HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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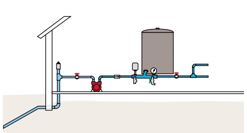
Features

6 Integrating PV with Utility Power

Cliff, Darlene, and Sarah Millsapps run their refrigerator, freezer, and lights on solar power instead of the utility grid connected to their South Dakota home. See why they like solar better than the utility.

14 Solar Powered Observatory

Rod Wheeler powers his grid connected astronomical observatory and California mountain cabin with solar energy. A neat, tidy, and code correct system for $7,100.



20 DC Submersible Pumps II

Windy Dankoff provides practical information about using DC-powered booster pumps and pressure tanks in home water systems.

32 Solar Hydrogen Production by Electrolysis

Walt Pyle, Jim Healy, and Reynaldo Cortez provide detailed technical information about operating their home-sized solar-powered hydrogen project.

48 The Great Electric Boat Race

Andrew Muntz reports on the Second Annual Spada Lake electric and solar boat races. Sound sedate? Well, top speed of the winner averaged over 41 mph!

Fundamentals

26 Tower Economics 103

Mick Sagrillo concludes a series on wind tower economics. Learn what happens when you don't go high enough.

78 Solar Cooking Basics

Learn how the geometry of light affects solar cooker design.

GoPower

44 The Leeds' Speedster

Michael Leeds tells of the design, development, and competion of his Open class electric vehicle.

58 Electric Vehicle Gauges

Shari Prange discusses instrumentation for the working electric vehicle. Get the info you need for that extra mile.

Things that Work!

71 Carrizo Copper QuadLam

Sam Coleman tests this recycled PV module. Performance specs and I-V curve for this $3 per watt PV.

74 Exeltech 1000 Watt Sine Wave Inverter

Home Power tests the cleanest 1,000 watt sine wave inverter ever. This inverter delivers cleaner power than any utility!

Cover: This solar-powered cabin houses an astronomical observatory. Story on page 14. Photo by Rod Wheeler

Homebrew

53 Motor Controllers for Simple Electric Vehicles

Michael Hackleman shares his designs for simple, easy to build, electric vehicle motor controllers. Learn how to use relays to control small electric vehicles.

62 A Low Cost, High and Low Battery Voltage Alarm

Here is an effective battery alarm from Dan Lepinski. Never let that battery get too low or too high again.

68 Charge Shuffler

Want to run 12 Volt appliances on a 24 Volt battery? Chris Greacen's circuit will do the job at under $20, and delivers 3 Amperes.

86 Power Politics

Michael Welch assesses the impact of NAFTA on renewable energy and our environment.

90 IPPP

Independent Photovoltaic Power Providers support your right to solar power.

92 Home & Heart

Kathleen Jarschke-Schultze tells about learning herbal medicine from a video course.

97 The Wizard speaks...

On free energy.

108 Glossary

Here is a glossary of home power and renewable energy terms. It will help make sense of technical alphabet soup.

Columns

40 Using the Home Power Computer Bulletin Board

Michael Welch shows you how to put Home Power in touch with your computer

82 *Home Power's* Third Annual Solar Cooker Contest

Design a solar cooker and send it in! First prize is a 60 Watt photovoltaic module

84 Ask NREL

What are the differences between PV technologies?

Regulars

4 From Us to You

80 Home Power's Subscription form

81 Home Power's Biz Page

94 Happenings — *RE events*

98 Letters to *Home Power*

105 Q&A

110 Micro Ads

112 Index to Advertisers

Access and Info

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THE TURNING OF THE TIDE

As I write this, it is the eve of the winter solstice. With the new day, the year turns its face to the summer. The sun is at its lowest in the sky, it has no speed, and it is at its maximum acceleration. It is the peak of the turn. The great engine of the planet will take months to respond to the increasing strength of the sun, the deepening of the days, and the increasing speed with which the light's rays touch water, land, and life to the north. At this time of the year, this is the day I celebrate.

The sky is wild, the earth uncertain. Still, I surrender to the feeling of what a wonderful place this is to be, in the midst of a full, strong tide. One that is turning.

Bless all of you in your efforts.

Michael Hackleman, who speaks for the whole HP Crew.

"Think about it..."

"I am not born for one corner; the whole world is my native land."

Seneca (The Younger)

Introducing the *LINK 2000*

Integrated Battery Monitoring and Inverter Control

QUESTION: Can the *LINK 2000* be used as a battery monitor only?

ANSWER: YES! The *LINK 2000* monitors the battery and sources independently of the inverter. Consider it an "Inverter ready monitor/control system" compatible with the Freedon Series of U.L. listed Residential inverters.

Control

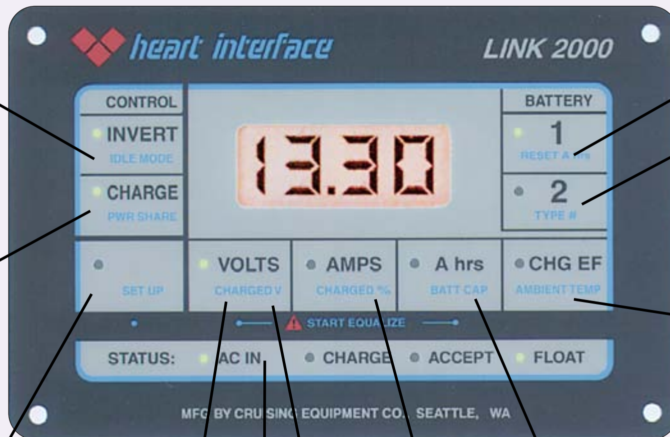
Green LED indicates on.

INVERTER may be turned On or Off independently from charger.

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

CHARGER may be turned On or Off independently from inverter.

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



Monitoring

Green LED indicates selection

Selects BATTERY #1.

RESET A hrs to zero.

Selects BATTERY #2.

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

Green LED indicates parameter displayed.

CHARGE EFFICIENCY FACTOR of selected battery displayed as percentage.

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

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

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

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

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

Red CHARGE LED flashes when in equalize mode.

STATUS indicators for AC power and charge cycle state.

AC IN: Green LED on when AC is present.

CHARGE: Red LED on when charger is in bulk charge mode.
Flashes Red when charger is in Equalize mode.

ACCEPT: Orange LED on when charger is in Acceptance mode.

FLOAT: Green LED on when charger is in Float mode.

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

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

AMPS charging into the selected battery are displayed as a positive number. Discharge Amps displayed as a negative number. Range ± 500 Amps with 0.1A resolution below 27A and 1.0A resolution above 27A.

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

VOLTAGE of selected battery is displayed. Range 8.5–50 Volts with 0.05V resolution.

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

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

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

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

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Integrating PV With Grid Power

Cliff Millsapps

My wife Darlene, daughter Sarah and I live on seven acres in eastern South Dakota, which is between the "corn belt" and the "buffalo commons". Rural Electric Association (the grid) is well-ingrained into people's lives around here. The power lines link the area like a net, often running every mile along the east-west or north-south roads (gives it a checkerboard appearance from the air). You sure don't have to go far to find a power pole.

The power lines are not pretty, but the area has qualities and a beauty that holds us here. When I am asked, "Why the hell would anybody live in South Dakota?" I answer, it's because everybody else in the world doesn't want to move here. There's more to it than that, but space is one of the pluses.

We have gradually integrated photovoltaic renewable energy into our lifestyle over the past four years. We already had the power from the utility grid, so it was partly a philosophical decision. I believe, though, that there is practicality and common sense in reducing our dependence on the utility. The utility is undependable and uses fossil fuels, which are limited and dependent upon the political winds….

About Us

Darlene is the Horticulturist, Gardener, Vet, Canner, Soap-maker, Sheep Shearer, and Washing Machine/ Computer Jockey. I'm the Fence Fixer, Carpenter, Mechanic, and Mortgage Payer. We have two kids between us, Josh and Sarah. Josh is in college, and into baseball, girls, English, and history, in order. Sarah is an 11th grader, and into keeping her heap running (I think I have her sold on the merits of electric cars).

We have the usual assortment of farmstead animals on our seven acres, with the most recent addition being six Romney sheep. The sheep keep the grass and grass fire danger down, and provide meat and wool, along with free pelletized lawn fertilizer. Darlene is into spinning and weaving and plans to sell sweater and hat kits featuring her handspun wool yarn.

We bought the Solar Pathfinder company from Bernie Haines a year ago. The Haines are great people, and they gave us a great turnover on the Pathfinder manufacturing and mail order business. We manufacture out of our home shop, and the beauty of mail order is that you can even do it in South Dakota.

The Solar Pathfinder business is a good small industry for us. I understand the concepts behind the Solar Pathfinder, with a background heavy in math, physics, and atmospheric sciences, and Darlene has the computer skills, attention to detail and insistence on timeliness.

Our Current System

Our system uses six Kyocera 51 Watt photovoltaic (PV) panels to convert sunlight into electricity. A 19 cubic foot Sun Frost refrigerator/freezer is the main system load. Energy is stored in twenty-two 2 Volt lead calcium cells recycled from the phone company. Two Todd 12 VDC, 30 Ampere battery chargers allow refilling the batteries from the commercial electric grid. A separate 12 VDC system powers a Flojet pump, a homemade 12 VDC Electric Fencer, and some lights.

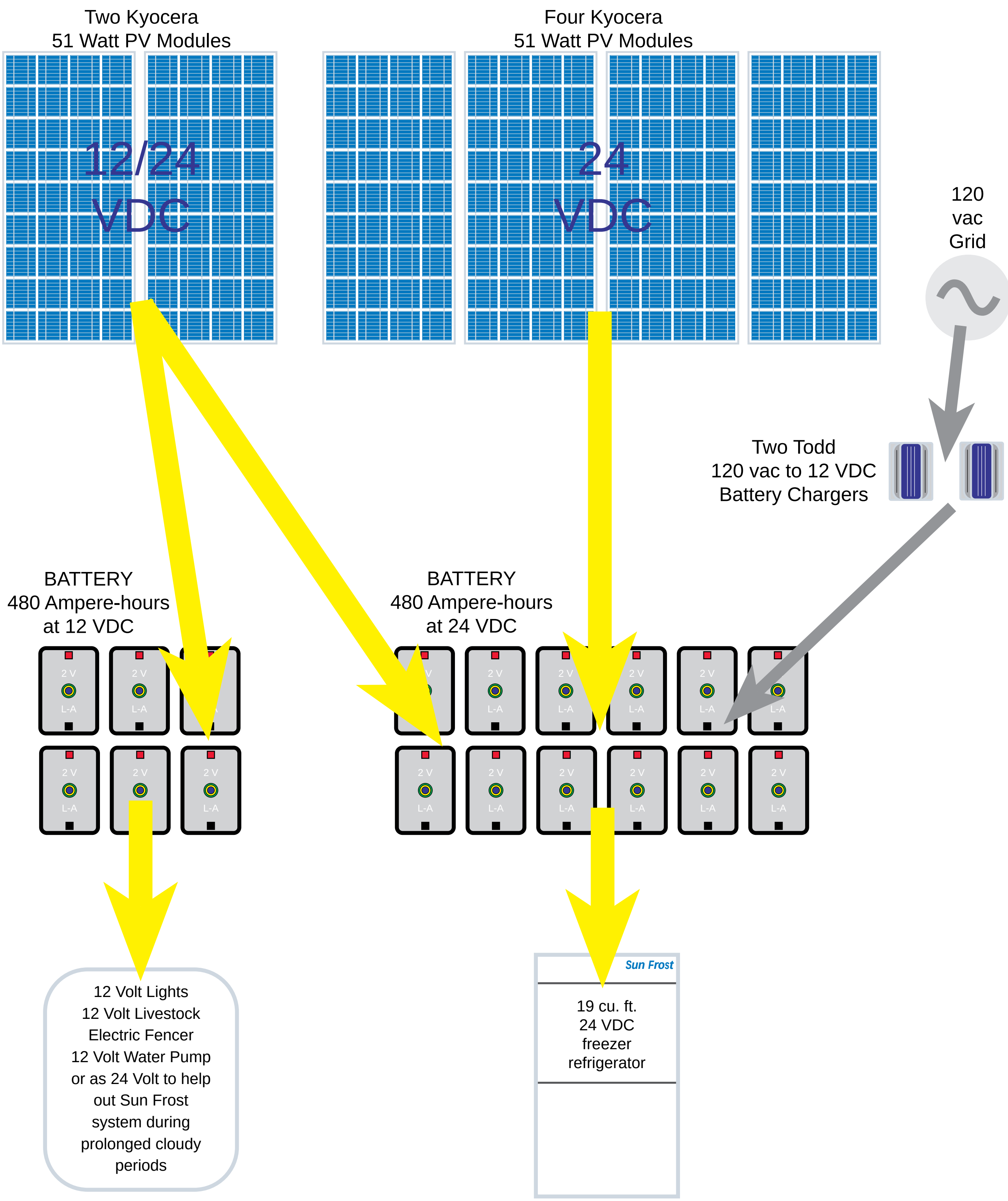
First Project — the Solar Pump

I bought a single PV panel, a Flojet pump, and a linear current booster (LCB) about four years ago. The original setup was an old unused cistern collecting rainwater from the pump house roof, and then the Flojet pumping the water onto the garden, or available for emergency household water.

It was a excellent first project for someone who wasn't being rushed into producing his/her own power. The PV panel was connected directly to the LCB, and the LCB was connected directly to the pump. With the panel at different angles to the sun, and in different cloud conditions, I got a feel for how hard the pump would work. Take the LCB out and the pump didn't work nearly as well, especially in the morning and evening. The LCB modifies the PV panel's energy in a way that gets more work done. LCBs can be cost effective, especially for PV panels directly powering a frequently used water pump.

Below: Six photovoltaic modules on the roof of the Millsapps' home. Photo by Cliff Millsapps

Cliff & Darlene's Photovoltaic Energy System



My Flojet is about right for soaker type slow irrigation. The rainfall here is usually, but not always, sufficient for our garden. The biggest problem with the Flojet is that it doesn't tolerate bugs, sand, grass, or anything like that in the water. A good quality filter is required, as the rubber diaphragms seem to easily catch little particles, which keeps them from sealing, and the pump from pumping. If you have much debris in the water, the filter quickly plugs up.

For the time being, the 240 vac, 120-foot-deep submersible pump running off the grid will likely continue to pump the household water. I'm attracted to the simplicity and non-mechanical aspects of rainwater collection and gravity-pressurized lines. Friends of ours in Minnesota have been using rainwater collected off their house roof for years. They store it in a stainless steel tank in their basement, so have to pressurize it for household use.

Electric Fencer
A couple of years ago, Richard Perez wrote an article on how to build a DC fence charger in *Home Power (*#21, pp. 78–82). I tried to build it, but my limited time and electronics background nixed me. It was spring on an acreage with gardens, orchards, tree groves, grass, weeds.... I went down and bought a commercial fence charger. By midsummer, the Longhorn steer, bored with his pasture, took to pushing up and leisurely walking under the farm store's supershocker electric fence charger.

I tried the homebrew charger again. I pulled the gob of potentiometers, timers, resistors, and capacitors off the electronic breadboard, carefully put them back on, and this time I got it right. The beauty of the homebrew charger was that it wasn't anemic, and it was adjustable. It puts out whatever voltage a 12 V Corvair automotive coil develops (plenty), but the length of the pulses and time between pulses are adjustable. (The downside is that it fries components if hooked backwards to the battery). I cranked it up to put out some frequent long pulses and got the steer's attention. It also zapped us human types a few times too, so I tuned it back down after I made my point.

When hooking up the batteries for the homebrew charger, overcharging worried me, so I used a couple of hefty 6 Volt batteries in series to make 12 VDC. The idea was to have a battery that was large in capacity relative to the source that was charging it.

Sun Frost
A refrigerator/freezer is a large and consistent load, and a natural for being the first big load to convert to PV power. Sun Frost makes refrigerator/freezers that are 6–10 times more efficient then the commercial units.

Above: Cliff shows off his solar-powered 19 cubic foot Sun Frost refrigerator/freezer.
Photo by Darlene Millsapps

Sun Frost makes a DC version also. All ac refrigerators that I know have to convert the ac electricity to DC anyway, so why suffer all the conversion losses of going from DC to ac, then back to DC again?

The greatest loss we would suffer if the grid went down is the loss of all the home grown peas, corn, broccoli, meats, butter, and eggs. We want electricity for warm weather refrigeration, and for us, PV power was the simplest renewable energy option for producing electricity.

Coughing up the bucks for a 19 cubic foot Sun Frost and four more Kyocera Panels was a harrowing experience, especially in comparison to dropping a mere $15–$25 a month for grid power. We would be able to avoid that $15–$25 (and climbing) a month for the rest of our lives, but it still wasn't easy. One unexpected joy was that our 16-year-old daughter, who sometimes wishes her parents were more Mid-America, really was impressed with the idea of sun-run refrigeration. That's good, as every indication is that our Sun Frost will outlast us, and she could inherit it.

Only time will tell, but the Sun Frost just seems high quality. If you want the refrigerator at 38 degrees and the freezer at 15 degrees, that's what you set the independent controls at. You don't have experiment with settings between 1 and 5 until you get the best trade-off between frozen lettuce and melted ice cream.

We pointed out to our political types that Sun Frost should have been eligible for the $30 million in government incentives to develop a mass-produced high-efficiency refrigerator. With $30 million, Sun Frost could get tooled up for mass production just as easily as, say, Whirlpool could reinvent the wheel and retool. Producing Sun Frosts by the hundreds of thousands would make them less expensive, and precipitate an enormous energy savings to the entire nation.

The old ac refrigerator now sits in the northeast corner of our house. It will get a couple of four inch adjustable vents to the outside this winter for passive refrigeration. We have had good luck running similar ducts to our root cellar for storing potatoes, onions, squash and carrots.

The Battery
The 22 lead calcium cells were a windfall, another advantage of living away from the action. Few people want excess commercial batteries here, and there are some people in charge of disposing commercial batteries who aren't intimidated by all the rules for disposing of "hazardous waste". I suspect that I will eventually even find a set of salvageable nickel-cadmium (nicad) or nickel iron batteries. In my case, the batteries will not present any more of an environmental hazard then if the rules were followed — probably just the opposite.

Cliff & Darlene's System Cost

Component	*Cost*	*%*
19 cu. ft. Sun Frost Frig/Freezer	$2,625	51.8%
Six Kyocera K51 PV Modules	$1,900	37.5%
Adjustable Todd charger	$160	3.2%
Fixed Todd charger	$115	2.3%
Flojet pump	$65	1.3%
PV rack angle iron & bolts	$60	1.2%
Linear Current Booster	$50	1.0%
Wiring	$50	1.0%
Fencer Electronics	$35	0.7%
Eight 12 Volt incandescent lights	$10	0.2%
Battery Cables (Home made)	$0	0.0%
Ground rod, conduit, etc. (salvage)	$0	0.0%
Salvaged Batteries	$0	0.0%
Total	$5,070	

Nickel iron would have been my choice if I had bought batteries, but the lead calcium cells are doing the job. The batteries were a telco spare set that likely received marginal attention. A factory label on the outside of one of the 70-pound-plus cell cases indicated that full charge was 2.2 Volts. After a good long, hot charge, my batteries quickly (overnight) fall back to 2.06 Volts. Other people have told me that they have had similar experiences with telco batteries.

I added a couple tablespoons of EDTA to twelve of the 22 cells, and then charged them without a load for a month (before the Sun Frost arrived). I then put six of the extra cells without EDTA on a single panel for a month. I haven't done any measurements, but I can see no obvious difference in the EDTA and non-EDTA treated batteries. Like they told me, "It may or may not help, but it doesn't seem to hurt either."

Using only efficiency and capacity considerations, the ideal battery bank in our grid-integrated system would be smaller than what we have. All batteries I know of slowly self-discharge, and the more battery storage you have, the more energy you lose. In addition, I am told that the lead calcium batteries are some of the least efficient. The calcium was evidently added to the lead in the cell to cause it to increasingly bleed off charge as it approaches full charge. This was to minimize gassing and loss of water, which was more of a concern to the phone company than efficiency. Our battery bank just happened, and has advantages in being initially free, and being able to absorb any conceivable overcharge.

Where To Put The Batteries?
During a South Dakota winter, at least one temperature of –20°F can be expected, and it has gotten colder than –30°F more than a few times. I chose to keep the batteries in the house. I put them in our fairly open basement, near a floor drain and the ac power panel. I plan to eventually get an inverter, and I may consider pulling a circuit or two off the ac panel and rerouting it to an RE power panel. If we ever have a battery problem, it would be relatively easy to clean up. We keep a half dozen boxes of baking soda nearby.

We don't live right by our batteries. The largest amount of time spent in the basement is with the wringer washer and exercise bench, which are both separated from the batteries by a short wall. The biggest chance that I take is using our extra john (right next to the batteries) for a few minutes each day. The bathroom on the main floor is used by the rest of the family. It works well for me to have a regimented daily commune with the stool and the battery bank.

Currently, battery gassing is very slight. The battery bank is large relative to the PV panel output, and the calcium-impregnated lead greatly reduces potential gassing. The large open basement would further reduce hydrogen concentration. If the system grows, I would put in a vent system to the outside, just to be on the safe side.

12 Volt or 24 Volt?

A 24 Volt system has about one-quarter the line loss of a 12 Volt system. And I was given enough lead calcium telco 2 Volt cells for a 24 Volt system. I actually have all but two cells of an old 48 Volt battery bank. So I need to either give away ten cells, or get a small wind machine (hybrid system), or get two more cells to make another 24 Volt string, and an inverter to make, store, and use more renewable electricity.

Todd Charger (Grid-Connect Controller)

I bought two Todd 12 VDC 30 Ampere battery chargers. These chargers are not the big heat-producing, induced current transformers that the local garage uses. These are efficient, and if left connected, will supply a charge to the batteries when the batteries fall below a set voltage. One charger has an adjustable potentiometer with a low threshold between 12 V and 15 V. The other has two settings, 13.5 V or 15.5 V, and is harder to change between settings.

During the past cloudy, cool summer, I still had more than enough power from the PV panels. This winter, during long cloudy stretches, the batteries and Sun Frost will be protected from low voltage by the two Todd Chargers. I'm not 100 percent sure what the best trade-off between good equalizing charges and letting the PV panels do as much as possible will be, but I'll err on the safe side until I learn. Todd makes a 24 V charger, but I bought two 12 V chargers for flexibility.

Right or wrong, I've avoided the high cost of dedicated power controllers in my projects because: the main load is the fused Sun Frost, which is a relatively large consistent load; the lead calcium battery bank is large, relative to our PV panel output, and easily bleeds off excess electricity, which could occur during strings of long sunny days; and the Todd Charger offers a low voltage safety net, although not ideal.

When I eventually get a larger system, I will likely invest in a power control unit.

The PV Rack

I used plans from Richard Perez's four panel PV collector article in *Home Power* #2. These excellent instructions make nice strong, easy, angle iron racks. The finished sloped interior walls of our story and a half farm house made for some problems finding the rafter studs, but luckily Darlene has been a doll about the few extra unpatched holes in the drywall over our bed. She says, "As long as they don't leak on my side…."

Above: Darlene at work on her loom.
Photo by Cliff Millsapps

Wiring

It's about 50 feet from the PV rack on the roof to the batteries in the basement. The original single PV panel was wired to the battery with two conductor #10 Romex in $^1/_2$ inch conduit. It will be joined shortly by a second Kyocera in series for 24 V.

When the Sun Frost and four more Kyocera panels arrived, I was unconventional again and bought three conductor, plus ground (4 wires) #10 UF wire. It was the most copper for the money that would serve the purpose, and give me some expansion potential. Two of the four wires go to the positive terminals, and two go to the negative terminals. I chose the type in the roundish black sheath instead of the flat ribbon type. The 4-wire #10 required a $^3/_4$ inch conduit, which I didn't have, so I decided to use garden hose instead. (Are there any good reasons why you shouldn't use garden hose for conduit? Besides finding a use for an old leaky hose, I didn't need a conduit bender.) I ran a #6 bare copper wire ground from the panel frames to a 10 foot copper-clad ground rod. The ground rod was one of many reused treasures found on our old farmstead.

Wrap Up

The PV system is a bit of a balancing act of money, efficiency, safety, personal preference, and mostly just what works. It's not beyond the average do-it-yourselfer with ambition and the information in *Home Power*. I went a step further as I got caught up in the renewable energy enthusiasm, and spent a worthwhile week last fall at Solar Energy International's Advanced PV course.

I hope to see renewable energy spread into the mainstream and into the midwest. Out here on the plains we have both a great wind and a great solar resource. We are lucky to have people who have been slowly making things happen in wind energy over the years. However, our farmstead is cosied down with a large mature shelter belt (mostly to the north and west), which is great for breaking the frigid winter winds. But, the trees would cause a lot of turbulence for a wind machine unless it had an 120-foot tower, which initially made wind energy less attractive to us.

A small grid-integrated PV system was cheaper than the wind tower by itself, and a PV system can grow gradually, as money and experience come along. If you can find (or create) a place where PV panels will get fairly unobstructed sunshine year around, then you will appreciate the quiet, simple, low-maintenance, and unobtrusive nature of PV.

Access

Cliff Millsapps, Solar Pathfinder, Route 2, Box 147, Hartford, SD 57033 • 605-528-6473

SOLAR DEPOT AD
full page
four color
camera ready on negative

They use the whole page

this is page 13

Above: Rod's solar powered observatory is nestled in the San Bernardino Mountains of southern California.
Photo by Rod Wheeler

Solar Powered Observatory

Rod Wheeler, WA6ITC

I've had a fascination for the stars since I was nine years old. So I have always liked telescopes. Probably every amateur astronomer longs for a permanent telescope to avoid the time and energy spent setting up and packing away the oft-used stairway to the heavens. I found the spot for my permanent telescope near Big Bear City, California where the Riverside Telescope Makers Conference is held every year on Memorial Day weekend.

Adding Solar

At a local electronic swap meet, I met a person who was building an electric powered car and was selling some astronomy magazines that I wanted. As I was getting the magazines he showed me a copy of *Home Power*. Some articles in it interested me, so I took down the magazine's address so I could subscribe. Reading my first copy started me thinking about adding some back-up power to my mountain getaway.

The articles showed that not only were my ideas possible but practical. I read everything I could get my hands on to start the system design. The ads were as important as the articles and many of the advertisers provided lots of help and information. The more I read and designed, the larger the system grew.

Home Away From Home

The house is located in the San Bernardino Mountains at 7,200 feet in the town of Big Bear City, California on Deadman's Ridge. Big Bear City is blessed with 330 sunny days a year and that is good for solar power and astronomy. When I built my mountain getaway I included a transfer switch on the main electrical feed to the house. The original intent of the transfer switch was to be able to use a generator in case of emergencies. However this switch could just as easily connect to my planned solar power system.

The house is a common wood frame construction. I did a lot of extra insulation to help hold the heat — cooling is not a problem. The house is 800 square feet, just one bedroom and a den. The den is used as a “Ham Shack” (amateur radio station) and work area. The area under the house is a large storage and workshop. My home also has an observatory. The three meter dome houses a six inch GOTO ƒ15 refractor telescope on a MEADE computer controlled mount. The electrically controlled dome is manufactured by the Observadome Co.

Needing Space

Originally the observatory was a 12 foot x 12 foot room with the dome roof which I thought would be plenty of room. In actuality there was only room for the telescope and the roll-around platform to climb up to it. There was no room for a computer, desk, or bookshelf.

The lack of space in the observatory was solved by an addition to the house. The addition was a 8 foot x 12 foot “Control Room” to the west of the observatory. The observatory addition was a two story addition so it also provided a 8 foot x 12 foot storeroom on the first floor as a bonus. Since I had the contractor there, I also had him build a 3 foot x 8 foot power/battery room on the west side of the house.

Now the computer sits in the control room adjacent to the observatory. A TV camera is placed on the telescope and viewed from inside the control room on the monitors.

Solar Electricity

The original solar electric system consisted of six sets of QuadLams, or twenty four M52 photovoltaic modules. These were divided into two sets of three QuadLams for 15 Amps of charging current each. The sets were regulated with two ASC 16 Amp charge controllers. This charging arrangement was used to charge two banks of “Telephone” batteries. I had picked up twelve 250 Amp-hour and twelve 350 Amp-hour cells for the hauling. The PowerStar 1300 watt inverter changed the 12 Volts DC to regular household 120 vac. A Perko battery switch allowed selection of the desired bank.

Below: The beautifully permanent telescope. Photo by Ernie Williams

Believe it or not there was no hassle from the building inspector as far as the solar powered system and batteries. The hassle came in the strength and weight of the actual solar panels. I had the company that I purchased the panels from send a letter stating that snow would not break them. Then I had the contractor re-calculate the snow loading of the roof to allow an extra three pounds per square foot, and the building department was happy.

It seems that in actuality the solar panels lower the snow load because the snow either does not stick to or melts faster from solar panels, I do not know which. I recommend that if anyone is planning on installing a solar powered system to have the roof loading calculations include the extra weight and save yourself the hassle.

The original system worked fine. I use the battery system on the weekends when I am at the house. Then when I leave, I switch back to grid power.

Above: The power/battery room. The inverters are safely sequestered from the battery in their own room.
Photo by Rod Wheeler

Changes for a Safer System
While reading more about other people's systems in *Home Power*, I discovered that I had built the power/battery room wrong. The placement of the batteries, inverter and switches in the same room was not really safe. A change was needed and I really wanted to get true deep cycle batteries.

The first change was to divide the power room into two rooms. I had originally installed two doors so it made the task easier. I simply built a wall between the two doors. This provided a room for the batteries and one for the controls and monitoring equipment. I wanted to change to a single battery bank instead of two. So I replaced the "Telephone" batteries with twenty Norton 3H Clarke 270 Amp-hour 6 Volt lead acid batteries. They were arranged in a series-parallel arrangement to provide 12 volts at 2700 Amp-hours or about 32,000 kiloWatt-hours of storage. These batteries are not of the golf cart type but are of a special deep cycle construction.

