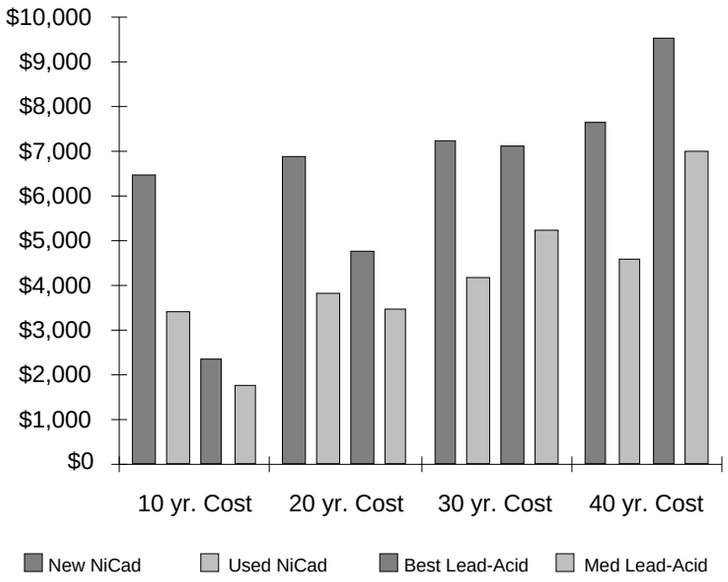
The operational cost of the nicads is electrolyte replacement. Every ten years, this replacement will cost about $385 to recondition the cells' electrolyte (based on a battery of 800 Ampere-hours at 12 VDC, i.e. 50 @ ED-160 cells). This is also factored into the cost comparisons that follow.

Cost Comparison between Lead-acid and Nickel-Cadmium

The chart and table tell the tale. The overall winner in the cost comparison are the reconditioned used nicads. These used cells will pay for themselves within 25 years over a medium quality lead-acid system, and within about 15 years over a best quality lead-acid battery.

These comparisons assume that the lead-acid battery lasts ten years. I'm sure that there will be more nicad packs that last forty years than lead-acid packs that last ten. My experiences have shown me that all batteries are totally emptied once in a while. Nicads will not be harmed by this, whereas lead-acids will lose capacity and longevity. This cost projection is very conservative as it assumes that the lead-acid cells receive only the finest treatment, which they probably won't.

Battery Cost Comparisons



BATTERY TYPE	Initial Cost	Total 10 year Cost	Total 20 year Cost	Total 30 year Cost	Total 40 year Cost
New NiCad	$6,500	$6,500	$6,885	$7,270	$7,655
Used NiCad	$3,424	$3,424	$3,809	$4,194	$4,579
Best Lead-Acid	$2,130	$2,381	$4,762	$7,143	$9,524
Med Lead-Acid	$1,500	$1,751	$3,502	$5,253	$7,004

Nicad Maintenance

Articles in HP#15 detail the maintenance and electrolyte replacement procedures required by nicad cells. Electrolyte replacement can be done by a careful user. The big problem is what to do with the old electrolyte. Do not dispose of used electrolyte in our environment. Our Earth is polluted enough already. Spent nicad electrolyte must be disposed of properly-through an EPA certified recycler. Pacific West Supply is offering a nicad electrolyte replacement kit that **includes** proper disposal of the old electrolyte. For $55, the kit includes: 4 gallons of new electrolyte, 8 oz. of mineral oil, funnel, safety glasses, rubber gloves, return shipping labels, and complete instructions. The user returns, in the shipping containers provided, the old electrolyte to Pacific West for proper disposal. Electrolyte, in the proper containers, can be shipped via United Parcel Service cheaply. Shipping is paid by the user in both directions. The sample battery mentioned here (50 @ ED-160 cells) would require seven of these kits at a cost of $385 every ten years.

In all fairness, nicad batteries are not the only battery that requires responsible disposal. Spent lead-acid cells should be returned to a lead-acid battery dealer for proper disposal. The same is true of all "disposable" batteries like alkaline flashlight cells. Batteries use very active chemicals. If they didn't, then they wouldn't work. Before you chuck out that dead battery, consider where it is going to wind up. Research your local area and find an EPA certified recycler. Even if it costs a few bucks to dispose of batteries or electrolyte properly, it's worth it. In the words of the Master, "It's a dumb bird that fouls its own nest."

Zomeworks Ad

SUNAMP POWER COMPANY AD

Compact AC Fluorescent Lights

Jerry Fetterman

In our remote home, we have progressed from kerosene lights, to Aladdin lamps, to propane lights, to 12 volt DC aircraft lights, to DC fluorescent fixtures, and finally to compact AC fluorescent lights. And now my wife is happy! You see, my wife, the daughter of a General Electric lighting engineer, grew up in a house where almost every other light was a three-way (100-200-300 watt) incandescent bulb, and she has always had a great aversion to fluorescent lights.

So why is she happy?

First of all, compact AC fluorescent lights give off that warm yellowish hue which is characteristic of incandescent lights. Second, because compact fluorescents fit in ordinary lamp fixtures, my wife can place lights all over our living and dining room area in order to eliminate those dreaded shadows. Third, since compacts have electronic ballasts they do not hum or flicker. And finally, they provide adequate light for reading without her having to snuggle up to the light with her book or magazine.

After trying several of the lights in our home, I decided to do a semi-scientific study of the various models currently available on the market. In this study I wanted to measure for each model the amount of power consumed and the amount of light produced. To do this, I wired a socket to the output of a Statpower 100 watt inverter, mounted the socket on the ceiling of our mostly-white bedroom, and placed a large amorphous panel (a Sovonics L100) on the bed approximately five feet below the socket. To determine the amount of power consumed, I used a STEAMCO Solar Power Monitor to measure wattage used. To determine the amount of light produced, I used my handy Fluke portable multi-meter to measure the current generated by the panel. In addition to testing seven compact AC fluorescent lights, I decided I'd compare my results with four types of DC lights - a 40 watt fluorescent, a quartz halogen, a PL tube and an incandescent bulb. (Low voltage DC incandescent bulbs provide more light than their 110 VAC counterparts; it would take a 90 watt 110 VAC bulb to produce as much light as the 24 VDC 50 watt bulb which I tested). The results of these tests are presented in Table 1.

Light Output

As can be seen from Graph 1, the 40 watt fluorescent fixture gives off the most light of all the lights tested. This is not too surprising, since it is the highest-wattage fluorescent light tested. After the 40 watt fixture, the lights producing the most illumination are the 18+ watt compact fluorescents and the 50 watt incandescent bulb. On the low end of light output comes the 15 watt AC fluorescents, then the PL tube and finally the 23 watt quartz halogen bulb.

Efficiency

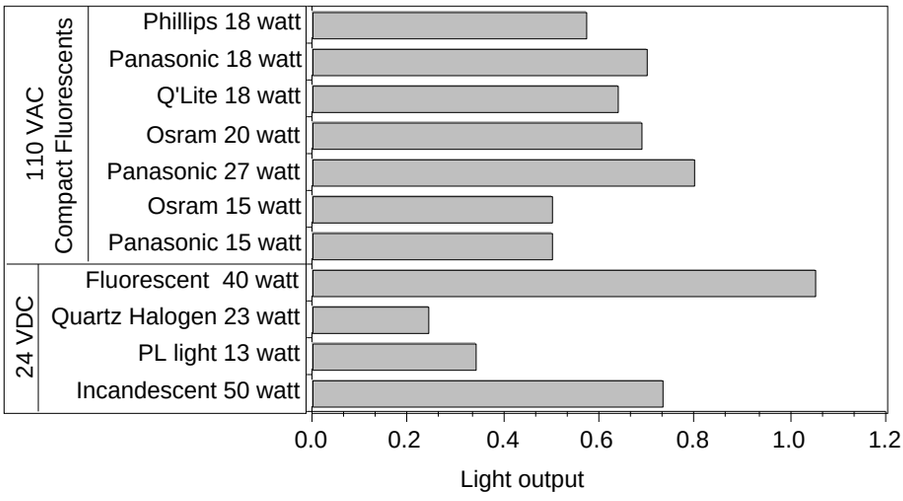
While light output is a big concern to any homeowner, efficiency is an equally important consideration, especially for alternative energy homeowners. To calculate efficiency we divide the light output by the power consumed; the resulting figures are plotted in Graph 2. As you can see from the graph, the Panasonic 18 watt fluorescent is the most efficient bulb we tested. The other eight fluorescent lights are all similar to each other in efficiency, with the Osram 20 watt bulb being the most efficient and the Q'Lite being the least efficient of the group. The incandescent and quartz halogen bulbs are the least efficient, being one-third to one-half as efficient as the fluorescent bulbs.

Cost

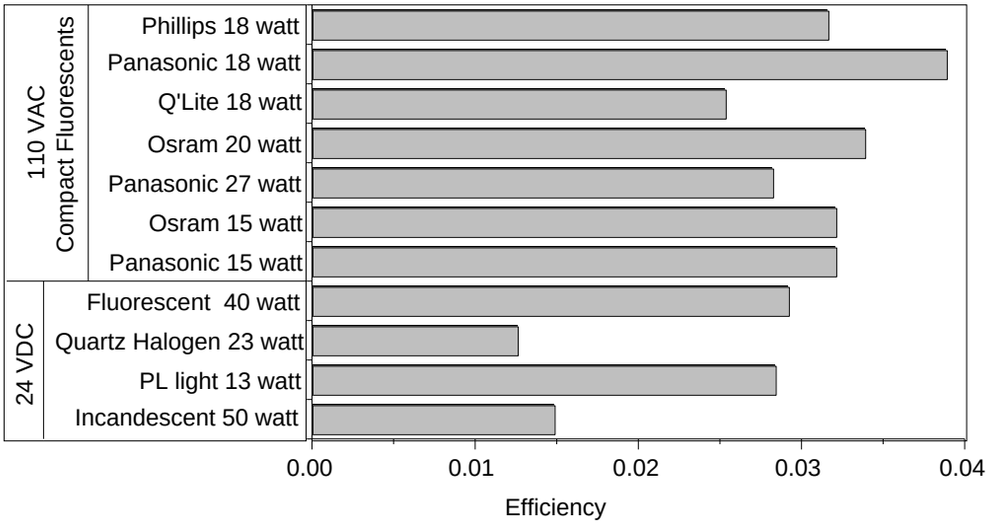
Cost is often a major factor in deciding which model to purchase. With light bulbs there are two cost factors: 1) the initial cost and 2) the power and replacement cost. The initial cost for a bulb can vary from $2 for an incandescent to $58 for a 40 watt fluorescent (which includes a fixture). The power and replacement cost was calculated based on the cost of using a light for three hours a night for 10 years. Included in the calculations were initial cost, replacement

TABLE 1.

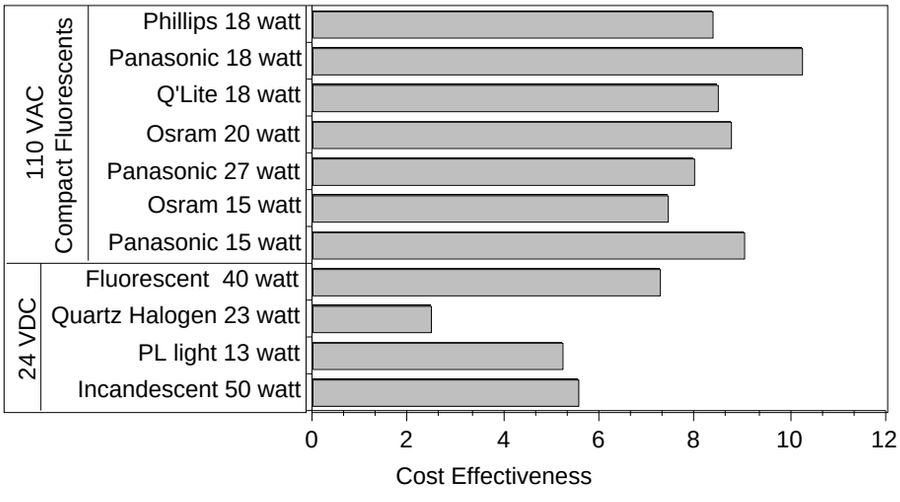
	Operating Voltage	Rated Watts	Actual Watts	PV Output in Ma.	Rated Lumens	Size Width inches	Size Length inches	COMMENTS
110Vac FLUORESCENTS								
Phillips SL*18	110 Vac	18	18	0.57	1100	2.7	7.2	Starts quickly warms up slowly. Globe covering tube
Panasonic EFT18LET	110 Vac	18	18	0.7	1100	3	7.4	Starts quickly warms up fast. Globe covering tubes. Electronic ballast
Q'Lite	110 Vac	18	25.2	0.64	nd	2.6	7.4	Starts quickly warms up fast. Exposed tubes
Osram Dulux	110 Vac	20	20.4	0.69	1200	2.2	8	Starts quickly warms up fast. Exposed tubes
Panasonic EF027LE	110 Vac	27	28.4	0.8	1550	2.5	7.9	Starts quickly warms up fast. Exposed tubes
Osram Dulux	110 Vac	15	15.6	0.5	900	2.2	6.7	Starts quickly takes 1 minute to warm up. Exposed tubes
Panasonic G15	110 Vac	15	15.6	0.5	900	3.5	6	Starts slowly, slight hum, 60 Hz. flicker. Globe covering tubes
24 VDC LIGHTS								
Rec Specialties model 239	24 VDC	40	36	1.05	3300	5	48	Starts quickly warms up relatively fast
Quartz Halogen bulb	24 VDC	25	19.2	0.24	nd	2.5	5.5	Starts quickly
PL quad light	24 VDC	13	12	0.34	850	1.75	6.5	Starts quickly but takes 1 minute to warm up
Incandescent	24 VDC	50	49	0.73	850	2.2	4.2	Starts quickly, small size



Graph 1. Light Output



Graph 2. Light Efficiency



Graph 3. Cost Effectiveness

cost (if lifespan was less than 10 years), photovoltaic panel cost, battery cost, and inverter cost ($20) on AC models. The results of these calculations are detailed in Table 2.

As can be seen from Table 2, with regard to initial cost the incandescent bulb is the least expensive bulb tested and the 40 watt light fixture was the most expensive. But if you factor in power and replacement costs the incandescent bulb is one of the most expensive and the PL light is the least expensive. If you eliminate the cost of an inverter from the calculations on the AC bulbs, the Panasonic 15 watt ends up the least expensive bulb tested.

Cost Effectiveness

To determine the performance you can expect for your dollar outlay, we divided the light output by the initial, replacement and power costs. The results of these calculations are shown in Graph 3.

This graph shows that the AC compact fluorescent will provide you more light output for your dollar invested (in lights, panels, batteries, and inverter) than any other type of light tested. And specifically, the Panasonic 18 watt light will provide you with more light for less money than any other light tested. An unexpected finding is that the incandescent light will provide you with more light for your dollar invested than the PL kit; this is the result of the much greater illumination produced by the incandescent bulb.

Recommendations

It appears to me that the new electronic ballast AC compact fluorescents are the answer to remote home lighting. Of the AC compact fluorescents tested, the Panasonic 18 watt light is the best light for efficiency and cost effectiveness.

While DC lighting has its place in emergency lighting situations and locations where simplicity is desired, I feel that for most remote homes and cabins DC lighting has come obsolete.

The advent of reliable, efficient inverters had made AC power available for lighting in most remote homes. In the rare event of inverter failure, for emergency purposes the homeowner could install a few DC lights or purchase a small inverter such as a Statpower or Power Star to power lights until the main inverter is fixed. Since wiring costs are considerably lower for AC lighting, inexpensive fixtures are widely available, and AC compact fluorescent lights are the most cost effective lights, I believe a homeowner would be much better off using AC rather than DC lighting.

COMPACT AC FLUORESCENTS	Initial Cost	Initial, Replacement, & Power Cost
Phillips 18 watt	$25.00	$88.20
Panasonic 18 watt	$25.00	$88.20
Q'Lite 18 watt	$15.00	$95.48
Osram 20 watt	$30.00	$98.96
Panasonic 27 watt	$32.00	$120.16
Osram 15 watt	$30.00	$87.44
Panasonic 15 watt	$18.00	$75.44
24 V DC LIGHTS		
Fluorescent 40 watt	$58.00	$144.40
Quartz Halogen 23 watt	$10.00	$96.08
PL light 13 watt	$36.00	$64.80
Incandescent 50 watt	$2.00	$131.60

Table 2.