Cost of Rod Wheeler's Solar System

Equipment	*Cost*	*%*
48 M52 (Lams) PV modules	$2,700	38%
20 Norton 270 A-h batteries	$1,700	24%
Trace 2512 inverter	$1,100	15%
wire & electric boxes	$600	8%
Heliotrope CC120D charge controller	$375	5%
Cruising Amp-hr+ meter	$365	5%
400 Amp switch	$295	4%
Total	$7,135	

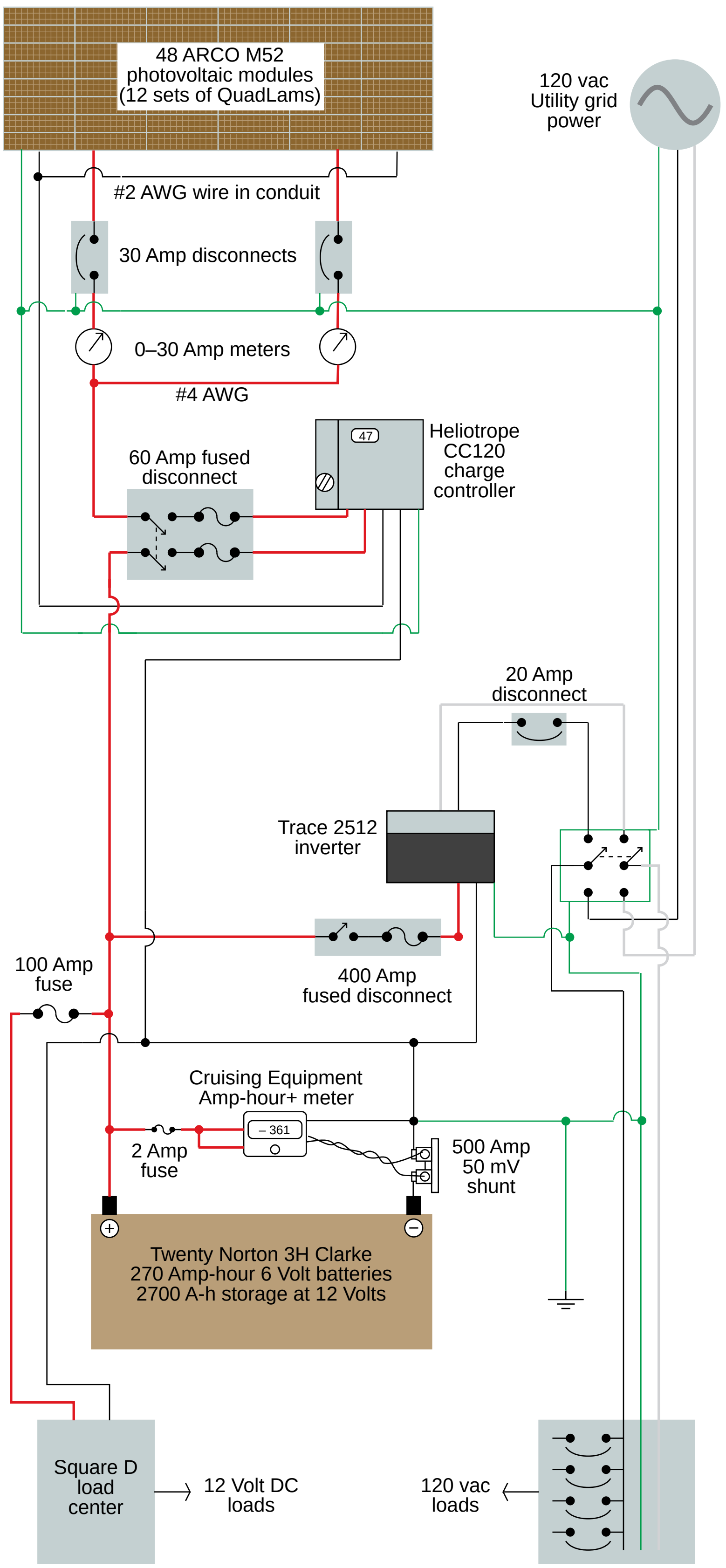
The batteries are connected with 1 inch x $^1/_4$ inch buss bars. The buss bars are connected to the batteries with stainless steel hardware and spacers. In turn the buss bars are connected with 0000 jumper cables.

To keep the new batteries charged I added another six sets of QuadLams for a total of 48 M52s. These are divided into two banks with each providing 30 Amps of charge current. The charge controller was changed to a Heliotrope CC120D.

I wanted to be able to run anything in the house from the new system, so I replaced the inverter with a Trace 2512 — a 2500 watt inverter. Finally everything in the house could be used without fear of overtaxing the inverter or running down the batteries. One problem is that the Heliotrope Pulse Width Modulated charge controller creates a lot of noise on the 12 Volt source and further filtering needs to be added.

Mounting the Solar Panels
The M52s are mounted to the roof with a combination of 2x4's and 2x2's. The 2x4's are mounted vertically on 24 inch centers on the roof beams. They are made from clear redwood and are 8 foot 6 inches long; 13 of them support the array. To hold the M52s I then mounted

Rod Wheeler's Power System



notched 2x2's horizontally. The bottom 2x2 was placed first, then M52s were used as a gauge to mount the succeeding 2x2's. This way everything fits snug. To hold the M52s in place, a 1 inch x 1/4 inch board was screwed to the top of the 2x2 as the panels were installed. The panels are more than three inches off the roof and the 2x4's provide for air circulation. The panels run quite cool — I lose less power during the summer.

System Usage

The new system works fine and provides all of my electric need for my weekend stays. I still return the house to the grid when I leave. To help in battery management I added a Cruising Amp-hr+ meter. It has been very useful and I highly recommend them.

The solar panels will produce about one kiloWatt of power or about five kiloWatt-hours of energy per day. The house has high-efficient lighting. The local Home Club had a sale on five Watt Osram compact fluorescent lights — I bought as many as I could. These five Watt lights work great in track lighting fixtures. The appliances are all 110 volt and include a small 11 cubic foot refrigerator and microwave oven.

The refrigerator is the major continuous power consumer and some day I will change it to a SunFrost. The TV is the next biggest power consumer along with the satellite receiver. Three small TV's are included with the 27 inch TV load — I only use one at a time. I am now in the process of eliminating all phantom loads and converting the heater control to 12 Volts. I hope to get the house's total current draw in the "night mode" to less than one Amp (the burgler alarm would consume most of that). Propane is used for the cook stove, and water and space heating.

Other loads include the ham radio gear; however, the HF Radio Amplifier is not used on the battery system. I am also an amateur radio operator as well as an amateur astronomer. My daily work entails maintaining the two way radios at Disneyland. And on weekends, I converse with other hams at my mountain getaway. In *Home Power* #32, I wrote about educating boy scouts about solar energy and ham radio — I am the scout master of Troop #101 in Pomona. Recently I submitted a manuscript to the Boy Scouts of

Above: Rod Wheeler at the helm of the computer.
Photo by Ernie Williams

America for an "Alternative Energy" merit badge. So far, no response.

When I added up the power usage it came to over 3.3 kiloWatt-hours per day (see usage chart). Most of the power is used to run the big TV set. I need to find a large screen 12 Volt set. The refrigerator is quite efficient but a Sun Frost would be better. The panels do provide enough power to keep up but I either need more panels or to use a little less power.

Daily Power Usage

DC Loads	*Current*	*hours*	*W-hrs*
burgler alarm	0.50	24.0	144
5 inch B&W TV	1.00	0.5	6
night lights	0.05	8.0	5
VHF radio receive & transmit	1–10		as used
UHF radio receive & transmit	1–10		as used
High Frequency radio Rx &Tx	1–20		as used
telescope computerized mount	0.50		as used
telescope TV camera system	0.50		as used
antenna tower winch	50.00		as used

ac Loads	*Watts*	*hours*	*W-hrs*
27 inch TV	220	7.0	1540
refrigerator	150	3.6	540
satellite receiver	50	7.0	350
bathroom heater	1500	0.2	300
heater fan & control	10	24.0	240
microwave	700	0.3	210
compact fluorescent lights (5 W)	25	7.0	175
control room computer	300		as used
observatory lights (on dimmers)	100		as used

According to the bill from the power company the house uses two kiloWatt-hours per day average. I use very little lighting power, however I am forever watching the Sci-Fi Channel on the Satellite TV system. If I am there it's on and I can watch it in any room (yes, even the bathroom has a five inch B&W TV.)

Future plans call for solar water heating, a well, and a garage. I am going to continue reducing the power needs. What I learned in constructing this system was that it will end up bigger than you planned and cost more than you thought!

Access

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They use the whole page

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DC Submersible Pumps Part 2:

Storage Tanks, Gravity Flow, and Booster Pumps

Windy Dankoff

DC diaphragm type submersible pumps have been developed especially for solar photovoltaic power because of their very low energy requirements. Part 1 of this article (HP #38) covered their installation in water wells. Because of their low flow capacity, water must be accumulated in a tank so that it can be released on demand for use in the home. There are three ways to do this: pumping directly to a pressure tank, using an elevated storage tank and gravity flow, and using a booster pump to pressurize water from a storage tank to a pressure tank.

The first method, pumping directly to a pressure tank, was covered in *HP*#38. It is simple and inexpensive, but low in both volume and lift capacity.

The other two methods utilize a storage tank to accumulate water over a longer period of time. This makes it practical to utilize a slow and/or intermittent water source, or combination of sources. Therefore, much of this article applies not only to solar pumping, but to water pumping windmills, generator powered pumps, and rain catchment. The beauty of solar pumping is that it produces the most water when it is needed the most — on long, sunny days! The smallest solar pumps are not expensive, and may be installed and pulled from a well by hand.

The Storage Tank
A storage tank, also called “holding tank”, is a non-pressurized vessel large enough to store several days’ to several weeks’ supply of water. The tank may be made of metal (galvanized steel), reinforced concrete (ferro-cement) or plastic.

Storage Tank Size
Size: Bigger is better. For irrigation pumping, a four day supply may be adequate, since you don’t need it when it is raining. A ten day minimum is good for domestic use. More storage is recommended if you don’t have a back-up supply of water or energy.

A larger tank gives you more for the money, because geometry is on your side. If you double the surface area (material) of a tank, the volume quadruples. It never hurts to have a reserve of extra water in case of pump failure, fire, or unexpected situations.

Material and Placement
A tank placed on the surface of the ground is easy to install. You have the choice of steel (galvanized for drinking water) or plastic (must be protected from sunlight) or concrete built on-site. In cold country, your problem is freezing. If your water runs low, the whole tank may freeze and any unburied pipes may freeze no matter how well insulated they are.

A buried tank has advantages. It is out of sight, and protects the water from freezing and summer heat. You don’t want your tank any lower than necessary, so don’t bury it too deep. The top of the tank can be a foot or two above frost line. The bulk of water below frost line will keep it from freezing.

Plastic is an ideal material for a buried tank. Get a tank made of food-grade polyethylene, like a giant milk bottle with thick corrugated walls for strength. It will last indefinitely if not exposed to sunlight.

Method 2: Utilizing Gravity Flow
With the tank located higher than the house and garden, water can flow down by gravity. You can’t get much simpler. You need high ground on which to place a tank, and in freeze country you must bury the feed pipe below frost line. Here is the equation of elevation to pressure:

2.3 Vertical Feet = 1 pound per square inch (psi)

Standard house pressure is 30–50 psi, or the equivalent of about 100 feet elevation! However, if you can get a tank as little as 15 feet higher than your house (floor level) you may be able to use gravity flow. And, it will take less energy to get the water up there.

How to Utilize Low Pressure Water:
1. Run big pipes. A two inch feed pipe is typical, to carry water to and from the tank. It can’t be too big. Make all your house plumbing at least one size larger than minimum. Minimize pipe lengths and use of elbows. In a standard house with minimum size

plumbing, a third of the pressure supplied to it is depleted by pipe friction.

2. Avoid up-and-down humps in the piping. A hump may accumulate air. An air pocket that cannot escape downward will obstruct the flow of water.

3. Tankless (demand-type) water heaters have minimum-pressure requirements. Check them before you buy. A standard tank-type heater will work fine.

4. Some shower heads won't work well, including most low-flow ones. Buy a cheap one and if it doesn't flow well, enlarge the holes with a drill.

5. Clothes washers work fine with low pressure, they just take longer to fill.

6. If you need pressure for a tankless heater, a dishwasher, a purifier, or a shower on the second floor, you may install a small booster pump to add pressure to just part of your system.

7. Irrigation: Most drip irrigation systems work on low pressure, but there is a minimum requirement, so check with your supplier. Don't plan on using a sprinkler, unless you can supply at least 30 psi. Use large (¾ inch) garden hoses.

Method 3: Pressurizing with a Booster Pump
If your site does not include high ground for gravity flow, or if it is too rocky to allow easy pipe burial, you may use a booster pump. It will develop all the pressure you need, just like "in town". The tank may even be placed somewhat lower than your house. Either Method 1 or Method 2 may be expanded into this "deluxe" system at a future time.

The Pump
If you have utility grid electric power, you would probably use a $^1/_2$ or $^3/_4$ horsepower (hp) ac-powered "shallow well jet pump". This is a type of centrifugal pump that creates pressure by spinning the water with an impeller. However, energy use is high and it puts a very high surge load on the inverter in a renewable energy system. We can save energy by using a pump with an efficient DC motor. DC jet pumps are made by A. Y. McDonald, for instance.

Smaller, positive displacement pumps are more popular for our energy and water-conserving homes. The Flowlight® Booster Pump is a "rotary vane" pump of only $^1/_4$ hp in size, and can serve the needs of a small family. Still smaller and less expensive are the diaphragm pumps made primarily by ShurFlo®. These are adequate for some small homes and for supplemental uses. Most renewable energy dealers carry a variety of DC pumps and can help you make a choice.

Placement of the Pump
Pumps are better at pushing than at sucking water. At any rate, you cannot depend on any pump to draw any more than 10 or 20 vertical feet by suction. It is best to place your pump lower than the bottom of the tank and close to it, if that's possible. An ideal system consists of a buried tank with a "pump pit" next to it. The pit goes down below frost line. It is walled in with concrete block or culvert material, and covered with a tight lid, possibly insulated. It may be made large enough to contain your pressure tank as well. This setup allows you to install a water supply before constructing a house. It takes up no space in the house, and muffles any pump noise.

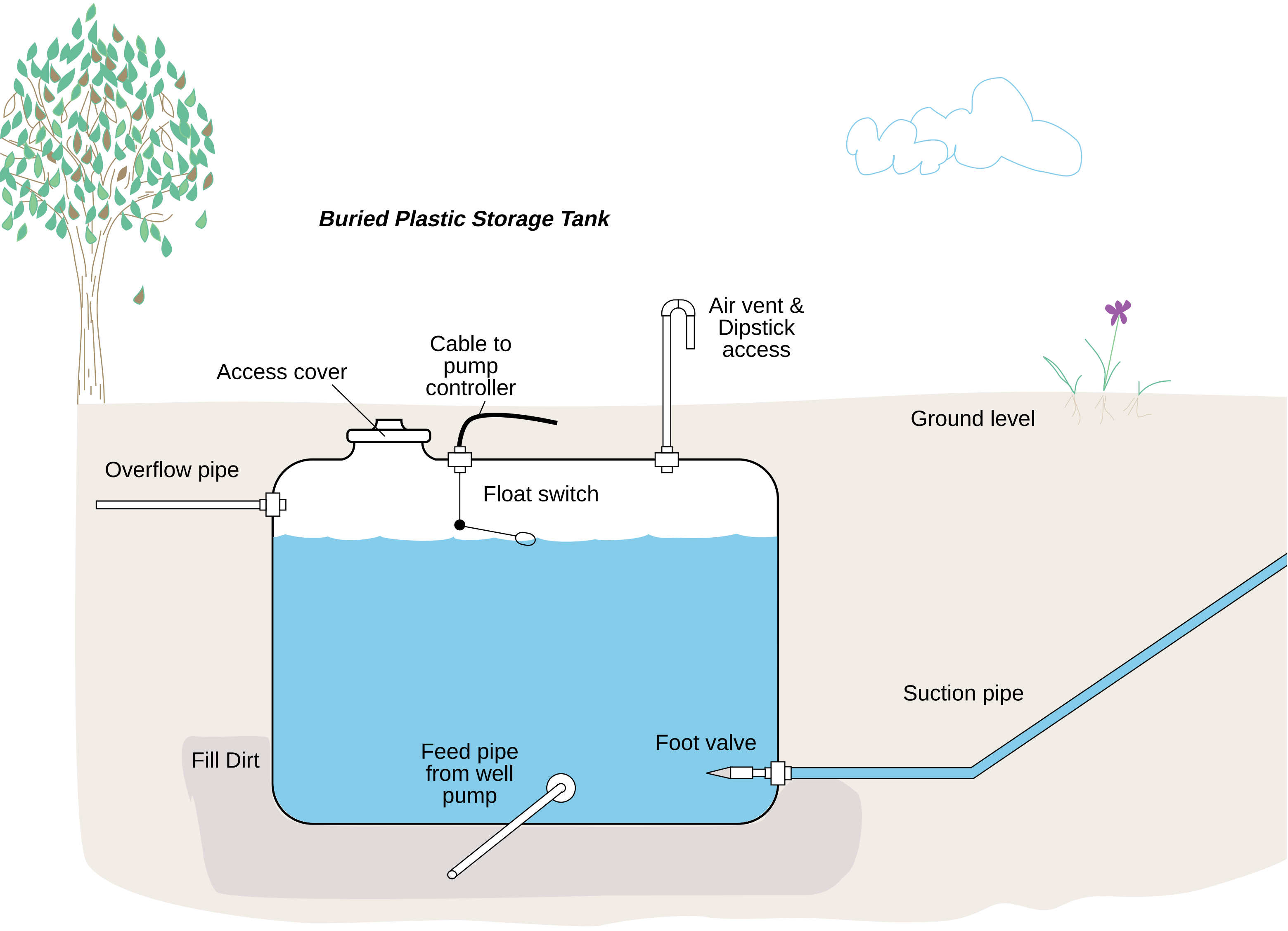
If Your Pump is Higher than your Tank
If your pump is to be located higher than the bottom of your storage tank, take special precautions. Minimize the suction lift by keeping the tank as high, and the pump as low as you can. Keep suction lines large in size and short in length, with no humps to form air pockets. Make extra-tight connections so you don't get air leaking into the line.

You will need to "prime" the intake pipe by pouring water into it at its highest point, so provide a valve or plug for this purpose. A foot valve is placed at the intake prevent water from flowing back down the intake pipe. Do this even if your pump is "self-priming". It may self-prime (by sucking air) when it is new and clean, but perhaps not when it is worn or dirty.

Pressure Tank and Controls
The pressure tank, pressure switch and associated valves and plumbing may be the same common hardware used for conventional ac domestic water systems. The pressure switch determines at what pressure the pump turns on (cut-in) and off (cut-out). Inexpensive diaphragm pumps have a pressure switch built-in, but I recommend bypassing it and using an external switch for increased reliability and range of adjustment.

For a small house, a 40 gallon pressure tank (captive-air type) is minimal. The bigger the better. Read its instructions and "pre-charge" it properly. Your pressure should be set as low as feasible to minimize energy consumption and maximize pump performance. Part 1 of this article (*HP*#38) has tips on tank sizing and pressure adjustment for use with low power pumps.

Fuse or Circuit Breaker Protection: When a motor gets hard to turn due to either a mechanical flaw, freezing, or flow blockage, it draws excessive current (amps). It will overheat if you don't install a fuse or breaker sized according to the manufacturer's instructions. Don't wire up your pump without one. You may end up with expensive trash and a possible fire hazard.



Dry Run Prevention: Most pumps will be damaged if they are run dry. A water tank will certainly run dry sometime by accident, leakage, or failure of the primary pump. It is best to have an automatic shut-off. This may be a float switch placed in the tank to turn the pump off if the tank level runs low, and reset automatically when the water supply recovers. For the Flowlight Booster Pump, a dry run switch may be attached to the pump.

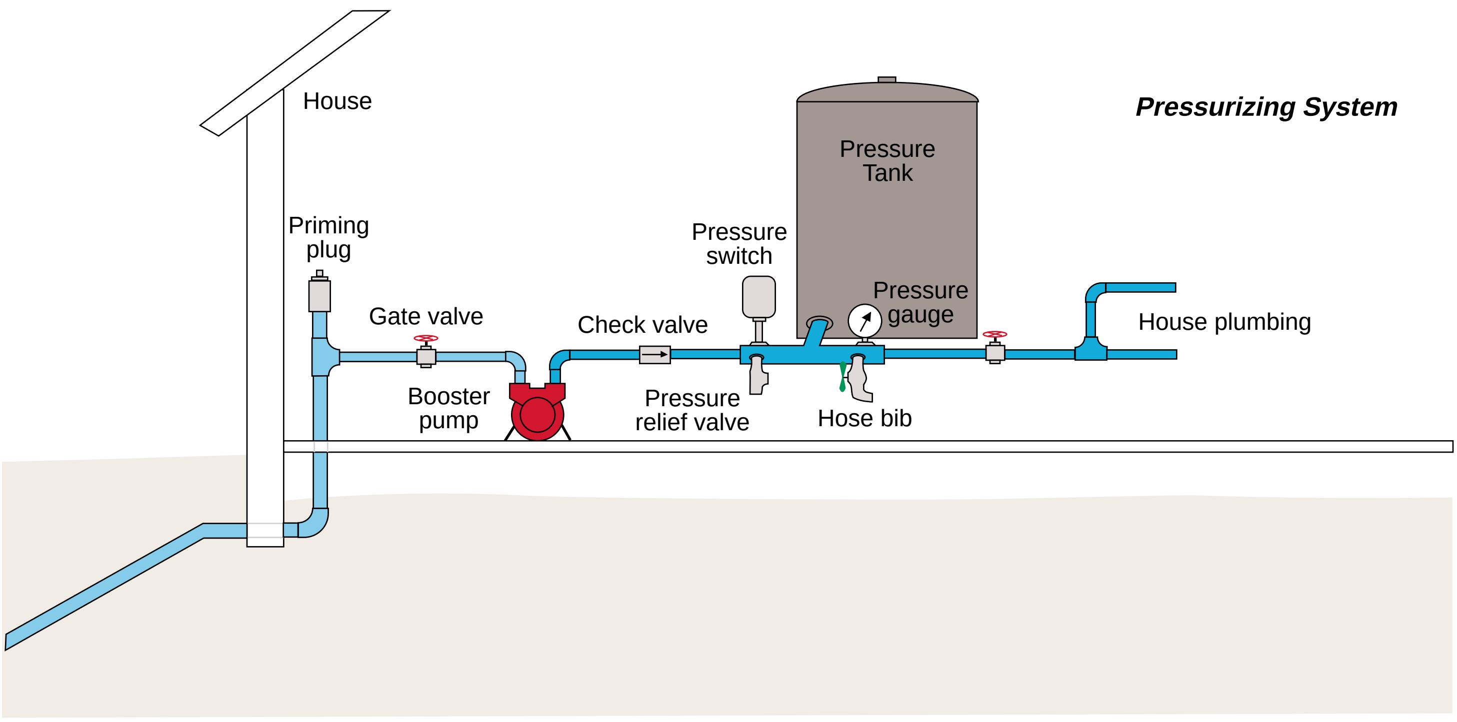
See the diagram above. Here we have a buried storage tank, filled by water from the well pump. A booster pump pulls water from this tank and pressurizes it. The pressurized water in the pressure tank feeds directly into the house. A few pointers for this type of system:

1. Air vent: Air must move in and out as tank empties and fills. A screen keeps bugs out. Keep a joint near the top loose so you can check the tank level with a dipstick.

2. Tank fittings: These are gasketted compression fittings made for plastic tanks. Use a hole saw on an electric drill to cut the holes in the tank.

3. Access cover: Make sure this seals tightly, and cover it over with a sheet of plastic. Make note of its location (measured from the vent pipe) so you can find it in the future.

4. Float switch level control: Use the type of switch that swings on the end of a cord. Simply attach a weight at the pivot point and suspend it as shown. Or, use level sensor probes if your controller is equipped for them. Fill the pipe joint with silicone sealant around the cable. You may use small-size irrigation control or telephone cable with electronic controllers, because the cable will carry only microamps of current. Another float switch may be placed low in the tank, to prevent the booster pump from running dry if the level gets too low.



5. Overflow pipe: If your level control fails, you don't want your tank to settle in a mess of mud. This pipe should lead safely away from the tank, and down a hill and out of the ground if possible. If you can run this pipe down to where you wish to irrigate, you can make use of extra water automatically during the summer. Install a switch to bypass the float control when you want to tank to overflow to trees or garden.

6. Foot valve: If your booster pump is higher than this point, you need a foot valve to prevent water from flowing back into the tank.

7. Feed pipe from well pump: If you don't need a foot valve, this pipe may be joined to your outlet pipe, thus eliminating a tank fitting.

8. Fill dirt: Use sand under the tank, firmly packed to resist settling. Surround the tank with soil or sand. There must be *no rocks* near the tank, especially right under it!

9. Suction pipe: Use one inch or larger pipe. Minimize the length and vertical rise. Avoid humps that can catch air pockets.

10. Priming plug: This is placed at the highest point so that when you fill it with water, all air is displaced.

11. Gate valve: Put this shut-off valve in if the pump is lower than the top of the tank.

12. Booster pump: Mount the pump as low as possible to minimize suction draw.

13. Controls: A "tank tee" allows easy connection of your control devices — pressure switch, pressure gauge, and pressure relief valve if required (run its outlet to a drain). The gate valve lets you shut off house plumbing and still obtain water from the hose bib.

Energy Consumption

The energy (watt-hours) required by a booster pump system for conservative domestic use is quite low. In a photovoltaic home, it may be less than the power supplied by a single typical (50 watt) photovoltaic (PV) panel.

Plan for Failures

Sooner or later something will quit, usually when it's freezing outside and Mom is due to visit. Pumps and plumbing should be accessible, with room to swing elbows and wrenches around. Use plumbing unions or flexible connectors at the pump, so it can be removed without sawing pipes apart. Install shut-off valves to isolate sections of the system during repair. Draw diagrams, take pictures, and keep records so that underground and concealed parts can be located years from now.

Professional Installation

Water supply is not the place for amateur experiments or junkyard material. Don't hesitate to seek professional assistance to get the job done right. If you are hiring a contractor to install your system, it is usually best to purchase materials from him/her. You might get a better deal on the work and better service if there is a problem. Many plumbers are not familiar with pumps or pumping principles. A water well contractor may have more experience in this area. A copy of this article will help familiarize your installer with the unique aspects of this technology.

Access

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Tower Economics 103

Mick Sagrillo

The amount of power produced by any renewable energy technology is, to a great extent, a function of the quality of the fuel resource being used: wind, sun, or water. The higher the "quality" of your fuel, the more power your site specific electron generator will crank out.

Recap Recap

In Tower Economics 101 (*HP*#37), we defined turbulence and ground drag and why each is detrimental to the production of wind-generated electricity. We then examined the relationship of height above ground and wind speed, and how the power available to a wind generator increases with wind speed.

In Tower Economics 102 (*HP*#38), we compared the incremental cost of taller towers versus the incremental increases in power generated by the wind system on those taller towers. Depending on the system size, incremental tower costs varied between just under 5% to just over 8% of the cost of the entire system. Yet those same tower increases yielded a whopping 24% to 38% in additional incremental power output!

The Dilemma

I don't know of any other investment that offers those kinds of dividends. Yet, folks continuously resist installing tall towers for their wind generators. And for good reason. I'm not all that fond of heights either. However, the numbers don't lie.

In this article (part three of a two part series, and the last one I promise), we'll take a look at a few poorly sited installations with inadequate tower heights and the consequences. To cover various generator sizes that might be installed by a home power producer, we'll analyze three different sized wind systems installed in three different locations by three different individuals. As different as these three examples are, however, the mistakes by the installers are unfortunately the same.

Photo 1

We'll start out small, and use myself as the first example of what not to do.

Mick's Marlec

The first system incorporates a micro-wind generator, a Furlmatic, manufactured by Marlec Engineering in England. It is rated at 140 Watts in a 36 mph wind. The Marlec mounts on a 2 inch water pipe, which is typically sold in 21 foot lengths. This machine was installed next to our shop for testing purposes. For a load, we can connect the Furlmatic to an automotive headlight, a car battery, or three electrolyzers to produce hydrogen.

Figuring that most people with a machine this size would probably install it on a very short tower, we bought two 21 foot lengths of galvanized water pipe for the Furlmatic to perch on. With this, we fabricated a 42 foot tilt-up tower that is guyed at two heights on the pipe. Anchors were installed, guy cables attached, wire was run down the tower and into the shop, the Marlec bolted on, and up she went.

In a light breeze, the Furlmatic aimed straight to the wind and produced a few watts. In a day or so, the winds picked up to a steady 35 mph, just about at the

Marlec's rated wind speed. However, connected to a car headlight, the Furlmatic would only put out 19 Volts at about 4 Amps, or 76 Watts. That's only half this micro-genny's rated power! What gives?

A trip outside revealed an odd thing happening whenever the wind picked up. Photo 1 (left) shows the Marlec spinning away on its 42 foot tower. On the right is a much larger Survivor wind generator on an 80 foot tower. The Survivor is pointing right at the north/northwesterly gusts, but the Marlec is aimed....backwards. It's pointing to the south! Again, what gives?

Let's analyze the installation for problems. A look around showed that the wiring is oversized and all of the connections secure. No losses due to resistance. The load happened to be a headlight, so there wasn't a problem of a battery not being able to draw any more current. If we look at the site, we find that the 42 foot tower stands 20 feet over the 22 foot peak of the shop, and .... Bingo!

Take a gander at Figure 1 below. This diagram depicts the zone of wind turbulence caused by ground level obstructions, such as trees and buildings. Now look at Figure 2 (right), the layout of the shop and buildings around the Marlec's tower, along with their heights. Our problem is turbulence. The tower is too short for this site, even with this tiny machine.

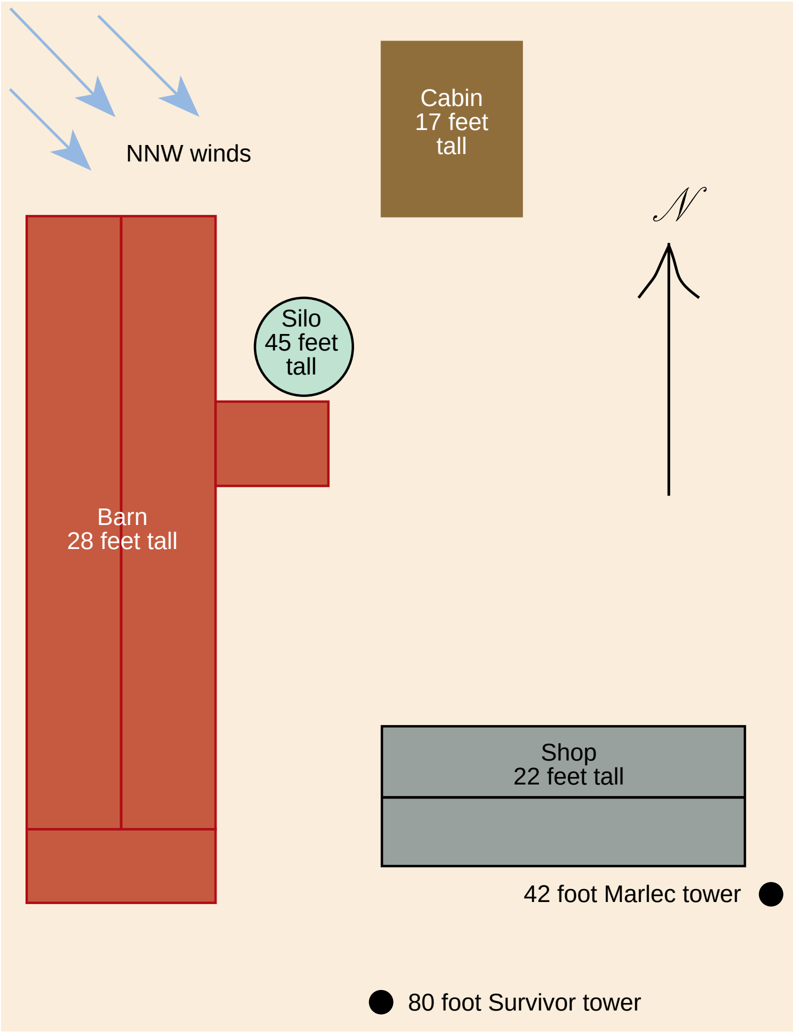


Figure 2

But Mick, you say, how do you know that? Elementary...all the evidence is presented. Go back and look at Photo 1, the one showing the Marlec and Survivor are aimed in different directions. Combined with terrible power production and the information presented in Figure 2, our culprit reveals himself. It's true that we can't see the wind. But between Photo 1 and Figure 1, the only conclusion that we can come up with is that the Marlec's problem obviously is caused by that archenemy of wind generators everywhere: turbulence.

The solution? Add at least another 21 foot section of pipe to the Marlec's tower. While the Marlec was installed for demonstration purposes only, a 63 foot tower would demonstrate its abilities far better than the existing 42 foot tower. A 21 foot tower extension is in the works.

An Un-EXCEL-ent Bergey

John and Kay bought a beautiful passive solar, superinsulated, earth-bermed house complete with a solar hot water system and a wind generator. The wind

Figure 1

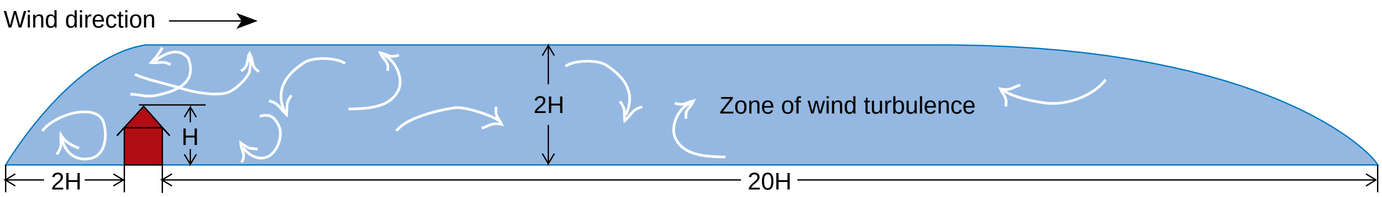


Photo 2

Photo 3

system (Photo 2, top left) is composed of a 10 kW Bergey EXCEL mounted on a 92 foot guyed tower with a synchronous inverter to sell excess electricity back to the utility company.

An engineer with a penchant for numbers, John began taking monthly kiloWatt-hour (kWh) production readings for the EXCEL. After four years of numbers, John is somewhat disappointed with the wind generator's output. The EXCEL only averages 530 kWh of electricity per month. Yet John and Kay live in an area with a decent average wind speed of about 10 mph. Bergey's literature indicates that John should expect at least 1000 kWh per month at that annual average wind speed. What gives?

A check around with other EXCEL owners finds Sid, who is not too far away, touts a monthly average of 1133 kWh per month. Sid's EXCEL is on a 99 foot tower, a mere seven feet taller than John and Kay's tower. Sid's annual average wind speed is also 10 mph. Again, what gives?

The view of John and Kay's EXCEL in Photo 2 was shot from the west-southwest. Notice the lovely backdrop of trees behind the wind generator. The trees are mature oaks, standing only about 45 feet tall. But, they are on a ridge that runs from the north to south along John and Kay's property, the same ridge that their home is bermed into. If we drive 45 feet up to the top of the ridge and look back to the west, we would have the view portrayed in Photo 3 (previous page, bottom).

What happened to the wind generator, you ask. It's still there, in amongst the tree tops. You can really see the problem from Photo 3 — 45 foot trees combined with a 45 foot ridge equals virtual ground level, as far as the wind is concerned. The laminar flow of the wind is interfered with the nemesis of wind generators everywhere: turbulence.

The former owner installed the EXCEL on the flat in front of the house so that he could admire the wind generator, rather than on the ridge behind the house where his view would have been obscured. The trees and ridge form an effective wall over which the wind must climb, leaving the EXCEL in its wake.

The solution? Relocate the wind generator tower to the top of the ridge, albeit in the trees. John and Kay bought a pre-existing condition. A well thought out site analysis by the previous owner or the dealer who originally installed the EXCEL would have foreseen and caught the problem before any concrete was poured.

Things that don't work

Edwin had a set amount of money to invest in his life-long dream: a wind system. His local wind/used car dealer sited the tower in a field surrounded by fencerows of six foot Christmas trees. Both a 2 kW and 4 kW wind generators were considered, as well as towers from 40 feet to 90 feet tall.

Since he only had so much money to spend, the dealer advised Edwin to cut back in tower height but install the larger capacity wind generator to compensate for the reduced height. A 4 kW wind generator was installed on a 42 foot tower rather than a 2 kW wind generator on a 90 foot tower. After all, everyone knows that Christmas trees rarely grow over 12 feet tall, so the tower would always be above the minimum 30 feet above anything within 500 foot rule. Right!

Well, for various reasons Edwin quit cutting and selling Christmas trees out of the fence rows. That was fifteen years ago. Because it rains where Edwin lives, today those six foot Christmas trees are approaching 45 to 48 feet. The tower, however, is still only 42 feet tall! Trees grow, towers don't. (Note: this installation is too embarrassing to include a picture.)

Possible solutions? Cut down all of the Christmas trees. Or install a taller tower. Neither option is very palatable when you realize that the problem could have been avoided with some forethought. (I hope Edwin never buys a used car from this guy.)

Actually, if we go back to "Tower Economics 102" in HP#38 and examine Table 2 on page 28, we find that going from a 40 foot to an 80 foot tower yields a 109% increase in power. Extrapolation to 90 feet gives us about a 130% power increase. This is backed up in Chart 2 on page 27. The bottom line? The 2 kW wind generator on the 90 foot tower would have produced 30% more power for Edwin than the existing 4 kW unit on the 42 foot tower, even on open ground without the Christmas trees.

Lessons Learned

Folks often ask what pitfalls to avoid when sizing and siting a wind generator for their homes. The three most common mistakes made in wind installations are:

1. Too short a tower
2. Too short a tower, and
3. Too short a tower.

Short towers rob you of your precious fuel, the wind. Turbulent winds compounded by ground drag result in poor fuel quality. A wind generator is a serious investment that you make affecting your life and lifestyle for, presumably, many years into the future. Settling for poor fuel quality means you are squandering your investment dollars, wasting your time, and compromising your better judgement.

An analogy I use is that of buying PV panels. but then permanently installing them on the north side of your house. Sure, they'll work, but not very well. Would anybody in their right mind do this? You either have to buy a whole lot more panels than you really need (i.e., a bigger wind generator) or settle for poor performance. I am dismayed when I listen to someone complain that their wind generator, which was installed at tree-top height, doesn't live up to their expectations. A frequent comment is that wind generators don't work, or that wind-generated electricity is too site specific. It's not wind power technology that's at fault.

Back in "Tower Economics 101 (*HP*#37), I used an example of a Windseeker installed on a 100 foot tower versus two Windseekers each on 25 foot towers. Each installation would produce about the same amount of power at a given site. What this means is that installing a Windseeker on a 25 foot tower, in effect, derates the generator from 600 watts to 300 watts in a given wind speed. This is a lot like facing your PV panels north.

The examples I have cited are typical of poor judgement in siting as well as mediocre economic investments. Cutting corners by cutting costs at the expense of tower height compromises the entire wind installation, its power output, and your investment for the several-decade life of the system.

Onward

Next time we'll take a look at the tools you can use to determine the tower height you need at your site, as well as where on your property to locate your wind system.

Access
Mick Sagrillo looks way up at his wind generators at Lake Michigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

Photo by Cliff Millsapps, Hartford, South Dakota

Solar Hydrogen Production by Electrolysis

Walt Pyle, Jim Healy, Reynaldo Cortez

Why would anyone want to produce hydrogen at home? Hydrogen can be used as a non-toxic energy storage and transport medium. Hydrogen that is made from water using solar energy is a sustainable and renewable home energy supply. Make hay (or hydrogen) while the sun shines. Then use the stored hydrogen to produce heat and electricity on demand, day or night!

We got excited about solar hydrogen production during the seventies and the first oil shocks. What happened between the seventies and nineties? For the most part we worked with thermolysis (splitting water with concentrated solar heat) and photoelectrolysis (splitting water in a liquid solar cell). We also followed the work of other hydrogen pioneers, such as Roger Billings and his associates, who produced and used hydrogen in home appliances and vehicles.

The article by Richard Perez about the Schatz PV Hydrogen Project (*HP* #22, pp. 26–30) and a subsequent visit to Humboldt State University's Trinidad Marine Laboratory launched us into designing and making a "home-sized" system based on electrolysis of water. Electrolysis is the competition for thermolysis and photoelectrolysis at this juncture.

Hydrogen and oxygen can be produced from water using electricity with an electrolyzer. This article describes the installation and operation of a 12 cell Hydrogen Wind Inc. 1000 Watt electrolyzer. This electrolyzer can produce 170 liters/hour (6 cubic feet/hour) of hydrogen and 85 liters/hour (3 cubic feet/hour) of oxygen (at standard temperature and pressure).

In addition, we describe a homebrew purification and storage system for the hydrogen and oxygen produced by the electrolyzer. With proper after-treatment, the gases produced can be stored safely. The purified hydrogen and oxygen can be used in fuel cells (to produce direct current electricity) and catalytic burners (for heating and cooking) without poisoning or damaging the noble metal catalyst materials. The gases can also be used for welding and cutting, as well as for motor vehicle fuel.

!!!!Safety First!!!!
Making and storing hydrogen and oxygen is not kid's stuff — this is "rocket fuel"! Use flashback flame arrestors on the hydrogen and oxygen outlets from the electrolyzer. Secure dangerous caustic from small prying hands. Make sure your gases are pure before storing them. More on safety follows.

How Much Hydrogen Do I Need?
This varies tremendously from household to household, depending on how well the Demand Side Management job has been done. We can run our Platinum Cat space heater for about three hours on a cubic meter of hydrogen. The amount of gas needed can be estimated from the energy consumption of any appliance. Amanda Potter and Mark Newell's article in *HP* #32 (pp. 42–45) describes the operation of an electrolyzer and shows how to calculate the amount of gas needed to run appliances. See articles on hydrogen space heating in *HP* #34, hydrogen cooking in *HP* #33, and making electricity from hydrogen with a fuel cell in *HP* #35.

How Much Power Does It Take?
A cubic meter (35.3 cubic feet) of hydrogen gas takes about 5.9 hours to produce in this electrolyzer, when operated at its rated input power of 1000 Watts. This means the energy required to produce a cubic meter of hydrogen and 0.5 cubic meter of oxygen is about 5.9 kW-hr. This translates to an efficiency of 51%, where 3 kW-hr/m^3 equals 100% efficiency at 20°C. Typical industrial scale plants operate at about 4.5 kW-hr/m^3 or 67% efficiency at high current density. The efficiency is better at lower current density.

What Is Needed to Produce Hydrogen at Home?
Our system includes the following components and sub-systems (see the block diagram next page):

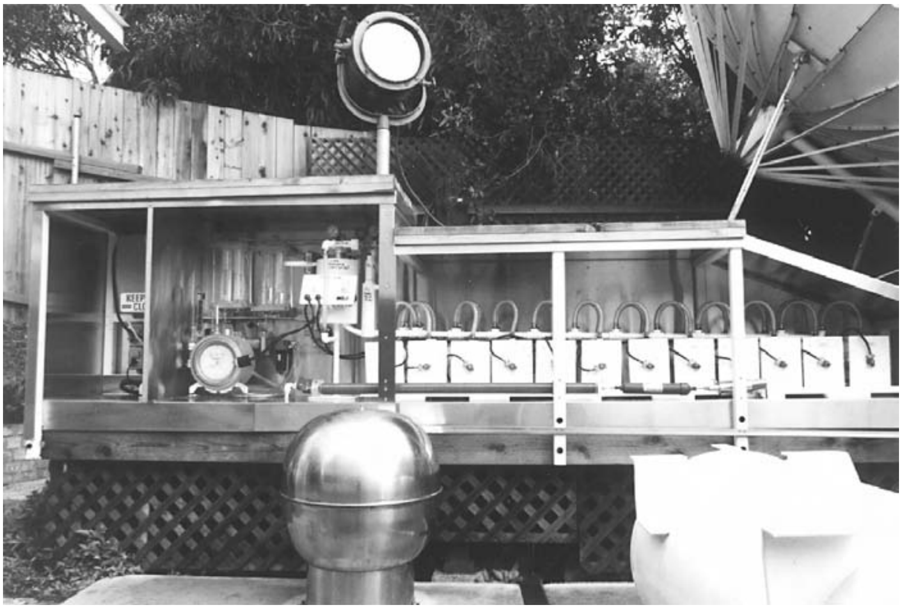
- Solar electric power and/or utility grid power
- Power Controller
- Electrolyzer
- Hydrogen Purifier
- Oxygen Purifier
- Hydrogen and Oxygen Storage Tanks
- Electrolyte Storage Tank and Transfer Pump
- Makeup-water Purifier

Where Can I Get An Electrolyzer?

The Hydrogen Wind electrolyzer was introduced by its designer Lawrence Spicer in *HP* #22 (pp. 32–34). Hydrogen Wind Inc. electrolyzers are available in single cell units for small demand or educational use, and in multiple cell configurations which provide higher gas production rates.

We purchased a 12 cell 1000 Watt system with the gas pressure controls and electrical metering. Larger systems with up to 24 cells or smaller three cell and six cell systems are available. Another article by Spicer, describing the individual cells in more detail along with an introduction to cell arrays, appears in *HP* #26 (pp. 34–35).

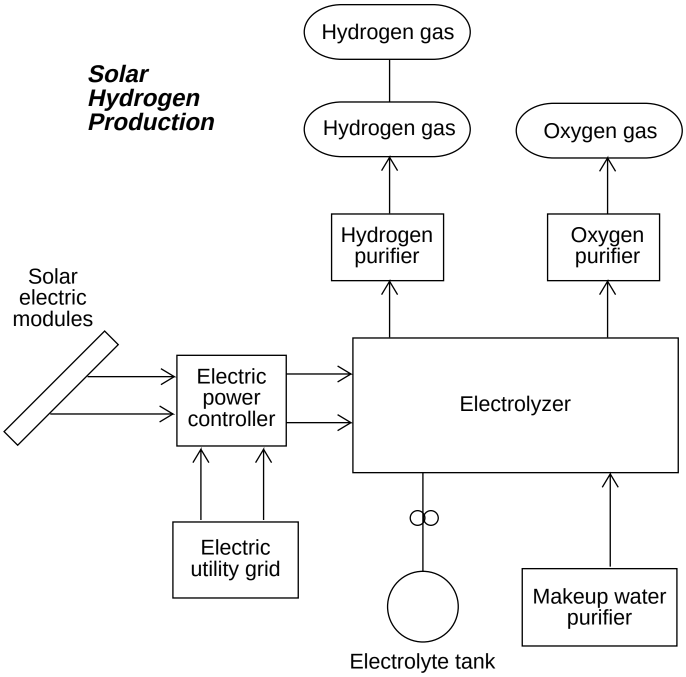
The cell electrodes are fabricated from rectangular metal plates with tabs on one end. Both the anode and the cathode metal plates are made from porous, sintered nickel. Two clusters of nickel electrode plates, 14 for the anode and 14 for the cathode, are separated by porous plastic sheets folded accordion style within a separator container.



Above: An overview of the electrolyzer system. The power supplies and electrical controls are on the far left. Purification equipment is to the right of the power controls. The electrolyte reservoir and hydrogen and oxygen float valves with pressure gauges are to the right of the purification equipment. Twelve electrolyzer cells are shown on the far right. A feedwater purification system is just below the twelve electrolyzer cells. The caustic electrolyte storage tank is on the ground below the float valves.
Photo by Reynaldo Cortez

The plastic separator container is open at the horizontal ends, and closed at the top and bottom. This lets the larger hydrogen gas bubbles (which escape from the negative electrode or cathode) rise in the electrolyte, due to their buoyancy, and exit the separator container on one side. The hydrogen remains separate from the smaller oxygen bubbles which evolve from the positive electrode (anode) and exit on the opposite side.

Solar Hydrogen Production



The micro-porous polypropylene separator container and the electrode clusters are housed inside sections of steel pipe with flat steel plates welded on one end and bolted on the other end. The steel cell housings hold the water and potassium hydroxide electrolyte, and keep the hydrogen and oxygen gases apart after they rise from each end of the separator container.

We installed our electrolyzer inside a small weather-protected shelter made from box tubing and sheet metal. We chose stainless steel sheet metal for its corrosion resistance to caustic electrolyte and long-lasting “perma-culture” value. The photograph above shows an overview of the system.

Solar Power and Utility Grid Backup Power

Our solar electric power is produced by two 16-panel Carrizo Solar “Mud” photovoltaic arrays and a gaggle of other smaller panels. On a good summer day we get up to 75 Amperes at 14 Volts for charging the

Above: The bi-directional bubblers and purification systems. Photo by Reynaldo Cortez

house batteries. When the two house battery banks are fully charged, our two 50 Amp SCI charge controllers disconnect the PV power, and the PV voltage rises. An Enermaxer controller senses the voltage rise and transfers the PV power to the electrolyzers to make hydrogen and oxygen during the remainder of the day. A utility grid electrolyzer power supply is used to make hydrogen and oxygen when there is insufficient solar power available.

How Do We Purify the Gases?

The gas purification system is shown in more detail in the diagram on right. The hydrogen gas and the oxygen gas are purified by two different systems.

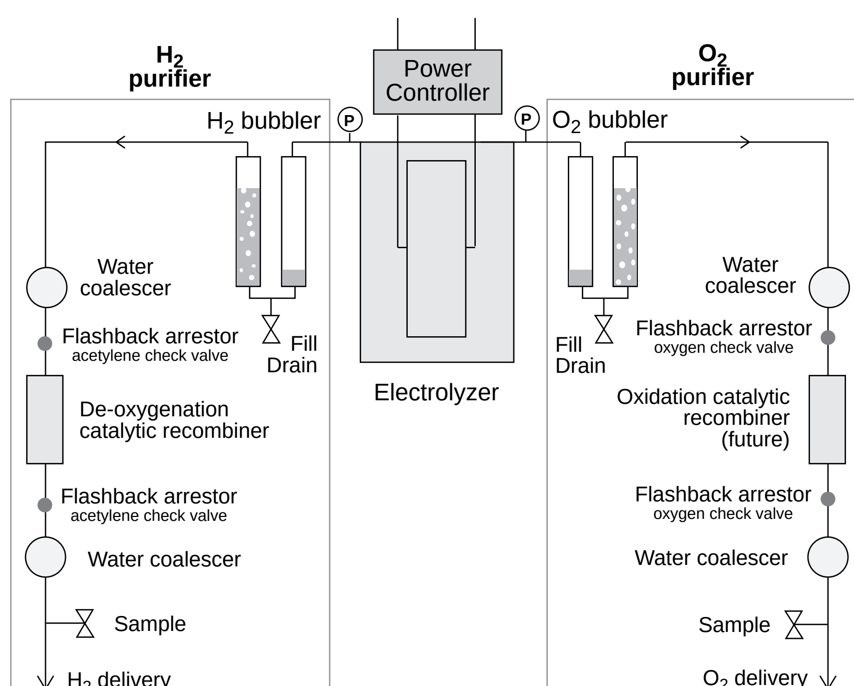
Bubblers

First, each gas is scrubbed by passing it through a water bubbler column. Each of the gas scrubbing bubblers is made from two vertical plastic tubes with end caps. A pair of fish-aquarium type bubbler frits was glued into holes drilled in the inside bottom caps of each acrylic plastic tube, using methylene chloride solvent. Flow of gas into or out of a bubbler can then be seen by the operator. The bubblers are filled about one-third full with distilled water using the drain and fill valves on the bottoms.

We call these "Bi-directional Bubblers". The bubblers are tolerant of flow in any direction, without letting the scrub-water into the product storage system or the electrolyzer. We got the idea for making these bubblers from Dr. Peter Lehman and his associates at Humboldt State University (Schatz Solar Hydrogen and Fuel Cell Laboratory.)

The gases entering the purifier are saturated with water vapor and may contain minute amounts of caustic electrolyte aerosol and particulates like rust. After passing through the bubblers the gases are still saturated with water vapor, but virtually caustic- and particulate-free. Installing another coalescer before the bubbler would prevent particulates and some aerosol from entering the bubblers.

Gas Purification System



Coalescers
Next, the gases are partially dried by passing them through coalescing filters. Special materials were required for the oxygen coalescer filter to prevent spontaneous combustion, and no oil or hydrocarbons can be present.

Recombiners
The hydrogen gas purifier treats the hydrogen gas in a catalytic recombiner. The purpose of the recombiner is to recombine any oxygen impurity in the hydrogen product, and make water. The noble metal catalytic recombiner removes the oxygen impurity to make the hydrogen gas safe to store and handle. As a safety measure, we installed flashback arrestors between the first and second coalescers and the recombiners. The flashback arrestors prevent flashback of poor purity gases (oxygen impurity in the hydrogen produced) when they reach the recombiner and ignition source. The recombiners must be installed with their major axis vertical and the entry at the top.

Some data recently published by W. Hug et al from the German Aerospace Research Establishment *(International Journal of Hydrogen Energy*, Vol. 18 No. 12, pp. 973–977) shows that purity of the gases produced by an alkaline electrolyzer is affected by the current density and temperature of the cells. From the graphs we see that the purities of the hydrogen and oxygen gases are poorer at low current densities (such as when a cloud covers the sun for example). This is because diffusion of the gases through the liquid electrolyte is a more significant fraction of the total production at low current densities.

The data also imply that there is more danger of having hydrogen impurity in the oxygen than the reverse. Note that the lower flammable limit, 4% for hydrogen impurity in bulk oxygen, is approached at low current densities.

How Does One Store the Gases?
The hydrogen will be stored in two 0.47 cubic meter (125 gallon) propane tanks, and the oxygen will be stored in one propane tank.

REMEMBER: hydrogen gas is safe to store — hydrogen/air or hydrogen/oxygen mixtures are NOT safe to store! Put safety first! Safety is your responsibility. It is our intention to give you the information you need to follow safe practices.

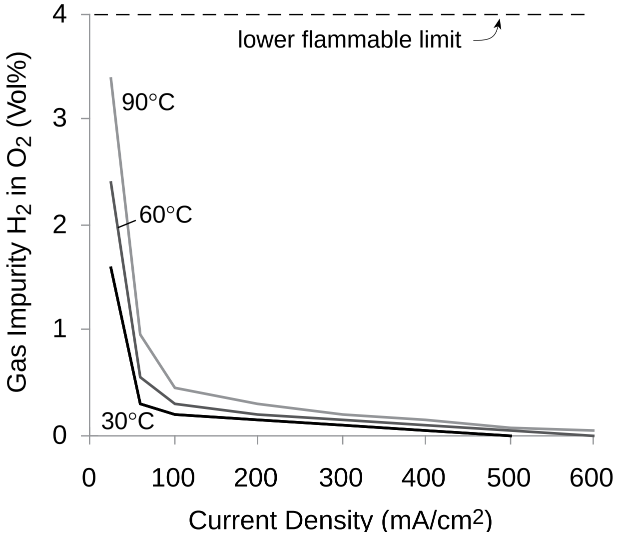
Each of our used propane tanks was cleaned thoroughly and hydrostatically tested to 13.8 bar (200 psig.). Pressure relief valves on each tank are set for 10.3 bar (150 psig.). A pressure switch is installed on the hydrogen tank feed line to shut off the electrolyzer power supply when the pressure reaches 6.9 bar (100 psig.), the rated maximum output pressure of the electrolyzer.

The produced hydrogen gas is pressurized by the electrolyzer to its maximum rated pressure of 6.9 bar or less. Our two hydrogen tanks hold the equivalent of: 6.9 bar x 2 tanks x 0.47 cubic meter = 6.5 cubic meters (at standard temperature and 6.9 bar pressure).

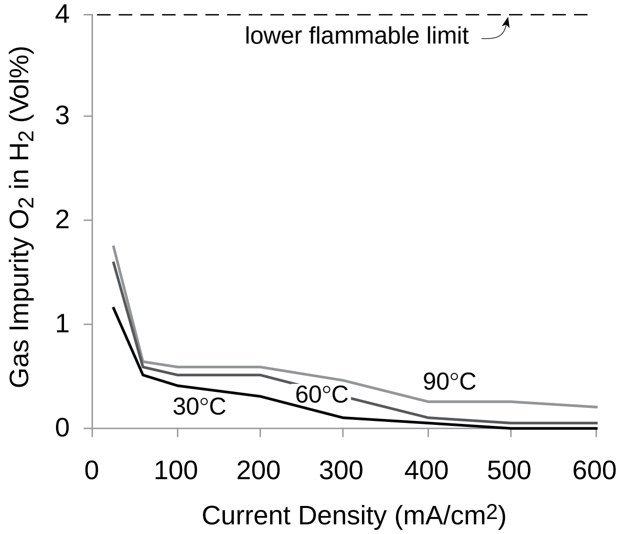
Makeup-water Treatment System
As hydrogen and oxygen are produced in the electrolyzer, water is consumed and it must be replaced. We produce our makeup-water using the local Utility District water, which is piped into the home.

We want to prevent the formation of “mineral scale” on the surface of the electrodes inside the electrolyzer because we want them to last a long time. First, the

Amount of Hydrogen in Oxygen
Taken from measurements by Hug et al, *IJH* 18:12, 1993



Amount of Oxygen in Hydrogen
Taken from measurements by Hug et al, *IJH* 18:12, 1993



Water Purification Results

Element	*Before Purifier, ppm*	*After Purifier, ppm*
barium	0.009	nil
calcium	7.3	0.006
potassium	0.37	nil
magnesium	0.7	nil
sodium	1.8	nil
silicon	3.8	3.8

water is passed through a 20 micron interference filter to remove particulates like rust and sand. Second, the water passes through a charcoal drinking water filter to remove organics and chlorine. Third, the water passes through a de-ionizing column to remove metallic ions. The water before and after the purifier was analyzed. The results are shown in the table above.

As you can see, we removed some scale-forming material. Other elements were below the lower detectable level of the instrument (approximately one ppb). Our water before the deionizer and charcoal filter is not very "hard" at this location; it does not contain very many dissolved minerals. After the de-ionizer there is a marked reduction in elemental concentrations of everything except silicon.

Why Conduct a Hydrostatic Test on the Electrolyzer?
Prior to filling the electrolyzer with caustic electrolyte, we conducted a hydrostatic leak test by filling the cells with purified water and pressurizing the cells and electrolyte reservoir to 6.9 bar (100 psig) using utility line pressure. Several tubing fittings leaked until tightened. Fixing water leaks during the initial hydrostatic test is much better than fixing leaks when they involve caustic electrolyte! Getting caustic on your tools, gloves, safety glasses, and clothes is a real drag. Plan ahead!

When installing the tubing clamps, position them so you can tighten them later when the cells are tied together. An improvement would be to mount the cells higher to allow for access to the clamps from below.

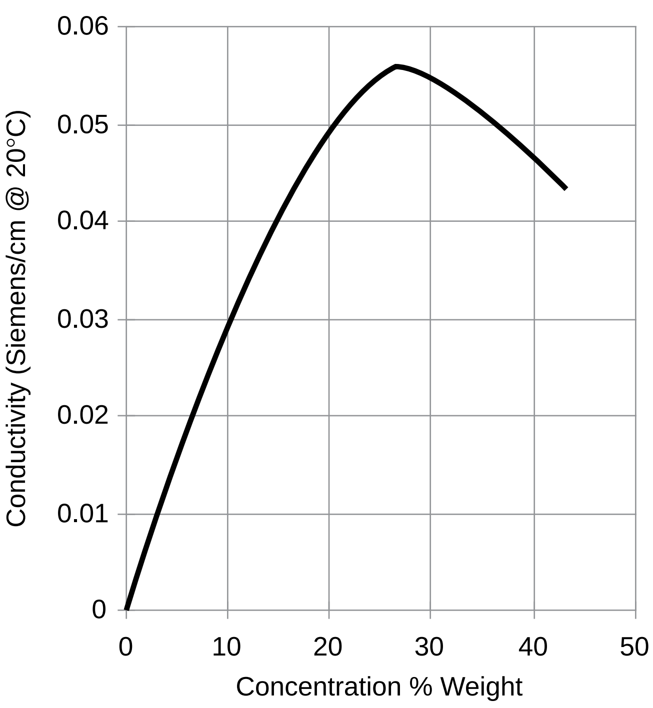
Why Do You Need the Caustic Electrolyte?
Potassium hydroxide (KOH) in the water makes it electrically conductive, so that ions can be transported through the electrolyte during electrolysis. See graph showing the conductivity of the KOH electrolyte as a function of weight percent KOH in water on right.

We have chosen KOH as the caustic. The twelve electrolysis cells and the electrolyte reservoir hold about 61 liters (16 gallons) of water plus 15 kilograms (33 pounds) of KOH. This solution is about 23% KOH by weight. The strength of the electrolyte solution can be tested with a battery hydrometer. The specific gravity should be about 1.1.

Safety is a Must When Handling Caustic Electrolyte!
DANGER!! Potassium hydroxide is very corrosive and hazardous to handle. KOH deserves great respect. Goggles or safety glasses with side protectors, and plastic or rubber gloves are absolutely necessary when handling KOH. When caustic comes into contact with the skin, the natural oils of the skin are chemically converted to a soap, which initially gives a slippery feeling. Prolonged contact will dissolve the skin and give a chemical burn similar but more severe than that given by handling lime or fresh wet concrete with bare hands. The best treatment for any accidental spill is flushing with copious amounts of water, or neutralization with a weak acid such as vinegar. Always have a water hose hooked up and operational before handling KOH caustic. Keep the electrolyzer outdoors and locked so only qualified people can service it. A cyclone fence with top and sides might be the solution.

DANGER!! The mucous membranes of the eye are especially susceptible to caustic damage. It has been estimated that 15 seconds of contact to the eye with concentrated KOH caustic is enough to produce permanent blindness. If any KOH comes into contact with the eyes, the best treatment is to flush the eyes immediately with pure water for at least 15 minutes and seek medical attention.

Conductivity vs. KOH Concentration
Omega Conductivity and pH Measurement Catalog



What Provisions Need to be Considered When Handling Caustic?

To service any of the cells, we need a way to drain the electrolyte and store it for re-use. We have a drain valve and line on the bottom of the electrolyte reservoir that allows the KOH solution to gravity drop into a stainless steel tank at a lower level on the ground. A tubing roller pump is used to refill the electrolyzer cells with KOH after the maintenance is completed. Our KOH tank was previously used as a swimming pool filter case.

We mixed the water and KOH in the ground level caustic storage tank. Water and KOH mixing produces chemical heat, the "heat of solution", which is surprisingly high. After we mixed in all of the KOH flakes, the water temperature rose from 20°C (68°F) to about 82°C (180°F).

At this point we made our first big mistake. After the KOH and water electrolyte solution was mixed (and hot), we immediately started pumping it into the electrolyzer reservoir and cells, using the tubing pump. Within minutes, the tubing pump began leaking. We stopped the pump and drained the KOH back to the ground level tank. After cleaning up the mess, we found that the silicone tubing had split open. We let the KOH solution cool overnight. The next day we replaced the tubing in the pump, and tried again. This time the transfer proceeded without pump tubing problems.