Access

Jerry Fetterman and his wife, Linda Honeycutt, are owners of Yellow Jacket Solar, POB 253, Yellow Jacket, CO 81335 • 303-562-4884. Yellow Jacket Solar supplies remote home PV systems and water pumping systems to their local SW Colorado neighbors and has a mail-order catalog. Jerry and Linda have lived with photovoltaic power since 1981.

MicroPowered Appliances for Emergency Use

Richard Perez and Sam Coleman

An Emergency MicroPower System (EMPS) is a low power electrical system for emergency use when all else fails. It contains a power source (usually a PV panel), a small portable battery, and a small inverter. If an EMPS is to be effective, great care must be taken in selecting appliances for the system. Low power consumption and efficiency are paramount. This article discusses the Home Power Crew's choices for EMPS lighting and communications equipment.

Low Power Consumption

An EMPS is small (less than 10 pounds & fitting into a backpack or briefcase) and portable. It must be able to travel and be set up quickly just about anywhere. Its size and therefore its performance is limited. For example, a typical EMPS battery will contain about 43 Watt-hours (≈3.5 Ampere-hours at 12 VDC). A portable PV panel (like the Sovonics SP-105) produces about 35 Watt-hours daily. A regular 25 watt lightbulb can drain the EMPS in 1.5 hours. If a light is required for four hours nightly and a radio/TV is used constantly, then these appliances must be low power consumers.

Lighting

The only type to consider for EMPS use is fluorescent lighting with an electronic ballast. It makes little difference to the EMPS whether this lighting is 120 vac via the micro inverter, or 12 VDC directly from the battery. Our best pick for 12VDC lighting is the low power consumption PL light. The 5 Watt PL5 is ideal and costs around $45. An EMPS can power this light for 3 to 4 hours nightly and still have enough power leftover for 24 hour per day communications gear. On the 120 vac side, our best pick is the Dulux "EL7" compact fluorescent. this has an electronic ballast, consumes 7 Watts, and costs about $25. Most Home Power advertisers either stock these lights or can get them.

In any battery based system the cardinal rule is, "If you are not using an appliance, then turn it off!" In an EMPS, conservation is even more important because of the EMPS's small size. If you're not using the light for even a few minutes, then shut it off. Conservation of the EMPS's power will assure that the energy is there when you really need it.

Communications

In an emergency situation communications are critical. The information provided through radio and television can be lifesaving. At the very least, effective communications can relieve the anxiety of not knowing what is going on. When we picked the communications gear for the EMPS, we used low power consumption and performance as main criteria. During an emergency, listening to certain communications channels can most effectively provide useful information. We selected the following: NOAA weather radio (164 MHz.), FM stereo band, AM radio band, VHF TV audio (channels 2 thru 13), CB band (27 MHz.), Police and Fire Bands (VHF in the 150 to 170 MHz. range).

Radio Gear

The following radios will cover some or all of the frequencies listed above and have low enough power consumption to function well in an EMPS. The least expensive is the Radio Shack Patrolman® SW-60 (RS#12-779 for $99.95). This radio covers AM, FM, Shortwave (6-18MHz.), and the VHF Fire, Police, & Weather band frequencies. The SW-60 can be operated via the microinverter at 120 vac or by the EMPS directly through the DC/DC regulator (12 to 6 VDC converter supplied with most EMPSs). Power consumption is low, about 0.06 to 0.1 Amperes. Size is 10.5" X 12" X 4".

For those wishing a higher quality radio, the best is the Sony ICF Pro 80. This amazing radio is very tiny (3.5" X 6.25" X 2.2") and weighs about 1.5 pounds. The Sony ICF Pro 80 gives continuous coverage between 150 kHz. to 216 MHz. This means it covers AM, FM, TV sound, Police, Weather band, Fire, Aircraft band, CB band, and all shortwave bands, including Ham bands. It features direct access digital tuning, 40 memories, and four varieties of scanning. Power consumption is low (≈0.05 Amps) and the price is high about $380. What makes the Pro 80 so attractive for EMPS is its incredible coverage. It will listen in so many places (and get there quickly via scanning) that information is sure to be available regardless of the magnitude or type of emergency/disaster. Its small size makes it very portable. It can be powered by internal AA batteries, 12 VDC (with optional Sony DCC-127A converter), or via 120 vac (with the optional AC-D4L converter).

For those wishing a TV set to use with the EMPS, our pick is the color LCD TV marketed by Radio Shack (RS#16-119 for $219.95). This TV uses a two inch Liquid Crystal Display (LCD) instead of a picture tube. This gives it not only small size (5.2" X 3.25" X 1.25"), but also low power consumption. It can be powered by internal AA batteries, or optional adaptors for 12 VDC or 120 vac.

PV that Meets the National Electric Code

John Wiles

Civilization is spreading throughout the country, and with it, the bureaucracy of building codes and electrical inspectors. The intent is good and safety is the objective-- especially now that the National Electric Code (NEC) addresses PV (article 690). The inspectors know we are out there and PV power systems in dwellings, businesses, and RV's are subject to the code. Best not to fight since mortgages, fire and hazard insurance, and habitation permission all rely on the good nature of your local inspectors.

Learn the Code and Work with the Inspectors

The SWRES will be publishing a "PV and The National Electric Code" manual for electrical inspectors in late 1990. The content of that manual will follow these articles so read and heed for safer PV that will make your inspector smile. If you are doing your own installation, pick up a copy of the 1990 Code and really study it. Contact your electrical inspector early and see if your state allows home owners to do their own wiring--possibly after a home owner's code test. You and your inspector should know that the NEC is a guide and he has the authority to authorize variations that HE feels are safe.

Module and System Marking

Individual PV modules should be marked showing polarity, maximum rated power, operating voltage and current, open circuit voltage, short circuit current, and the maximum overcurrent device rating for the module. UL listed modules like those from ARCO and others will already be marked with this information. A neat, durable homemade label should suffice from data provided by the module manufacturer. A similar set of data for the combined output of the PV system must be displayed near the PV disconnect switch.

Water and Strain Relief

Module junction boxes, where present, are generally waterproof. To maintain the UL listing for modules so listed, the interconnect cables must enter the box through water tight, strain relief bushings. The knockouts on older ARCO and Solarex module junction boxes are standard half inch electrical trade size. You can pay over $3 for metal, water tight strain relief bushings for these and similar modules or you can call Heyco Molded Products in NJ at 800-526-4182 and ask for product info on items 3231 and 3224. Minimum order is 50 and price will be less than $1.50 each. Some newer modules have waterproof gaskets and strain relief built in. Modules with and without junction boxes must have the interconnect wiring firmly fastened to the module and array frames to prevent mechanical abuse. Nearly all white nylon, cable wrap ties frequently used for this purpose are NOT sunlight resistant and will crumble in less than a year. Thomas & Betts makes some weather resistant products which might be special ordered through your electrical supply house, but a cheaper alternative is probably a stainless steel hose clamp, a metal fixed size cable clamp, or even a couple of turns with a piece of the module interconnect wire.

Array Frame Grounding

PV arrays are usually mounted on roofs or in other areas away from obstructions to maximize the collection of solar energy. In these locations they are good lightning rods and the frames need to be well grounded for safety and equipment protection. Each individual metal module frame should be connected by the most direct route to the mounting frame and then in the most direct route to the grounding conductor. The largest wire size affordable should be used, but must not be smaller than number eight copper wire. Avoid splices and sharp bends. If this grounding wire, when routed directly to the nearest soil, can be connected to the system grounding electrode, then connect it there. For arrays mounted some lateral distance from the system grounding electrode, the array grounding wire should be connected to a separate grounding rod close to the array. This rod should be bonded (connected) to the system grounding electrode with a wire sized as above. None of this discussion on grounding pertains to grounding one conductor of the PV system.

Ampacity and Overcurrent Protection

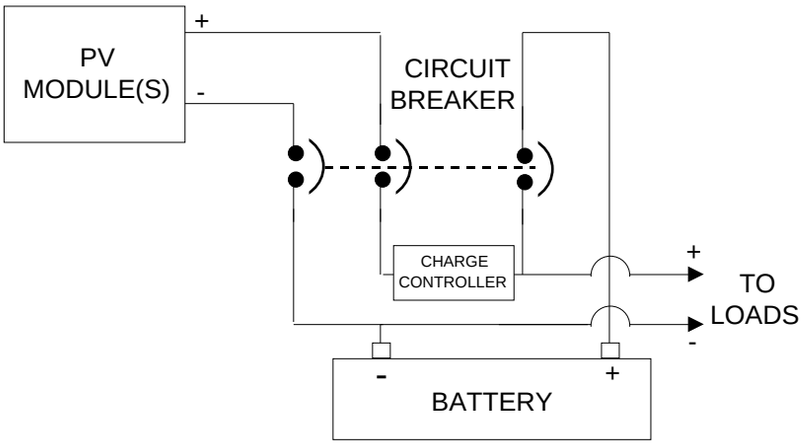
The National Electrical Code (NEC) requires that ampacity of the conductors used to wire the modules and the rating of the fuses or circuit breakers protecting those conductors be at least 125% of the module or parallel module short circuit current. The fuse or circuit breaker does not protect the conductors from high module currents or short circuits of that current. It does, however, protect the module wiring from high--very high-- short circuit currents that can be delivered by the battery. The blocking diode may not block short circuit currents and should be left out of this consideration. If you have a direct drive (no battery) system, then the conductors can be sized at 125% of the short circuit current and no overcurrent device is required. Use the Flowlight Workshop equations (see HP14, page 32) to increase the conductor size over the 125% minimum as required to minimize voltage drop.

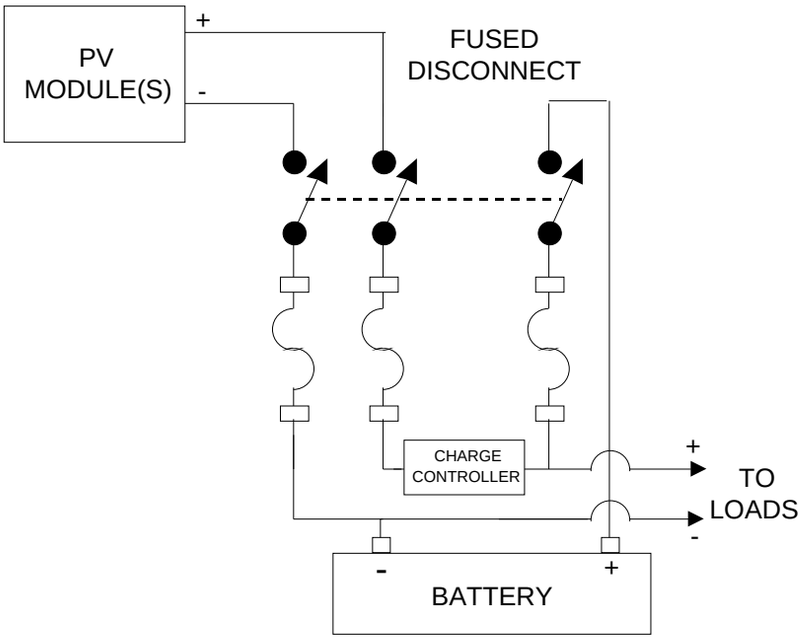
Fuses and Switches

DC rated fuses and DC rated switches are hard to find. The arc that forms when a DC circuit is opened is hard to extinguish and will destroy ac rated devices in a short period of time. In the array circuits, the Code allows supplementary fuses to be used. These are the small glass or ceramic bodied fuses used inside various pieces of electronic equipment which provide protection above and beyond that provided by the main branch circuit fuse or circuit breaker. Glass or plastic automotive fuses are NOT considered supplementary fuses, are rated only to 32 volts, and are not tested or listed by Underwriters Laboratories for supplementary use. They SHOULD NOT be used in PV systems. DC rated and UL recognized fuses in the 13/32" x 1 1/2" midget size are available.

The NEC requires that the fuses have switches on both ends to remove all sources of voltage prior to servicing. This requirement, plus the need for DC rated switches, indicates that circuit breakers are the way to go. The standard Square D QO residential circuit breaker is UL listed to 60-70 amps and 48 volts. You must use the PV array open circuit voltages when specifying components so these breakers can be used for both 12 and 24 volt systems.

Square D makes small boxes that hold these QO breakers as well as the larger residential load centers.





See the figure below that illustrates the overcurrent protection and disconnects required for a small PV system with no inverter.

Access

DC rated, UL listed fuses are made by Littlefuse, Power Fuse Division, 800 E. Northwest Highway, Des Plaines, IL 60016. CALL 1-800-TEC-FUSE for the name of the nearest power fuse stocking distributor. Use midget type KLKD for array wiring and to protect electronic devices. Use FLN-R type for branch wiring as well as battery to inverter fuse.

Marathon Special Products, PO Box 468, Bowling Green, OH 43402 makes fuse holders and power distribution blocks. Call 419-352-8441 for a catalog and the name of the nearest distributor.

Chesapeake Marine Fasteners, Inc., 110 Willow St., Annapolis, MD 21401 has stainless steel hardware, UV resistant cable ties, battery cable crimp on terminals and more. Call for catalog 1-800-526-0658. Discount price sheet for dealers.

REPORT FROM AUSTIN TEXAS

John D'Angelo

Austin Texas was really buzzing from March 19 - 22. There were four conferences going on simultaneously. The American Solar Energy Society (ASES), The Solar Energy Industry Association (SEIA), The Photovoltaic Association Solar Society (PASS) and The National Passive Solar Conference (NPAC).

The mood was set in the beginning of the conference with S. David Freeman's talk "Racing for the Sun". He warned the audience that things are looking up but that the fossil fuel industry is gigantic compared to the Solar industry and now is the time to give it all we have. The time is now! Things are changing in our favor. I felt the most encouraging speaker was Cathy Zoi, Senior Environmental Scientist, Environmental Protection Agency. She gave an excellent presentation and was really excited about the contribution the solar industry could make in reducing our pollution problems. She was clearly asking the audience for input. It is certainly great to see this type of person in the government. Perhaps the Bush administration will do better on environmental issues than we thought.

There were two exhibits. One was an educational exhibit the other was the SEIA exhibit. All the major players were at the SEIA exhibit (Siemens, Solvonics, Solorex, etc.) along with some new players. Sanyo was there displaying there solar product line for the first time. They have plans to sell their "solar shingles" in a year or two.

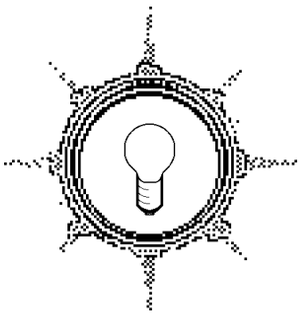
The exhibitor that was creating the most excitement was Midway Labs, Inc. There were selling a product called the PowerSource* which is a light concentrating PV array using Optical Power Technology. The rating was 75 watts @ 12V with prices comparable to a Solarex 60 Watt PV module. Because the product is so new there is only a 3 year warranty.

Sustainibility and daylighting in buildings were hot topics at the conference. However, the most interesting topic for me never made the agenda. Steve Baer of Zomeworks Corporation compiled a "Citizens' Survey Of The Solar and Federal Buildings Projects". Over 700 projects were installed throughout the US. Remember the solar collector on the white house? The survey found that most systems were removed for various reasons. I think the survey bore out what I have learned in my 18 years of dealing with different types of solar systems. Keep it SIMPLE! We made a lot of mistakes, so lets build the future with lessons learned from the past! For a copy of this report contact Steve at Zomeworks, POB 25805, Albuquerque, NM 87125.

A new magazine called "Solar Today" is being published by the Amercian Solar Energy Society. You do not have to be a member of the society to enjoy this excellent magazine. Call ASES at 303-443-3130 or write ASES, 2400 Central, Unit B-1,Boulder, Co. 80301.

After seeing the news clip about solar and wind power on Peter Jennings "American Agenda" last night (March 28th) the future prospects for renewable energy will definitely be on the upswing in the months and years ahead.