By the time the caustic was about half pumped into the cells, we found that six of the tubing fittings on the first two cells were dripping KOH onto the floor of the shelter. The hot KOH the night before had damaged some of the pipe thread seals which were made with five minute epoxy. The threads in cells further away from the caustic KOH entry point were not damaged, presumably because the caustic KOH solution had cooled by the time it reached those points. We drained the caustic KOH back to the ground storage tank, removed the affected fittings and replaced the epoxy thread sealant. The next day we filled the cells back up with KOH solution for the third try.

More caustic KOH leaks! This time we had leaks on the tubing fittings on the gas-trap tubing loops where the hydrogen and oxygen come out of the cells at the top. Additional tightening of the tubing clamps with a 12 point box wrench stopped some leaks. Other fittings had to be removed and thread epoxy had to be reapplied. When will solid polymer electrolyte electrolyzer cells be available at a reasonable price so we won't have to hassle with KOH???

What Were the Cell Operating Conditions?

The cells require about 1.7 volts each to begin operating; at higher currents there is a greater voltage requirement. The direct current requirement is about 40 Amperes for each cell at rated gas output. In a twelve-cell system the cells are wired in series, so that all of the cells get the same current and the voltages add up to 12 x 1.7 V or 20.4 Volts total at 20 Amperes of current. The cells can also be wired in series-parallel for 10.2 Volts total.

Our solar photovoltaic system and grid back-up power supplies can only produce about 25 Amperes at the moment, so we cannot yet achieve full gas output. The 20.4 Volt operating voltage was not a problem with our Carrizo solar electric arrays, however, since they have an open circuit voltage of about 25 Volts.

Strange and Unusual Behavior?

When operating the electrolyzer the first day on direct current power, the power controller behaved predictably. We measured about 22 Volts and 25 Amperes flowing into the electrolyzer cells. We had gas flow only through the oxygen bubbler however!! And occasionally, the oxygen float valve "burped" some KOH solution upward with a release of gas. The fix for this problem was to raise the electrolyte level from about 5 cm (2 inch) on the reservoir level gauge to 20 cm (8 inch).

At first startup the gas comes out after a delay of about an hour while the cells are "charging" and the gas bubbles on the electrodes get large enough to break away. Voltage across the cell array gradually rises during "charging" from 18 to 19 to 20 Volts before gas comes out.

On restart, hydrogen comes out later than oxygen since it must first fill the top of the electrolyte reservoir tank to pressure-pump the system. When both gases were coming out of the electrolyzer pressure control float valves, the pressure on the reservoir was 2.5 bar (36 psig) when discharging to atmospheric pressure.

The next day we may have had our first personal demonstration of William Grove's astonishing observation that an electrolyzer can run backwards and become a power source. Grove discovered in the early 19th century that the reverse reaction — supplying oxygen and hydrogen to electrodes — causes an electrolyzer to produce direct current electricity and act as a fuel cell.

Before we turned on our power supply the next day, the voltmeter showed about 16 Volts DC on the electrolyzer terminals indicating it was acting as a "source". After that we put a resistive load on the electrolyzer leads and generated about 16 Volts and 10 Amps for several hours (160 Watts) before it "ran out of gas". Was the cell acting as a fuel cell, as an alkaline nickel-iron battery, or a combination of both?

Grunting and Wheezing Sounds are Normal!
Inside the Hydrogen Wind gas pressure control system there are three float control valves. Two float valves are used for the oxygen and one is used for the hydrogen. When the float valves are filled with gas (vertical acrylic tubes with top caps), they float on the electrolyte in the chambers. As each chamber fills with gas the electrolyte is gradually displaced and the the buoyancy of the float decreases. When the buoyancy is low enough, the float falls which releases the elastomer plug from the exit passage and allows the gas to leave the system.

The float valves cycle over and over again to release “bursts” of gas to the purifiers. You can hear grunting and wheezing sounds when standing alongside the unit. A little back pressure on the discharge lines makes the release less violent and quieter. With 1 bar (14.5 psig) back pressure we had good results.

Budget & Economics for Gas Production & Storage
The approximate cost for the solar hydrogen system equipment is listed below, broken down by sub-system.

The labor used for this installation was our own and was not tallied. Normally, for a “first time” system such as this, a rule of thumb is that the labor costs will about equal the capital equipment costs. Labor on any future clone would be significantly less. Capital equipment costs could have been reduced by using fewer stainless steel and more plastic components.

We didn’t work out the “payout” or ROCE for this system before going for it. We made it because we thought it was nifty stuff!

It would probably take quite a while to pay for this system. However, don’t forget, it’s a prototype. Mass production has a way of cutting costs by factors of ten. How does a cloned system capital cost of $678 sound?

Status and Future Direction
Startup of this system occurred during the first week of December 1993. Our next task is to measure the purity of the hydrogen and oxygen product gas streams before we attempt storage.

Eventually, when we have a use for the oxygen gas product in a large fuel cell, we plan to add an oxidation recombiner to the oxygen side. This will remove any hydrogen impurity from the oxygen side and make it safe to store and handle. For now, we are not storing the oxygen. Instead, we will supply the oxygen to the root system of vegetables in some experiments with a horticultural friend of ours, but that’s another story......

A future article will focus on safe storage of hydrogen and oxygen. We plan to cover compressed hydrogen and oxygen gas storage and hydrogen storage in metal hydride.

Hydrogen System Cost

Equipment	*Cost*	*%*
12 cell electrolyzer system (incl S&H)	$2,300	34%
Photovoltaic modules (used)	$1,500	22%
Gas storage tanks, relief valves, tubing	$1,100	16%
Hydrogen purification system	$950	14%
Oxygen purification system	$350	5%
Caustic storage and transfer	$300	4%
Feedwater purification system	$275	4%
Total	$6,775	

Acknowledgements
Alternative Energy Engineering, David Booth and David Katz, for the upgrade to our Enermaxer power controller.

Jim Robbers and Mike Robbers for the used stainless steel swimming pool filter cases which we use for electrolyte storage.

Access
Walt Pyle, WA6DUR, Richmond, CA • 510-237-7877
Jim Healy, WH6LZ, Richmond, CA • 510-236-6745
Reynaldo Cortez, Richmond, CA • 510-237-9748

Electrolyzer
Hydrogen Wind Inc. RR 2 Box 262, Lineville, IA 50147 • 515-876-5665

Purifier and Storage Components
Hydrogen Coalescer (Coilhose 27C3-S): Weill Industrial Supply Inc. • FAX 510-235-2405

Bi-directional Bubbler: H-Ion Solar Co. • FAX 510-232-5251

Flame Arrestors: Check valve flashback arrestor, flash arrestor body with female inlet check valve. Part # FA-3CV. Western Enterprises • FAX 216-835-8283

Oxygen Coalescer Finite Housing S2M-2C10-025: A F Equipment Co. • 408-734-2525

Hydrogen Recombiner Deoxo Purifier D50-1000: GPT Inc. • FAX 908-446-2402

Pressure Relief Valves (Nupro 177-R3A-K1-A): Oakland Valve & Fitting Co. • FAX 510-798-9833

Power Sources
Solar arrays: Carrizo Solar Corp. • 800-776-6718

Enermaxer controller: Alternative Energy Engineering (see ad index) • 800-777-6609

Using the Home Power BBS

Michael Welch

Would you like to get an article or an entire issue's articles from older, out of print Home Power Magazines including #1? Would you like to have rapid communications with others interested in home-made energy? Would you like to get scholarly reports on national energy issues? Do you have questions to be answered by recognized experts? Are you interested in schematics for home power electronics projects? Do you like the idea of a paperless information system?

If yes, then the Home Power Bulletin Board System (HPBBS) is for you. *Home Power Magazine* is one of the sponsors of Redwood Alliance's 24 hour computer BBS, and we want to encourage you to use the system. But, we understand that using computers and modems and BBS systems can be daunting, so we are offering you this basic primer for getting into the BBS.

What you need

Basically, you need a computer, modem, telecommunications software and a phone line. Recommending particular products is difficult since there are so many out there. Procomm Plus for MS-DOS systems and Microphone Pro for Mac are both popular, full-featured software packages that will allow you to do anything you want with BBS's. Many times, adequate software is included with a modem. When it comes to modems, almost anything will work, even a $29.95 Brand-X. But, if you really want to get into tele-communications, you'll want a high-speed modem.

With a high speed modem, you can save on long distance phone bills and waiting time at the computer. Modems that transmit 2400 bps (bits per second or baud) are very common these days, with 300 bps rarely supported because the technology is primitive. But, once you try a high-speed modem (14,400–28,800 bps) you will never again be completely satisfied with slow modems. At higher speeds, BBS menus and functions will fly by with little waiting and file transfers will zoom. If you decide to buy a high-speed modem, I highly recommend one of the more well-known brands like Hayes, AT&T, Supra, and USRobotics. Cheaper ones will work, but you get what you pay for.

OK, now we start

The first step is to make sure that your computer, modem, and software are working properly. Follow the installation instructions with your software and modem, and you should be ready to go. If these items are not working correctly together, it can be frustrating. Calls to the manufacturers' technical support can usually get you straightened out.

Now you're ready to connect to the BBS. Start your communications software, and configure it for 8-n-1 (8 data bits, no parity and 1 stop bit, which is what most BBS's require). Tell the software to dial 1-707-822-8640 (the HPBBS telephone number), and it will take over until a connection is made. After you are connected, the BBS computer will send you an opening screen. If you can read it OK, you are ready to get into the BBS system. If nothing happens or you get lots of garbage on your screen, then you should disconnect and recheck your settings.

With your "connect" made, you can start interacting with the BBS. Don't be afraid to hit the wrong key or to experiment. There's nothing you can do to hurt the system, and the worst that can happen is that you'll be disconnected and have to try again. As part of the log-on process, you will be prompted for your first name, second name and the city and state you call from.

Now you're "online". If this is your first time, there are a series of questions to be answered: First question, "# of characters per line on screen". Set this for your software and computer's maximum screen width, usually 80. Secondly, you'll be prompted for your type of terminal. If color capable, choose one of the ANSI choices; if IBM compatible choose either IBM no ANSI or IBM ANSI OK; if you've a color Mac choose MAC ANSI, if not choose Mac Generic. If none of the choices suit you, then you have the option of doing a custom setup by hitting the <CR> key (carriage return). Third question is "do you wish to modify this?" — usually the answer is no. Fourth question will ask you if you want a pause after each display page. Answer yes unless you want everything to scroll past the screen too fast to read. Finally, “How many lines per display page”. This is the length of your usable screen; for most software 24 works well, but some are different.

Next you will be asked for a password. The first time you enter the password, you’ll be prompted to verify it to make sure it is the one you want. In the future when you enter your password, “****” will echo back instead of what you type in. This keeps the system secure by making sure others don’t get hold of your password. Once you have chosen a password, write it down. Remember that it is case sensitive which means it can tell the difference between lower case and capital letters. Try VERY hard not to lose your password, as it is the key to getting into the BBS.

Next, you will see some informational screens to welcome you, and then you will need to register. You will have the opportunity to ask that the information be kept confidential, but it is mandatory that this section be filled out. After registering, the BBS rules are simply presented, and agreeing to them will allow future access to the Home Power BBS. Once you have gone through the New User process, you will not have to do it again. Future log-ons will give you full and immediate access to the information available.

Now you’re an official HPBBS user

Once you are into the system, you will see menu choices to navigate the system and perform functions. Most choices are selected via “hot keys”, which means that a menu item can be chosen with one character without following it with a <CR> (Carriage Return) key. Sometimes, but rarely, a menu choice requires you to enter a number or a full word, and since many numbers have more than one digit, these choices require a <CR> afterward to denote you are done entering.

The Main Menu

Let me reiterate that you absolutely cannot hurt anything by accidentally hitting the wrong key. You should fully expect to make mistakes as you embark into a technological tool that is new to you. Once you have practiced a little and have gotten used to what it takes to get around the system, you will find yourself able to take control of the BBS session with barely a conscious thought.

Once at the Main Menu, you’ll see that this is the point from which you can reach the major functions of the BBS. These major areas may appear complex, but really there are only three: the Message areas, Electronic Mail and the File areas. From the Main Menu you can take care of sundry things like changing your password, seeing who else has been using the system lately, displaying your user statistics, and accessing the Offline Reader utility (more on this later).

Introduction to PC Communications

by Phil Becker et al

reviewed by Michael Welch

This book is self-described as “The Ready-Reference for Modem-Based Computing”, which is accurate. Principal author Phil Becker is the right one to write such a book. He designed one of the finest Bulletin Board System (BBS) software packages available, and wrote the communications programs that control the hundreds of heliostats at both the Sandia and Barstow solar energy projects. This guy knows his stuff and is a strong proponent of grass-roots level computer communications.

Most of this book is easily understandable to anyone with even the slightest experience with computer communications. It is a good tool for anyone interested in more than “plug & play.” For most nerds, it also delves quite sufficiently into cabling, programming communications ports, advanced modem techniques, and even complicated modem commands. Since I’ve read this book, I’ve learned that Full Duplex is not two houses stuck together without a For Rent sign, but rather a communications channel capable of handling data in both directions at the same time.

This book includes a disk copy of adequate software for MS-DOS communications called Procomm Light. This is a scaled-down version of Procomm Plus, one of the most popular communications software packages.

The book also goes into BBS’s, several of the major commercial information services, computer viruses, mainframe-to-PC connections, and modem troubleshooting. All this is easily understandable as long as you start at the beginning and work your way through. Experienced communicators will find this book to be a good desk reference, as well.

The one disappointment with Mr. Becker’s book is that it is slanted toward IBM clones, but this is not very important because there is very little difference between serial communications on a Mac and a MS-DOS machine.

Introduction to PC Communications is available in bookstores and computer stores or you can get an autographed copy by sending a check for $23.95 (less than retail and includes shipping) to eSoft, Inc. 15200 E. Girard Ave. #3000 Aurora, CO 80014. eSoft will also take credit card phone orders at 303-699-6565

There are three things to remember when navigating the menus: pressing <0> will take you to the Main Menu, you can get the previous menu by pressing <->, and you can exit the BBS by pressing <G> for GOODBYE. Now, on to the BBS's major functions:

Message Conferences
My favorite part of a BBS is the ability to interact with other users that have similar interests. There are several public message areas that allow you to do this openly on various topics. For example, there is a BATTERY message conference that has had an ongoing discussion on building your own deep cycle batteries (mostly about why you shouldn't). Other message areas range from PHOTOVOLTAICS and VEHICLES to EDUCATION, and even include an area for CLASSIFIED ADS. There is also a menu choice that allows you to do a COMBINED read of all the areas.

Once you are in a message area, you can pick several ways of reading them. If you choose <N>ew, you will only be shown the messages that you haven't seen yet. This is a good way to keep up with the messages, especially when using the COMBINED read. Other choices are reading in forward or reverse direction, selecting by sender, receiver or subject, and scanning just the message headers.

Electronic Mail
This is a message area that works much like the above, except that any message sent is private to the person who is the intended receiver and the person sending the message. There are always those times when it is nobody's business but your own what you have to say to a person.

This is a good time to mention the security of the HPBBS. It uses the finest and most secure BBS software available, called TBBS. If you leave an E-mail message, other users will not see it, unless they steal a password from you or the receiving person. It is a great medium for communicating privately with individuals. We do ask, however, that you use the system mostly for energy related purposes.

A useful feature of E-mail is that you can enclose a self-contained file within the message to another person. For example, I often leave Richard Perez a message saying "Here's an article for the next issue of Home Power Magazine," and enclose a file by going through a process called uploading, and then Richard will find the E-mail the next time he logs on and be able to download the enclosed file. To use this feature, after writing the accompanying message, press <F>ile to be prompted for the upload process before you <S>ave the message. To download the enclosed file, press <E>nclosure while reading the E-mail sent to you. More on file uploading/downloading later.

File Areas
The last major part of the Home Power BBS contains computer files. These are files just like you have on the disk of your own computer. All of the files are related to the subject of energy, except for those that we make available as utilities to help you use the BBS and its contents. Each Message Conference area has its own file area containing files on that particular topic. There is the *Home Power Magazine* file area that has a directory for each past issue of the 'zine, a utilities area that offers shareware to view graphics, decompress files, and utilize offline readers, and a brand new section strictly for home-brew energy electronics schematics.

Most of the files are "zipped", which means that they have been compressed in order to take less room on the HPBBS hard disk, and they usually take less time to transfer, or download, through the phone lines. "Zipping" also allows more than one file to be compressed into the zipped file, if required. The Utilities files directory contains a utility to unzip the files so that you can use them at home.

Once text files are unzipped, they can be imported into any word processor for viewing, modification, or printing. Where necessary, the zipped files may contain graphics files in a GIF format. This format is usable in every computer, be it IBM or Mac. Utilities are also available to view GIF files on your own computer.

Downloading & Uploading
Picture the BBS computer on a hillock above all the users that access it, and you'll easily grasp the terms downloading and uploading. When you want to send a file to the BBS, it goes up the hill and is called uploading. Likewise, obtaining a file from the BBS is called downloading. Downloading files is one of the most common uses of BBS's in general, and certainly is the number one use of the Home Power BBS. Folks are calling from all over the world to get their hands on past *HP* articles from the BBS.

The trick with file transfer is that both the sending and receiving computer must use the same protocol. These protocols make sure that the two computers are communicating appropriately so that they can mutually check when the file transfer starts and finishes, check for transmission errors, and keep track of other important things that need to happen during the transfer. These protocols have weird sounding names like Xmodem, Ymodem, Kermit, but I usually recommend that users choose Zmodem from among the list because it is reliable, easy to use and allows multiple files to be transferred in one session. If your communications software is a little old, it may not have Zmodem as a choice, in which case Xmodem is usually the second best alternative.

From within the BBS, you can either choose your protocol every time you do a file transfer, or you can go into <A>lter User Settings from the Main Menu and set both the upload and download default protocols to whichever ones you want.

High speed modems will make their most obvious difference when doing file transfers. A file that takes six minutes at 2400 bps will only take one minute at 14,400 bps. When you are sitting there waiting, that extra 5 minutes seems like a very long time. You will also notice a difference in your long distance phone bill.

Once you've got some experience....
Offline readers are a popular tool for BBS users. They allow you to review and respond to BBS messages without being online, thus saving telephone costs and allowing you to take your sweet time dealing with the messages. From the Main Menu on the HPBBS you can choose <Q>WK Offline Reader Utility. This will automatically run a program on the HPBBS computer that gathers all the messages you haven't seen yet, zips them into a packet, and sends it via modem to your computer.

Then, you can hang up and run your offline reader software on your computer (offline reader software is available in the Utilities file area of the HPBBS). Your software will automatically unzip the packet, and allow you to read and even respond to the messages at your leisure and without being online. Once you are finished, you exit your reader and it automatically zips your outgoing messages and replies into a similar packet. Then, the next time you call the HPBBS, you can choose <Q>WK again, and upload the packet into the BBS system. The messages and replies will appear just as if you had done all the work while online!

Open your door to BBS
Try the Home Power BBS. As you get used to it, you will find it to be a fun and useful tool. And, as more and more people participate, the usefulness of the system will increase dramatically. Let the Home Power BBS open your door to a whole new way of communicating. There are about 20,000 BBS's out there, and their purposes run the spectrum from home schooling to ethnic discourse, and from aids awareness to adult entertainment. Believe me, there is something for everyone in the BBS world.

If you have problems with the Home Power BBS, leave me a message on the BBS or give me a voice call at 707-822-7884.

Access
Author: Michael Welch, c/o Redwood Alliance, POB 293, Arcata, CA 95521 • 707-822-7884 voice • 707-822-8640 computer BBS

The Leeds' Speedster: *The Evolution of an Electric Prototype*

Michael Leeds

We were driving south on California Coast Hwy #1, driving home to Santa Cruz from the 1990 Auto Show at Moscone Center in San Francisco. With me was Dick Rahders, a longtime friend, EV videojournalist, and lifestyle pioneer.

Dr. Rahders and I were discussing the design of our personal solar-powered transportation module. Gazing upon the incredible vistas of unspoilt California coastline. Sending and receiving Fax's, lounging in splendor whilst our car of the future bore us along on the sun, wind, and harnessed gravitational energy. The Neville Brothers screamed, "Fly free, fly free as a bird" through our state of the art circuitry. We were rollin'.

We laughed out loud recounting the reactions from the $500-an-hour corporate execs from GM, Chrysler, and Ford as Dr. Rahders demanded to know, "Where are the alternative transportation units?" I videotaped their stunned, slightly embarrassed open-mouth stares. The thing is, Dr. Rahders just can't leave things like that alone. He wanted answers. He wanted them now. He repeated the question, veins popping out on his neck, left temple throbbing, louder still. We imagined that they were, at this same moment, many hours later, getting a laugh themselves, too, recalling those "troublemakers". Perhaps they might even take a moment to question. "Where are those alternative transportation units?" We rolled on down the coast, designing our trans-Australian race car, retrofitting houses with stand alone off-grid power systems, and addressing other pressing world environmental issues.

Dreams come true
The following week reunited me with my old pal, Dr. Paul Lee, herbalist, local environmentalist, and homeless advocate. "Has it been that long?" Paul asked. "So, what are you doing?" "Dick and I want to build an electric race car," I replied. "Really?" Paul said. "How much do you need? I'll have a check for you next week!" Well, that part was easy!

We first built a "mule". A mule is a platform to test design concepts and components. Dr. Dick had already amassed a research library, including the GM Sunraycer Case History. It saved us about ten years of work. We set parameters. We wanted to use only off-the-shelf, readily available and affordable components. Lead-acid battery technology.

We had the mule running quickly but hadn't even started on the chassis for the race car. Time was running out to complete the car for Australia. We were $20,000 away from our solar array, too.

The Solar & Electric 500 was coming up at Phoenix in a couple of weeks. The race would be a good test. We did a midstream switch, fashioning a body for the mule.

The 1992 Phoenix Electric Race
The Leeds' Speedster, as it came to be known, was kind of a hybrid mutation — go-cart, mini-bike, motorcycle, forklift, mountain bike, surfboard — with an aerobic spandex body. Folks at Phoenix would walk by and say, "These guys must be from Santa Cruz!"

The time came to do test laps. Temperatures on this desert track were 140 degrees plus. Our high pressure, low-rolling resistance tires quite literally melted off the car and the wheels collapsed under the strain! After frenzied phone calls, we found a local bike shop and an understanding owner who stayed up all night, rebuilding our front wheels using heavy duty rims.

Below: A careful look at traffic precedes taking the speedster on the road for the first test run.

Above: Michael Leeds and Dick Rahders pose for the camera as Ward Phillips, Ely Schless, and Shirish Gooptah troubleshoot faulty wiring.

Sunday dawned, the last day of racing and the main event for Open class. Our strategy, after a frustrating two days of blowouts and wheel failure, was to hit the track and "see what this baby will do." I had never been on a race track before and had no idea what the Speedster could do. Each successive lap, I opened the throttle a little more. I built a five-lap lead on the field. The car was "singing". I've built a lot of fast hot rods and I've drag-raced motorcycles, but this was different! The car was practically silent. Only one moving part. There was a perceptible hum from the motor and whine from the high performance go-cart racing chain. The rest was just the sound of the wind. It was a special moment for me.

Finally, the pedal was to the metal. The Speedster was clocked at 71 mph, a track record in the lightweight open class. I ran the car until the batteries were depleted. We went home happy.

1992 Electric Grand Prix

Next, we set our sights on the International Electric Grand Prix in Los Angeles. We were invited down to Cal State L.A. by Ward Phillips (of 1990 Australian race fame). We drove the Speedster down in my '41 Chevy 1 Ton Panel. Dick Roberto and the Cal State Solar Eagle team took time out to overhaul the Speedster, machining parts, fine-tuning components and wheels, and checking electrical circuitry.

Shirish Gooptah, an electrical engineer working with Paul MacCready at Aerovironment, and Ward Phillips, had an experimental motor controller he wanted to test. It was grafted to the side of the battery box and wired in. Then it was off to the Electric Grand Prix.

The first day (and the first of three legs of the race) was from Veterans Stadium in Long Beach to Santa Monica College. Most of the 36 miles was along the Pacific Coast Highway in normal traffic. This was the point of the rally: to prove the viability of EVs on the street.

A few miles out, we were pulled over by the cops. They wanted to know what this "thing" was doing on the street! Fortunately, across the street was a billboard, announcing the Electric Grand Prix! We pointed at it. Still, we had to produce registration, insurance papers, and issue the proper number of "sirs" before we were allowed to proceed.

Near the LAX airport, our batteries gave out. We definitely had electrical problems. Dick Rahders nursed the car along the highway to Venice, where an unemployed engineer from Hughes Aircraft slipped us a tow from his motorcycle and we made it to Santa Monica college.

We were unable to find the problem and hit the sack, resolved to pack it in and head home. When we arrived early, Ward Phillips yelled, "Park the truck! We're in the race." Working since 4 AM, Cal State students, Ward and Shirish had debugged the Speedster.

The second leg of the event was designed to end up at the Rose Bowl in Pasadena. The route even included a short section of freeway. The Speedster evoked a response we hadn't expected. People in cars and folks walking on the street gave us the thumbs up, waved, yelled, screamed, and some even danced little jigs! Once, when we stopped, somebody said, "Thanks for helping us." These people had no idea what the challenges of the technology were, or the politics. They just saw someone who was doing *something.* Someone who had had an idea, and reduced it to practice. The wheels were on the road.

This race was a kind of rally, which meant that it was timed. To discourage speeding, an ideal time was established prior to race days by officials. We had a chase/lead car *and* each entrant had a course map and route navigator. Part of the challenge was making the right turn at the right place. We managed a wrong turn just three blocks from the Rose Bowl. I remember near panic. We maneuvered wildly, and got back on track. We crossed the finish line and later learned — we had a perfect time. To 1/100th of a second. Hot stuff!

We went on, doing extra laps around the Rose Bowl for extra points. Again, the Neville Brothers were screaming, "Free ... fly free" in my head. Yeah!

The third day and leg of the rally was a killer — a brutal 60 miles out to somewhere in the toolies near San Bernardino. Could we do it? We had done only 29 of 35 miles the first day. However, on the second leg, we had logged 45 miles in synchronous perfection with the Universe.

The day dawned hot. Dick took the helm. We got onto Foothill Blvd, sliding along the foot of the mountains, settling into a pace easier than L.A. traffic. We found the rhythm of the traffic lights to help conserve power. Later, when we went back to Pasadena to retrieve our support vehicles, I realized it was really quite a long route. At the time, though, I guess all that adrenaline of competition made it seem like it was a blink of the eye. The good parts go too fast while the bad parts last too long!

Above: Michael Leeds brings home the 2nd place trophy for the Open Class in the Electric Grand Prix.

We cruised past most of the field of competitors who didn't have the range. We crossed the finish line with power to spare. To our surprise, our name was called on the P.A. system. We took home the 2nd place trophy for the Open Class!

SAE

The Society of Automotive Engineers asked us to be their guests and featured speakers at a dinner at FMC in the Silicon Valley. We spoke to executives from Mercedes, Chrysler, Ford and GM. There were heated discussion about the Impact and other technologies. What was going to be the next great mode of transportation?

It came home to me then. These were the guys who were planning and designing our future vehicular reality. My own accumulation of experience said that there were a number of alternatives that had potential. I recalled a conversation that was said to have taken place between Rockefeller and Ford. The agreement was that if Ford made his cars run on petrol, Rockefeller would set up the infrastructure for them. The question wasn't, "What is best?" It was, "Where's the profit?"

We had come full circle. We had been here before, asking them, "Where are the alternative transportation modules?" Now, two years later, we were telling them about something very, very good.

The Next Generation

As a teen in Los Angeles, my generation got to experience the pinnacle of technology in a guilt free environment. Not only will I not give up my autonomy, freedom, or quality of experience, I want *more!*

Most recently, I have been distilling my experience down into a next generation alternative, environmentally-correct, personal street machine. A safe, sexy, rubber-burning, electric road rocket. It will charge in 3–4 hours at my place, from grid power or a solar array on the roof. Or it will "do it" wherever I'm going. It will have a 60+ mile range. Easily 70–90% of my lifestyle needs — business, shopping, errands, and recreation — fit these performance parameters at a 13 cents per gallon gas equivalent.

I tend to think that the solutions are not incremental improvements of existing technology that survive our "investments". Instead, I perceive solutions that may be as far fetched to us as the things we take for granted today were to people only 100 years ago. Perhaps the real answer to the challenge of our times and the emerging "global tribe" are in the areas of "lifestyle pioneering". As healthy and happy inhabitants of this planet, we can't help but to make the world, not virtually, but actually, a most wonderful reality.

The art of energy efficiency is a critical element. As we move through time and space, the trail of garbage we process through our bodies as lifestyles, chemicals, hydrocarbons, nuclear waste, etc. acts like an anchor, keeping us from moving ahead not only physically, but also, perhaps, spiritually.

Society is headed toward the year 2000 with the accelerator mashed to the floor. Yet, the voice in our head says, "Consider the consequences". We are paralyzed, like in a dream, to remove our foot from the throttle, like lemmings to the sea.

Wow, is this my life? Here we go....

Access

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Above: Michael Bittman covered 40 miles to win the solar-powered boat race in NOPEC II. See the sidebar on the next page for details. Photo by Jerry Gay

The Great Electric Boat Race

Andrew Muntz

There were no roostertails and certainly no ear-splitting roars, but this newest form of boat racing put on a show that proved every bit as exciting as race boats that go many times faster and consume much more energy. A new world speed record, a down-to-the-wire marathon race and a near doubling of performance by the competitors highlighted the 2nd annual Electric Boat Regatta held in late July and early August near Everett, Washington. The only event of its kind held in the world, the three-day event featured competition for battery-powered and solar-powered boats.

New Speed Record

Burton Gabriel of Port Ludlow, Washington, established a new speed record when he made two runs through a one-kilometer speed course at an average speed of 41.187 miles per hour, nearly doubling his own record established last October (see *HP*#32). The course was set on Spada Lake, a pristine alpine lake located in the foothills of the Cascade Mountains east of Everett.

Gabriel's ultimate goal was to break the overall world's record for electric-powered boats, currently held by Great Britain's 74-year-old Dowager Lady Arran, who averaged 50.825 miles per hour in 1989. Lady Arran established her mark using a $100,000 hydroplane that featured four special motors and exotic batteries — a far cry from the home-built racing runabout hull developed by Burton Gabriel and Ward Phillips of Friday Harbor, Washington. The Gabriel-Phillips boat was powered by an Advanced DC electric motor bolted up to the lower half of a standard outboard racing unit.

Gabriel experienced difficulties in handling the boat and the failure of a motor controller just as it neared the finish line, but he was happy with the effort. "The boat showed that it has everything needed to break the old lady's record," he said. He and Ward Phillips are planning another attempt to break the overall record soon.

Endurance Boat Racing

A week after the world record run, a field of fifteen battery-powered boats competed in the six-hour Delco Voyager Battery Marathon race on Silver Lake near Everett. Most entrees came from the Pacific Northwest with a few from as far away as Milwaukee, Wisconsin.

David Mischke of Edmonds, Washington won the event for the second year in a row. He held a narrow advantage over a boat campaigned by a group of electric vehicle enthusiasts from Port Townsend, Washington that call themselves the NOPEC (North Olympic Peninsula Electric Craft) Racing Team, in a not-so-subtle reference to the oil cartel.

In winning last year's race with a boat named SEVA, Mischke grabbed an early lead in the 12-hour endurance test and held it until the end, despite a last-minute challenge from David Janos in the NOPEC boat. In that challenge, Janos had come to within five feet of passing Mischke with only one minute remaining in the race. Mischke made a last-minute dash and held on to first place by just 20 feet when the race-ending signal was given.

This year, the roles were reversed. The same boat from the NOPEC team took an early lead and held it throughout. A new boat developed by Mischke ran second. Victory for the NOPEC boat seemed assured when, about four hours into the six-hour endurance test, Mischke's Sea Saber suffered a broken propeller, putting it out of the running for about 20 minutes while repairs were being made. This allowed the boat from Port Townsend, called J' M' N' and again driven by David Janos of NOPEC, to build a two-lap lead over the Sea Saber.

One of the intriguing aspects of competition between battery-powered boats is the strategy that results because the boats can only use a limited amount of energy. For example, the boats in the battery marathon race use only the energy that can be stored in no more than 125 pounds of batteries. During the event, therefore, competitors pay close attention to how much energy remains in their batteries, carefully calculating the best rate of consumption in an effort to use all the energy available to them, but not so much that their boat can't finish.

Mischke had been running his batteries at 11 amps throughout the race but, with about an hour left, decided to risk depleting the energy and ordered a 25-percent power increase, adjusting the current to 15 amps. As a result, the boat started running laps about two minutes faster.

A Sunlight Cruise

Michael Bittman

The solar boat NOPEC II was sponsored by our local electric car club, Northern Olympic Peninsula Car Club (saying NO to OPEC). This same club also builds electric racing cars, and finished first in "C" stock at Phoenix last year.

The NOPEC II is a converted rowing boat, build by co-pilot Gerald Douglas of Catspaw Kayaks. A $^1/_4$ hp motor turns a ten inch prop via a chain. I helped design the solar rack with Burton Gabriel of Gabriel Marine, holder of the Electric boat displacement world record, and Burton build it. The propulsion system was designed and constructed by Tim Nolan of Tim Nolan Marine Designs. The solar panels, twelve Solarex 36-watt panels, were donated by Creative Alternative Utilization of Sustainable Energy (CAUSE), a non-profit organization funding non-petrol propulsion system. CAUSE now owns the boat.

The boat was competitve in last year's race. The only modification for this year's race was a change in the size of the chain sprocket. A Cruising Equipment digital meter is used to monitor current flow between the panels and motor. The array is adjustable fore and aft, and port and starboard. The pilot adjusts for maximum amps.

In the race we traveled 40 miles in six hours around the one-mile-plus course, averaging 6.64 mph, with some laps over 7 mph. Our lead was never threatened. Halfway through the race and two laps behind, the Sun Warrior II was flipped over by the wind. The students used life jackets to right and float their boat and its array to shore. After repairs, they re-entered, winding up with second place in the race!

NOPEC II was also entered in the battery marathon the day before, taking sixth place after traveling 46 miles in six hours. It was awarded first place in the practical, non-racing hull category. This is a boat you could use everyday with more than one passenger.

I'd like to thank everyone that helped, including our additional sponsors, Port Townsend Sunrise Coffee and Cruising Equipment.

Access: Michael Bittman, UROWN Power Company, POB 796, Pt. Townsend, WA 98368 • 206-385-7341

Above: Loy Cloud takes a turn piloting the SEVA on its way to victory in the 12-hour battery maraton race. A 20-foot hull powered by a one hp electric motor, SEVA was propelled using a large 14-inch diameter propeller spun at a leisurely 180 revolutions per minute.

Below: Burton Gabriel of Port Ludlow, Washington speeds through a one-kilometer course to establish a new world speed record for electric-powered displacement boats. Gabriel averaged 41.187 miles per hour on Spada Lake, east of Everett, Washington. Photos by Jerry Gay

Using the boat's greater power, the driver of Mischke's entry, Edmonds resident Kathy Bonallo, began picking away at the NOPEC boat's advantage until, with only 17 minutes left until the end of the race, she sped into the lead and crossed the finish line with a 100-yard advantage over the NOPEC boat, claiming the $2,500 first prize offered by Delco Voyager Batteries. The operators of the J' M' N' were awarded $1,000 for second place. Finishing third and winning $500 was a boat campaigned by Mischke's partner, David Cloud of Seattle, and fourth was SEVA, the boat Mischke used to win last year's race.

"It was a great day," said Mischke. "I was more than pleasantly surprised by the boat's performance. I didn't think we had the batteries left to catch the leader, but decided to make a run for the lead with five laps to go. After we caught the lead boat, it was just a matter of staying in front. It was a great feeling to see it all work out. I didn't think we had enough to pull it off. Kathy Bonallo was happy to compete. She was aggressive."

The boats showed a tremendous improvement in performance this year. In 1992, Mischke's winning SEVA averaged 5.5 mph. This year, Mischke's boat covered 56 miles during the six-hour race, an average speed of over 9 mph! Had the propeller not broken, the average would have exceeded 10 mph easily. Compared to other forms of racing, the boats consumed virtually no energy. The winning boats were able to race all day using an amount of energy equivalent to a *cup* of gasoline.

Solar Boat Racing

The next day, only the sun's energy was consumed during competition between boats. Qualified boats for this six-hour race are restricted to solar panels of terrestial grade cells not exceeding an area of 40 square feet.

The winner was Michael Bittman of Port Townsend, another member of the NOPEC Racing Team. Bittman's NOPEC II led the race wire-to-wire, covering an impressive 40 miles before time ran out. Averaging almost 7 mph, the NOPEC II handily improved on the 5 mph average set by the 1992 winner.

"I finished third in 1992," Bittman recalls. "I felt that I could have won the 1992 event had it not been for the wrong sprocket on my chain-drive motor." Bittman was looking forward to the rematch with last year's winner. Unfortunately, the defending champion's boat was damaged in an exhibition only a month before the race and was not able to compete.

The day's only incident occurred about four hours into the race when the Marquette University boat caught a gust of wind and capsized. The boat, named Sun Warrior II, was taken back to shore, repaired by the engineering students, and reentered in the race, completing four more laps before time expired. It finished second.

Electric race boat enthusiasts plan to organize a group interested in this form of competition and hope to present races at other sites next summer.

Electric Boat Racing Directorship

The Electric Boat Regatta was presented by Snohomish County Public Utility District, an electric utility serving the area immediately north of Seattle. This event is held as a way to showcase the development of battery and solar technologies.

We are interested in the development of alternate resources and feel competition like this encourages the development of these technologies and also has a practical application. Internal combustion engines are being banned from lakes with increasing regularity. The performance of these boats demonstrates that a person can still enjoy a full day of fishing and cruising while using battery power.

Access

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Motor Controllers for Simple Electric Vehicles

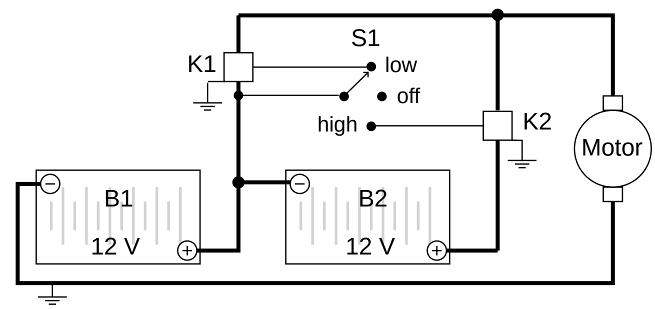


Figure 1: Voltage-Tap Controller (Not Recommended)

Michael Hackleman

If you're building a small electric vehicle, most folks will tell you that you need an electronic controller. With this black box and its potbox, power flows from the batteries to the motor in direct proportion to the amount of "pedal" you give it. A modern MOSFET controller is just a larger version of the standard light dimmer switch. It is efficient, compact, tough, reliable, and a straight bolt-up. It is also expensive. At $300 or more, it could beat out the motor as the most expensive part of your vehicle. There IS an alternative. If your budget is low, consider the technique of voltage-switching.

Voltage Switching

Voltage-switching is a control technique that feeds power to the motor in a series of "steps". Each step is a different voltage. Batteries wired in series add their voltages. Where a battery pack consists of two or more batteries, voltage switching is a possible control technique. A series-parallel control system is like a set of stairs whereas an electronic controller is similar to a wheelchair ramp!

(Note: Voltage-switching is NOT recommended for larger vehicles (over 300 pounds) or high power circuits. When the mass of a vehicle increases, even a minor leap of 12 Volts is likely to cause a jerk and a big inrush of current to the motor. This is rough on transmissions, motors, batteries, and the driver! As the number of batteries increases (in the battery pack), the voltage "steps" are larger and the effectiveness of the circuit less attractive.)

In electrathon racing, the size of the battery pack is limited by weight and type. For example, competitive vehicles will likely use two 22NF batteries. These are rated at 12 Volts each. This is an ideal application for a control technique like voltage switching.

There are two *types* of voltage switching circuit: voltage tap and series-parallel.

Voltage Tap

At first glance, the circuit shown in Figure 1 appears to be a simple way to accomplish voltage switching. OFF is center position on switch S1. When the toggle is switched to low for slow speed, contactor K1 is energized, and the motor sees 12 V from battery B1. When switch S1 is switched to high for a higher speed, contactor K2 is energized, and the motor sees 24 V from both batteries B1 and B2.

What's wrong with this circuit? The answer is: unequal discharge. Even if the slower speed position is used briefly, battery B1 is used more often than B2. So, in use, B1 will be the first battery to be discharged. Also, during recharge, it will be the last to reach a full charge. Because of unequal discharge, then, either B1 will be undercharged or B2 will be overcharged.

Series-Parallel

By using switches, relays, or contactors, it is possible to electrically wire the battery bank to provide voltage switching that *avoids* unequal discharge. The trick is to wire the two batteries in parallel for the 12 V position and in series for 24 V. This is called series-parallel.

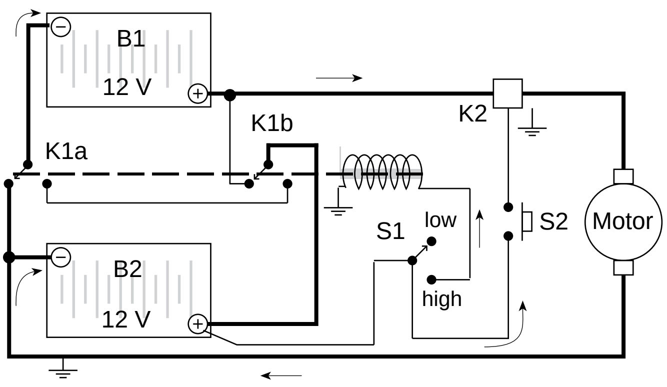


Figure 2a: Series-Parallel Controller — energy flow in the low (12 Volt) position.

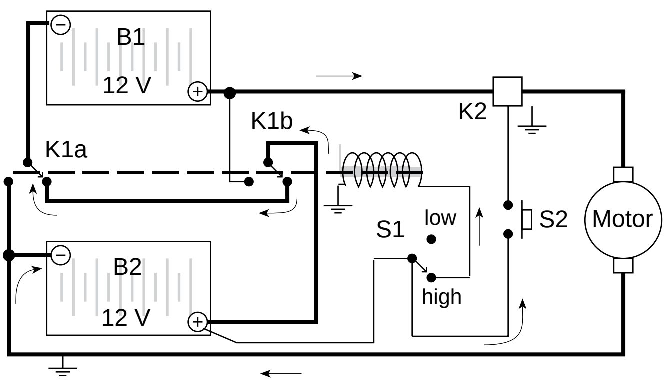


Figure 2b: Series-Parallel Controller — energy flow in the high (24 Volt) position.

Figure 2 illustrates a simple series-parallel circuit. Figure 2a more clearly shows the path of electricity when the two batteries are in parallel. Remember, parallel wiring of batteries does not result in an increase in voltage. Instead, the Amp-hour capacity of the batteries is increased and equals the sum of the two capacities. In the low setting, then, the batteries *share* the motor current. Most importantly, they are equally discharged. Figure 2b shows the path of electricity when the high speed setting is selected and the batteries are arranged in *series.*

At the heart of the series-parallel circuit is the DPST (double pole, single throw) relay, K1. Unenergized, it holds the two batteries in the paralleled, 12 V mode. When S1, a SPST switch, is thrown to the high position, it energizes K1, rewiring the two batteries in series and producing 24 volts.

The motor does not see either 12 V or 24 V until the pushbutton (momentary contact) switch S2 is depressed, energizing a 12 V contactor, K2.

When the battery pack is plugged in for recharging, the 12 V charger sends the same amount of current to each battery until each reaches a full charge state. This will compensate for the small amount of current battery B1 will supply during vehicle operation to power the relay, contactors, horn, lights, turnsignals, etc. If you get in the habit of leaving S1 in the low position when you're parked, battery B2 will actually make up any differences in states of charge between the batteries.

Electric Vehicle Circuitry Design

There are *several* ways to wire the series-parallel circuit. For example, a keen electrician might note that S2 and K2 could be eliminated by using a DPDT switch for S1 and a DPDT relay for K1.

I did the same thing when I built my first series-parallel circuit. However, this simpler circuit places the burden of switching *current* on the relay itself. Sustained motor currents of 25–40 Amps and switching surges of 40–60 Amps will quickly burn the relay contacts of the more affordable relays.

High-current 12 V contactors (another word for power relay) are cheap and tough. So, for applications like electric bicycles, motorcycles, and electrathon racers, a SPST contactor (like K2) is used to handle the current surges that occur as the voltage(s) are applied or disconnected from the motor. This allows the use of a relatively light-duty relay for K1, since *it is never switched under load*.

The Deadman's Switch

There are several other reasons for using a series-parallel circuit with S2 and K2. Since S2 is momentary contact, if you let go, power is off. This is the infamous (but very smart) "deadman's switch". If you lose control of your vehicle or have an accident, your thumb or fingers are likely to let go of switch S2, shutting off motor current. Being dragged down a street or in a tight circle by your own vehicle is embarrassing, at least.

Coasting

Coasting is a big part of electric vehicle operation. It helps to think of S1 and K1 as a way to shift gears, low and high (even if it's all electrical). S2, then, is the power-or-cruise switch. Don't think that just because you've let go of S2 that the vehicle will stop. Oh, no. This only disconnects battery power from the motor. Hereafter, the vehicle will *coast*, slowing down only because of drivetrain and aerodynamic losses. In a larger electric vehicle, the fine art of coasting is one of the least expensive ways to increase vehicle range by 15–20%.

Incidentally, in the same way that an electronic controller switches the motor ON and OFF at very high speeds, the operator of a series-parallel controller can regulate vehicle speed somewhat by alternately pressing and releasing S2. Onlookers will swear that you've got an electron coil misfiring, but it works.

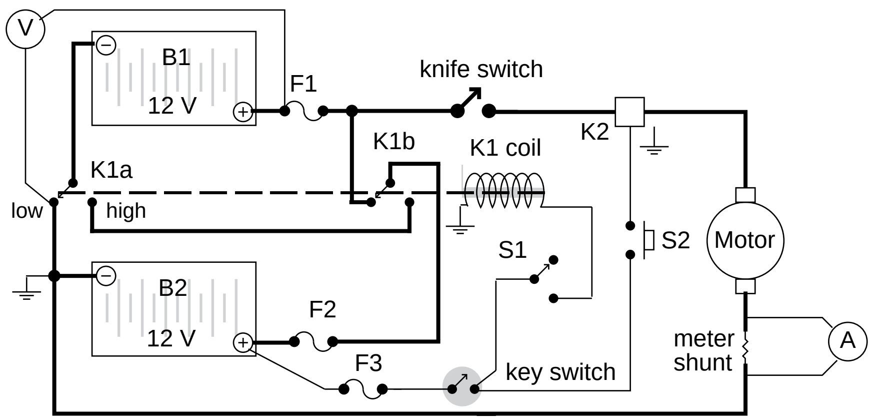
Regenerative Braking
If you point your vehicle down a steep grade, it may increase speed once you go into coast mode. When this happens, pressing down on S2 will help slow the vehicle somewhat. This slowing is called regenerative braking. Current is actually flowing from the PM (permanent magnet) motor to the batteries. There's a direct relationship between motor rpm and its voltage. And, when motor voltage is higher than battery voltage, and the two are connected, current will flow from the motor to batteries. Since it takes power to make power, electrical energy is being made by stealing some of the vehicle's energy of momentum. *Ergo*, the vehicle slows down.

A vehicle with a motor running at high speed will experience very strong *regenerative braking* when the battery pack is switched from 24 V to 12 V. You can verify this if your meter will display reverse current flow. This is another reason that it's wise to use something like S2 and K2 in a series-parallel circuit. The driver of a fast EV could be in serious trouble if strong *regen* braking is activated unintentionally. It *will brake* the vehicle. It might also *break* the vehicle, lock up the wheels, or result in an accident.

By this circuit's design, then, the driver cannot *inadvertently* activate strong *regen* braking. To initiate strong regenerative braking, the driver must perform three actions. Release S2. Flip S1 back into low position. Press S2. Conversely, if S1 and S2 were combined into a single DPDT switch, the driver could inadvertently toggle *through* the center off position directly into the low setting. By locating S1 and S2 near each other in such a way that the same finger or thumb operates each, S2 must be released in order to change the setting of S1.

When the vehicle has slowed and the ammeter is showing zero current, release S2 to coast. Remember, if S2 stays ON, the vehicle will zip along at the top speed that low position would normally give.

Practice Makes Perfect
All this detail makes this controller sound a lot more complicated than it is to actually operate. Don't be put off by it. It takes very little getting used to. A little



F1, F2: max motor current x 2 = rating
F3: 5 A slo-blo
wiring: motor circuit: #10 stranded or larger
control circuit, metering: #18 stranded or larger
digital meters: Radio Shack, Micronta model 22-171A
shunt: 50 Amp 50 mV

Figure 3: Complete Series-Parallel Controller Circuit for a Small Electric Vehicle.

experimentation works wonders. After that, everything becomes quite automatic. True, it is intimidating to newcomers. If it's a thief, that's good. If it's a bystander wanting to try it out, you've got choices. Either bow out with an explanation of its complexity or give a lesson.

This circuit will not work for the average consumer. Thinking is required. If you're not thinking, you could do something dumb. That's just nature's way of telling you that driving without thinking isn't good for your health.

Wiring up the Circuit
Figure 3 shows the same circuit as Figure 2 with the safety stuff added. Unlike most battery packs, this circuit gets *two* fuses, one for each battery. These should be rated at 150–200% of continuous motor current. A breaker switch or knife switch (within the driver's reach) wired in series with K2 will disconnect the motor if the contactor fails in the closed position. This is mandatory. The fuses won't normally blow in a runaway vehicle. Finally, add a key switch. Its job is to ensure that relay K1 is de-energized (independent of S1's position) when the vehicle is at rest, so that charging of both batteries will occur.

Take care to wire the relay correctly. It is *easy* to make a mistake here, so take your time and get it right! Test the completed relay's wiring with two D cells (energize the relay coil with a 12 volt battery) and some auto lamps or a voltmeter. Observe all safety rules concerning wire size, circuit ampacity, batteries, and motors. Add the battery connections *last.*

When you're finished, *enjoy* your simple controller. Smile. A vehicle equipped with an electronic controller rarely has the ability to do regenerative braking, and is less efficient than your circuit at some speeds!

Dynamic Braking
I like this barebones controller because, with just a few additional parts, it can also perform *dynamic breaking*. Dynamic braking is similar to regenerative braking. Both use the motor as a generator. However, dynamic braking slows down the vehicle by routing low-quality motor current — power at too low a voltage to charge a battery — into a resistive load. Dynamic braking is cheap and effective. It saves brakes a lot. And it is legal as one of the two "brakes" in electrathon racing!

Access
Michael Hackleman, POB 63, Ben Lomond, CA 95005

Parts Access: Relay (K1) 2PDT, P&B, 12 V coil (0.25A), 25 amp (contact) rating, 240 vac. RL8951 is $9.95 from C & H Sales, 2176 E. Colorado Blvd, Pasadena, CA 91117-9988

Relay (K2)12 V contactor is standard automotive (old-style) starter motor solenoid. Check your local auto store.

Electric Vehicle Gauges

Shari Prange

It's important to have some instrumentation in your electric car to tell you what's going on. The original speedometer and odometer will still function. But other gauges such as oil pressure or temperature are now useless, and need to be replaced with instruments to give you new information.

Although few cars have all of them, four types of gauges are appropriate in an EV: ammeter, fuel gauge, low voltage gauge, and tachometer.

Ammeters

The one you will use the most is the ammeter. This acts as an efficiency meter. It tells you how much current you are consuming at a particular moment. Once you learn how to use the information it provides, it can help you refine your driving style for maximum performance and efficiency.

Most ammeters read from 0 to 400 amps. However, in the future we will have gauges that read up to 550 amps to accommodate new higher current controllers.

Fuel Gauges

The second gauge is a fuel gauge. These come in many forms. For years, most cars simply had a voltmeter. This would typically read from 50 to 150 volts. Although it can give you precise data, it requires some mental processing to translate the voltage into fuel capacity. A fully charged lead acid battery is actually about 8.3% higher than its nominal voltage, so a full 96 Volt pack is actually at 104 Volts. A pack is depleted at 80% of its actual full voltage. For a 96 Volt pack, this is about 83 Volts.

Many people find it more convenient to use a state of charge gauge. This is calibrated to the size of the battery pack, and simply reads from full to empty, like a gas gauge. It might read in numbers from 0 to 100%, or it might be a bar scale with segments that light.

There are a couple of things to remember when reading a state of charge gauge. The first applies to numerical gauges. These are, in actuality, voltmeters. The readings will be about 10% too high when you first get into the car after it has rested. This reflects a "surface charge" on the battery pack which will quickly dissipate as soon as you start to drive.

The gauge will also fluctuate as you drive. The more you draw on the battery pack, the lower the gauge will read, even down to 0% while hill climbing. When you release the throttle, the reading will increase. The time to get a true state of charge reading is when you are completely off the throttle, either coasting or at a stop.

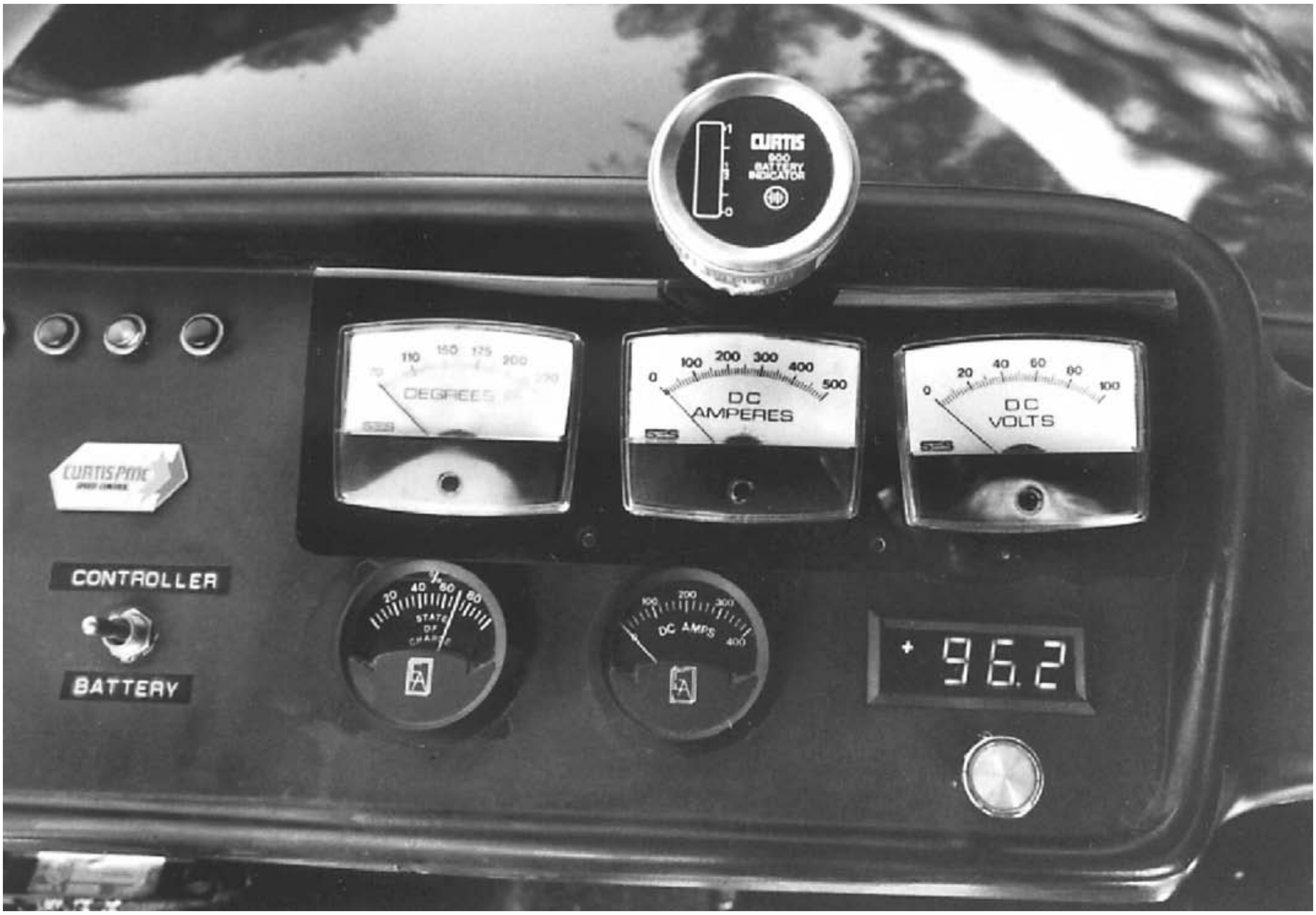
Another point to remember applies to bar gauges. These are generally sampling voltmeters. They periodically sample the battery pack voltage and reflect that data by adjusting the number of segments showing. The problem is that the gauge may do its sampling while you are drawing down the pack to accelerate or climb a hill. It will show an unrealistically low reading. Some of these gauges will not reset higher when you let off the throttle and the pack voltage comes back up. The gauge will read too low until the car is parked and fully recharged.

A different type of fuel gauge is a watt-hour meter. It measures watts going out during driving and watts going in during charging, and displays the balance. This is a useful tool for diagnostics or research, but does not suit the average person who simply wants to drive. The meter must be calibrated to the car & battery. In an electric car, "empty" does not mean "out-of-juice". It means "too low to realistically drive". This is a subjective measurement. The "full" state will vary over the life of the battery, as it breaks in performs through its prime, and starts to fade. Periodic recalibration of watt-hour meters is necessary.

Low Voltage Gauge

The third type of gauge is the low voltage meter. This measures the charge on your 12 Volt auxiliary battery which powers the lights, horn, and accessories. On the old cars with a "total loss system" this gauge was important. The 12 Volt battery was simply expected to slowly drain itself as the car was used, and then be recharged when the car was plugged in. In dark and rainy conditions, the auxiliary battery could run out before the main pack did.

In most modern conversions, there is a DC to DC converter powered by the main pack which keeps the auxiliary battery charged at all times. In this situation, the low voltage gauge isn't as important, but it's still nice if you have room for it. It will tell you if your DC to DC converter is functioning properly.



Above: Gauge Styles: LED Bar Scale (top), panel meters (center), automotive (lower left), and LED digital (lower right). Note: leftmost panel meter is sun-faded. Photo by Shari Prange

Tachometer
The fourth type of gauge is a tachometer. It's a nice gauge to have, although few conversions have one. Standard automotive tach drives will not work with an electric motor. Instead, it is necessary to use a magnetic or optical sensor to count flywheel teeth or some protrusion. The tachometer must be calibrated to match the sensor.

Panel Meters
These types of gauges also come in different styles. Early cars used panel meters that had been refaced to suit electric car data. These gauges were never designed to withstand the heat, dust, and vibrations of automotive use. The faces would fade, dry, and curl. The needles would fall off. Calibration would deteriorate. They were not backlit for night use.

Digital Instruments
At the other extreme, there is a tendency to go for digital instruments because they seem to suit the futuristic style of the electric car. However, there are drawbacks with digital gauges as well.

One drawbacks is that readings may fluctuate rapidly while driving, especially when accelerating. It is difficult to get meaningful data from a digital gauge when it is fluctuating.

A digital gauge is more difficult to process mentally. It uses a different part of the brain. The position of a needle on an analog gauge can be identified at a glance as "OK" or "Not OK". A number requires interpretation.

Automotive Gauges
Not surprisingly, the industry is moving towards round analog automotive style gauges. There are good reasons this type of gauge is standard in internal combustion cars. An electric car is still a car, and the same good reasons apply.

This type of gauge is a round analog (needle type) gauge, backlit, and built to withstand the temperatures, sunlight, humidity, dust, and vibration of life in a car dashboard. Essentially, it is designed to be an automotive gauge.

Mounting Gauges
Visibility is the crucial criterion for mounting gauges. Ideally, they would be in the dash gauge cluster, right in the driver's line of sight. However, since you still need the speedometer, there is often not enough room for other gauges. In newer cars the dash itself is a giant circuit board for the instrumentation, and trying to modify it is likely to cause you grief.

If you are using two inch round automotive gauges, there are numerous attractive mounts for these available in auto parts stores. They may mount on top of the dash or suspend just below it. Be careful! Don't mount the gauges where you will bump them with your knees.

Sometimes the dash area to the driver's right will have a blank spot that can be used. Gauges can also be mounted in a center console, although that is far from the driver's line of sight and not the best choice for visibility or safety.

Be sure that you can actually see the numbers, not just the face of the gauge in general. When a standard round gauge is mounted too low, the bezel around the top starts to obscure the numbers. To solve this problem, we have gauges that are built "upside-down". That is, the needle still swings from left to right, but it sweeps across the lower half of the gauge, and the numbers are printed accordingly.

Electric Smiles
In a short time, you will become an expert at reading electric car gauges, just as I have. They tell me when I need to shift gears, when I have a soggy tire, and whether I'm driving efficiently or not. When I have to drive a gas car, I miss my ammeter.

The only gauge they haven't figured out yet for an electric car is one to measure smiles per mile.

Access
Shari Prange, Electro Automotive, POB 1113, Felton, CA 95018 • 408-429-1989

The Window-Watcher: A Low Cost High and Low Voltage Alarm

Dan Lepinski

Once again, we found ourselves doing laundry, cleaning, and other battery-draining chores — all on the same day. What's worse, we'd grown a bit too complacent about checking battery voltage, which can cause big surprises (as we found out). The cure? Here's a simple and inexpensive circuit that can save you a lot of grief if you lean into your batteries too hard with your electric loads. Better yet, it works on either 12 or 24 volt systems without changing any components!

In the Beginning

It was a bright sunny day — the kind that makes the wash dry quickly in a light breeze. The solar panels were making gobs of electricity and we were busy putting the finishing touches on the housework. Though we were getting lots of power from the sun, we were using much more than we were producing. Drew, our 10 year old, bolted up from the basement, wide-eyed and a bit out of breath. He reported (over the noise of the vacuum cleaner) that the inverter was "making a funny noise". You see, the inverter has a built-in low voltage alarm, and it was emitting a teeth-gritting, high pitched, nails-down-the-blackboard screech. In spite of all its volume, we couldn't hear it upstairs. The inverter is tucked away next to the batteries in the basement out of our living space — and also out of earshot. The roar from the vacuum cleaner completely obliterated the sound from the alarm as the batteries died the silent death of total discharge.