Subscription Form



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

☐ **As my only power source** ☐ **As my primary power source**

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

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

☐ **As my only power source** ☐ **As my primary power source**

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

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☐ **Wind Power** ☐ **Other** _____

HP#16

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☐	☐	**Photovoltaic cells**	☐	☐	**Gas/Diesel generator**
☐	☐	**Wind generator**	☐	☐	**Batteries**
☐	☐	**Water power generator**	☐	☐	**Inverter**
☐	☐	**Battery Charger**	☐	☐	**Control systems**
☐	☐	**Instrumentation**	☐	☐	**PV Tracker**

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HP#16

Kyocera Mega-System

The Charles Wayne Group, one of the largest developers in Florida, recently opened the world's first tract home with its own electrical energy supplied by sunlight. The three-bedroom, 2,480 square-foot home, has a solar system on the roof capable of supplying 100 percent of the electricity needed even after seven days of continuous cloudy weather. The solar system runs air-conditioning and heating, lights, washing machine, television, stereo, water heater, and kitchen appliances including refrigerator, freezer, microwave and garbage disposal.

The Charles Wayne Group is the first home builder to offer a solar system that can power a typical home at an affordable cost. "With solar, there is no pollution, noise or maintenance required and there are no monthly electric bills." says John Kimball, Kyocera regional sales manager. The cost of this home, with solar system included, is $179,000.

The house has 108 Kyocera 59 watt PV modules installed on the roof with a single axis tracking system. As the sun moves across the sky, the solar panels track its movement. This tracking system allows the homes to be oriented in a variety of positions and still achieve maximum power.

Kyocera's photovoltaic modules have been tested by the U. S. Department of Energy (Jet Propulsion Laboratory Block V Test), and have a life expectancy of twenty years. Industry estimates are fifty years or more with virtually no loss of power output.

The system stores energy in a battery bank composed of lead-acid gel cells. The system uses two separate battery packs. Storage is 1,600 Ampere-hours at 48 VDC, for one battery and 200 Ampere-hours at 325 VDC for the second battery. Lifetime of these batteries is estimated at ten years. The system uses two 3,000 watt true sine wave inverters to convert the battery stored DC into conventional ac power.

The house uses conventional electric appliances with the exception of a gas range and clothes dryer. The walls are insulated "Energy Wall" with a rating of R-29.7. The ceilings are insulated at R-40. Domestic hot water is provided by an Energy Conservation Unit (ECU) on the heat pump with a freon reversing control for winter use.

Access:

Laura Schumacher, Kyocera America, Inc., Solar Systems Division, 8611 Balboa Ave., San Diego, CA 92123 • 619-576-2672.

Editor's Note: This is really a BIG system. I mean it's REALLY BIG! I have included it in this issue so you can see that PV is catching middle America's imagination. RP

MIDWEST RENEWABLE ENERGY

Plans for this summer's Midwest Renewable Energy Fair are solidifying. The Fair will introduce the general public to a wide spectrum of renewable energy technologies and their contemporary applications. Through educational workshops, and demonstrations thousands of individuals of varied backgrounds and educational levels will have access to an abundance of new ideas and products that will help conserve energy, save money and protect the environment. Here's what's happening.

Come to the Fair and get a T-shirt too!
The first wave of T-shirts are ready. The shirts are white with our logo outlined in black with red, yellow, and orange highlighting the design. One of these beautiful works of art can be yours, along with admission to all fair activities and entertainment, for a small but needed donation of $25.

Workshops
We are in the process of organizing a wide variety of workshops and seek additional individuals who would like to share their expertise. Richard and Karen Perez will be our featured speakers.

Planned workshops include:

- ◊ Fundamentals of Energy, Electricity, and Electronics
- ◊ Energy/Environment
- ◊ Politics of Energy
- ◊ PV
- ◊ Microhydro
- ◊ Wind
- ◊ Solar Thermal
- ◊ Integrated systems
- ◊ Passive Solar Architecture
- ◊ Construction Technology for Super Insulation
- ◊ High Efficiency Appliances
- ◊ Water Systems - Pumping
- ◊ Transpo
- ◊ Batteries

Activities
Music and dancing is scheduled for Friday and Saturday night with Greg Brown, a contemporary folk musician, opening the show on Friday night. Tom Pease will be staging a children's concert during the day Saturday. Plans for an alternative vehicle rally have been modified to an exposition. There will be a showcase of not only solar electric, but also super high mileage and electric vehicles. A Solar Cook-Off is scheduled on Saturday .

For those of you who are already using alternative energy and are interested in meeting others who share your experience, there will be a networking breakfast on Sunday morning at the fair.

Exhibits
Booths are being reserved by businesses and schools representing PV, windpower, controllers, batteries, solar vehicles, and electric cars.

Booth space is available indoors or outdoors, with or without electricity. Booths will be approximately 10' X10'. Cost is $25. not for profit education/info, $125. for business/manufacturer, $500. for sponsorship level which also includes extra booth space and sponsorship recognition. Limited exhibitor camping is available on site.

Where Is Amherst
Amherst, Wisconsin centrally located 14 miles East of the intersection of U.S. highways 51 and 10, will host the 1990 Midwest Renewable Energy Fair August 17, 18, 19 at the County Fairgrounds. This well maintained thirty acre facility features sunny open spaces, as well as numerous buildings and ample parking. The surrounding area boasts hotel, motel and park facilities capable of accommodating the thousands of people who regularly visit beautiful, sunny central Wisconsin.

When
All these exciting activities and more will take place between 1 p.m. on Friday, August 17 and 3 p.m. on Sunday August 19 at the Portage County Fairgrounds near Amherst, Wisconsin.

Info
If you would like more information on exhibiting or attending, contact us at our NEW business phone:

715-592-4458

or write:

Midwest Renewable Energy Fair
286 Wilson Street
Amherst, WI 54406

Editors' Note:
Karen and I just got our Midwest Renewable Energy Fair T-shirts. In our opinion these folks are right when they call their T-shirts a work of art. The colors a vibrant and the image is packed with energy. We're proud to wear their colors. RP & KP

The Alternate Energy Fair in Summertown, TN

Welcome to the Alternate Energy Fair hosted by the Farm community. We are looking forward to your participation in this significant educational event. The Farm is a cooperative of families and friends living on 1,750 acres in southern Tennessee. We started the Farm in 1971 with the hope of establishing a strongly cohesive, outwardly-directed community, a base from which we could, by action and example, have a positive effect on the world as a whole. The Farm, a community where ideas can find expression in daily life, has pioneered in fields of midwifery, soy technology, Third World relief, solar energy, alternative education, and cooperative living.

The Farm School

The Farm School is a unique alternative education research center, accredited member of the NCACS (National Coalition of Alternative Community Schools) and home to its national office. Alternative birthing services as well as books, videos, and a training program, are offered by the Farm midwives. One World Trading Company, marketer of Guatemalan goods, and the Natural Rights Center, a public interest law project, are thriving divisions of PLENTY International, the charitable relief and development organization originated on the Farm.

The community is supported and maintained by the approximately 250 residents and 40 businesses including the Soy Dairy, the Book Publishing Company, The Tie-dye Works, and an electronic firm, S.E. International, manufacturer of the Radiation-Alert.

Workshops and Activities

Here's a list of the planned workshops.

- ◊ PV's for Today
- ◊ Solar Cooking
- ◊ Solar Cars
- ◊ Third World Communications
- ◊ Climate in Crisis
- ◊ Alternative Education
- ◊ Homebirth
- ◊ The Amish Alternative
- ◊ Mindlinking

Informal entertainment on Friday and a live concert is scheduled at 8:30 p.m. on Saturday.

Exhibitors Information

Booth space is available indoors and outdoors, with or without electrical hookups. Booth size in approximately 10' X10'. Cost of a sponsorship level booth space is $500., Business/Manufacturer booth is $100., Non-profit educational booth is $25. On site camping is available for an additional $30. Reservations must be made by May 10.

The Alternate Energy Fair will be advertised in local and national media.

To Attend

Rates for camping, food (vegetarian) and workshops are $75 per person (kids under 15-$25), Family rate is $175. On site camping is available for attendees and exhibitors. Camping only $30, camping and food $48, family rate $75, family rate & food $175. Kid care can be provided upon request. Children's activities are scheduled Friday & Saturday. Sign up for (1) Help with a least one meal; (2) If you wish to attend or give a specific workshop.

Please bring your own eating utensils, bedroll, camping equipment; flashlight; soap; etc. General needs store will be on site. Some sleeping space possible in solar & high school buildings. Two large tents will be provided for vendors & eating. Local accommodations are available in Lawrenceburg & Columbia motels & in some Farm homes.

Where and When

The Farm is located in Summertown Tennessee. From Nashville take I-65 south to Chapel Hill exit #99 (right) to 31 (right) Columbia to 43 (right) 20 miles to Hwy 20 (right) fork thru Summertown.

Arrival and setup are scheduled for Thurs. June 7 1990. The Fair exhibits and workshops will be all day Friday, June 8 and 9. Closing meeting is scheduled at 1 p.m. Sunday, June 10.

For More Information

For more information and registration forms contact Mary Ellen Bowen at 615-964-2534 or Karen Heikala at 615-964-3816. Or write to The Farm School, c/o Mary Ellen, 50 the Farm, Summertown, TN 38483.

WILLITS
FULL
PAGE

Things that Work!
The Pensol Portable Gas Soldering Iron

tests conducted by Sam Coleman and Richard Perez

This little soldering iron is the bee's knees. It requires no electricity and is very effective even on heavy wires.

How the Pensol works

The Pensol is a pencil type soldering iron that is about 7 inches long and 3/4 inches in diameter. It is constructed out of heavy plastic, with a spark ignitor and spare flints in the cap. It will accept four sizes of metal soldering tips, 4.8mm, 3.2mm, 2.4mm and 1.0mm.

Pensol is powered by butane gas stored within the soldering pencil. Instead of direct combustion, it uses catalytic combustion- no flame once the unit is fired up. Refueling is accomplished via a standard butane cigarette lighter refueling cartridge. The unit contains an on/off valve and an adjustable metering valve that allows you to set the temperature of the iron.

The proof of the pudding…

I must admit that I was initially skeptical about the Pensol. It looks more like a toy than a serious tool. I was wrong. It is a tool. It took me several soldering jobs before I appreciated how well this small wonder works.

Test #1

It was a very cold (<28°F.) February evening on Agate Flat. We were all gathered around the AM radio to hear Gary Starr of Solar Electric Engineering verbally fight it out with a paid oil company apologist on the nationally broadcast Larry King radio show. For us, this means tuning in KFI in Los Angeles CA, some 800 miles away. Our AM radio was delivering nothing but static, obviously something was wrong. A quick check of the system revealed that ice falling from our roof had broken the feedline connecting the radio to its 300 foot long wire antenna. This was a job for Pensol! The Wiz and I quickly got a ladder and soldered a new 16 gauge copper feedline to the 18 gauge steel antenna wire. It was snowing at the time and the wind was blowing an estimated 20 MPH. In short it was a freezing mess. The Pensol fired right up, despite the wind and it stayed lit. I adjusted it for max heat out (about 60 Watts according to the manufacturer) and proceeded to solder. In the very few moments that the Pensol took to make the solder joint, I thought about the extension cord I'd have to use if the Pensol didn't do the job. But it did. In spite of the cold, the falling snow, and the wind, the Pensol heated up the freezing wires and made a good, bright solder joint in about 10 seconds. I was and still am impressed. Not only does the Pensol work, but it works under super–severe conditions. We got the radio back in time to hear Gary Starr and I didn't have to break out the 300 watt soldering gun, run an extension cord and use inverter supplied electricity to do the job.

Test #2

I was up a ladder making some solder joints on the telephone system we installed at Rancho Chatuco (see HP#10, page 5). The day was sunny, the temperature was warm, and the nearest electricity was miles away (we didn't have Victor's system operational yet). The Pensol, with its output turned down to the minimum 10 watts, made good solder joints on the small wires without turning them into crispy critters. Once again, good solder joints without the extension cord.

Test #3

I was working on our radiotelephone hidden in our back room. I soldered two 10 gauge copper wires together with ease. And then I discovered something new. The Pensol also does shrink tubing! For years I have used a butane lighter to shrink the heat shrink tubing used in place of electrical tape. The waste heat from the Pensol shrinks the tubing better than any device I've ever used, and that includes a $200 hot air gun designed specifically for this purpose.

Conclusions

The Pensol works well and has lasted us in hard service. Its strong points are its adjustability and lack of extension cord. It's truly portable. It has enough heat output to solder large wires (up to 10 ga). It's easy to use and refill. The Pensol has become a standard tool in my toolbox. I use it instead of an electric soldering iron because it works well and is more convenient for jobs where the electricity is some distance from the work.

Access

You can get a Pensol from Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002 for about $20. The same Pensol (under another name) is also available from Radio Shack (RS #64-2161) for $29.95.

Things that Work!

Home Power Tests Cruising Equipment's Digital Ampere-hour Meter

tests conducted by Richard Perez and Alex Mason

The constant question in any battery based system is, "How full is the battery?" There are many ways to determine a battery's state of charge (SOC). The easiest to understand and most accurate method we've ever seen uses Cruising Equipment's Digital Ampere-hour meter. It's a "gas gauge" for all types of batteries, both lead-acid and nickel-cadmium. It not only works, but its information is direct and understandable by even the most nontechnical battery user. The Cruising Equipment Ampere-hour meter has become our prime instrument for determining our battery's state of charge. If you are going to use only one instrument to fly your system, then this is the one.

Ampere-hour Measurement

There are many ways to measure a battery's SOC. In lead-acid cells, you can measure the specific gravity of the electrolyte with a hydrometer. But this is inaccurate as it depends on temperature, and risks contamination of the cell. In nicads, specific gravity of the electrolyte is meaningless for determination of SOC as it doesn't change with the cells' state of charge. We've always used a specially made, expanded scale voltmeter to determine SOC. But this is not very accurate, and varies with the battery's temperature. Measuring SOC by voltage is also dependent on the current flow through the battery. If the battery is under charge, then the voltage is higher. If the battery is under discharge, then the voltage is lower. And after you have compensated the voltage measurement for current and temperature, then you must still consult a SOC versus Voltage chart to accurately determine the battery's State of Charge. Sound confusing? Well, it is. All this confusion is cleared up by Cruising Equipment's Ampere-hour meter.

Ampere-hour measurement is the best way to determine battery state of charge. The measurement doesn't depend on temperature, cell type, and doesn't care whether the battery is being charged or discharged. Consider this example of a 100 Ampere-hour battery. If the 100 Ampere-hour capacity battery has 10 Ampere-hours withdrawn, then its state of charge is 90% ([100 A-h- 10 A-h]/100 A-h, or [100-10]/100, or 90/100=90%). If we can measure the actual number of Ampere-hours of electricity withdrawn from the battery, then we will know exactly how much power remains (its state of charge).

Ampere-hour meters come in many types. Most are totalizing types that add up the Ampere-hours flowing in a single direction. The Cruising Equipment Ampere-hour meter is optimized as a Battery SOC meter. The meter is bi-directional. It measures current flow when the battery is being charged or discharged.

The Cruising Equipment Ampere-hour Meter Concept

The meter should be installed on a fully charged battery. At this point the digital display will read zero (0). This makes sense since the battery is full and we haven't yet withdrawn any power from it. As the battery is discharged, the digital display counts the Ampere-hours withdrawn from the battery. For example, say our battery is full in the afternoon, and during the night we withdraw 40 Ampere-hours. Early the next morning, the Cruising Equipment Ampere-hour meter will read -40 (that's MINUS 40) to indicate that we've withdrawn 40 Ampere-hours from the full battery. As the Sun comes up and the PV array (or **any** other power source) starts recharging the battery, the Ampere-hour meter begins counting up (from -40, it counts to -39, -38, -37, etc.) to zero as the battery refills. When the battery is full, the meter again reads zero. At that point any additional recharging of the battery is read as positive numbers on the display. For example, after the battery is full, if we put 20 Ampere-hours more through it, then the display will read 20 as "overcharge Ampere-hours". After charging stops, the meter resets itself to zero regardless of the number of overcharge Ampere-hours. This makes sense since overcharge Ampere-hours can not stored by the battery since it is already full.

Cruising Equipment's Ampere-hour Meter.
Photo by Laura Flett

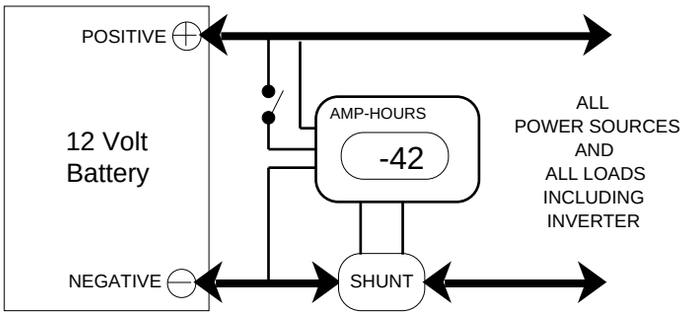
What makes the Cruising Equipment Ampere-hour meter so slick is that it is designed for only one job-- battery state of charge. This meter works so well because it does this one job better than any instrument. It isn't designed to measure the long term power production of PV/Wind/Hydro sources or to measure the long term consumption of appliances. It will work for short term Ampere-hour measurement For example, we've used it to measure the actual consumption of our microwave powered by the inverter/ batteries.

Shipping, Packing, and Installation/Operation Instructions

The unit arrived via our local UPS service in fine shape. It was packaged very well and should survive shipment just about anywhere. The instructions are detailed and very complete. They include well written, step-by-step installation instructions for the novice electrician and an installation schematic for impatient techies. Operation instructions included are complete with a "what does it all mean?" section with electrical basics such as Ampere-hour definition, battery capacity explanation, and use in multiple battery systems.

Test System
We installed the meter on our main system at Agate Flat. This system is described in detail on page 7 of this issue. This system uses a 384 peak Watt PV array (≈2kWh daily) feeding a battery of four Trojan L-16W lead-acid batteries (700 Ampere-hours at 12 VDC). The major DC consumer is a 2.3kW Heliotrope inverter.

Installation
The Cruising Equipment meter is easy to install. There are five wires involved. Two of them go to the battery PLUS and MINUS (either directly or to the battery's buss). Two go to the shunt in series with the battery's (or buss's) negative terminal. And the last wire can be connected to battery PLUS via a switch to turn the meter's backlighting on or off. A schematic is shown below.



The Cruising Equipment Ampere-hour meter uses a shunt to detect current. A shunt is a very small resistance inserted in a current path. This resistance has a voltage loss that is directly proportional to the amount of current flowing through it. See HP#6, pg. 35, for a technical discussion of shunts. The shunt used here is a precision shunt (1%) with a resistance of 0.001Ω. The shunt is available in 100 Ampere maximum current for small systems, and 300 Ampere maximum for larger systems. We chose the 300 Ampere shunt because our inverter often consumes well over 100 Amperes on surges (like starting the microwave). Since the shunt is installed so that all the electrons moving either in or out of the battery MUST flow through it, the shunt must be capable of handling the largest sustained current flow that the system will ever undergo.

Performance
We installed the meter on our fully charged battery pack on 15 January 1990. We have been watching it like hawks ever since. We measured its accuracy against a Fluke 87 (reading true average current simultaneously through the same shunt at the same time). The Cruising Equipment Ampere-hour meter agrees with the Fluke 87 test setup to within 2%. And that's close enough to be within the limits of error in our testing procedure.

The Cruising Equipment meter has replaced our homebrew expanded scale battery voltmeter (see HP#2, page 31) as our main instrument for flying our system. Every morning the first thing we check is this Ampere-hour meter and it tells us at a glance how much we've used from the battery. During the day, we watch the meter measure the gradual refilling of our battery by the PV array. If the Sun doesn't shine, then the meter tells us when the battery is getting low and thereby, when its time to fire up the generator. We use the overcharge measurement feature to determine when equalization charges are completed on our lead-acid pack.

If I could only have one instrument for information in a battery system, it would be the Cruising Equipment digital Ampere-hour meter. As a techie, I use the information provided by some 14 meters staring me in the face. But this Ampere-hour meter now has the final say on battery SOC, and the rest of the instrumentation is strictly for fun and/or special jobs.

On a nontechnical note, Karen has had trouble determining SOC with our battery voltmeter. She easily grasped the idea behind this digital Ampere-hour meter and now has no trouble flying our system on her own. While all the techie info here is well & good, you don't have to understand any of this to effectively use this meter. When it comes to "how full is the battery?", this has got the answer.

Cost
The digital Ampere-hour meter costs $199.00, the 300 Ampere shunt costs $39.95 and the 100 Ampere shunt costs $19.95. I recommend the 300 Ampere shunt for any system using a 1,000 Watt or greater inverter.

Conclusion
The Cruising Equipment digital Ampere-hour meter is definitely a "Thing that Works!". It is the best instrument for measuring a battery's state of charge that we have ever seen. It works equally well on both our lead-acid and nicad batteries. Best of all, you don't have to be an electrical engineer to understand its information.

Access
Contact: Cruising Equipment, Inc., 6315 Seaview Ave. N.W., Seattle, WA 98107 or call 206-782-8100.

Things that Work!

Home Power tests the Trace 2524 Inverter/Charger

tests conducted by Richard Perez and John Pryor

Testing Trace inverters could be boring, if it weren't for the continual amazement I undergo every time I use one. The Trace inverters have become a standard in the inverter industry for performance and just about zero failure rate. The 2524 is an upgraded model of the 2024, with higher wattage output, especially surge power output for starting inductive loads like large electric motors. The boys at Trace deserve flowers for continually improving their products without increasing their prices. That's right, this new, more powerful, inverter costs just the same as the earlier model. What a deal!

Inverter Specifications

The Trace 2524 converts 24 VDC battery stored power into 120 vac for use in conventional appliances. The use of the very latest in high-power Field Effect Transistors (FETs) and new impulse phase correction circuitry has allowed Trace to increase the output of the 2524, its largest model. The Trace 2524 is rated at 2,500 watts output for at least 1/2 hour. It is capable of supplying the surge power needed to start a 1 horsepower electric motor.

The model 2524 we tested came with all the factory installed options: built-in battery charger, digital metering deck, and the turbo fan option to keep things cool.

Shipping Container and Installation Instructions

The Trace 2524 arrived in fine shape via UPS. All Trace inverters are very well packaged, with foam inserts that keep the inverter in good condition even through very rough handling. The installation instructions are complete and detailed. If you can read English, then you can install this inverter properly.

Test System

We installed the 2524 in the largest 24VDC system in our neighborhood. This system uses eight Trojan L-16W batteries (700 Ampere-hours at 24 VDC), and is sourced only by a 6.5 kW. ES6500 Honda 120/240 vac engine/generator. This system really gave the Trace a workout, especially its built-in battery charger. We wired the Trace to the battery with two cables (each 4 feet long) made of 0 gauge copper cable.

Test Results

The first thing we noticed was that the Trace 2524 was able to start and run larger electric motors than the previous 2024 model. Motors in appliances like the 120 vac deep well pump, the washing machine, and a very large vacuum cleaner started easier and more quickly. And the 2524 ran these motors for a much longer period of time than the earlier model 2024.

Technically speaking, the Trace 2524 is capable of starting and running electric motors that were some 15% to 25% larger than the earlier model. Peak voltage remained at ≈162 Vp until we overloaded the 2524, when it dropped off to protect the inverter from overload damage. RMS voltage was rock solid at 117 vac. According to our Fluke 87, the frequency output of the Trace 2524 varied not more than 0.1 Hz from 60 Hz., regardless of the type or amount of load we placed on the inverter. Efficiency of the 2524 was within the specifications set by Trace Engineering, that is far more than 90% from 200 watts to over 2,000 watts output. Efficiency while running inductive loads like motors, fluorescent lights, and transformers was much greater than the earlier model 2024. This is due to the new impulse phase correction circuitry invented the techies at Trace. The bottom line on this new circuitry is that the Trace 2524 will not only start bigger motors, but it will run them for longer periods of time without the heat build-up that "browned-out" the earlier models.

The Trace 2524 survived repeated and deliberate overloading and even short-circuiting of its output. It's as tough as an old rhino. The only way you can kill it is with a shotgun.

The test system we used is sourced only by an engine/generator. The battery charger in the Trace got a real workout. This charger is rated by Trace at 50 Amperes. Our instrumentation showed that this is true, at least when the battery pack was less than 60% state of charge. As the battery filled, and the system voltage rose, the charger's output tapered off to a solid 42+ Amperes. This tapering is caused by the turns ratio with the Trace's transformer and the fact that most all generators don't really produce high enough peak voltage output sufficient to drive the charger at maximum output. If the generator is capable of maintaining the ≈160 Vp necessary, then the charger will, in fact, deliver the current specified by Trace. Extended operation of the charger at its highest output level caused the turbo cooling fan to automatically operate to dissipate the heat build-up by the charger.

The optional digital metering deck in the Trace worked well and agreed (±2%) with our outboard metering. The built-in Trace metering allowed the user of this system to adjust the Honda

generator to the proper speed (RPM) to maintain a constant 60 cycles per second output from the generator. The peak voltage section of the meter allows the user to know when he is overloading the generator. When the generator is overloaded the peak voltage drops below the ≈160 Volt peak level required by the charger. A note on generators is appropriate here. Most generators we've ever seen have trouble maintaining peak voltage when fully loaded. The higher priced (and worth it) generators, like the Hondas, do significantly better in maintaining their peak voltage under heavy load. Regardless of the generator used, the digital meter built into the Trace tells the tale and allows the user to better and more efficiently apply his generator.

The Turbo fan option functioned well. It is thermostatically controlled and turns itself on whenever the inverter gets hot. The turbo greatly extends the operating time and power of the inverter, both in inverter and charger mode. The fan nestles underneath the inverter and can be retrofitted to any of the larger Trace inverters.

Conclusions

The Trace 2524 is an ultrafine and supremely reliable large inverter. Its power output is significantly higher than the previous 2024 model (especially on inductive loads) and at the same price. We recommend that anyone buying this inverter also include the charger, turbo and digital metering deck. These options greatly increase the inverter's utility and output. Cost of the basic 2524 inverter is $1,350. Cost of the 2524 with the factory installed battery charger, turbo and digital metering is $1,820 and worth every penny. Congratulations to the fine fellows at Trace for constantly improving their already legendary inverters and for keeping the cost the same. It's amazing.

Access

Trace Engineering, 5917 - 195th N.E., Arlington, WA 98223, or call 206-435-8826.

Tour de Sol Ad

TRACE AD

Things that Work!
Home Power tests the Solar Pathfinder™

tests conducted by Richard Perez, Bob-O Schultze and John Pryor

Placement of a PV array is critical. Determining exactly how much solar energy a specific location receives throughout the year is not easy. Hills, trees, buildings and other obstructions may shade the PV array and reduce its output. And to further complicate things, the Sun's angle keeps changing with the seasons. The array needs to be located at the one place on a site that receives the most sunshine. The Solar Pathfinder is THE tool for this job. It takes all the guesswork out of predicting exactly how much sunshine the array will receive, at a specific site, throughout the year. The Solar Pathfinder is easy to use and accurate enough to measure changes in array position down to a few feet.

How the Solar Pathfinder Works

The Solar Pathfinder uses a highly polished, transparent, convex plastic dome. Reflected in this dome, the user sees a panoramic view of the area around him. All the hills, trees, buildings or other obstacles to sunshine are plainly visible as reflections on the polished surface of the Solar Pathfinder's dome. Since the dome is transparent, the user can also look through the dome to a sun chart within the Solar Pathfinder. This chart shows the Sun's path through the sky for all months of the year. The chart is also calibrated by the hours of the day.

The dome has slots in its sides and the user traces the outline of the horizon's reflection on the dome onto the sunchart. The traced line shows exactly at what hours of the day, and months of the year an obstacle will shade the PV array. For example, a sunchart for the array we use (see page 10 for photo) told us exactly when the array would be shaded by the hills and trees around us. From this information, we can accurately predict the array's performance at any time of the year.

In this case, a picture is worth at least one hundred thousand words. Describing how the Solar Pathfinder works is difficult. Everyone who has watched it being used instantly groks its operation to the fullest. The photo shows the Solar Pathfinder in operation at a poor location. We selected a poor location because its many solar obstacles are plainly visible on the dome. Brian Green outlined the skyline, by tracing the obstacles, to make them more visible on his photograph.

Using the Solar Pathfinder

The unit is simple to use. First, unpack it from its heavy metal case (this machine is built to travel in the outback for sure). The Solar Pathfinder stands on an adjustable, telescoping tripod. The unit contains a magnetic compass to find magnetic North. The base of the pathfinder rotates and locks to adjust for magnetic declination-- thus correcting for the local difference between true North and magnetic North. The Pathfinder also has a built-in bubble level so the entire unit can be oriented level and facing true South. The user selects the sunchart for his latitude and inserts it into the base of the Pathfinder. The dome goes on top. All that remains is to trace the reflection of the skyline onto the sunchart. The thorough, 20 page manual provided with the Solar Pathfinder shows how to convert the sunchart into specific information about the array's performance.

The graphic here shows a sunchart with a skyline already outlined on it. The user has only to count up the shaded areas (easily definable in 15 minute intervals and calibrated in percent) to determine, for example that the array is shaded by a big tree and only receives 75% of the possible sunshine during the month of say December. The Solar Pathfinder is very specific and leaves no doubt about the solar insolation situation. The unit comes with suncharts for just about every latitude and even suncharts optimized for heating and solar architecture applications.

We found that we wanted to run suncharts in many different locations around our site and compare the amount on sunlight

received at each. By doing this, we were easily able to select the best place to put the ground-mounted array. And I mean down to the last foot! No guesswork, no *"Well, it looks to me…"*, just the straight and accurate facts.

Just one observation provides complete info on a site, and the info is adjusted for shading objects and seasonal changes. The Solar Pathfinder can be used anytime of the day, anytime of the year and in either cloudy or clear weather. In fact, we found it easier to see the reflections in the dome when it was overcast, at dawn, or at sunset.

The Info that the Solar Pathfinder Provides

Here is a list of just some of the information that the Solar Pathfinder gives its user. Actual sunrise and sunset times, for each month, at a specific location. Times of the day when objects will shade the site, for each month of the year. Percent of solar radiation available for the average day each month. Percent of solar radiation lost to obstacles due to shadows for each hour and month. Output info is available from the Solar Pathfinder in a variety of units, everything from percents to BTUs per square foot per day.

Conclusions

The fellow, Mr. Bernard Haines, who invented the Solar Pathfinder deserves some kind of award for forward thinking and design. Not only does his device work great, but it's easy to use, accurate, ruggedly built, and just plain ingenious. Cost for the Solar Pathfinder is $149.00 shipping prepaid in USA and this includes the metal case, tripod, instruction manual and suncharts. Considering that our array cost almost $3,000, the Solar Pathfinder is inexpensive because it allowed us to put the array in the just right place to get its maximum yearly output. Every solar energy user should take the Solar Pathfinder on every job he does. We do. In fact, the Oregon Dept. of Energy requires a sunchart before paying off on their renewable energy tax credits for new PV systems. Even the taxman is hip to the Solar Pathfinder and respects its information. Nuff said…

Access

Order from : Solar Pathways Inc., 31 Chaparral Circle, Glenwood Springs, CO 81601 or call 303-945-6503 • 303-945-5334.

Ohm's Law & Digital Multimeters

Alex Mason

If you understand Ohm's Law and know how to use a Digital MultiMeter (DMM), then your renewable energy system holds no mysteries. Through the application of Ohm's Law and accurate measurement with a DMM, we can find out just about everything we need or want to know about our system's operation and performance.

Ohm's Law

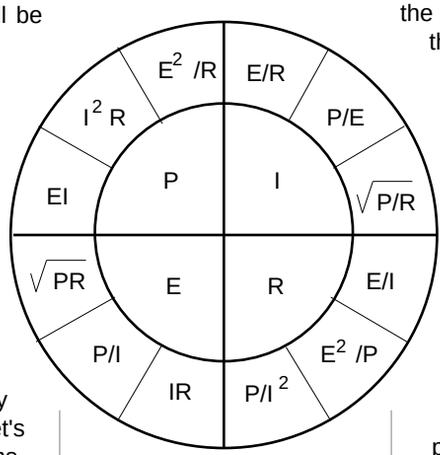
You loved it before, and we're serving up it again by popular demand. All Nerds, Techies, and Electroweenies can skip this explanation of Ohm's Law and proceed directly to the DMM Stuff.

Ohm's Law describes the relationship between three characteristics of electricity. The first characteristic is Voltage (abbreviated as "E" in the formulas). Voltage is the concept and measurement of electron pressure, similar to the idea of water pressure. The second electrical characteristic is Current, or the rate of flow of electrons. Current is measured in Amperes (abbreviated as "I" in the formulas). The third electrical characteristic is Resistance. Resistance is the property of all matter to resist the flow of electrons. Resistance is measured in Ohms (Ω) and abbreviated as "R" in the formulas. This then is our cast of characteristics: Voltage (E), Current (I), and Resistance (R). A particularly awake human named Georg Simon Ohm worked out the relationship between these characteristics in the 1800s. His equation is:

$$E=IR$$

Which may not seem too earthshaking, but it allowed ancient electrotechies to use electricity as something more than a curiosity. This relationship between Voltage, Current and Resistance is sublime and unavoidable. This relationship is built into every device in our systems. All devices using electricity operate by the grace of Ohm's Law. Understand this relationship, learn to measure these characteristics with a DMM, and your system will talk to you. You will know all, and by knowing, you will be better able to use and maintain your system.