It became apparent that we needed a portable low-voltage warning system that could be located anywhere in our living space where we could hear it. We wanted early notice of impending battery doom, before we turned the batteries into total mush by discharging them too deeply. Most modern inverters are equipped with circuits that will shut the inverter off if the battery voltage gets too low. It's a nice feature. Unfortunately, by the time you reach that point, the batteries are nearly dead. We wanted a low-voltage warning device that could be adjusted to our desired voltage level so we could have it alert us *before* trouble occurred.

Like many solar homes, ours is wired with both DC and ac circuits. The ac from the inverter is used for most of our day-to-day living needs. The DC is used to power radios, a telephone answering machine, and many other small devices, so we have DC outlets in almost every room. The easy access to our battery voltage was to be our salvation, and this little circuit was to be the solution.

The "Window" Alarm

Batteries don't just suddenly quit making electricity as they discharge. Like a slow moving roller coaster at the top of that first steep drop, they start down gradually as they approach total discharge. The voltage decreases, then gets faster and faster, gaining speed the longer the battery is used. The trick is to stop draining the batteries before they get to the point where they're starting down and long before they reach the bottom.

Enter the "window-watcher" alarm, or "window" alarm for short. The window alarm actually does double duty. It will warn you if the battery voltage gets too low. It will also warn you if the voltage gets too high. Two adjustments let you determine the trigger points. All that's needed to set the trigger points is a digital voltmeter. As long as your battery voltage remains between the two values you select, (hence the term voltage "window"), the alarm will remain silent.

The Basic Circuit

The heart of the window alarm is an LM339 integrated circuit (shown as "U2" in the schematic). This is a "voltage comparator" whose sole purpose in life is to turn its output on or off when the input voltage reaches a predetermined value. There are actually four independent comparator circuits built into a single IC package so it's a simple matter to use one comparator for low voltage sensing and one for over-voltage sensing. The outputs from each of the circuits are then combined to activate the alarm.

The 2.2 MΩ feedback resistors (R4 and R5) are used to create a "snap" action similar to an ON-OFF switch. Without those resistors, the circuit tends to oscillate (or "flutter") as it approaches the preset voltage limits that you will establish.

U1 is a 7805 three terminal voltage regulator. The 7805 provides a stable voltage reference to the comparator inputs while your battery voltage wanders up and down.

R14, R15, and R16 are 1 kΩ resistors. They will prevent any damage from occurring to the alarm if you inadvertently short circuit any of the test points while making adjustments.

Diode D6 is present just in case you accidentally reverse the power leads to the alarm. Instead of destroying all your components, D6 will act as a short circuit to the power and the fuse will blow.

If you don't have access to a digital voltmeter, alternate circuits are shown which will permit you to construct the alarm with fixed voltage sensing points, eliminating the need for any adjustments. If you assemble the non-adjustable version, you will need to determine in advance whether you wish to use the 12 or 24 Volt version, as the range will be fixed by the components. The fixed low/high voltage trigger points for the non-adjustable circuits have been set at 12 and 15.6 Volts, or 23.4 and 31.2 Volts for the 12 and 24 Volt versions respectively. Also note that the fixed version sometimes uses three or four resistors in combination to attain the desired reference voltage. While these fixed "equivalents" could have been constructed with two resistors, the values chosen reflect those listed in the current 1993 Radio Shack catalog. The goal was to make the parts as easy to find as possible and still provide reasonable voltage limits. To construct the alternate input circuits, omit variable resistors R1, R2, and R3 and replace them with the equivalent fixed circuits shown in the schematic.

R1A is a standard value for either 12 or 24 Volt operation and is a single resistor in both cases.

R1B is actually a combination of two resistors. For 12 Volt operation, a 10 kΩ resistor and a 470 Ω resistor are connected in series (end to end) to achieve the desired resistance. For 24 Volt use, R1B is a series combination of a 10 kΩ resistor and a 3.3 kΩ resistor.

R2A is a standard value for 12 Volt use and is a single resistor in that application. For a 24 Volt environment, R2A is a 22 kΩ resistor in series with a 1 kΩ resistor.

R3A, R3B, R3C, and R3D are all standard resistor values.

All components are readily available from Radio Shack or almost any of the many mail order firms which sell electronic parts. There are no critical or precision components used. Cost for the components, including a small plastic box and a circuit board, will be about $25 if purchased from Radio Shack. Mail order houses may charge less, but often have minimum purchase quantities. If you already have some of the parts, or you are good at scrounging, you should be able to cut the cost in half. Either way, this is cheap insurance for your batteries.

Adjusting the Alarm

If you have assembled the alarm using the fixed resistor equivalents, you have no adjustments to make, and you may skip this section. Otherwise, adjusting the alarm is a very easy process. After assembling the alarm and checking your wiring, connect the voltmeter negative test lead (usually the black lead) to the point shown as "TP5" ("TP" is electronics lingo for "Test Point"). The negative lead will be connected to this point for the remainder of the tests.

Next, connect the alarm to a source of DC. This could be a 9 Volt transistor radio battery, a small 12 Volt battery, or your home battery system, whichever is most convenient. If you do use a 9 Volt battery, don't leave it connected for more than a few minutes at a time. The current used by the alarm, though small, is still more than most 9 Volt batteries are designed to supply for any extended period.

Attach the positive lead of the voltmeter to the point marked TP1 (low voltage alarm point) and adjust R1 for a reading that is exactly one tenth of your desired minimum alarm voltage point. For example, if you will be connecting to a 12 Volt battery and you wish the alarm to trigger at a low voltage of 12.1 Volts, adjust R1 for 1.21 Volts measured at TP1. (If you'll be connecting to a 24 Volt system, you'll need to double all the voltage values mentioned. Thus, for the low voltage point, instead of 1.21 Volts, you'd adjust R1 for 2.42 Volts, etc.) I like to use 12.1 Volts as the low voltage alarm point as it represents a 50% discharged point for our heaviest loads. You may need to set your alarm trigger voltages differently depending on your system size and how you use it. (See *HP*#36 pp. 67–68 for graphs of battery voltage versus state of charge for various load conditions.)

For the next adjustment, move the positive lead to TP2 (the over-voltage alarm voltage point) and adjust R2 for one tenth of your desired maximum voltage. In our system, we wanted the alarm to trigger if the battery voltage exceeded 15.7 Volts, so the value at this point was set for 1.57 Volts. This allows us to attain an equalizing voltage of 15.5 Volts without triggering the alarm.

Finally, attach the voltmeter positive lead to TP4 (the battery positive input) and note the battery voltage applied to the alarm. Then move the voltmeter positive lead to TP3 and adjust R3 for exactly one tenth of the battery voltage just measured. That's it! Your alarm is ready to use.

Using the Alarm

Most of the time, we leave the alarm plugged into a DC circuit where it can easily be heard throughout the house. When we're using a noisy appliance that might prevent us from hearing the alarm in its usual location, we move it to the room where we're working, or as near as we can get it. This gives us a simple means of monitoring the charge level of our batteries during periods of heavy use — without the hassles of running to the basement.

You can leave this alarm connected full time as the current draw is only about 15 milliAmps (4.5 Watt-hours a day) for a 12 Volt system, or about 18 milliAmps (10 Watt-hours a day) for a 24 Volt system. Even when triggered, the current required is still a miserly 35 to 40 milliAmps. If you'll be installing wires specifically for the alarm, in addition to the internal fuse, you should also install a 1/4 Amp fuse in the positive lead and as close to the batteries as possible. Wire size for powering the unit isn't critical since the current used is quite low.

Should the alarm sound, the LED indicators provide a visual indication of what's wrong. The red LED will be lit if the voltage is too high; the yellow if it's too low. An optional "on" indicator LED is shown which adds little to the current drain (about 5 milliAmps). It may be omitted for a slight savings in both component cost and power drain. I like it because it's a visible indication that the alarm is "ON".

The "test" button (PB1) is also optional but it gives you a means of checking the unit for proper operation. I'd recommend including it in your circuit. It activates the alarm in the "under-voltage" mode.

We built our alarm into a small mini-box from Radio Shack and attached a cord with a connector to fit our DC outlets. This way it can be left in one location or moved from room to room as needed.

As presently configured, the alarm will sound continuously as long as a fault condition exists (battery voltage too high or too low). It will automatically turn off when the battery voltage returns to a range that is inside the voltage "window" you've determined with R1 and R2. If you are equalizing your batteries, or some other situation exists to cause

Parts List for the Window-Watcher Alarm

Qty Rqd	*Schematic Reference*	*Part Description*	*RS P/N*	*#/Pkg*	*RS $*	*Total*
2	C1, C3	2.2 uF 35 V Tant	272-1435	1	$0.69	$1.38
2	C2, C4	.01 uF disc	272-131	2	$0.49	$0.49
3	D1, D2, D6	1N4001 diode	276-1101	2	$0.49	$0.98
1	D3	Green LED	276-022	2	$0.79	$0.79
1	D4	Red LED	276-041	2	$0.69	$0.69
1	D5	Yellow LED	276-021	2	$0.79	$0.79
1	F1	1/4 Amp	270-1270	3	$0.99	$0.99
1	PB1	N.O. Pushbutton	275-1566	1	$1.89	$1.89
1	Q1	2N2222 or similar	276-2009	1	$0.59	$0.59
3	R1, R2, R3	10 KΩ pot.	271-282	1	$0.49	$1.47
2	R4, R5	2.2 M	271-061	2	$0.29	$0.29
4	R6, R7, R9, R12	4.7 K	271-1330	5	$0.39	$0.39
4	R8, R10, R11, R13	470 ohms	271-1317	5	$0.39	$0.39
2	R14, R15	1 K	271-1321	5	$0.39	$0.39
1	SA1	Sonalert	273-060	1	$3.29	$3.29
1	SW1	SPST	275-645	1	$1.99	$1.99
1	U1	LM 7805	276-1770	1	$1.19	$1.19
1	U2	LM 339	276-1712	1	$0.99	$0.99

Miscellaneous Items Required:

Qty	*Description*	*RS P/N*	*#/Pkg*	*RS $*	*Total*
4	Snap-in holders for LEDs	276-079	5	$0.59	$0.59
1	Project box w/PC board	270-283	1	$3.99	$3.99
1	In-line fuse holder	270-1281	1	$1.19	$1.19
1	14 pin IC socket	276-1999	2	$0.89	$0.89

Optional fixed resistor equivalents used if you don't have access to a digital voltmeter. Omit R1, R2, and R3 and install the appropriate selection of resistors in their place:

For a 12 Volt version of the Window-Watcher:

Qty Rqd	*Schematic Reference*	*Part Description*	*RS P/N*	*#/Pkg*	*RS $*	*Total*
2	R1A,R2A	33K	271-1341	5	$0.39	$0.39
1	* R1B-1	10K	271-1335	2	$0.39	$0.39
1	* R1B-2	470Ω	271-1317	5	$0.39	$0.00
1	R2B	15K	271-1337	5	$0.39	$0.39

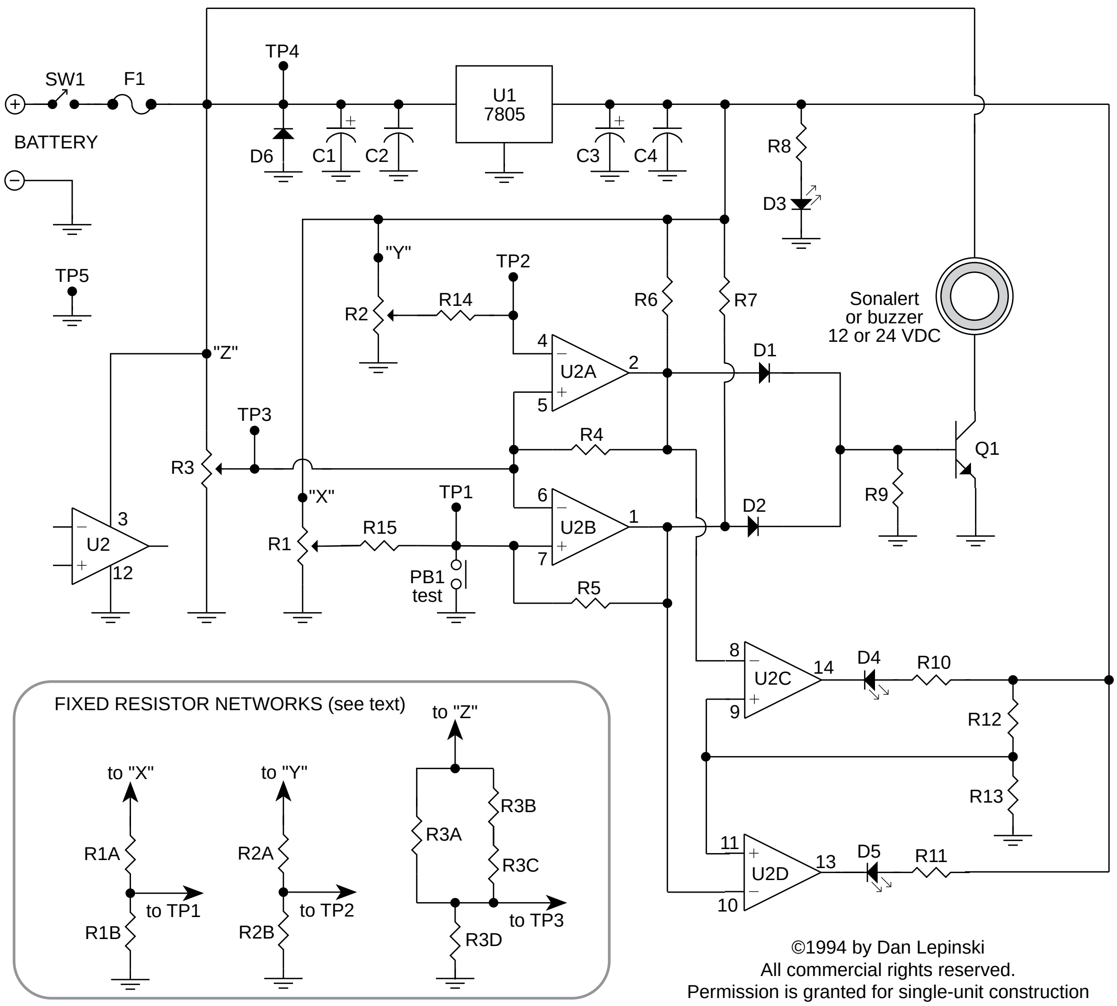
* NOTE: R1B is actually a combination of two resistors; a 10K and a 470 ohm resistor in series. A spare 470 ohm resistor is available from the regular components purchased for the Window-Watcher and need not be purchased separately if this optional input circuit is used.

For a 24 Volt version of the Window-Watcher:

Qty Rqd	*Schematic Reference*	*Part Description*	*RS P/N*	*#/Pkg*	*RS $*	*Total*
1	R1A	15K	271-1337	5	$0.39	$0.39
1	* R1B-1	10K	271-1335	2	$0.39	$0.39
1	* R1B-2	3.3K	271-1328	5	$0.39	$0.39
1	* R2B-1	22K	271-1339	5	$0.39	$0.39
1	* R2B-2	1K	271-1321	5	$0.39	$0.00

* NOTE: R1B and R2B are actually combinations of two resistors in series; for R1B, a 10K and 3.3K resistor are used. For R2B, a 22K and 1 K resistor are used. A spare 1K resistor is available for R2B from the regular components purchased for the Window-Watcher and need not be purchased separately if this optional input circuit is used.

The Voltage Window Watcher Alarm



For either the 12 or 24 volt version of the Window-Watcher:

Qty Rqd	*Schematic Reference*	*Part Description*	*RS P/N*	*#/Pkg*	*RS $*	*Total*
1	R1A	15K	271-1337	5	$0.39	$0.39
1	R3A	10K	271-1335	5	$0.39	$0.39
2	R3B, R3C	47K	271-1342	5	$0.39	$0.39
1	* R3D	1K	271-1321	5	$0.39	$0.00

* NOTE: A spare 1K resistor is available for R3D from the regular components purchased for the Window-Watcher and need not be purchased separately if this optional input circuit is used.

All references to external components are from Radio Shack.
If you are dealing with a mail order firm or other source of parts, you will need to purchase the additional components as shown.

Part numbers and prices were taken from the 1993 Radio Shack catalog.
Qty Rqd is the total quantity of that component used in the Window-Watcher.
#/Pkg is the quantity of the component sold per package at Radio Shack.

the alarm to sound continuously, simply turn it off or unplug it — but don't forget to turn it back on after the condition that caused the alarm to trigger has been corrected.

Some suggestions…

If you're using an inverter that has its own low voltage alarm, set the window alarm low voltage trigger point to a value that's higher than the value used by the inverter alarm. That way, you'll be able to head off trouble before it occurs. I like a voltage that represents about a 50% discharge level on our batteries.

If the alarm sounds, look for the cause. If your battery voltage is low, reduce your electric loads or turn them off completely. If it's too high, try to discover why. Running your batteries at a low voltage will seriously shorten their useful life. Running them at too high a voltage can damage your batteries or other components in your power system. The window-watcher alarm is cheap insurance against both.

Coming up... Enhancements!
The window-watcher is a very versatile little circuit. It represents a building-block to other applications. As such, it's not limited just to the alarm action shown here. There are more ideas to follow. Here's a sample:

1) A user programmable alarm option for the window watcher. (The present version resets itself.) If the fault that originally triggered the alarm goes away, the alarm will continue to sound until you reset it. The alarm is nice as long as you are home to hear it. But what happens if something goes wrong while you're gone? This option will continue to sound an alarm until *you* reset it.

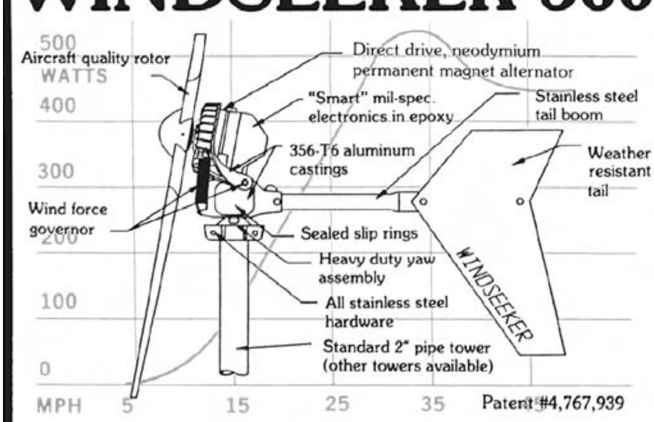
2) A hi-low tone alarm circuit to match the respective voltage warning condition — high pitch for high voltage, lower pitch for low voltage. You'll never have to look at the alarm again. The difference in pitch will tell you immediately what triggered the alarm.

3) Using the window watcher alarm as a simple charge regulator. No threat to the big boys, but a pleasant and simple introduction to battery charging.

4) A load diverting accessory. Batteries fully charged? Still making electricity with your solar panels, wind generator, or other device? How about putting that excess power to work in other areas!

Stay tuned!

Access
Author: Dan Lepinski, Rt 1, Box 268A, Exeland, WI 54835 • 715-943-2525



Charge Shuffler

Chris Greacen

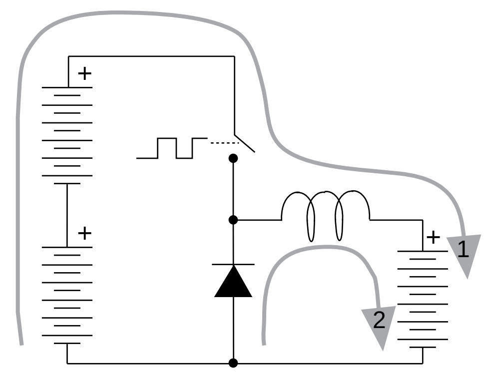
Do you want to run 12 Volt appliances off a 24 Volt battery pack? You've got several options. The easiest but least elegant solution to the problem is to tap your battery pack in the "middle". The problem with this is it eventually leads to battery imbalance; the cells powering the appliance end up with lower voltages than their neighbors. For small appliances, you can use a linear regulator like the LM 317, or LM 7812 to "burn off" the excess voltage as heat. Functional but inefficient. Or you could use the more efficient buck regulator Homebrew circuit in *HP*#37, but still you're limited to about three Amperes. The elegant solution is to tap your battery in the middle, but use a circuit that shuffles the charge from the high pack to the low pack as necessary to keep them at equal voltages.

That's what this circuit does — and it will deliver up to three amperes to the lower 12 Volt battery. This means you can power appliances continuously which draw up to six amperes. And you can use 12 Volt appliances which draw even more than this, provided the appliance is turned off enough each day for the charge shuffler to "catch up".

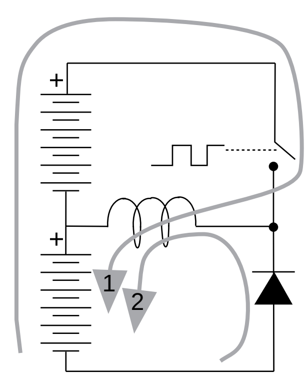
The Vanner Voltmaster™ is a commercial circuit which does this same job, but shuffles more current (5, 10 or 25 Amperes). See Things that Work! *HP*#33, p 84. The Voltmaster also shuffles current both ways, whereas this circuit requires you to put the load on the 0–12 Volt pack. But this circuit does have a lower idle current — 1 mA compared with 17 mA or so for the Vanner 60–50A.

How it works

How does the circuit shuffle charge from the top pack to the lower one? It's easiest to think first of a buck regulator charging a 12 Volt battery from a separate 24 Volt battery. (for the basics of buck regulators see HP #37, page 40). Pulses of current from the 24 Volt battery flow through the inductor and into the 12 Volt battery. As each pulse dies, the inductor's decaying magnetic field draws yet more current up from ground through the diode. If the buck regulator and batteries were 100% efficient, the 12 Volt pack would get twice the current drawn from the 24 Volt pack.



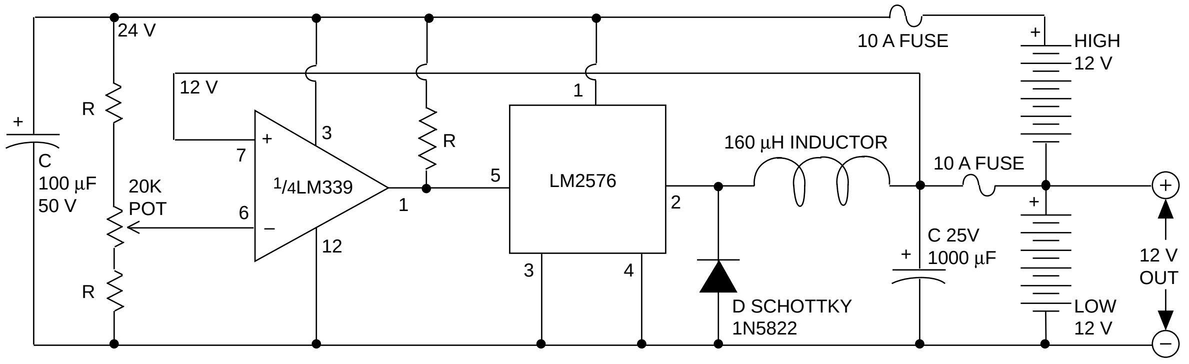
Now imagine using the 24 Volts to charge the lower half of itself! The current flows in the somewhat bizarre path shown below.



Meet the Parts

The heart of the circuit is the LM2576 buck regulator chip. This, in combination with the inductor, diode and filter capacitors, changes higher DC voltage, low current into lower DC voltage, higher current. See homebrews in either of the last two issues for more on how this DC to DC converter works.

The two resistors R (use identical resistors, the value can be anywhere between 100 kΩ and 250 kΩ) and the 20 kΩ potentiometer form a voltage divider, splitting the 24 Volts in half. This voltage is compared with the voltage of the lower 12 Volt pack in the LM339 quad



comparator. When the voltage of the "lower 12" (pin 7) is lower than half voltage of the 24 Volt battery (pin 6), then pin 1 of the LM339 goes low, turning on the LM2576. Otherwise, the pull-up resistor (R can also be 100 kΩ to 250 kΩ) from pin 5 of the LM2576 to 24 Volt keeps the LM2576 turned off.

Efficiency and Quiescent Draw

When the 24 Volt pack was giving 150 mA to the buck regulator, the regulator was delivering 250 mA to the lower 12 Volts of the pack. This works out to 83% efficiency (250 mA/(2 x 150 mA)). Expect this to lower to around 75% at maximum load.

When it's not shuffling current the circuit uses very little power. I measured 1010 µA, or 1.01 mA. This low standby power criterion is why the circuit was built with the LM339 chip. Using the common LM331 comparator, or the LM723, would have cost more than five times as much quiescent power. The low power LP331 or LP339 could have been used, but it is less readily available than the LM339.

Building and Adjusting the Circuit

Even through the circuit switches power at radio frequencies, it works fine on a prototyping breadboard, using alligator clips to the batteries. Try to keep wire leads short. For a more permanent construction, I used the ugly but cheap ham radio "bug" technique: use a piece of unetched PC board and solder all grounded pins of the chips directly to it. Bend up the other pins and solder the connecting components. The low parts count of this circuit makes this less messy than you might imagine. The technique provides a great ground plane, and it's cheap and quick.

Connect the ground wire to the battery first, then the 24 Volt wire, and finally the 12 Volt wire. To disconnect, pull the 12 Volt wire first. You'll probably need to adjust the potentiometer to get the battery voltages equal. This is easiest with two voltmeters, one across each of the 12 Volts. But it's possible to use one: attach one lead of the voltmeter to the +12 Volt, and the other alternately to 24 Volt or 0 Volt.

Radio Frequency Interference

Since the switcher operates at 52 kHz, I wouldn't recommend using it to power radio equipment which operates near this band. But I noticed little interference on an FM (~100 MHz) radio. If you notice interference, there's always the option of temporarily disconnecting the charge shuffler when you want to use the power from the lower 12 Volts. Use a switch on the wire to the +12 Volt to do this. When you reconnect, the charge shuffler will work to bring the voltages back to equal.

Access

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Parts: DigiKey now sells the LM2576T-ADJ — for $14.16. But they don't have any in stock and they don't know when they will have them. Call 1-800-DIGIKEY. I'll order a bunch of these and sell them to you for $15 each — but I warn you, depending on how many folks are interested, these too may be on back order. Schottky diodes (1N5822 3 Amps, 40 PIV) are available from All Electronics • 800-826-5432. Hosfelt Electronics, 2700 Sunset Boulevard, Steubenville, OH 43952 • 614-264-6464 has a 160 µH inductor for a buck, part number 18-123. All the other parts are widely available. I'll send you all the other parts (not including the LM2576), but including a piece of unetched circuit board, fuses and holders, instructions, and a box for $20. Allow six weeks for delivery.

Carrizo Copper QuadLams

Things that Work!
tested by *Home Power*

tested by Sam Coleman

A while ago my friends at Home Power asked if I would like to put up a set of Carrizo Copper QuadLams for testing. I agreed to test these PV modules and here are the results.

My System

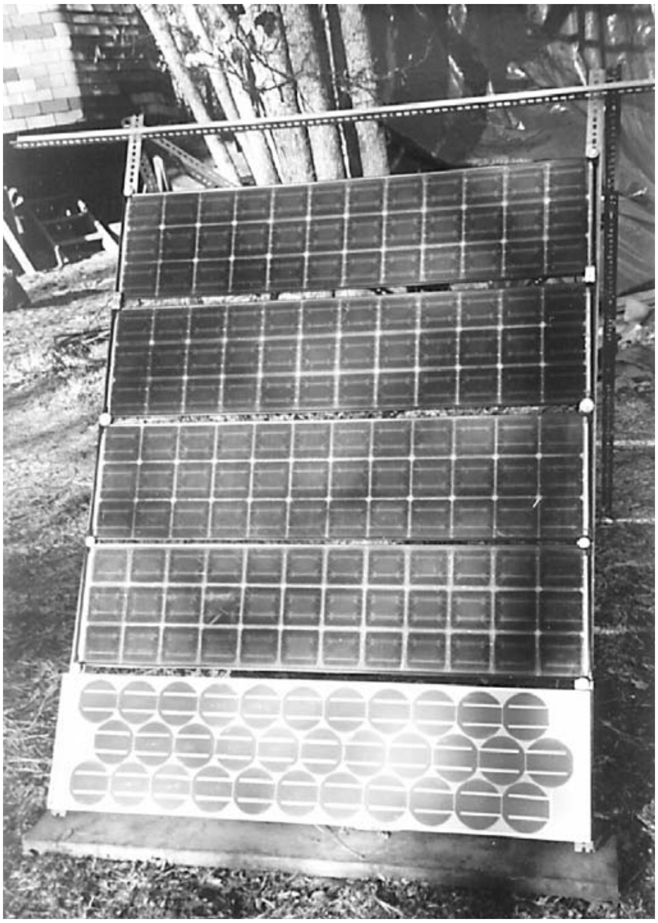
I had just recently upgraded my 12 Volt battery pack with 200 Ampere-hours of used nickel-cadmium batteries. For solar input, I have a 48 Watt Kyocera panel and a used 16-2000 Arco panel. There is a Heliotrope CC-20 charge controller, a Power Meter 15 battery system monitor, a 200 watt PowerStar inverter, and a 450 watt Honda generator. I use between 10 and 30 Ampere-hours of capacity daily.

Unpacking The Quadlams

The set of Carrizo Copper QuadLams came packaged in a sturdy box with many staples. The box was well-filled with packaging material to keep the panels apart and to prevent their moving around. It was still rather easy to unpack and remove the individual panels.

Installation

Upon examining the panels I discovered that they were very lightly framed with hard plastic. There were no holes in the framing for mounting and no place to drill any holes. This problem was overcome using a combination of nuts, bolts, and washers. A large washer was placed on a bolt, followed in some places by small washers and nuts as spacers. In some cases it was necessary to put a small washer on before the large one. The entire assembly was bolted to a rack of slotted steel angle. The panels were arranged so that the large washers fit over the edge of the panel framing. When this assembly was tightened down, the large washers formed a pressure fit that held the panels firmly in place. In two places I didn't have large enough washers so I used pieces of aluminum with holes already drilled in them. These worked fine. I then wired the set of QuadLams in series using the installed J-boxes and paralleled the series configuration into my system. For this I used #10 stranded wire.