Let's look at Ohm's Law more carefully. It is an algebraic equation. If we know two of the three quantities, we can mathematically determine the third. Seem abstract? Well it isn't. Consider this example. We want to know how much current the inverter is consuming from our battery. Since direct measurement of the large currents (>500 Amperes) is difficult and expensive, we insert a small amount of resistance between one of the inverter cables and the battery. This small resistance is called a "shunt" and is precision made to have a very specific amount of resistance. In this case let's consider, a shunt with a resistance of 0.001 Ohms. If we can accurately measure the Voltage drop across the shunt, and we know the Resistance, then we can calculate the amount of current (Amperes) flowing through the inverter. Very useful, this. See HP36, pg. 35 for the gory details.



where:
P= Power in Watts
I= Current in Amperes
R= Resistance in Ohms
E= Voltage in Volts

And this is just one place that Ohm's Law and a DMM can provide accurate information about system performance. The three components of Ohm's Law can be used to calculate other electrical characteristics like Power. Electric power is measured in Watts and abbreviated as "P". Power is the product of Current and Voltage (P=IE). Consider the inverter shunt example. Since we've already determined the current flowing through the shunt, all we have to do is measure the battery's voltage, multiply the Current times the Voltage and presto we have the Power that the inverter is consuming in Watts. All this from two measurements, and the practical application of Ohm's Law. The graphic shows the mathematical relationship between Voltage, Current, Resistance, and Power. You can get the needed equation for any of the quantities shown in the center of the circle by looking to the outside rim.

This article is not intended to be a complete course on all the ramifications of Ohm's Law. Techies have written entire books on the subject. The serious renewable energy person will find that time spend learning and understanding Ohm's Law is time very well spent. See the following Home Power issues for more information: #1- pg. 35, #3- pg. 40, #4- pg. 33, and #6- pg. 35. Get a basic physics book and read up on electricity. My favorite is the one I used in high school, Modern Physics (the latest edition has ISBN# 0030884888). It's simple, to the point, and understandable.

Nerding Ohm's Law with a DMM

Modern electronic instrumentation has reached the point were accuracy and utility are out of sight. For even a few bucks, the average user of electricity can buy a digital meter that will accurately measure all three components of Ohm's Law. Twenty years ago, this equipment would have cost a fortune and filled a room. Now it is affordable and packs into a lunchbox. The best of the lot now are the Digital MultiMeters (DMMs). They all measure the following electric parameters-- Voltage, Current, Resistance. Some models also measure Frequency, Capacitance, and Duty-Cycle. Accuracy varies from 3% to 0.1%, depending on the DMMs quality. They all display their information as numbers on a Liquid Crystal Display (LCD). The LCDs are rugged, and consume minuscule amounts of power, so the DMM is very portable and suited for backwoods use. What follows below are descriptions of three DMMs, of varying quality and cost. In the field of instrumentation, you get what you pay for.

Three DMMs at work measuring our battery voltage. On the left is an earlier model ofthe Radio Shack unit mentioned in this article. In the middle is the Fluke 77. On the right is the Fluke 87 reading in 4 1/2 digit mode. Photo by Laura Flett.

The Radio Shack DMMs

Radio Shack offers many DMMs in their catalog. These are entry level meters and we list them here because they are inexpensive and available everywhere. The current model that works best and is most cost effective is their #22-185 for $59.95. It works and measures down into the milliVolt range, making it useful for shunts like our inverter example. The quality of the hardware used to make these Radio Shack meters is not very high. In our experience, two years of heavy use will wear out the rotary switches. We test their basic DC voltage accuracy at around 3%, which is not bad considering their price. One problem with the less expensive meters is that they will not be able to accurately measure either the ac Voltage or ac current produced by inverters. Accurate measurement of nonstandard ac waveforms (like inverter power) requires the use of a peak reading and true RMS reading meter. None of the Radio-Shack meters offer true ac Voltage measurement.

The Fluke 77

This DMM is rugged and an entry level professional model. Basic DC voltage accuracy is 0.1% and that's very accurate. In fact, all the Fluke DMMs mentioned here have calibration traceable to the National Bureau of Standards (NBS). This means that your Fluke talked to a meter that talked to a meter that talked to THE METER. Cost is $150. This unit uses a microprocessor to run a self-check on all functions every time the 77 is turned on. The Fluke 77 is very well constructed of high quality components and will last many years of hard service. The unit comes in a rubber armored case to protect it from Life's little knocks. The Fluke 77 does not have true ac voltage measurement so it can't accurately measure inverter power output. That takes its big brother the "87".

The Fluke 87

This meter will delight even the most jaded techie. The Fluke 87 offers all the standard DMM features of the Fluke 77 mentioned above, 0.1% DC accuracy, and it measures peak and true RMS voltages. The 87 can accurately measure all the electrical parameters of an inverter's output! And a host of other things, like: frequency down to 0.1Hz, duty-cycle, and capacitance. The Fluke 87 also records measurement data and can function as an Ampere-hour meter, among other things. The record feature works in most functions and detects maxima, minima and true average measurements. The meter will measure and record ac or DC data as fast as 1 millisecond. This makes it very useful for measuring surges and transients. It will record data for up to 35 hours. It is also capable of 4 1/2 digit operation, which gives the user even greater accuracy than either of the meters above. Price isn't cheap, ≈$280, but then this is a hell of a meter.

Use it!

It's not important which DMM you use, but if you are making your own electricity, you should know how to use a DMM. Understanding Ohm's Law, and armed with your DMM, you are ready for anything your system can throw at you. You can troubleshoot problems. And, most importantly, you can effectively measure and manage your system's energy.

Access

I will answer questions on instrumentation, write Alex Mason, C/O Home Power, POB 130, Hornbrook, CA 96044.

Radio Shack is everywhere and you don't need my help to find one.

Call Fluke at 800-443-5852 for access data on your nearest Fluke dealer.

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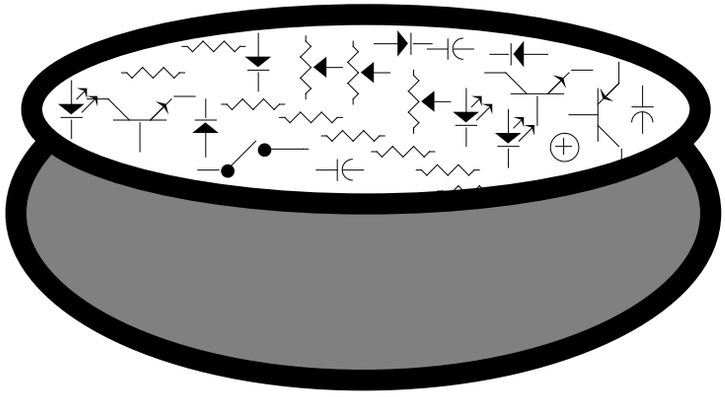


Homemade Low Voltage DC Refrigeration

Bob McCormick

For years electrical refrigeration and freezing of perishable foods was the "Achilles Heel" of AE power systems. In the last few years, low voltage refrigeration appliances have become available. They have very low power consumption rates, but priced at figures few of us backwoods people can afford. I will explain here how the use of low voltage refrigerators and freezers can be more affordable to a larger portion of AE users. Especially if you don't mind doing a little work.

Food Preservation Essentials

The preserving of perishable foods by canning, drying or freezing has been a way of life for modern people. We no longer hunt for our food from day to day. Many of us who make our own electricity, live where it is not practical to buy our food each day at the supermarket. We need some way to keep our perishable foods from spoiling. This is true whether we grow our own food, or buy it at the store.

Canning and drying foods is time consuming and we loose some of the nutrients, as well as flavor and appearance, during processes. Freezing is the preferred method of storing food for long periods. Freezing is quick, convenient, healthy, tasty, and more appealing.

Freezing Before PV

We have lived beyond the power lines for 22 years. We froze foods until 1985 with 3 old Servel propane refrigerators. We simply removed the temperature sensors from the main control units. The burners operated at high flame continually. This provided adequate freezing when they were placed in the coolest location available. This method was costly, but did the job.

Our First 12 Volt Freezer

We purchased our first 8 Kyocera PV modules in 1985. The system was sized for our short winter days. These 8 modules powering our energy conservative home meant we had a considerable amount of excess power available during long summer days. The logical choice was to use the excess power for refrigeration and freezing.

12 volt refrigerators and freezers are expensive. None are manufactured in Canada where we live. Importing to Canada would add 40% to their cost. To say nothing of the extra freight charges involved.

Instead we bought a DANFOSS 12 volt DC refrigeration compressor with electronic control and a capillary type temperature control sensor. This is the same compressor used in many manufactured appliances, like the Sun Frost units. We replaced the 110 volt ac compressor with the DANFOSS in a conventional freezer box. The capillary temperature control sensor was needed, as the 12 volt compressor would not operate on the 110 volt controls in the box.

We discussed the installation with our local refrigerator repair man. He said our idea would work. He also told us that if we installed an external condensing unit on the back of the freezer box we could super-insulate the box with styrofoam, urethane foam, or bat insulation. This would cut down the running time and power consumption dramatically.

We found a used 7 cu. ft. deep freezer, with a good box, whose 110 volt compressor had given up the ghost. Our helpful refrigerator repair man replaced the 110 volt compressor with the 12 volt DANFOSS compressor, electronic control unit and capillary temperature sensor. He installed a properly sized external condensing coil on the back of the box. The completed unit was ready to charge with refrigerant. Our repair man evacuated the system of air, charged it with refrigerant, and the installation was complete.

The tested unit maintained an internal temperature of 0°F. The running time of the compressor to maintain 0°F was 30 to 40 minutes per hour at an ambient temperature of 70°F. The compressor consumes 4.1 Amps per hour. With a running time of 30-40 minutes per hour our "new" freezer would consume 60 amp hours per day. Three of our Kyocera modules output. This seemed excessive, so we went to work insulating the box.

Super-Insulating the Box

We purchased enough 2" thick styrofoam board insulation to completely cover the four sides and top of the box. We cut the styrofoam to overlap at the sides and edges for neat square edges.

The styrofoam was applied to the box with PL 200 multi-purpose construction adhesive. If styrofoam is used, care must be taken in the choice of adhesives. Some compounds will melt styrofoam and it will not adhere properly to the box.

We also purchased enough 1/8 inch thick acrylic bathroom or kitchen panel board to completely cover the styrofoam. This board makes the exterior easy to clean and gives a pleasing appearance. The acrylic paneling was applied to the styrofoam with the PL 200 adhesive. The corners and edges were finished with 3/4 inch 90° cabinet moulding, in a contrasting color.

One word of caution for you do-it-yourselfers, DO NOT attempt to place any screw or nails into the sides of the freezer box. You could pierce the cooling coils, lose the refrigerant and make the freezer box useless with no hope of repair.

Running Time Cut In Half

After completing the super-insulating of the box, we plugged the unit into the 12 volt DC of our house. Of course the freezer was located in the coolest possible location.

The average running time at approximately 65°F was cut from 30-40 minutes per hour to 15-20 minutes. This was with the box empty. After filling it and the food were frozen, the running time was even less. The closer to full any freezer is, the less will be its running time.

Now, on an average summer day it only takes 1.5 Kyocera modules to run our freezer. We can live with this quite well.

Since starting our AE business in 1986, we've sold a number of these units in various sizes ready made. Finally the lack of available, good freezer boxes has led us to marketing the DANFOSS compressor, electronic unit, and capillary temperature sensor as a package. The customer finds a local refrigerator repair person to do the installation in the box of their choice. A lot of money is saved in freight costs.

The size of the external condensing unit will vary somewhat with the size of the box used. These will be available from your installer. Prices will vary slightly with size.

These single compressor installations have been made in freezers and refrigerators from 5 cu. ft. up to 12 cu. ft. Only the amount of super-insulation will vary with box size, to keep running time to a minimum.

These compressor units can be used in tandem in freezers from 15 to 20 cu. ft. with a corresponding increase in power consumption. Only one temperature sensor is required when a tandem configuration is used.

Cost in Canadian Dollars

The following cost figures will generally be about 15% less in US dollars for components and materials. Installation costs may vary somewhat from place to place.

ITEM	Cost Canadian $
12VDC Danfoss compressor,& controls	$425.00
Used 7 cu. ft. freezer	$35.00
External condensing coil	$36.20
1 sheet 2" Styrofoam insulation	$22.00
1.5 sheets 1/8" arcylic panel & moulding	$32.80
2 tubes PL 200 adhesive	$6.98
Installation & charging system with refrigerant	$127.50
TOTAL	$685.48

This is about 1/3 to 1/2 the price of 12 volt refrigerators and freezers that are manufactured today.

Access

Bob McCormick, Northern Alternate Power Systems, POB 14, Pink Mountain, BC, Canada V0C 2B0.

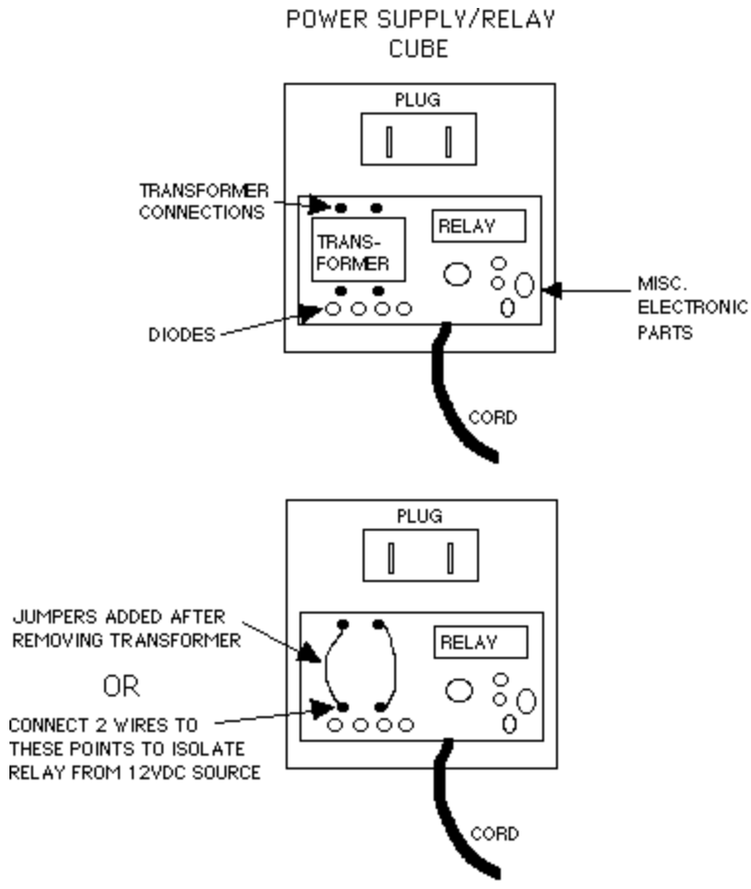
TIMER CONVERSION

David W. Doty

After converting most of our home's lighting and general purpose outlets to inverter power, we were faced with the dilemma of those 24 hour/day loads (clocks, timers, answering machine, VCR, etc.). We solved these problems in several different ways. First, we added extra power switches to the TV, VCR, and computer to eliminate these as 24 hour/day loads. Second, we purchased a nice "School House" style wind-up clock for the living room. Our next problem was the telephone answering machine. Because our battery bank is located in a detached garage, we didn't have a nearby source of 12 VDC to power the items that could be converted to low voltage. To solve this, I installed a second solar system with the batteries located out on the deck. This system was intended to run only small 12 volt loads like the answering machine and a car stereo. Later, we added a pair of reading lamps for our bed, an area light (PL-13), and a small 12 volt color TV. We get a tremendous amount of pleasure and utility out of this small system. After all this, we still had one obstacle, the alarm clock. I just couldn't find a battery operated or wind-up clock that I liked. I finally stumbled across a seven day electronic programmable timer at Radio Shack. This timer was designed for 110 volt use, but is easily converted for 12 volt applications. After completing the conversion, I connected the timer to our 12 volt stereo and presto, we had a seven day, programmable, alarm clock/stereo.

The timer we used is a Radio Shack # 63-889, and sells for $29.95, but we got one on sale for about $25. This unit has a control console with an LCD display attached to a plug-in relay/power supply unit. The relay/power supply unit is easily disassembled to bypass the transformer for 12 volt operation. The relay has a rating stamped on it of 16A@240V, 1/3HP, 16A@24VDC. There are also provisions for two "AA" batteries for memory back-up.

To convert this timer, simply remove the four screws that hold together the plug-in relay/power supply unit. Make sure you use a screwdriver that fits properly, because the heads on these screws strip-out quite easily. After opening the case, you need to remove or by-pass the transformer. I chose to remove the transformer completely on mine using a desoldering tool. Then add jumper wires where the transformer was. Polarity is not important at this point, because the bridge rectifier is still in the circuit. After you reassemble the case, the conversion is done. You can now plug the unit into 12 VDC and have the timer control the outlet on the cube. CAUTION !! Do not try to plug this unit into 110 volt AC after this conversion--it will smoke instantly if you do.



If you wish to control a 110 volt load with this timer while using 12 VDC to run the clock, you may do so by isolating the relay contacts from the source that runs the timer. To do this, do not add the jumper wires after you remove the transformer. Instead, connect a length of two conductor, 18 gauge wire to the spot were the transformer was connected to the bridge rectifier. Drill a small hole in the case for the wires to pass through. You may now power the timer from your 12 volt batteries using these wires, and use the relay to control a separate 110 volt load.

Access

David W. Doty, 14702 33rd. Ave. N.W., Gig Hatbor, WA 98335 • 206-851-2208.

Build A Multi-Purpose Voltage Controlled Switch

Alan Yelvington

All the parts needed to build this all purpose controller are available at Radio Shack. It will switch loads or power sources either on or off at user set voltage limits. It measures the voltage of the battery and operates a small relay which in turn can operate a larger relay connected to an appliance or a power source (like a PV array).

Control Design

Here's the basic scoop. The controller is made up of four sections. 1) the voltage reference (LM317), the voltage threshold detectors (1458 Op Amps), the control logic section (4011 NAND Gate), and the relay driver section.

The reference voltage section not only provides a "benchmark" voltage level (10.0 VDC ±0.1 VDC) that is used to compare the input voltage; it also provides a regulated voltage to power the rest of the device's logic. This keeps the logic stage in the face of battery voltage changes. The input regulator (LM317) allows this circuit to function from 11.5 to 36 VDC.

The threshold detectors (1458 Op Amps) are used to compare the reference voltage to the input voltage form the battery. The input voltage is divided down through the 10kΩ input potentiometers to make voltage switch point user adjustable. The outputs of the detectors are apparent by the lit LEDs.

The control logic section is an RS Flip Flop made of the two NAND gates in the 4011. This serves as a toggle so that the opposite threshold must be met before the switch will toggle back. This prevents the relay from "hunting" and chattering at a threshold point. The NAND gate also permits a very wide range between the two voltages setpoints determined by the detectors.

The simplicity of this device is what gives it its flexibility. For example, Load divert when the batteries are at 105% SOC with return to charging when the cells are at 90% SOC. Generator start at 50% SOC and generator stop at 95% SOC.

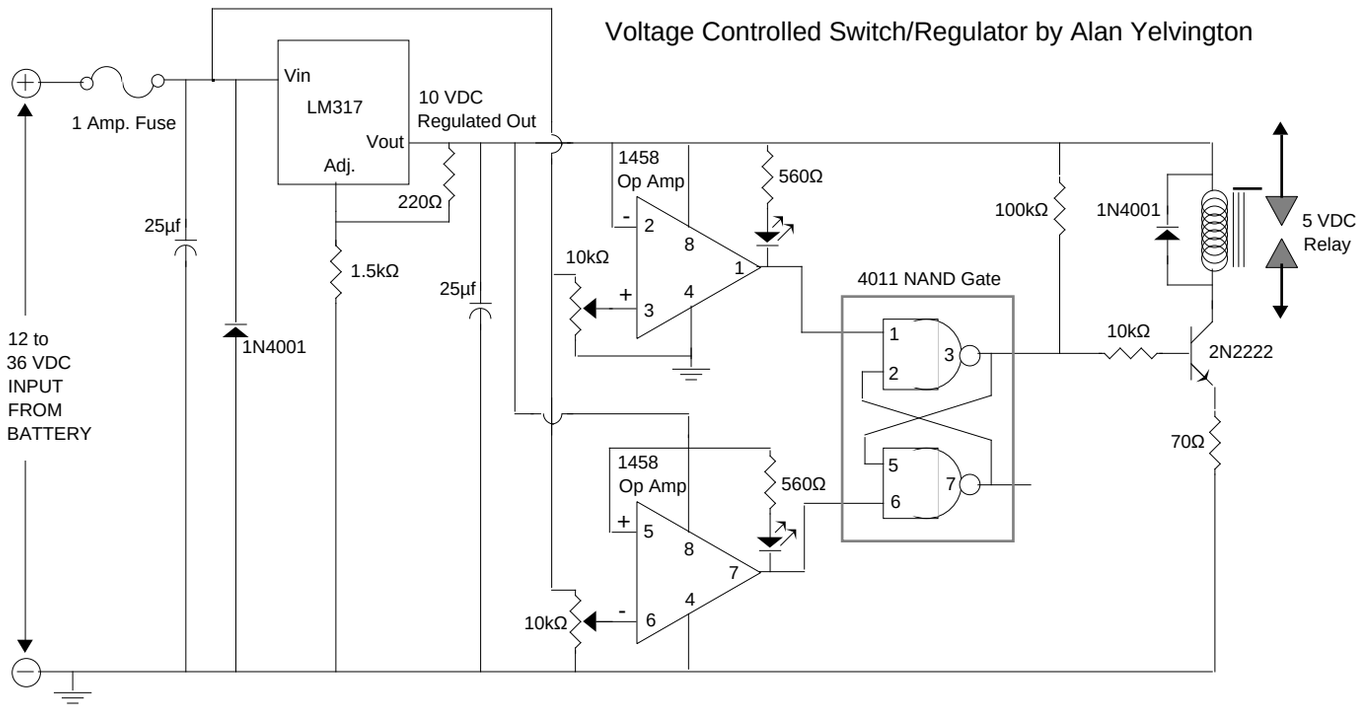
The option of either a normally open or normally closed circuit (through the relay) makes interfacing the control easy in all applications.

If you would be interested in buying an etched and drilled circuit board for this project, I would be interested in knowing. If I receive enough responses, then I'll make some PC boards, instructions, and part lists. I expect I can do this for 10 to 15 bucks. Send me a self-addressed stamped envelope and I'll get back to you with the verdict. DON'T SEND MONEY!!

Access

Alan Yelvington, 219 Blanche St., Houghton, MI 49931.

Voltage Controlled Switch/Regulator by Alan Yelvington



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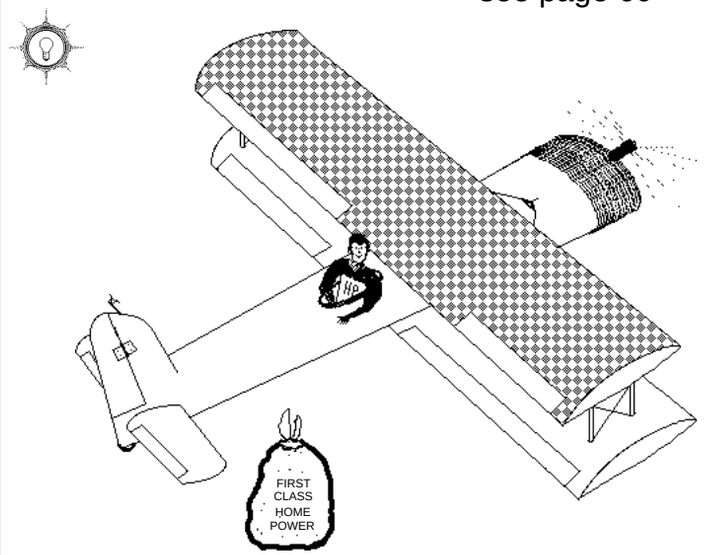
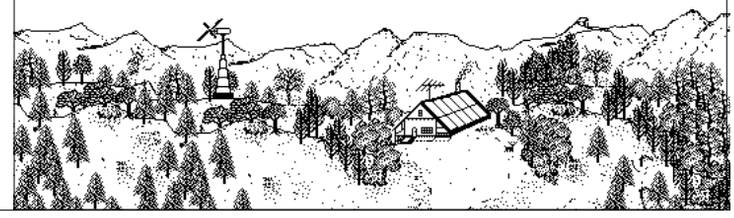
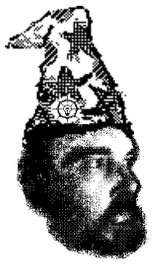






The Wizard's Dining Car

A Menu for a Better World

Appetizer:

Home Power Magazine

Entree:

Solarelectric panels, garnished with microhydros and wind machines, with batteries, inverter and a side order of controls and instruments. Sunshine sauce optional.

Dessert:

Energy efficient appliances

Entertainment by:

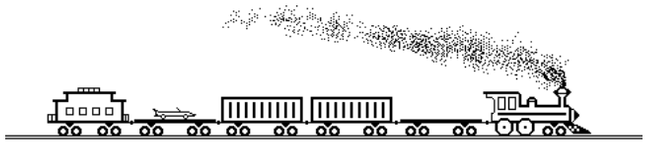
the Eternal Electron Dance Company

Nutritional Content:

Renewable energy for the preservation of our ecosphere and all our furry friends living within it. Contains no nuclear waste, air pollution, acid rain, or greenhouse effects.

Price:

Less than 1/2 mile of power line, or a used gas guzzling automobile.



Nerd's Corner

We try hard to keep the info in Home Power accessible to anyone who managed to stay awake during high school science. And all of you techies cuss us out for not getting down with some heavy nerding on high tech stuff. Well, here it is: a column that assumes that you are experienced. This column is for electronic and computer techies to get as complicated as necessary without providing basic access for non-electronic types. Damn the transistors, full speed ahead!

Seikosha SP-1000AP Printer

Six months ago I was knocking out correspondence on my old Canon Typestar 4 DC cell battery powered typewriter, having completely given up on my relic Vic-20 and accompanying *Gorilla Banana* printer.

Richard and Karen Perez made me a deal I couldn't refuse on their venerable, historic, Apple Mac 128 upgraded to 512E. Old and slow by today's standards, it changed my whole concept of computers. Words, numbers, data, graphics - Oh my!

Unfortunately, hard bargain-drivers that they are, and low-budget hacker that I am, I couldn't quite talk R&K out of the Imagewriter I that went with it. Computers are really great and all, but without a printer they're kinda...well, abstract.

After casting around for an Imagewriter unsuccessfully, I hit upon the Seikosha SP-1000AP. I couldn't find anyone who knew a damn thing about 'em, but the price was right, the specs looked good, so, gulping visibly, I plunked down the loot. Everybody gets lucky sooner or later, and this was my turn. It's a beautiful unit.

The Seikosha is Mac and Apple II compatible with full Imagewriter I emulation. 75 cps in the draft mode (bi-directional) and 15cps in the NLQ mode (pretty slow as printers go these days, but the quality is very good). It'll punch 3-part forms, has a 10" carriage, both adjustable and quickly removable tractor feed, and single-sheet friction feed as well. 15.4"W x 10.9"D x 4.7"H, weighs in at 11 lbs, and is a bit quieter than the Imagewriter. It works just fine on my Trace 2012 inverter.

The only real complaint I've got is that the tractor feed grabs the paper after the printhead; so if you're only printing one sheet, you've got to burn half of the next one to get it out.

Here comes the best part- $229.95 with a 2 year warranty! Ain't a bad little rig for the price.

Access

Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002

Bob-O Schultze, Lil Otto Hydroworks!, POB 8, Forks of Salmon, CA 96031

Muddy Roads

Kathleen Jarsckhe-Schultze

Living the AE lifestyle can be very different from what mainstream America is used to. Finding a life mate is a difficult and precarious proposition no matter where you live. The problem is magnified in the country, where most AE folks choose to live, by the small population base and the lack of suitable, single, prospects. In some areas there just aren't any singles to choose from- let alone suitable ones. Hence the concept of mail-order romances. It's not as strange an idea as it sounds. Nearly anyone who has ventured forth alone into the country to find and claim their own "piece of the rock" will testify that after just one solitary, rainy winter the path of a life and dream shared looks mighty good.

My husband and I met through the mail. A mutual friend got us writing to each other. After a lot of letters we met for a week long visit which hasn't ended yet. We were married a year after we met.

We have single friends, of both sexes, that have written to people hoping to cement a relationship, just to have the chosen person realize that they "could never live like this".

So, we devised a little quiz, which, while not having any right or wrong answers, will tell you both whether or not your urban penpal has a working understanding of your AE lifestyle and has that most important quality, a sense of humor.

Self-**C**ritique **R**esponse of **T**he **U**rban **M**ale
or
Self-**C**ritique **R**esponse **U**seable **F**or **F**emales

I could live in the Country because:
- (A) I love the outdoors
- (B) Primitive living doesn't scare me
- (C) I can shoot a gun well
- (D) I can split wood and haul water
- (E) All of the above
- (F) None of the above

I perceive myself as;
- (A) independent
- (B) dependant
- (C) willing and able
- (D) adventurous
- (E) C&D only

I would like to be;
- (A) a busy street corner
- (B) a forest trail
- (C) a college professor
- (D) the clothing department at Sak's

I would be leaving a life;
- (A) I love
- (B) I hate
- (C) I could return to
- (D) I would not return to on a bet

I would rather;
- (A) watch TV
- (B) walk in the woods
- (C) clean a fish
- (D) have a washer & dryer
- (E) party all night

I think a two-holer is;
- (A) a golf shot
- (B) a unique opportunity for communication with another human being
- (C) a type of shotgun
- (D) a new kind of doughnut
- (E) none of the above

Lentils are;
- (A) a series of Catholic holidays
- (B) a sort of New Years-Easter resolutions
- (C) door jambs
- (D) right up there with beans and rice

C.B. means;
- (A) CensusBureau
- (B) Call Back
- (C) Captivatingly Beautiful
- (D) Chicken Butt
- (E) Not being a hood ornament on a logging truck

Position desired;
- (A) missionary
- (B) modified missionary
- (C) Queen Bee
- (D) All of the above
- (E) more than the above

Cabin Fever is;
- (A) a ski trip to Vail
- (B) a fifties rock&roll band
- (C) putting too much bark in the woodstove
- (D) when the windows steam up on the inside
- (E) curable by a night (or two) in a motel room

KVCR is;
- (A) the most popular TV station in the Country
- (B) the only TV station in the Country
- (C) all of the above
- (D) an acronym for Kleptomaniacs Versus Cheap Retailers

D.C. means;
- (A) demented children
- (B) diaphanous clothing
- (C) safe, sane and cheap electrical power
- (D) District of Columbia
- (E) Damned Cold

The best way to end a long dry spell is;
- (A) decide to work on your vehicle tomorrow
- (B) hang out a lot of laundry to dry
- (C) plan a trip to town
- (D) spray the orchard with dormant oil
- (E) split some firewood and leave it on the sidehill to dry

I'd rather be;
- (A) making dinner
- (B) making money
- (C) making firewood
- (D) making whoopee
- (E) making popcorn

CQ HOME POWER HAMS

KE5HV • KG6MM • N6HWY • KB6HLR

Regional Home Power Nets
(local times indicate local nets)

7.230 MHz on Sundays at 1330 Pacific, Central & Eastern.
3.900 MHz on Wednesday at 2000 Pacific & Eastern time.
14.290 MHz Sunday at 1900 UTC.

Novices

Wednesdays at 0300 UTC-
7.107 to 7.110 MHz. Listen for Dave KB6HLR
7.110 MHz on Wednesdays and Saturdays at 0500 UTC.

HAPPENINGS

1990 American Tour de Sol

The time is right for the American Tour de Sol, an exciting 5 day solar/electric car race, which will run from Montpelier Vermont to Boston, Massachusetts May 23-27, 1990. Conventional gasoline and diesel vehicles burn 68% of all the oil used in this country, and contribute 30% of the air pollutants such as hydrocarbons, nitrous oxides and carbon dioxide, which cause environmental problems such as the greenhouse effect, acid rain and smog. "Solar electric vehicles are completely non-polluting" state the organizers of the race, the Northeast Solar Energy Association. No exhaust, no greenhouse effect, no smog.