Above: The QuadLams on the rack with an old ARCO 16-2000 PV module. Unfortunately there is a tree that shades the rack, but only in the dead of winter.
Photo by Sam Coleman

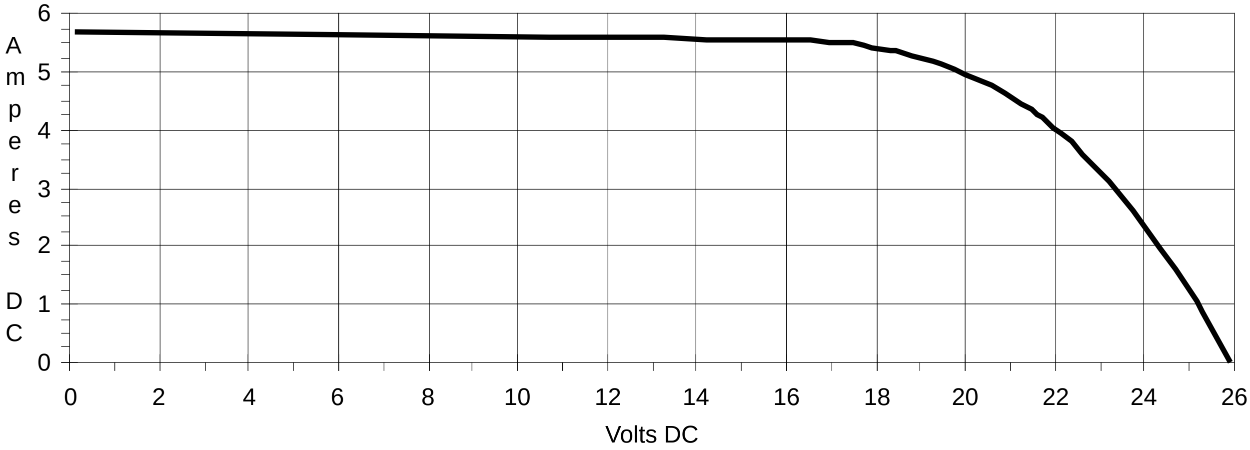
Testing and Results

I immediately noticed an increase of around 5 Amperes in the maximum amperage that was being delivered by my solar array. After a few days I also noticed that my daily solar input had at least doubled. The QuadLams have performed very well for a couple of months now. I didn't even need my generator.

On December 20, 1993 I measured the current versus voltage characteristics of the QuadLams. The results are summarized in the accompanying table and graph.

The Carrizo Copper QuadLams exceeded their specified values in all cases except for the short circuit current (I_{sc}). The high value of the peak power voltage (V_{pmax}) ensures that the panels will equal or exceed their rated wattage even at high panel temperatures. The rated wattage at 50°C is 72 Watts, while at 75°C it is 60 Watts.

Carrizo Copper Quadlams I-V Curve



Conclusions

The Carrizo Copper QuadLams are a very good deal. While the Carrizo Solar Corporation no longer sells these panels with framing and J-boxes, your local dealer may have them. The unframed panels, without J-boxes, are priced by Carrizo at $210 per set of QuadLams. This is $2.12 per measured watt and $2.42 per rated watt. Framing and J-boxes would seem to add about $70 to $100 to the price. This would bring the price to around $3.00 per measured watt and about $3.40 per rated watt. The QuadLams are warranted by Carrizo Solar to produce at least 90% of their rated value at 50°C for one year. Failure from inadequate sealing is not covered. If you can obtain these Copper QuadLams with framing and J-boxes for less than $280 you will be getting a very good deal. Even at $300 the price seems right.

Carrizo Copper Quadlams Performance Table

	Rated Value	*Measured Value*	*Percent of Rated*	
Isc	6.00	5.63	93.8%	Amperes
Voc	25.00	25.96	103.8%	Volts
Pmax	87.50	99.27	113.5%	Watts
Vpmax	17.50	19.09	109.1%	Volts
Ipmax	5.00	5.20	104.0%	Amperes
PV Temp	25.0	27.5	110.0%	°C
Insolation	100	102	102.0%	mW/sq. cm.

Access

Author: Sam Coleman, c/o Home Power Magazine, POB 520, Ashland, OR 97520

Carrizo Solar Corporation, 800-776-6718, or contact your local dealer.

Exeltech's 1000 Watt Sine Wave Inverter


Things that Work!
tested by *Home Power*

Tested by Richard Perez, Bob-O Schultze, and Sam Coleman

We have been running all of *Home Power*'s computer equipment on this Exeltech true sine wave inverter for the last seven months. This inverter produces the purest sine wave power that we have ever measured in any inverter. This inverter delivers sine wave electricity that is cleaner and more reliable than any utility can provide!

The Exeltech SI 1000 Inverter
This inverter takes 12 Volt DC power and converts it into 120 vac, 60 Hz, true sine wave electric power just like the power company rents out downtown, only cleaner. Physically the inverter is tiny in relation to its output power. The SI 1000 measures 8.75 inches wide by 7.75 inches deep by 6.5 inches tall. It weighs a scant ten pounds.

This particular model accepts 12 VDC as input power. Maximum operating voltage is 17.5 VDC and minimum is 10.2 VDC — the widest operating window of any 12 VDC inverter I know. This wide window makes Exeltechs compatible with alkaline battery technologies like nickel-cadmium and nickel-iron. Exeltech also makes inverters which accept 24, 33, 36, 48 or 120 VDC as input power.

Output power of the SI 1000 is rated at 1,000 watts continuous and surge wattage is rated at 2,360 watts. Exeltech makes sine wave inverters from 250 watts to 5000 watts output in all the input voltages listed above.

The inverter is internally protected against overvoltage, undervoltage, overtemperature, and output short circuit. The inverter's input is internally fused which also protects it against reverse input polarity.

Installation
I installed the SI 1000 in Home Power's main system in June 1993. Here it feeds from our main battery of 150 NIFE HIP-10 nickel-cadmium cells (1,500 Ampere-hours at 12 VDC). The SI 1000 is connected to the Ananda Power Center with two 0 gauge copper cables with a combined length of five feet. The input lugs on the larger (1000 watts and greater) inverters will accept 0 to 4/0 gauge cable. The Ananda is equipped with a Deltech 500 Ampere, 50 milliVolt shunt for measuring the inverter's input current. The inverter is protected by a 400 Ampere fused disconnect built into the Ananda Power Center. Installation was simple. The SI 1000 is small enough for wall mounting, so I attached it to the power room wall next to the Ananda.

This Exeltech 1000 watt inverter has been powering our office and home for seven months. The only loads not operated on the SI 1000 are the laser printer, which with all the computers also running is too large for the SI 1000, and Therese's 1500 watt toaster oven. We have been leaving this inverter up all night, running a variety of electronics that demand 24 hour-a-day power (i.e., VISA/MC machine, cordless phone, and FAX).

Inverter Performance
We have been publishing *Home Power Magazine* for the last six years. During this time all of our computer equipment has been powered by solar energy via an inverter. We have operated eight different computers and a fleet of peripherals — everything from laser printers to 35 mm color slide scanners to 1.2 gigabyte hard drives. We have used seven different inverters over the years to power not only our office, but our home. Of all these inverters, this Exeltech SI 1000 has produced the cleanest and most stable power.

Since we have been powering our computer equipment with sine wave power, we have had much more reliable operation. Gone are system crashes, weird printouts, and dancing glitches on the monitors. Gone is the buzz on the TV, stereo, radiotelephone, FAX, and answering machine. All of our inductive loads, like the microwave and all motors, run quieter, faster, and cooler.

After seven months of 24 hour-a-day sterling performance, I decided it was time to break out the instruments and do some serious testing on the SI 1000. I called on Bob-O Schultze and Sam Coleman to lend a hand.

Testing Exeltech's SI 1000 inverter
Bob-O brought his monster mogul base lamp bar up to our system on Agate Flat. This lightbar has switched outlets for five incandescent lamps (25 watts to 1250 watts). All measurements were made with the inverter powering these resistive loads. We used a Beckman

2020 and four Fluke 87 digital multimeters to make the measurements. On the inverter's input side, we used the Beckman 2020 to measure input voltage and a Fluke 87 (in 4 digit mode) to measure current via a 500 Ampere, 50 milliVolt. Deltech shunt. The inverter's 120 vac output voltage was measured in rms and peak modes by two Fluke 87s. The inverter's output current was run through a Fluke 87 for measurement.

The Test Data

This is the data just as we took it. Over the last seven months I had come to suspect that the Exeltech was very stable because it never even hiccuped. The data we took was astounding!

The rms and peak voltages of this inverter are rock solid. By definition, 60 Hz sine wave power should have an rms voltage of 117 vac. The peak of this sine wave has a voltage of 164 volts peak. From no load to 1200 watts, the inverters output voltage changed by only 0.8 volts rms. The peak output voltage varied only 1.2 volts from no load to 1200 watts output. This is the most stable performance we have ever seen from any inverter.

After making the test measurements, we put a Hewlett-Packard AN/USM-339 oscilloscope on the inverter's output. Sam, Bob-O, and I ran around the house turning on and off the nastiest loads — like the 800 watt microwave oven, and the 600 watt swamp cooler blower. The trace on the oscilloscope remained a pure, smooth sine wave regardless of the load. We used the oscilloscope to zoom in on a portion of the waveform. We were looking for glitches, overshoot, undershoot, and general noise. We couldn't find any. According to Exeltech, the output sine wave is synthesized at 25 kHz. This means that each sine wave is broken down into about 416 pieces. Whatever the folks at Exeltech are doing is definitely working — this inverter's waveform is as smooth as a baby's butt.

Exeltech SI1000 Inverter Date: 29 December 1993
Serial #: 100055

INPUT DATA ON THE 12 VDC SIDE			OUTPUT DATA ON THE 120 VAC SIDE				
Battery Volts	*Amps IN*	*Watts IN*	*Vpp OUT*	*Vrms OUT*	*amps OUT*	*watts OUT*	*Eff %*
15.18	0.8	12.1	166.4	118.4	0.00	0.0	
15.09	2.5	37.7	166.4	118.4	0.20	23.4	62.1%
15.06	3.8	57.2	166.4	118.4	0.34	39.8	69.5%
15.05	5.1	76.8	166.4	118.4	0.51	59.8	77.9%
15.07	6.8	102.5	166.4	118.3	0.70	83.0	81.0%
15.08	8.0	120.6	166.4	118.3	0.84	99.1	82.2%
14.98	9.8	146.8	166.0	118.3	1.03	122.3	83.3%
14.84	12.2	181.0	166.0	118.3	1.28	151.8	83.8%
14.99	13.9	208.4	165.4	118.3	1.48	174.8	83.9%
15.03	22.9	344.2	166.0	118.2	2.45	289.7	84.2%
14.97	30.7	459.6	166.0	118.1	3.28	386.8	84.2%
14.90	36.8	548.3	166.0	118.1	3.91	461.3	84.1%
14.85	47.2	700.9	165.2	118.0	4.99	588.8	84.0%
14.73	60.4	889.7	166.0	117.9	6.27	739.2	83.1%
14.62	72.7	1062.9	165.2	117.9	7.41	873.6	82.2%
14.54	81.7	1187.9	165.2	117.8	8.22	968.3	81.5%
14.36	89.6	1286.7	165.6	117.7	8.87	1044.0	81.1%
14.42	100.3	1446.3	164.8	117.6	9.84	1157.2	80.0%
14.11	111.6	1574.7	165.2	117.6	10.59	1245.4	79.1%
Averages to 1000 Watts			165.9	118.2			

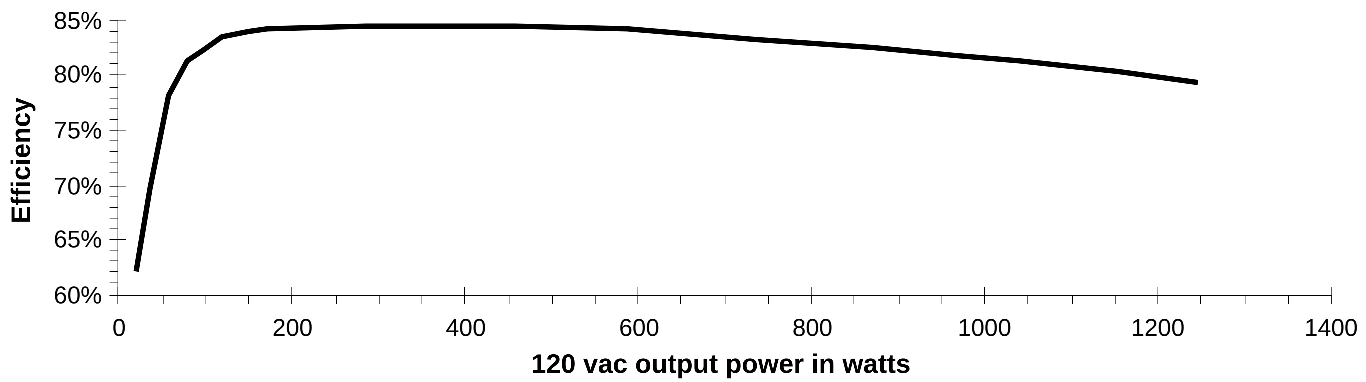
During the last seven months we have inadvertently overloaded the SI 1000 at least six times. It protected itself and shut off. During this round of testing we operated 1250 watts of lights on the SI 1000 for ten minutes. In my estimate, this inverter is very conservatively rated. The SI 1000 is a very quiet inverter, both to the ear and to radios. The only audio noise is the operation of the SI 1000's thermally activated cooling fan. We measured the inverter's no load power consumption at 12.1 watts which is very low for a sine wave inverter.

I was going to do graphs of the inverter's output rms and peak voltages verses its power output, but the graphs were boring straight lines — the rms and peak voltages don't vary. Instead I'll graph this inverter's least attractive feature, its efficiency.

Efficiency

While sine wave inverters produce cleaner power, they do so at a price — efficiency. The SI 1000 showed efficiency over 81% from 75 to 1000 watts output. This is about ten percent less efficient than a typical modified sine wave inverter of the same output power. In our case, the added inefficiency is more than balanced by the cleaner power. I figure that in our system it costs us the energy produced by two PV modules to support this additional ten percent inefficiency.

Exeltech 1000 Sine Wave Inverter — Efficiency vs. Output Power



Where to use the Exeltechs

Anywhere that a modified sine wave inverter is too noisy or its power is too dirty. Some devices, like laser printers and magneto optical hard drives require sine wave power. Almost every appliance will run quieter and in most cases cooler on sine wave power — it's what they're built to digest. Many home-powered, home businesses use computers. We know inverters are powering publishing companies, video editing suites, and recording studios. Just about everyone has video and audio equipment. Inverter-produced noise, both audible noise and distortion on the inverter's power output, can be a very real problem. In the case of *Home Power*'s system, we are overjoyed not to hear the inverter on our radiotelephone system. Changing over to sine wave power has increased the modem's speed from 1200 baud to 4800 baud over our radiotelephone. We have become accustomed to a clean picture on the TV. It's easy to get spoiled.

Conclusion

At a price of $1,190, Exeltech's SI 1000 is an outstanding value. Many systems will continue to operate modified sine wave inverters successfully. Sine wave models are more expensive to buy and operate than modified sine wave inverters. But if the cleaner, more stable power is worth the extra expense, then this is the inverter to use.

Access

Author: Richard Perez, c/o Home Power, POB 520, Ashland, OR 97520 • voice and FAX 916-475-3179 • E-mail via the Home Power BBS 707-822-8640.

Inverter's Maker: Exeltech, 2225 East Loop 820 North, Fort Worth, TX 76118 • 800-886-4683 • 817-595-4969 • FAX 817-595-1290

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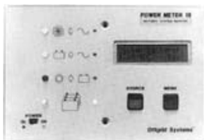

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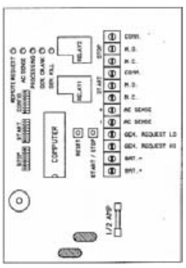

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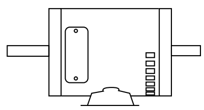

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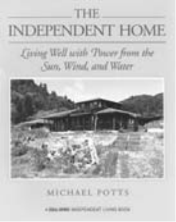

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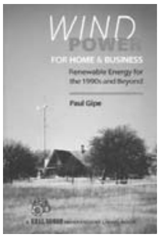

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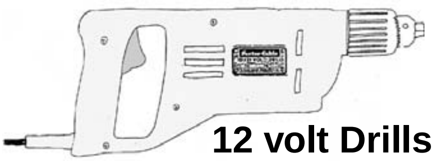

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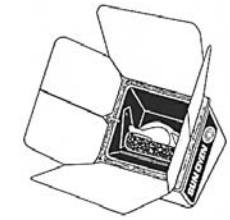

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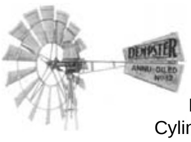

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Solar Cooking Basics

C. Alan Nichols

The concept of solar cooking began over 220 years ago and was used by the French Foreign Legion starting in the 1870s. All solar cookers work on the principle of concentrating the direct solar rays to raise food or water to cooking temperatures. Cooking begins at about 150°F although temperatures of 250 to 400°F cook food faster.

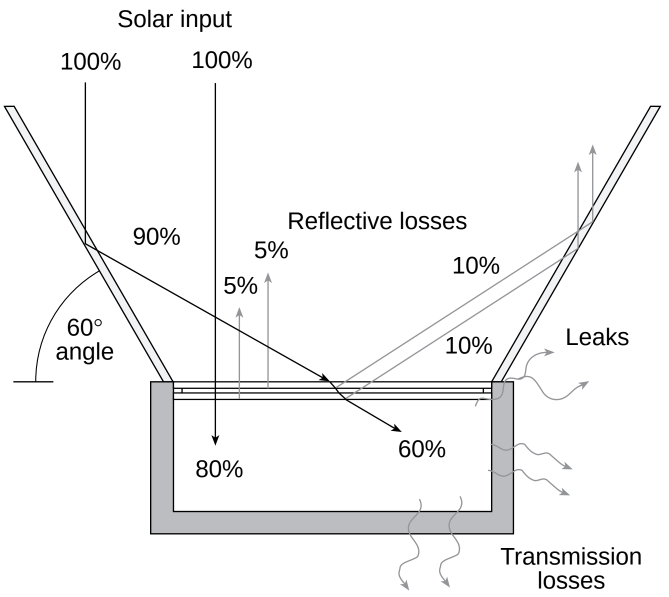
Open reflector type solar cookers focus the sun's rays on open cooking pots or pans. Solar *ovens* trap the sun's heat inside insulated boxes with transparent lids. Most solar ovens are variations of the bread box type developed by two Arizona women, Barbara Kerr and Sherry Cole.

These simple box cookers created in the 1970s are now being used world wide to overcome fuel and food shortages in developing countries. In places like Eastern Africa, native women travel 20 to 30 miles to gather a two day supply of cooking fuel. In other parts of the world increasingly high rates of malnutrition are caused by a lack of fuel. Basic grain foods cannot be cooked without cooking fuel, and water infected with chronic bacteria must be heated before drinking. Continued gathering of wood cooking fuel by chopping down trees has resulted in eroded hillsides with loss of precious topsoil thus reducing their ability to grow food.

Solar Cooking Saves

In America we concern ourselves with such things as operating costs, air pollution, acid rain, and the greenhouse effect. Let's say it takes one hour to cook a pot of beans on an electric stove using one kiloWatt. The coal fired power plant that supplied the electricity consumed one pound of coal and released 17.5 cubic feet or two pounds of CO_2. The power plant also consumes 0.7 gallons of ground water and released traces of SO_2 as acid.

Heat losses



Suppose you are cooking outside. Five pounds of steaks cooked on a grill will use a ten pound bag of charcoal and five ounces of lighter fluid. This fire will produce approximately 160 cubic feet or fifteen pounds of CO_2 and untold air pollution. Wood fires are even worse.

Cooking in the home averages over 100 hours a year consuming approximately 1175 kiloWatt-hours. At a cost of $0.10 a kiloWatt-hour this amounts to $117 a year. During the summer, cooking adds $50 to the air conditioning bill bringing the total to $167 a year. In Arizona, solar cooking can replace 70% of the cost of cooking. This will save 1675 pounds of coal and 3000 pounds of CO_2 generation from coal fired electric utilities.

Clearly solar cooking has come of age.

How Solar Ovens Work

A solar oven's cooking temperature is reached when the solar gain equals the heat losses. Thus an oven's cooking temperature is a balance between solar gain and heat losses. Heat losses fall into five categories: reflective losses, absorption losses, transmitted losses, leakage losses, and food losses (heat lost to cooking). See diagram above. Solar gain is a factor of the total area exposed to the sun and the effectiveness of collection.

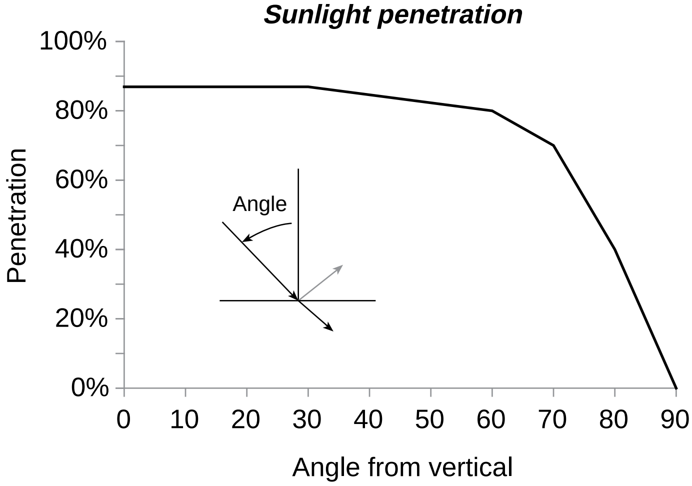
Of the five factors affecting a cooker's cooking temperature three of them are thermal loss. Transmitted losses are controlled with insulation. Double glass covers have twice as much insulation value as single glass covers. Leakage losses are controlled with tight construction. The chamber should be well fitted and protected from moisture on the inside.

Mirrors have a reflection of about 99% but lose 5% each time the light passes through the glass. Polished metal surfaces have about 90% reflection but no losses due to glass. The result is that each behaves about the same. A reflector equal to the width of the cooking chamber produces an optimum design for use of materials. Reflectors can be folded to cover the cooking chamber making the cooker portable!

For the reflectors, this property (reflection) is acceptable, but for the cover glass, light must enter the cooking chamber, or the reflectors are of no use. As a stone skipping across water, sunlight will skip off the surface of glass without penetrating if the angle of the reflector is too shallow (see chart below).

An optimum sized cooker will cook just about anything you put in it. Extending the reflectors to make the collector larger will produce more heat and will cook food faster. If you extend the reflectors, the cooker becomes less portable. Doubling the length of the reflectors increases its width by only 20% because the angle must be steeper. The shallow sun angle on the reflectors makes them more reflective. The penetration into the cover glass improves somewhat because of the more vertical angle.

Sunlight penetration

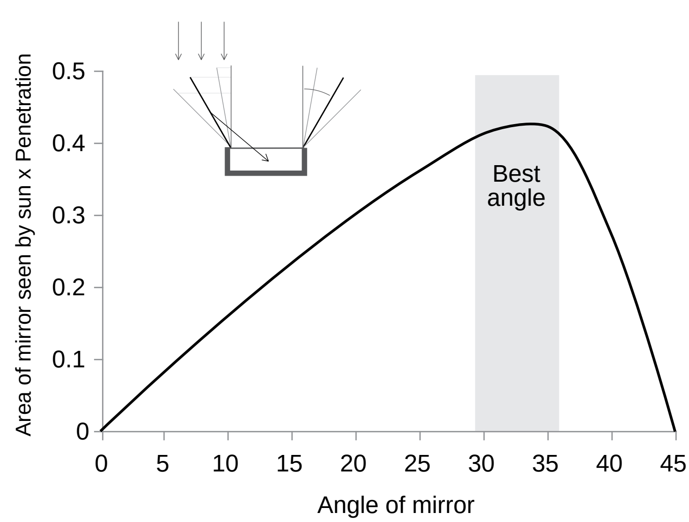


An angle of about 30 degrees from the vertical (or 60 degrees from the horizontal) for the reflectors yields good penetration. See chart on right. An angle of 45° catches a lot of the sun's rays, but much of it reflects off the glass. A 5° angle will allow much light to penetrate into the cooking chamber, but has a small area available to capture the sun. At a 30° angle, the area of the reflector available to the sun *and* the light penetration are optimal. Light striking the far edge of the reflector should enter the cooking chamber at the far edge opposite the reflector. You can check this using a small hand mirror. An angle of 30 degrees from the vertical with each reflector equal to the width of the cooking chamber will allow all the light striking the reflectors to enter the cooking chamber. With this geometry you can still fold the reflectors!

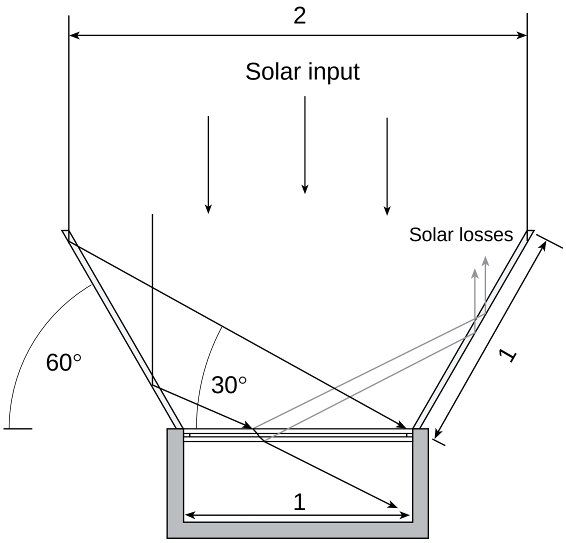
Above: Christi checks the status of food cooked in Al's tracking solar oven.

Solar heat is transferred into the food by three mechanisms. First by direct solar rays, that is sunlight striking the food directly. This is somewhat like a broiler. Second by convection, that is by the hot air surrounding the food inside the chamber. Third by conduction of

Optimum reflector angle



Optimum reflectors



heat from the tray upon which the food rests. If the tray is a heavy metal conductor, such as steel or aluminum, the sun's rays will heat the tray and conduct the heat under the food like a stove. All three mechanisms combine to make the food cooking process efficient.

Finally, as the sun's energy is transferred into the food the thermal loss drops the oven's temperature 25 to 50 degrees initially. This loss is only temporary.

As the food approaches the oven's temperature the aroma begins to fill the air — that's the whole idea behind solar cooking!

Access

C. Alan Nichols, 4220 N. Bear Canyon Rd., Tucson, AZ 85749 • 602-749-5962 Al Nichols has won an award for his tracking solar oven design. He will send plans for the cost of postage ($2).

Home Power's

Business

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

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Above: Fun in the sun at last year's solar cooking contest. Read all about it in *Home Power* #36. Photo by Richard Perez

Home Power's 3rd Annual Solar Cooker Contest

¡WIN! ¡WIN!

1st Prize — a Solarex MSX-60 (60 Watt) PV Module

2nd Prize — a Solarex MSX-10 Lite (10 Watt) PV Module

3rd Prize — a Solarex MSX-5 Lite (5 Watt) PV Module

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

Solving problems with the sun

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

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

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

A solar history

Solar cooker design and improvement began in earnest in the 1950s by scientists and engineers of the

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

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

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

Now it's your turn

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

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

The Rules

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

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

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

4. *Send your cooker and its plans* to Home Power Magazine by July 1, 1994. Include data on how long it takes your cooker to boil one quart of room temperature water (70°F [21°C]). Plans should be clear and complete.

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

6. If you are a finalist, we will notify you by mail. All entries will cook the same meal during the Cook-in. Bring, or send, your cooker to us at 19101 Camp Creek Road, Hornbrook, CA 96044.

7. Winners will be chosen by the Home Power Solar Cooker Contest Judges at the Solar Cook-in and Potluck. This will be August 6, 1994 from 10 AM to 4 PM at Pacific Power and Light's Camp Creek Recreation Area on Iron Gate Lake, 14 miles east on Copco Road from Hornbrook, California. All are welcome!

You need not be present to win. Employees of Home Power and their relatives are not eligible to enter. All designs become the property of Home Power. We'll ship cookers back to you after the contest. The winning design will be featured in an article in Home Power Magazine. Home Power promises all entrants that these designs will only be given away and never used for commercial purposes. This Solar Cooker Contest is for our planet, not for bucks!

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

Access

Send solar cookers to: Home Power, 19101 Camp Creek Road, Hornbrook, CA 96044 • 916-475-3179

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

Question: What are the differences among thin-film, amorphous, single-crystalline, and polycrystalline (also referred to as semicrystalline or multicrystalline) photovoltaic cells?

Answer: In general, all PV modules are more similar than they are different. All PV modules, by definition, use the photovoltaic effect. Each module has a positive and a negative terminal. The current-voltage curves are similar in shape, in that there is a short-circuit current, an open-current voltage, and an optimum operating voltage that maximizes the power output. All modules contain cells. The number of the cells, along with the type of cell, will determine the operating voltage. For example, most single and polycrystalline silicon modules have 36 cells connected in series. Whereas the same voltage can be obtained by connecting 26 amorphous-silicon cells in series.

Terms like amorphous, polycrystalline, and single-crystalline, refer to the atomic order of the photovoltaic material. Usually the photovoltaic material is silicon, but there are some new types of modules using compounds of cadmium and tellurium; or copper, indium, and selenium. If the material is in a crystalline order, all of the atoms are equally spaced in a well-defined order. If that atomic order is continuous across an individual cell of a module, then the module is referred to as a single-crystalline module. Good examples of single-crystalline silicon modules are the Siemens Solar Industries "M" module line. If the atomic order is not continuous across a cell, then the module is referred to as polycrystalline. Good examples of polycrystalline modules are Solarex's "MSX" module line. Each different shape on a Solarex cell represents a different crystalline orientation of silicon. The cell is crystalline but the crystalline order across the cell is interrupted, thus the name poly (meaning "many") crystalline.

In an amorphous material, the atoms are randomly distributed when the cell is made. There is no obvious atomic order in an amorphous material. The look of an amorphous silicon module is different than a crystalline module. An amorphous silicon cell can be made in a variety of different shapes. An example of an amorphous silicon module is Unisolar's UPM-880 module. The module contains 13 visible cells. Because each visible cell is really two cells stacked on top of the other, the module contains 26 cells connected in series.

There's also the term "thin-film", used to describe some modules. Thin-film refers to the quantity of PV material used. The atomic order of the thin-film can be single-crystalline, polycrystalline, or amorphous. The thin-film can be silicon, cadmium-telluride, copper-indium-diselenide, or other PV material. The premise is that if a PV module performs the same with less material and the process can be better automated, then the module will be cheaper to make. However, the potential cost reduction of thin-film PV modules is not fully established at the retail level.

So much for looks; on to performance. Depending on the photovoltaic material and atomic order, there will be some "subtle" performance differences. These subtle performance differences can make or break a system design. The obvious difference between crystalline-silicon and amorphous-silicon modules is the efficiency (defined as the power output for a given area). Because of the atomic ordering, the crystalline form will be more efficient than an amorphous form. Efficiency is important if you have a limited area to put your PV modules. Related to efficiency is whether any additional materials or installation costs are needed to support and connect the modules. However, the work is done by power not efficiency. Fifty watts of power from one module should be equal to 50 watts of power from a different module.

Another subtle difference is that when a PV module gets hot, the power output decreases more for crystalline silicon modules than for amorphous silicon modules. The system design should consider this for hot climates. Also, the amorphous silicon cell has a higher operating voltage than a crystalline silicon cell. However, that cell operating voltage difference is factored out when the module is made because the manufacturer will use a different number of cells. Thirty-six series-connected crystalline silicon cells will give a similar operating voltage as 26 series-connected amorphous silicon cells.

Usually, the difference types of PV modules are mentioned either because of real performance differences or because the manufacturer wants to establish product distinction (name recognition). Check the manufacturers' performance specifications carefully.