How a solar car works: First and foremost the car must be a very efficient electric car, with an electric motor and batteries to store the fuel, electricity. In the case of the solar car batteries are recharged by photovoltaic panels which convert sunlight into electricity. The panels can be located either on the car, or at home or work. Battery capacity and cost are the limiting factors of the solar/electric vehicle. At present most solar/electric vehicles have a driving range of 50-100 miles before they must stop to recharge their batteries. This meets the needs of the average person who commutes 20 miles a day to work and back.

The first Tour de Sol was held in Switzerland 5 years ago. That country now has a number of thriving solar/electric automobile manufacturers. The 1990 American Tour de Sol will have five vehicle categories to:

◊ Demonstrate that solar/electric vehicles are a viable option
◊ Educate the public about solar energy
◊ Create exciting design projects for engineering students, our automobile designers of the future.

Spectators are encouraged to view the solar electric vehicles which will be on display at numerous stopover points along the route. With your support and enthusiasm the 1990 American Tour de Sol can make a significant impact on the future of transportation and the quality of the environment in the USA. The second annual American Tour de Sol is sponsored in part by the US Department of Energy, the Solar Energy Research Education Foundation, New England Electric, and is endorsed by numerous environmental organizations. For more information please contact: Northeast Solar Energy Association. POB 541, Brattleboro, VT 05302 • (802) 254-2386.

California PV Tax Credit

Effective January 1, 1990, a new California 10% solar tax credit for photovoltaic applications went into effect. For further information contact the Public Advisor, Thomas Maddock, 916-324-3009.

Citizens for Solar - 8th Annual Tucson Solar Potluck

We invite you to come to our EXHIBITION and FEAST! It will be a potluck and you may either bring a prepared dish or bring your own solar oven and cook with us.
Place: CATALINA STATE PARK
11570 North Oracle Rd., Tucson, AZ.
Date: Saturday, May 12, 1990
Time: 9:00 a.m. to Sundown
$2.00 per car State Park admission fee.

New Mexico Solar Energy Industry Association (NMSEIA)

June 8-10, Annual NMSEIA Conference
June 9 (Sat.) 10 a.m.-5 p.m. "Solarfest", speakers - demonstrations - workshops. $10 to the public (proceeds to benefit NMSEIA, a non-profit organization). At "Ghost Ranch", north of Albuquerque, NM, 55 miles NW of Santa Fe on Hwy 84. For more information call Chris Fairchild, Pres. NMSEIA, (505) 884-1980.

IASEE- A New Association For Renewable Energy Educators

The International Assoc. for Solar Energy Education (IASEE) was founded in Göteborg, Sweden, December 22, 1989. Provisional by-laws were adopted.

The purpose of IASEE is to promote solar energy education worldwide by means of publication of a Newsletter and organization of international meetings and topical activities

"Solar energy" here means direct use of the sun's energy as well as other renewable sources of energy. The by-laws also state IASEE shall seek status as ISES (International Solar Energy Society) working group on education.

Permanent by-laws will be adopted at the meeting, scheduled in Reading, UK, September 26, 1990 (during the World Renewable Energy Congress). The Organizing Committee will conduct business in 1990, and will be replaced by the first elected Board.

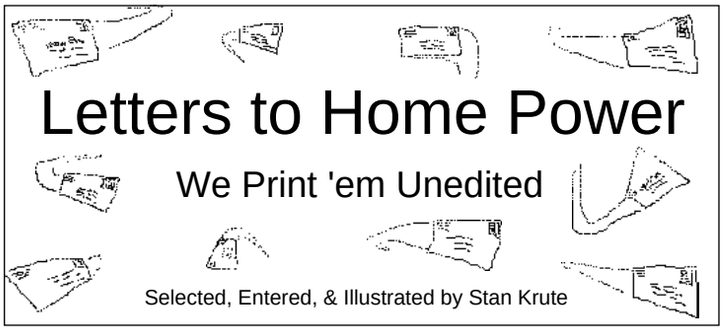
IASEE Newsletters are published quarterly by Dr. Blum, Univ. of Oldenburg in January, April, July and October. Deadlines are the 10th of the preceding month, the first was sent out in Jan. 1990.

Everyone interested in solar energy education is cordially invited to become a member of IASEE. The yearly membership fee is US $5., but members in countries with convertible currency are requested to add US $2. to help cover the "international" costs for members in countries with non-convertible currency. Individuals, as well as institutions, can be members in IASEE; institutions are asked to add a voluntary sum.

For further information and a membership application form contact: Lars Broman, Solar Energy Research Center, University College of Falun/Borlänge, P.O. Box 10044, S-781 10 Borlänge, Sweden.

SunAmp Seminar

SunAmp Power Company will hold a two day PV seminar on May 11th and 12th, and July 20th and 21st 1990. This seminar is designed for everyone from professionals to do-it-yourselfers. Some of the topics will be: Introduction to PV hardware, demonstrations of systems, instrumentation, information access, system design and marketing. Cost of the seminar is $145.00 ($100.00 for each additional person in the same party) which includes two lunches, refreshments, syllabus & classroom materials. For more info., contact Steve Bass at SunAmp Power, POB 6346, Scottsdale, AZ 85261, 602-951-0699 • 800-677-6527.



Minto Wheels: The Dope Is Nope

We received several responses to Don Jung's HP 15 letter about a gravity/heat engine called the Minto wheel. David Doty and E.J. Huss both pointed us to a series of articles that appeared in Mother Earth News issues #34, 38, 39, and 40. David even graciously sent copies of the articles, saving us a trip to the library. The Mother Earth folks built and experimented with a 22 foot diameter wheel, at a cost of $12,000. Bottom line: Minto wheels don't work. Here's Steve Baer's letter on the subject:

Dear H.P.

About the Minto wheel in HP 15. I predict anyone who builds a Minto wheel to produce mechanical energy will come away with a new respect for P.V. panels, hydro power, internal combustion engines, etc. The wheel was invented a century or so before Minto. It is a combination of inefficiency and overweight that will disappoint almost anyone. I have invented a fascinating cousin of this wheel -- but it is also useless, overweight, and inefficient -- though at least 10 times as efficient as the Minto, Iski (1882 patent) wheels. Such gravity engines work better on heavier planets.

Steve Baer, Zomeworks Corporation, 1011 Sawmill Rd NW, P.O. Box 25805, Albuquerque, New Mexico 87125

Thanks, Steve. For those who don't know him, Mr. Baer has been inventing, instigating, poking, and gyroscoping home power equipment for a couple of decades. His company, Zomeworks, makes passive solar trackers and other hardware. Steve also writes about the field. Here are some Baer writings you can order directly from Zomeworks at the above address:

Sunspots *About solar energy. Fun to read. 120 pages. Written in the early 70's. $10 postpaid.*

Subsidizing The Sun *Letters and essays that point out the difficulty of arranging subsidies for solar energy. Also includes material by William Shurcliff. 23 pages. Written in the 80's. $4 postpaid.*

Two articles on rotary liquid piston Stirling engines, the fascinating cousins mentioned above. $3 postpaid.

If you order any of these, Steve will include a copy of his article, "Citizens' Survey Of The Solar and Federal Buildings Projects". He calls this piece a description of a disaster. SK

Correction: Tankless Water Heaters Article Reference

*A letter from Lee Harwell in HP 15 referred readers to a Consumer Reports article on tankless water heaters, but we got the date wrong. The article appeared in the January **1986** issue of CR. SK*

Home Power Travelers Seek European Contacts

Dear Karen, Richard, and Crew!

This year my husband and I plan to visit our friends in Munich (München) and Frankfurt, Germany. We read where Home Power has some international readers, so we hope that if they can read about us coming, via your letter section, perhaps they will contact us. (address below)

We have several years of photovoltaic (PV) experience and should be living in our passive solar adobe within the next few months. We think it would be great to meet for some interesting solar/PV talks!

Katcha & Bill Sanderson, 20295 Panoche Rd., Paicines, California 95043 USA

We think it would be great, too. Let us know how it all goes. SK

Bebop Jazz Power Shower

The only thing I dislike about HP is the fact that I don't have a copy of your first issue. Keep up the good work. As a bebop jazz guitarist I'm pretty obscure up here in Ish River country (Puget Sound), but maybe they'll remember me for the 12 volt power shower -- xeroxes included. Feel free to recopy, pass around, whatever. After pots of water on the head, solar shower bags, wine bag showers, this setup **really works**. It only has a couple of problems, both because it's outside off the front porch: The lines will freeze in cold weather if you're not careful, and it gets a little chilly when the wind blows hard on colder days.

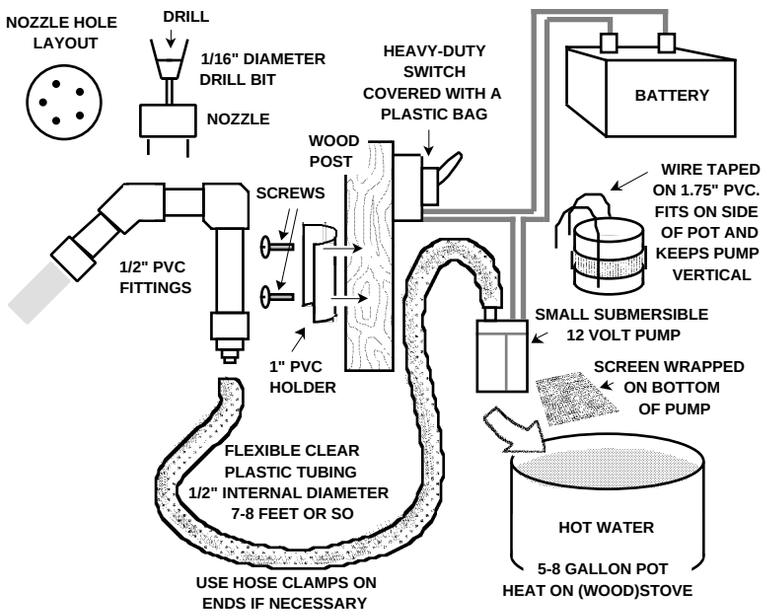
The 12V Power Shower

My pump is a Comet, made in Germany. I ordered it through the J.C. Whitney catalog -- a little over $13. They say it draws about 3 amps. I think it will pump around 3 to 5 gallons per minute with unobstructed flow.

The most critical (in fact the only critical) component is the spray nozzle. It is just a 1/2 inch PVC cap with drilled holes. I found drilling at 90° to be most successful, even though I started by drilling at angles. This didn't work as well. The nozzle is sized for a capacity of approximately five to seven gallons. A couple of more holes really increases the flow -- my shower became too short. Folks with larger water capacity might want to experiment with two to three more extra holds for a larger flow. The 1989 price for the whole setup is $20 or less, excluding battery. A couple of 1 inch holders can be positioned for different heights.

Chuck Easton, 741 Leland Valley Road East, Quilcene, Washington 98376

P.S. - An index to all issues, including letters, would be nice.



I like this shower invention a lot, Chuck. Thanks.

For those who don't know of it, the J.C. Whitney catalog is a fat compendium of more items than you ever imagined existed for automotive and related (12 volt devices, for example) needs. Their phone number is 312-431-6102. Their address is:

J.C. Whitney & Co.
917-19 Archer Avenue
P.O. Box 8410
Chicago, Illinois 60680

Regarding indexes: we ran an index of articles back in HP 11. We plan on running another in the near future. We don't have enough space or time to index letters. Any reader, of course, is free to take on such a completist activity, and offer the result to the public. We'd even give such a fan a free ad. SK

Thermovoltaic Questions And Answers

Dear Home Power,

Here's my $6 for another year of your excellent magazine. Now for a question. I'm very interested in finding out more about thermovoltaics. More specifically, a device that is placed in the woodstove to charge batteries. I'm fortunate enough to have hydropower, but many of my alternate energy friends do not. It seems it would be a perfect companion to solar here in the north woods. I usually read Home Power carefully, but maybe I missed a spot about them. If so please just refer me to that issue. Otherwise, what's the scoop? Are they still available and expensive? What about making your own? Thanks for your superb publication.

Steve Robinson, 1 Patterson Road, Somes Bar, California 95568

Thanks, Steve. Regarding thermovoltaics: take a look at the first letter on page 41 of HP 4 . Here are some Richard excerpts to emphasize and expand on what he wrote back then:

Thermovoltaic technology is not yet mature. In terms of dollars per watt, they're almost twice the cost of a photovoltaic device. The lifetime of such devices is quite short, less than two years in most units. A thermovoltaic can die overnight if you get it hot enough.

The technology is solid-state Peltier junctions. These are the same devices used in Kool-A-Tron brand refrigerators. In a cooling application, electricity goes in, and heat moves out. In a power-producing application, heat goes in, and electricity moves out.

Peltier junctions want to see a large temperature differential. However, if the temperature differential is too great, they fail. That's because if a thermovoltaic unit gets too hot, its Peltier junctions lose organization. This is sort of like remelting a photovoltaic device. The destruction of crystalline structure destroys the device.

At a mountaintop television transmission installation where I once worked, we used propane burners to heat up Peltier modules to run a television translator. These particular modules were very expensive. A 25 watt unit was about $2500. That's $100 per watt. Photovoltaics can be bought now for $6 per watt.

Also, thermovoltaics are not readily available. And making your own is pretty much out of the question. It would be akin to making your own photovoltaics. The pros do it in multimillion dollar fabrication plants that use more expensive high tech tools than you ever want to think about. RP via SK

A Light That's Liked

Howdy, how are ya ?

I've loved every free issue. The content has been exceptional, and the value (of course) tops. My latest find is the 110 volt, four barrel, They are called Q'Lites. These use 18 watts, and put out the total lumens *(a measure of the amount of light emitted. SK)* and nice yellow color of a good 75 watt incandescent bulb. I'm getting at least twice the light as a 12 volt 24 watt regular incandescent bulb. The price, $10, is one third the price of the 12 volt version of this high efficiency fluorescent, so the inefficiencies of running through my Heart inverter are fully justified. One problem: fluorescent electronic noise on VHF television channels 2, 3, and 4.

James Davenport, Rt. 1 Box 142, Wheeler, Wisconsin 54792

Thanks for the kind words and the light recommendation. SK

Conservation is a spatio-temporal aberration. As soon as we get up more photovoltaic panels than we need, the only way we can waste the energy is by not using it. Currently, the use of AC fluorescent lighting via an inverter is more cost-effective than wiring for and purchasing specialized low-voltage DC fluorescents. Reasons for this include the additional cost of 12 volt wiring, and the fact that every low voltage DC fluorescent contains its own individual micro-inverter. See page 27 of this issue for additional information on this subject from Jerry Fetterman of Yellow Jacket Solar. RP

More By Brodeur On Zapping

Dear Home Power folks,

Great magazine, as always!

I noted the reference to Paul Brodeur's series "Annals of Radiation" in the New Yorker magazine issues of June 12, 19, and 26 in HP 15, page 51.

Brodeur came out with a book in late '89, **Currents of Death: Power Lines, Computer Terminals, and the Attempts to Cover Up Their Threat to Your Health**, published by Simon & Schuster, Inc., 1230 Avenue of the Americas, New York, New York 10020, phone number 201-767-5937.

In calling Simon & Schuster, I was told the cost of the book was $19.95, and Simon & Schuster pays postage on individual prepaid orders.

Interestingly enough, Brodeur wrote a book, **The Zapping of America: Microwaves, Their Deadly Risk, and the Cover Up** (1977), which was not reprinted.

Take care.

Bud Wooten, P.O. Box 792, Rossville, Georgia 30741

Thanks for the information, Bud. And Paul. SK

Magic

Thanks for this new article *(George Hagerman writing in HP 15. SK)* on teaching kids about photovoltaics. I was beginning to think we were the only alternative energy folks with kids. Eight-year-olds are so curious about our power system, and they love the idea of playing Nintendo by sun power, but explanations they can understand have been difficult. It isn't really magic. Or is it?

Tommy & Gloria Payne, Route 2 Box 28-1, Sanger, Texas 76266

Everything seems like magic to me. Especially kids.

Hope you enjoy this issue's cover, and George's second article, starting on page 14. SK

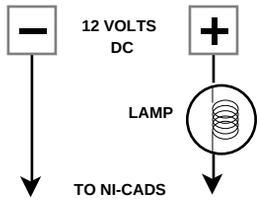
Poor Man's Ni-Cad Charger & DC-DC Down-Converter ??

Thanks for the most informative alternative energy publication around.

Here is my Poor Man's Ni-Cad Charger & DC-DC Down-Converter:

Incandescent lamps are swell semi-constant current devices, since

their resistance increases as they brighten. Select a lamp that will be about 1/4 or 1/2 bright under your desired charging current. Radio Shack has many small lamps of different voltages and currents. For my 9-volt scanner I use Radio Shack part #272-1098 lamps to both charge and operate. The lamp dims as the batteries charge, showing very roughly the state of charge. If you have a bad connection, the lamp goes out. If you short wires, the lamp blows or gets real bright. I've been charging various ni-cad packs daily for two years now from 12-volt photovoltaic-powered batteries with great results. As the batteries become charged, the lamps dim, so that the float charge current is much less than the initial charge current, which is ideal for battery longevity. Also, these small lamps have long wire leads, so they are easy to hook up.



Hugh Gregg, 2215 Empire Grade Road, Santa Cruz, California 95060.

Thanks, Hugh. This voltage control technique, by the way, is only 100% okay for recharging ni-cads. It is not recommended for supplying power to working electronics. Here's why:

When a lightbulb is inactive, the resistance of its filament is much lower than when the bulb is illuminated. This is due primarily to the change in temperature of the filament. The filament of a typical bulb can go from room temperature to 5000° Fahrenheit within the first half second of operation. The resistance across the filament changes accordingly. The voltage drop across the filament changes in lockstep with the resistance , in obeisance to Ohm's Law. Hence, you are feeding your equipment a high voltage surge when you switch it on. This surge remains until the lightbulb heats up. That can take just half a second, but that is long enough for a surge to destroy semiconductor devices.

For the cost of the bulb and a socket, you can buy an integrated circuit voltage regulator that'll do the same job faultlessly and safely under all conditions. Please refer to HP 6, page 37, for a schematic and more information on this superior form of voltage control. RP

Copiers And Inverters (And Laser Printers)

Hi,

My son recently moved into his new log home.

The place is powered by two Trace 2024 inverters, piggybacked, and eight Trojan L-16 batteries. All is going well, except for one glitch.

When we tried to use our Sharp Z-60 copying machine, we discovered that it would not print on the power furnished by the Trace. When we turned on the diesel-powered generator, it worked fine.

We called Trace, and they told us that, when powered by a Trace, some copiers don't print at all, some print black, and some print great. They volunteered that they have a fairly large Murata copier which does just fine.

We would be interested in hearing from your readers who have also tried to use copiers with Trace power. We are very interested in brands that work. We will summarize the responses and send them on to Home Power. Kind of a backwoods Consumers Guide.

Cordially,

Frank W. Hansen, Box 2127, Tofte, Minnesota 55615
Phone: 218-387-1360 Fax: 218-663-7980

Good idea, Frank. It seems that copiers and laser printers both can have hard times on inverter power. One reason is that some of them use a device called a thyristor, and thyristors just don't happily eat inverter power. We don't have a lot of hard data in this area. We encourage readers to send reports of their experiences with copiers and laser printers to Frank or Home Power. If you do so, it is important to specify model numbers and manufacturing dates for both the inverter and the machine that does/doesn't work with it. We'll report back in future issues. SK

The Resiliency Of Decentralized Systems

Gentlemen and Ladies,

Enclosed is my two year subscription and micro ad for our product. In September, 1989 I was in Los Angeles County, California, installing a dome shell. The eye of Hurricane Hugo made its way from Charleston, South Carolina, and passed directly over our manufacturing facility in Kings Mountain, North Carolina. In the next several days my wife related to me the disaster of the widespread power outages. For instance, very few gasoline stations could pump gas. People with electric stoves could not cook food. People with wells could not get water. The only fast food restaurant locally open had a line four blocks long. After several days, my wife felt it would be better for the children to move in with my mother, who had power returned a few days after the hurricane passed.

As I sat in the Mohave, the message became quite clear. Centralized resources are very convenient and may be deadly. I was converted to decentralized self-sufficiency by personal experience.

I wish the best for your efforts in the magazine.

With best regards,

Walter E. Long, Canterbury Dome Co., 815 Canterbury Road, Kings Mountain, North Carolina 28086

Yep yep yep. SK

A Few Laughs

Been receiving HP for years. Been off the Big Grid for eight years. Raised two great kids, who have left the nest and given us "Grand" titles. A warm thank you from Us! For it was primarily through your work that I achieved the support to endure. The power monopolizers have created a devastating sociological effect upon us all. As can be felt when any young father seeks alternatives to earth-ravaging power main lines of today.

Having sold our solar-powered home/mine in the Sierras last fall, we decided to rent a home while looking to buy elsewhere. This home is ten years old, and built by a retired power company employee. A refresher course, you might call it, in what we're going without! A heat pump to heat the home, a second heat pump to help the 120 gallon water heater, a third heat pump for the sauna. Motion lights and security lights on the sides, front, and rear. If it wastes energy we have one! Caught the meter reader last Friday. Asked her, "Is this home efficient? What are heat pumps?"

Answer:" You bet, with three heat pumps, very energy efficient."

The bill came. We weighed benefits gained versus kilowatts consumed. The answer: $263.60 for one month for two people and two dogs.

What do we feel good about?

We're back in the majority of energy-conserving Americans and at a price of only $250 a month.

Thought I'd share a couple of laughs with ya.

Richard Allen, P.O. Box 115, Forest Hill, California 95631

Yuk yuk yuk. SK

Any Biomass Brains In Hawaii ???

Thank you for the magazine. Here is $6 for the coming year.

Question: we are moving to Hawaii in the near future and don't have power near our property. Hawaii has a rich biomass resource, especially in our area. Has anyone out there found a workable methane generation system? I would appreciate any information on this subject, so I can evaluate its feasibility.

Thank you
Gene Thomas, 2101 Demerse Avenue, Prescott, Arizona 86301

Good luck to you in the island world, Gene. Any of you fine Hawaiian readers doing biomass? SK

Governmental Assistance

Dear Home Power

Although I'm not quite ready to go with all of you into the alternative energy life, I find your magazine great, and I start to visualize an ideal alternative energy system.

I would like to see a system used by a larger family than the usual two or three person household. It seems like just about everything has been downscaled to the point that my family of seven is left outside looking in.

I'd also like to comment on the talk in your letters column about government tax credits. During the late 1970's I was serving a sheet metal apprenticeship, and was required to take a course in solar heating from a solar training institute.

What I learned beside solar heating was that people who had no business in the solar industry were there to take advantage of people who tried to do the right thing with tax credits. Very poorly designed and installed systems costing a minimum of $10,000 and more, to qualify for the tax credits, were sold to well-meaning people by rip-off artists.

We apprentices, who thought we might get into the solar heating end of our trade, found a bad reputation waiting with the public. Then the government withdrew the tax credits and any other support for the solar industry.

I really believe that if only half of the money spent on nuclear energy since 1975 was spent wisely on the solar industries we as a world would be far better off.

So, in conclusion, please get better control of the industry and the governments before implementing any new tax credits. Better yet, forget about governments. After all, Mr. Edison brought us light without government help. It's up to us all to carry on the American way, with as little government interference as possible.

Respectfully,
Fred W. Düensing, P.O. Box 25, Mercer, Wisconsin 54547

I for one agree with you, Fred, concerning government tax credits. Repetitious historical experience shows that free and fair markets produce intelligent commercial technologies more often than governments. Books, personal computers, pencils, bicycles, hula hoops -- all did quite well, thanks, sans government subsidy. The preceding opinions are of course the sole responsibility of freedom-loving SK.

Retaining Grid Options & Requesting The Basics

Dear Mr. Perez,

I enjoyed your article in HP 11 on wiring an inverter to a 120 volt AC mains/breaker panel, but had a question to ask when I'd finished reading it. This hookup is fine if you intend to get 100% of your power from alternative energy sources via your inverter. But what if you wish to continue having access to the commercial grid? Some people may wish to retain the option of being able to switch from home power to grid power whenever they like. I'd like to see an article on how this hookup can be arranged. Wiring, switches, whatever. Also, how do utility companies feel about allowing access to someone who seldom ever uses their power? Are there special arrangements, costs, or problems involved?

Also, for those electronical neophytes like myself, who are just beginning to learn about electricity and energy, how about a special issue explaining principles, terminology, etc. A basic energy primer for the layperson. I realize your articles are geared for folks who already have a good basic working knowledge of these things, but for those like myself who are just learning, it would be an invaluable help and a service. Thanks for your time! Keep up the good work!

Sincerely, Glenn Early, 68 Old Chimney Road, Upper Saddle River, New Jersey 07458

It is possible to continue having access to the commercial grid. This involves large switches; for example, a four pole double throw 12 kilowatt capacity switch. The switch insures that the grid power and the inverter power are never online together. Switches like this cost around $600 and are best installed by a highly-qualified electrician. Richard is working on an article on this subject. He welcomes data from anyone who has successfully put together such a system. SK

Some folks are interested not only in staying connected with the grid, but selling power back to it.

The Public Utilities Regulatory Policies Act (PURPA) of 1979 requires commercial utilities to purchase electricity produced by small systems, provided the electricity is produced by renewable means.

The law does not state that the utility must make this easy for you to do. Here are a few of the significant warts of this program:

1 - The utility pays you its "avoided generation cost", which is usually less than half the rate they charge their customers. You are lucky to get 3.5¢ per kilowatt hour.

2 - The amount of paperwork and the depth of the red tape involved in a PURPA system is truly astounding. A fast trip through this bureaucratic mill takes at least two years when the guides are professionals who do it all the time.

3 - Each independent power producer who wishes to sell back to the grid must negotiate his own contract.

4 - The hardware requirements and installation procedures vary from utility to utility. So there are no real hardware standards in this area. But, suffice it to say, the hardware requirements in all of these systems are rigid and costly.

They make special inverters for systems that want to sell back to the grid. These inverters are synchronous sine-wave models. For example the Photoelectric, Inc. company's SolarInverter model is a 3 kilowatt synchronous sine-wave inverter approved in California for utility intertie applications. That's what they call this form of home power-to-grid connection. Phone numbers for Photoelectric,Inc.: USA outside California: 800-233-3411, within California: 800-542-6188. Cost is about $4000.

The only small-scale PURPA systems we know of where the producer turns a profit are sourced by hydro. RP

A primer issue has been on the back burner of our minds for a while. Someday it may percolate...

As to audience gearing: we try to aim at everyday people with no special expertise in the home power area. Sometimes we don't hit that target. Simplicity of exposition and dejargonization are

perpetual goals. SK

A Buncha Fine Little Questions

Dear Home Power,

Please find enclosed check for $6 for one year's subscription to your magazine.

I am about to start using a homemade generator of direct current (DC) as per the article in HP 2 *("Build Your Own 12 VDC Engine/Generator", by Richard Perez, on pages 23-26 of that issue. SK)*. I would like to know:

1- If I have to disconnect my 35 watt photovoltaic panel while charging one or two recreational vehicle batteries ?

2- How might the small gas engine/alternator setup be designed to also start cars in cold weather and weld? In other words, make it more all-purpose.

3- Can very small direct current motors, as commonly found in assorted toys, be powered by wind, water, etc., and made to produce current to charge small batteries, or would they blow up?

4- Can a linear current booster be used for citizen's band radio antennas ?

5- Can 12 volt air compressors be made to pressurize a very large capacity tank to use later to run whatever runs on air? I have some tanks that store air at 150 and 200 pounds per square inch pressure, and thought they could be rigged to run off wind or water, maybe.

Thank you for your dedication. Don't ever give up control to anyone for any reason. Any magazine sold to another should not be able to use the name of it, as new owners are new owners, and probably will not be at all like the original, Amen.

Home Powerfully Yours, Mike & Anita Underwood/Hicks, Route 16 Box 789, Lebanon, Missouri 65536

PS -- Letter was typed on a Brother EP43 hooked to our battery bank and voltage reduced to six volts via Gemini DC converter.

1- There is no need to disconnect. Charge away.

2- Disconnect the Mark VI regulator which is optimized for 12 volt charging. Use the rheostat specified in HP 2 as the controller. As a welder, though, this type of unit would be a pretty anemic setup. The power is just not there.

3- Yes, you can use them (the small motors). The lifetimes will be short because they are optimized as motors, not generators. Main limiting factor will be brush and bearing wear.

4- No. That's like asking if you can use a blender to change a flat tire. The unit is designed as a DC power device, and has nothing to do with radio frequency amplification.

5- Yes, this can be done. A friend used a large Ford truck starter motor to drive a compressor. The entire system was sourced by a 300 watt Winco wind charger.

As regards selling the magazine: We have found what we are meant to do in life. We intend to keep on doing it. RP

This Is Our Choice

Great mag. Enjoyed every issue since I started. It's O.K. with me to pay $6. Keep up good work.

Thanks

Alan Surprenant, Apple Valley Road, Ashfield, Massachusetts 01330

Power lines go by our house. This is our choice not to be tied into New England nuclear power!

I salute your choice. SK

Another Note For Demand Water Heater Users

People using Paloma and other gas-fired, demand water heaters would be interested in the "Lau Vent" thermally-actuated dampers for the vent pipe. They close down when the heat's off, so you don't lose all your indoor heated air out through the water heater vent. They open quickly when the fire's on. Theyare available from Johnstone Supply, which has branches around the country. An address is:

Johnstone Supply
P.O. Box 3010
Portland, Oregon 97208

The cost is about $35 for a 4 inch pipe.

Thanks, Al Latham, 470 Dharma Road, Chimacum, Washington 98325

Thanks, Al. SK

A Note Regarding Recycled Paper

Currently the paper we use is not recycled. It is recyclable, though. We have been unable to find a supply of recycled paper that will not quadruple our printing costs. We'll continue to work on this situation, and welcome pointers from all you fine folk. KP via SK

The Simple Still Life, With Birds And Flowers

You are a bargain at $6, even for us poverty-stricken folks who don't even have a telephone. I suggest you point toward people who want to simplify their lives. I lived with kerosene lamps, Coleman lanterns, propane lights. … and finally simplified it amazingly with two 35 watt photovoltaic panels, five deep-cycle 105 ampere-hour capacity recreational vehicle batteries, and dispersed micro lighting of my own design. Instead of hissing smelly yellow light, soot, changing mantles, filling tanks, and worrying about setting the house on fire, I have quiet, pleasant, safe lighting. I have AM, FM, CB, and SW radio, television, VCR and video camera toys, all twelve volt. (Simplify?) I've forgotten what utility bills are.

Where possible let sunlight, gravity, and precipitation work on your side. Do it manually instead of expensively, and you'll have more time to look at the birds and flowers.

Sincerely, Jerry Igo, P.O. Box 603, Mosier, Oregon 97040

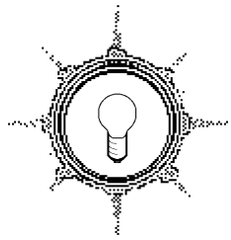
Amen. SK

Letters To Home Power
Departmental Policies And Practices

1. We print 'em unedited.
2. We DO change any extremely obfusucatory/painful errors of grammar, spelling, and/or usage.
3. For publication, we like 'em short, sweet, practical, inventive, and positive.
4. We print full addresses, so folks can get in touch with you, unless otherwise specifically requested not to.
5. We get lots of great stuff, and everyone reads it all, but can neither print nor respond to each piece due to space/time crunches.
6. Thank you thank you thank you for the wondrous letters you all send. You are us.

Home Power's Business

"The man who on his trade relies
Must either bust or advertise."
Thomas Lipton - 1870.



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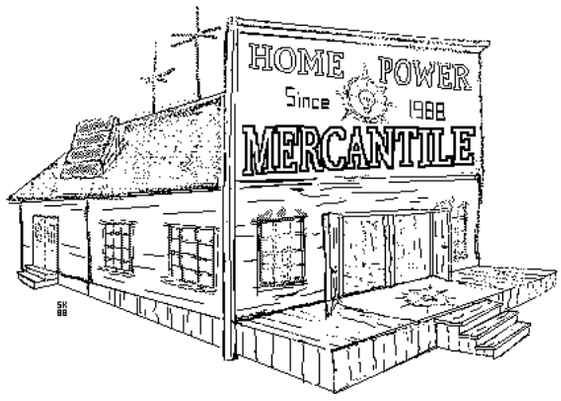

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