Access

Author: Byron Stafford, NREL

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

More On NAFTA

Michael Welch

Readers have expressed an interest in learning precisely how NAFTA (the North American Free Trade Agreement) will impact the future of renewable energy. It still isn't entirely clear. Indications are strong, however, that this trade agreement is good for multinational corporations, and bad for the environment.

Most of the reasons for using renewable energy focus on how environmentally friendly it is. NAFTA may give corporations the edge they want to ignore important environmental considerations. NAFTA could further erode our rights as U.S. citizens to participate democratically in the process of determining our energy future.

NAFTA was sold to us by the Clinton Administration as a tool to decrease trade barriers between Canada, the U.S. and Mexico. How it will be used will depend on who decides to wield it against whom. And, when it does get used in a manner that upsets someone, the telling story will be how the courts interpret both the letter and the intent of the law.

Greenpeace Report

Carol Alexander and Ken Stump of Greenpeace wrote an excellent analysis called "The North American Free Trade Agreement and Energy Trade." This report is available through Greenpeace and electronically on the Home Power BBS. Much of this column comes from information in that report.

In a nutshell, the Greenpeace report points out that our nation's oil, gas, and electrical industries have been working for many years to avoid government regulation that could increase their costs and decrease demand for their product. What they got with NAFTA will lock into law the deregulation they were looking for and a continued bias towards fossil fuel and other large supply-side energy projects. A bias like that bodes poorly for the future of renewable energy.

Although the energy portions comprise only twelve pages of the 2200 page NAFTA text, they will have far-reaching impacts on the course of energy development and consumption for decades to come.

Free Market Economy? ... *Not*

The entire basis for the NAFTA energy provisions hinges on reliance on a "free-market economy" which doesn't really exist. Under NAFTA, the market — not the government — controls the price and flow of fuels and electricity in North America. Specifically, NAFTA prohibits governments from intervening in energy markets in the form of tariffs, taxes, and other non-price safeguards.

In practice, if we had a true free-market economy, then maybe NAFTA would be good for us all. But, dream on! A free-market economy is nothing more than a myth, albeit a myth that corporate profit-grabbers have been able to use to their advantage. A truly free marketplace would embody *all* the costs of producing and using energy. (See HP#37 Power Politics, "Energy Subsidies and the Hidden and Societal Costs of Energy".)

Corporations selectively use the preference for a free market economy to avoid government regulation on the one hand, and avoid their environmental and social responsibilities on the other. NAFTA gives major North American energy industries increased access to non-renewable resources without holding them accountable for the environmental and social consequences of their actions.

At the same time, these industries receive enormous subsidies that give them an even greater unfair advantage in the marketplace. NAFTA even goes so far as to codify encouragement for continued subsidies for these industries, based on the need for "national security". Nowhere in NAFTA is there acknowledgement of the threat to national security posed by environmental degradation. Nowhere does it give significant credence to the desire for clean, safe and renewable energy supplies.

NAFTA's energy provisions actually help bias our economy away from a "true" free market wherein renewables would be able to compete with fossil fuels and nuclear on an even playing field.

NAFTA encourages environmental degradation by multinationals

The point behind NAFTA's energy sections is to give Canada and Mexico access to U.S. energy markets in exchange for guaranteeing U.S. access to their abundant and undeveloped fossil fuel reserves and hydro power potential, while prohibiting governments from hindering that process. The stated value is to increase our country's energy security by lessening our dependence on Middle East oil in the case of another embargo or if our own reserves dip too low.

In reality, the NAFTA energy sections will allow Mexican and Canadian energy producers to compete directly with U.S. producers. Since their fuel and electricity is likely to be cheaper than the U.S.'s because of less stringent regulation, the foreign producers will have a distinct advantage over our own. At the same time, NAFTA removes restraints that might dissuade companies from investing in foreign facilities instead of U.S. based ones. The net result? Multinational companies and utilities are already beginning to invest their capital in environmentally and socially unsound ventures on the other side of our borders.

Now that foreign-based facilities are guaranteed access to U.S. markets, you'll see a lot more mega-projects like the huge dam slated for James Bay in Northern Quebec and the MacKenzie Delta gas pipeline project in the Canadian Arctic. That translates to less demand for smaller and more environmentally responsible projects, and less jobs and power plants within the U.S. Projects like the James Bay hydroelectric project will only happen if foreign facilities have access to U.S. markets. The Canadians could not justify making a huge amount of electricity strictly for their own citizens. That electricity is meant to be consumed by the U.S. which is the single largest electricity market in the world. Likewise, Canadian nuclear fuel production far outweighs Canadian needs. They supply 50% of the U.S. uranium fuel market.

Carbon I & II Blacken the Skies

A good example of what can happen when trade is opened up across borders is the Carbon II coal powered electrical plant being built just south of the Mexican border from Eagle Pass, Texas. This plant is designed to burn lignite, a relatively high-sulfur and low BTU coal that produces 10 times more sulfur dioxide emissions than a U.S. plant would be allowed to produce.

A major owner in the Carbon II plant was to be Mission Energy, a subsidiary of Southern California Edison (SCE). SCE was hoping for big profits from the plant. The plant could produce cheap electricity because it would not be required to meet U.S. environmental regulations. Negotiations for connecting the Mexican plant to the U.S. utility grid were already underway.

Carbon I (II's predecessor) was already pumping pollution into south Texas and reducing visibility in the wilderness areas of Texas' popular Big Bend National Park. According to the U.S. Park Service, if Carbon II came online as well, visibility in the park would be reduced by as much as 60%, and would affect sites as far away as the Grand Canyon.

Carbon II illustrates what can happen when the environment is not considered in negotiating transnational agreements. Fortunately, this story has a happy ending, although Carbon I continues to pollute the area's air. SCE withdrew its participation in the plant when the International Finance Corp., the private sector lending arm of the World Bank, pulled out of its initial commitment to help finance the project. Without the IFC, the other lenders required SCE to put up guarantees, including $300 million in environmental modifications. SCE refused, backing out when they saw that they would not be able to make the killing that they had hoped for.

In this case, U.S. government officials were instrumental in influencing the financiers of the Carbon II project when Texas citizens started raising hell about the pollution. It is not hard to imagine what could happen under NAFTA when similar actions by our government officials might be considered "restraint of trade".

Free Trade Commission

Several states have adopted a utility pricing practice which includes "externalities". This method works some of the external (indirect) costs, like environmental costs, into the price of energy production. Unless these costs are included into the price of electricity, utilities will make resource decisions based on narrow economic considerations without regard to long term effects on society and the environment.

These states have the insight to realize that the lowest cost solution may end up costing much more in the long run than options that are screened out of the process for being initially expensive. This type of pricing has led to increased use of renewables, like wind energy, and decreased use of dirty power plants like coal.

When competing foreign plants are exempted from such methods, externality pricing will fall apart. U.S. plants can't be expected to continue such methods if it means they can't remain competitive with foreign pricing. Under NAFTA, Mexico and Canada would be sure to challenge such externality pricing as a non-tariff barrier to trade. This would force the state or other entity trying to uphold the externality pricing method to try to defend the practice before a panel of unelected trade diplomats called the Free Trade Commission.

Since NAFTA is an international treaty, it supersedes all other state and national laws, and would nullify any future laws that could be shown to be in conflict with it. Our government will be forced to follow the decisions of the FTC or face financial sanctions, which could not only doom externality pricing, but cripple state efforts to implement demand side management (DSM) programs. Under DSM, ratepayers pay utilities to help customers use less electricity, thus avoiding the building of expensive power plants. Utilities are paid a rate of return on their investment in DSM just like they would be paid a rate of return on power plant investment.

Under NAFTA, financial sanctions could be huge. A foreign entity could be entitled to any amount that they felt they lost out on because of an illegal barrier to trade. These, too, would be up to the FTC to decide. Since huge fines cannot be easily budgeted, there would be a further tendency in the government to avoid conflicts with NAFTA. The result: an even greater erosion of environmental concerns in government and industry.

Lawyers Win

The multinationals and foreign interests won't be the only winners with NAFTA. One of the largest beneficiaries of NAFTA will be attorneys. International trade agreements will spawn a whole new area of law. Everyone involved will be looking for favorable court and FTC findings. Industry, government, labor, and environmentalists will hire tons of attorneys looking to either use the NAFTA tool or try to deny someone the use of the tool.

Other Trade Agreements

NAFTA isn't the only thing going these days. There's the Canada/U.S. Free Trade Agreement of 1988 (FTA). That agreement sold the environment down the road in much the same manner as NAFTA, except that NAFTA extends the rules to include Mexico. Mexico has a far worse environmental and labor record than both Canada and the U.S. This, in fact, is what made NAFTA so much more controversial — Mexico is famous for its cheap labor and poor environmental laws.

Last but not least, is GATT, the granddaddy of them all. The General Agreement on Tariffs and Trade is the International equivalent of NAFTA and the FTA. GATT provided the framework for the trade rules that all three trade agreements rely on. The common denominator of concern is that power is removed from each sovereign government and its citizens to deal with the environment, resource issues, and product standards. That power is placed in the hands of appointed officials, who may not hold our best interests in a high regard.

Access

Author: Michael Welch, c/o Redwood Alliance, POB 293, Arcata, CA 95521 • 707-822-7884 voice • 707-822-8640 computer BBS

Greenpeace Action, 139 Townsend, San Francisco, CA 94107 • 415-512-9025

IPPP Update

Don Loweburg

Since its formation two months ago, the membership of Independent Photovoltaic Power Providers (IPPP) has grown to 21 PV business. IPPP was initially formed to coordinate an organized response to Southern California Edison's (SCE) plans to enter the off-grid energy market. Now, IPPP should seize this opportunity to increase public awareness and acceptance of the availability of independent power systems.

In November, SCE filed an advice letter with the Public Utilities Commission (PUC) seeking permission to install remote PV power systems and charge a monthly rate. Members of IPPP collectively and individually filed a significant number of statements opposing SCE's proposal. At the time of publication it is unclear whether the PUC will allow SCE to implement its program.

In either case, independent power providers must expand our efforts to develop a competitive off-grid market in which independent entrepreneurs, not monopolistic utilities, are the power providers. First, we can do this by mobilizing to prevent other utilities from entering the off-grid market. Most importantly, however, we must get the message out to potential customers that PV power is a viable solution to their power needs, that it is already available, and that it works.

As an organization, we need to develop concrete ways of accomplishing these goals. Possible approaches might include:

• A media campaign which would publicize the availability of off-grid systems.

• More workshops to inform and educate potential customers.

• A public relations effort to legitimize the off-grid industry in the eyes of finical lending institutions, so that remote homeowners can obtain financing for independent power systems.

As an industry we need to be proactive rather than reactive. If you are professionally involved in PV, or use PV power and value a strong and independent off-grid industry, please join our organization and help us develop a strategy to both protect the integrity of, and increase the vitality of, our industry. We need your ideas, your input, and your involvement.

Access

IPPP through Don and Cynthia Loweburg at Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643 • 209-877-7080.

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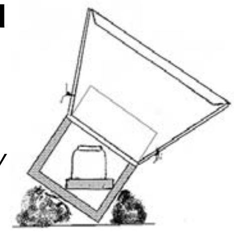
Heaven's Flame

a Guidebook to Solar Cookers by Joseph Radabaugh



Joseph Radabaugh's book of 96 pages with 11 photographs and 50 illustrations, provides plans to build an inexpensive, efficient solar oven from foil, glass, and cardboard boxes. Full color cover and durable binding. For under $15 (including the cost of the book) you can be cooking with the sun. Cook delicious food, save money on cooking fuels, and have more time to do the things you want to do.

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Home & Heart

Kathleen Jarschke-Schultze

There are a lot of wild rose hips where I live. I have collected and dried them for use in tea. I have made garlic oil for relief of earaches. I like to use natural remedies when I can but I really just didn't know much about it.

Home Herbal Medicine Chest
We received a set of video tapes and books from Debra Nuzzi, Master Herbalist, on Herbal Preparations and Natural Therapies. There are two video tapes and two books in a kit she sells to teach how to create and use a home herbal medicine chest.

Real Class
I watched the videos while referring to her companion manuals. The kit is set up like a class. On the tape Debra teaches a specific technique from the manual then suggests you try that technique on the other related recipes in the book.

Stewardship
One of the first parts of Tape One shows Debra riding her horse up a mountain to collect Osha root. She digs the root while talking about how to gather wild herbs and roots while leaving enough other plants to continue the species. She took some tobacco seeds and placed them in the hole left by removing the Osha root. She explained that this was how the Native Americans thanked the earth for its gifts to them. Then she quietly said thank you and covered the hole with dirt. No big deal really, but her respect for nature made me feel good.

Sections
There are four basic sections to the tapes and manual. Section One: Wildcrafting, Section Two: Tools and Ingredients, Section Three: Herbal Preparations and Section Four: Natural Therapies. Each Section is addressed on the tapes and followed through in the manual.

Debra
One of the best features is that I felt like I knew Debra. Her personality comes through on video. She is intelligent and full of humor. I found watching the tapes relaxing and informative. I really enjoyed her presentation. She took her time and showed the expensive equipment you could buy, but demonstrated with equipment you could find in your kitchen.

Resources
The resource section at the end of the manual is truly amazing. It lists wildcrafters, equipment supplies, herb wholesalers, publications, conferences, schools, computer programs, etc. — about 28 pages of where-to-find-it information. I was really impressed. Access is so important.

Conclusion
This herbal classroom in a kit has influenced me. I will plant as many of the different herbs in my garden as my climate will allow. I was surprised at how many useful herbs I already have. I now know where to get whatever else I need. I am ready to treat my family naturally whenever I can.

Access
Author: Kathleen Jarschke-Schultze gardens with herbs at her home in Northernmost California c/o Home Power Magazine, POB 520, Ashland, OR 97520

Kit: $149 from Debra Nuzzi M. H., Morningstar Publications, 646 Dixon Road, Boulder, CO 80302 • 303-444-7610

Correction from Home & Heart *HP*#38: the new address for Oasis Biocompatible Products™ is 5 San Marcos Trout Club, Santa Barbara, CA 93105-9726 • 805-967-3222 • FAX 805-967-3229. Also available through health food stores and Real Goods Trading Co., 966 Mazzoni St., Ukiah, CA 95482 • 800-762-7325

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for U.S. ZIP codes only, see page 81 for international back issues.

(Sorry, we're out of issues 1 through 10, and #15. We are planning to compile them into a book. Until then, borrow from a friend. If you have a computer (or a friend with one) download the article you're missing by calling the Home Power bulletin board at 707-822-8640. Or check with your local library; through interlibrary loan, you can get these back issues. Jackson County Library in Oregon has all issues as does the Alfred Mann Library at Cornell Univ.)

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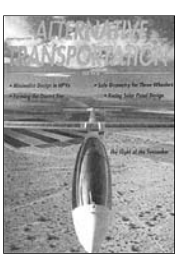

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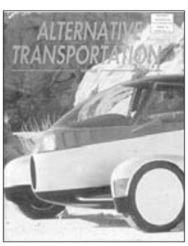

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HAPPENINGS

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

CHILE
The Engineering Faculty of Universidad de Tarapaca, Arica, Chile is organizing the Renewable Energies International Symposium SENESE VIII, to take place October 5-7, 1994. We are inviting academic and professional authors interested in presenting their work to submit abstracts (Spanish, English or Portuguese only) considering March 1, 1994 as deadline. The purpose of the Symposium is to provide a meeting place for those interested in renewable energy, environment, and efficient use of energy, allowing for diffusion of the development, reached by specialists from investigation center of universities, private, public and international organizations. For more information contact: Congresso International de Energias Renovables-SeneseVIII, Universidad de Tarapaca, Facultad de Ingenieria, Casilla 6-D, Arica, Chile, FAX (0056)-58-213807, phone (0056) 58-251673. Electronic Mail: BITNET: SENESE@UTAVAX.BITNET or INTERNET: SENESE@ALPACA.QUIPU.UTA.CL

NATIONAL
Don't miss the fifth annual Midwest Renewable Energy Fair, June 17–19, 1994 at the Portage County Fairgrounds, in Amherst, Wisconsin. The fair will include spakers and workshops for adults and children on solar, photovoltaics, wind, mycrohydro, wood, and energy conservation; vendor display booths; an alternative vehicle showcase; teacher curriculum workshops; entertainment and food. For further information, contact Midwest Renewable Energy Assn, POB 249, Amherst, WI 54406 • 715-824-5166

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

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

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

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

FREE NATURAL GAS VEHICLE MAGAZINE Send SASE to Frank Rowe Circulation, NGV Magazine, 1410 Grant St Ste A-201, Denver, CO 80203, 303-863-0521, FAX 303-863-0918

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

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

ARIZONA
The 12th Annual Tucson Solar Potluck and Exhibition is on Saturday, April 23, 1994 at Catalina State Park in Tucson from 9:30 AM till sundown and into the night. Come join the fun. For more information contact: Rod Zimmerman, Citizens for Solar, POB 40372, Tucson, AZ 85717-0372, (602) 748-7233 or Jim Arwood, Department of Commerce Energy Office, 3800 N Central Ave Ste 1200, Phoenix, AZ 85012 (800) 352-5499

Solar Energy International (SEI) will present two workshops in Tucson, AZ. "Passive Solar Heating and Cooling" is offered February 28 to March 10. "PV & Solar Water Pumping" will be held March 14 to 24. The two week hands-on workshops focus on Southwestern approaches to home comfort and solar electricity. SEI, POB 715, Carbondale, CO 81623 • 303-963-8855.

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

CALIFORNIA
Offline Independent Energy Systems Workshop: Designing Your Home PV Power System — March 6, 1994. The class will begin with a tour and discussion of a working PV system. We will then develop the following topics: basic system types, determining power needs, the PV array, the battery, and inverters. We will discuss how it's all put

together such as any special wiring needs, code requirements and safety, instrumentation and controls. We will also look at how to LIVE with PV in relation to appliances, computers and entertainment equipment, attitude and awareness. Cost is $35 for one person and $45 if two people sign up together. For further information, reservations and directions, please call or write Don and Cynthia Loweburg, Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643, 209-877-7080

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

SEI in cooperation with the Campus Center for Appropriate Technology (CCAT) of Humbolt State University in Arcata, CA is offering low-cost evening seminars. Session topics include: solar, wind and water for home power applications and the alternative building technologies of super-insulation, earth and straw-bale construction. Contact CCAT, Buck House #97, HSU, Arcata, CA 95521.

North San Francisco Bay Chapter of the Electric Auto Assoc. (EAA) holds meetings on the second Saturday of each month at the PG&E Business Center, 111 Stony Cir, Santa Rosa, CA from 9:30 AM–Noon. For information on the EAA and the chapter nearest you, send an SASE to 1249 Lane St, Belmont, CA 94002, or call 415-591-6698 (10 to 5 on weekdays).

Siemens Solar Industries is offering its 1994 five day Photovoltaic Technology and System Design Training Course. This premiere International technical training course in stand-alone photovoltaic system design, conducted continuously since 1981, with over 1,000 attendees from 30 countries. Learning begins by purchasing the two volume set of Training Manual and Technical Appendix for $175. The fee includes their award winning 30 minute videotape “The World of Solar Electricity”. Step two is a five day training class. The first Training Class of 1994 will be held February 21-25 at the Florida Solar Energy Center, Cape Canaveral, FL the week preceding SOLTECH ‘94 at a special rate of $550. The remaining classes will be held April 18-22, July 18-22 & September 19-23 at the Siemens Solar Training Center, Camarillo, CA. The training class, including the two set manual & video is $1500 (food and lodging not included). The course offers hand -on experimentation with inverters, controllers, batteries, modules, trackers and loads. The “final exam” is a full system design. Interested persons should contact the Training Department of Siemens Solar Industries to obtain a Course Information Package and application form. Contact Cindy Vernon, 805-388-6568, Fax 805-388-6395.

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

THE Solar Prosperity Exhibition will be held on June 25-26, 1994, in the San Jose Civic Auditorium Complex in downtown San Jose California. The Northern California Solar Energy Association (NCSEA) sponsored exhibition will provide an opportunity to showcase products, systems, and services to the general public as well as the Solar ‘94 Conference. The exhibition is designed for companies, organizations, non-profit groups and educational organizations involved in solar, and renewable energy, energy conservation, and related environmental issues. The event will also feature solar and electric cars. Indoor and outdoor booth space is available. For more information or to receive the exhibitors registration packet contact NCSEA, POB 3008, Berkeley, CA 94703 or call 510-869-2759.

The South Coast Air Quality Management District is hosting “Bring Fuel Cells Down to Earth” February 23-25, 1994, an international conference to bring together experts from around the world to focus on fuel cell applications that are currently available in the fields of transportation, power generation, manufacturing and consumer products. For more information contact Laura Fizzolio or Greg Fant at Cerrell Assoc., Inc. 213-856-5045.

CONNECTICUT

On April 11-13, 1994, a broad coalition of industry, environmental and trade organizations will convene RENEW’94, a watershed conference focused on bringing the production and use of renewable energy into the mainstream for the northeastern USA and accelerating the development of the renewable energy industry within this region. The Northeast Sustainable Energy Association, organizer of RENEW’94 invites exhibitors of products and services to participate. Contact: Paul Lipke, NESEA, 23 Ames St, Greenfield, MA 01301, 413-774-6051, Fax 413-774-6053

MAINE

Hands-On Workshops will include: solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $30.00, which includes lunch. For information on sites and dates contact Richard Komp, Maine Solar Energy Assoc., RFD Box 751, Addison, ME 04606 • 207-497-2204

MASSACHUSETTS

The Sustainable Transportation and Solar and Electric Vehicle (S/EV94) Symposium, car and trade show provides transportation planners, auto, bus and train industry personnel, business people, fleet owners and operators, students and concerned citizens a forum to exchange information on EV technology, policy, and business, as well as transportation planning strategies to create a non-polluting, equitable and efficient multimodal transportation system. For more info contact: NESEA, 413-774-6051.

The University of Massachusetts Lowell, Center for Sustainable Energy is offering a course on Photovoltaics. Topics include: the solar resource, production of electricity from light, photovoltaic systems and application, photovoltaic design and sizing, lead acid batteries–operation and maintenance, electric circuits, charge controllers, inverters, power point trackers, water pumping, rural electrification, and utility grid connected systems. The course will meet for three hours each on thirteen Tuesday evenings from January 18 through April 19, 1994. For more information contact: UMass Lowell Center for Sustainable Energy (508) 934-3377.

MINNESOTA

The American Wind Energy Association's WINDPOWER '94 will be held May 9-13, 1994 in Minneapolis, MN. The exhibition will feature the most active manufacturers, developers and consultants in the wind industry. For more information please call Linda Redmond, AWEA, (202) 408-8988.

NEVADA

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

NEW YORK

The New York State Energy Fair will be held June 11 & 12, 1994 at the Cortland County Fairgrounds. Workshops on solar, hydro, wind, environmental issues, and more. Vendors, children's activities, electric vehicles, alternative building technologies, etc. For more information contact: Dave Gerber at 607-849-3532

NEW YORK TO PENNSYLVANIA

1994 American Tour de Sol, Solar and Electric Car Championship, New York thru New Jersey to Pensylvania. Over 50 electric and solar powered cars will drive from the Statue of Liberty to the Liberty Bell, May 21-28 on a five day quest for the national electric and solar vehicle championship title. The American Tour de Sol, now in its sixth year, follows the century long tradition of using car racing as a proving ground for technical advances and to educate the public about new automobiles. Production electric vehicles will compete alongside two and four seater commuters and sleek solar racing cars built by entrepreneurs, students and individuals from around the country. The New York to Philadelphia event will have a carnival atmosphere at the many free displays of the cars along the route. For more info contact: NESEA, 413-774-6051

OREGON

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

WASHINGTON

Rides Publishing Company is offering two day seminars for marine electrical installer at various dates in 1994. The seminars are intended to solve the #1 problem with boat electric today... lack of accurate knowledge about batteries, alternators, chargers, inverters, regulators and instrumentation. In depth and general trade information about electrical systems will be presented. Seminars will be held at selected cities. Participants will learn about electrical systems from David Smead, principle author of "Living on 12 Volts with Ample Power" and "Wiring 12 Volts with Ample Power" and hardware and software engineer for Ample Power Products. To learn more about the training seminars, locations, and dates, and costs contact Rides Publishing Company at 206-789-5758, Fax 206-789-9003

WISCONSIN

The fifth annual Midwest Renewable Energy Fair will be held June 17–19, 1994 at the Portage County Fairgrounds, in Amherst, Wisconsin. Contact Midwest Renewable Energy Assn, POB 249, Amherst, WI 54406 • 715-824-5166

Solar Energy Institute (SEI) and the Midwest RE Assn., are co-sponsoring a two week workshop entitled "Wind/PV Hybrids — Design & Installation". Instructors include Mick Sagrillo of Lake Michigan Wind & Sun and Johnny Weiss of SEI. Participants will install the wind/PV power system for the Fair during the May 31– June 9 workshop. SEI, POB 715, Carbondale, CO 81623 • 303-963-8855.

the Wizard speaks…

Microcosm vs. Macrocosm

It is often said that the universe is built from the bottom up, from microcosm to macrocosm. However, it is also possible that the overall macrocosmic pattern can in some ways determine the states and interactions of the microcosm.

Consider a universal macrocosmic wave function collapsing in an anti-entropic manner towards a self-sustaining pattern. In such a process quantum or microcosmic states become more well-defined and of steadily decreasing bandwidth. The quantum uncertainty is then shifted upward in the direction of the macrocosm. This is consistent with the idea that the universal wave function is the basis for all local order. In this manner chaos becomes order which gives rise to further chaos, allowing a higher degree of order to develop.

This progression to higher order is anti-entropic and defines the evolution of parameters in the apparently entropic portions of the continuum. The process can be applied to any system in which the overall pattern of evolution determines the local patterns of interaction. Life itself is probably such a system. The unknown goals of the evolutionary process and the patterns of its development determine the manifest states of existence. RIDE THE WAVE.

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PV SALES AND DESIGN ENGINEER: Experienced photovoltaic system designer with sales background sought. Must be proficient & knowledgeable of ac and DC circuity, PV related components, system design & trouble shooting. Require a positive, outward, go-getting individual who enjoys working within a team atmosphere. If you are in the PV field presently and looking for a great place to work that's recognized for system design and customer service — we're looking for you! Compensation includes base pay, personal sales commission, team sales commission and profit sharing. Send resume and intro letter to Anderson Blackard, East 9116 Sprague Ste 231, Spokane WA 99206

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Letters to Home Power

A Major Phantom Load

Thanks for your article on phantom loads. After reading it, I checked my Sears gas range with electronic ignition. To my dismay it draws 1/3 amp at 120 vac continuously, even when “off”. This is 40 watts, 24 hrs/day. This is around 28,800 watt hours per month at 11¢/kW-hr. This wastes $3.17 per month or $38 per year. This more than pays for my *HP* renewal if I unplug or switch off the line cord when it is not in use!

Over the last 15 years that I’ve owned this range, it has wasted $570 or 5.184 mega watt hours (5,184 Kw hrs).

I could have invested this money in a couple of solar panels. I’ve read your previous article on phantom loads, but I’ve never considered my cooking stove! Thank you very much, Craig Daskalakis, 2233 N Hesperia St, Santa Ana, CA 92706

Well, Craig, most folks consider gas appliances to be nonelectric. Fact is that many gas appliances use electricity in some form and quantity. The easiest check is to look at the electric cord (if any) feeding the gas appliance. The bigger the cord, the bigger the load. A propane cook stove (that we returned) came with a heavy cord to feed the 600 watt glow bar used just to start the oven! Stoves do exist with piezoelectric ignition that works great on mod sine wave inverters and is not a phantom load. Look for a review of one next issue.— Richard Perez

Cultural Awareness

For the past two years I have been a subscriber to *Home Power*. I’m always surprised and amazed when I read each new issue. Your magazine not only does an outstanding job on the reporting of alternative energy news, it also does a superb job of informing readers about the non-technical, non-hardware aspect of alternative energy, humans!

Case in point, *HP* #37, “From Darkness to Light with the Power of the Sun”. Lalith Gunaratne did an outstanding story on the installation of a photovoltaic power system in Sri Lanka. Not only was the article supported by the nuts and bolts aspect of the installation, it also addressed the cultural and human need angle. Many “main stream” magazines forget about the cultural and human elements in their articles. Thanks for keeping this in mind.

Another excellent example of cultural awareness is the solar cooker contest. The winner of your solar cooker design competition, Jay Campbell, found a plausible solution to a real world problem in his own back yard. By designing a cooker that meets the needs of the Navaho tribe, Mr. Campbell designed a culturally significant solar cooker! It is important that people recognize the needs of people in their own community and try to do something to help out.

Without the cultural information your magazine supplies many of the articles, readers might assume that the systems you build, install and test are only for the privileged people of developed countries. Home Power includes the cultural, environmental, and social aspects of products for developed and developing countries without leaving out or sacrificing the human element. Sincerely, Paul F. Sanders, 103 W Pony Ln., Apple Valley, MN 55124

Thanks for the flowers, Paul. The way I figure it, the sun shines on us all. The human needs of cooking and light at night have been with us for millennia. After thousands of years, we’ve finally realized where the power comes from…. — Richard Perez

Lead Tax

I urge you to write your Congressperson and Senator opposing Senate Bill s.1347 and House HR 2479. This legislation is dressed in the benign title of “The Lead Abatement Trust Fund of 1993”. It will put an excise tax on new and reclaimed lead of 45¢ per pound. It’s purpose is to pay for the removal of lead-based paints found in old homes, even though lead has not been used in house paint for over twenty years.

This bill will more than double the price of lead and in turn freeze the development of electric vehicles and adversely affect the alternative energy industries.

We do believe that it is important to remove lead from the waste stream and that we need to minimize its use wherever possible. But just because you can drown in water doesn’t mean water should be banned. Lead-acid batteries are practical, cost-effective and recyclable. They are the heart of renewable energy systems (photovoltaics, wind and water generators) and a tax of 45¢ per pound would chill the industry that revolves around these systems. Renewable energy systems directly address many of the problems we in the United States need to work on: conservation of materials and energy use, non-polluting power systems. We look forward to the day when other types of batteries may prove to be superior to lead-acid batteries, but at the current time lead-acid batteries are still the most viable for most systems. This tax will also put a stop to the development of the electric vehicle industry, but we need non-polluting vehicles on the road today. We need to reduce air pollution and to increase our experience with alternative forms of energy both on the road and in our homes and businesses.

Legislation like this is not a good social policy: it endangers the future due to past sins that are not directly related. Gunars Petersons, Alternative Power and Light RE Center, 701 S Main St, Westby, WI 54667

Thanks for the alert, Gunars. If you look at say, a Trojan L-16 battery which are used in many RE systems, this tax will add about $45 to the cost of each battery. That adds about 25% to the cost of the battery bank. Yikes! I could maybe swallow a deposit on batteries to encourage recycling, but a tax is just a bad joke. The money will go for yet another boondoggle/bureaucracy to "administer" the paint removal and the public gets screwed again. Add to this the fact that practically all the batteries used in EVs and RE systems get recycled already and we have all the trappings of a very bad law. I'll be writing to my reps to oppose this turkey.—Bob-O Schultze

More Techie Gore

Thought this info may be of some value to your readers or yourselves.

1. Linear Technology (the next section after National parts in the DigiKey catalog) sells a few parts of interest. These are the LT1074 (5 amp, $8.33) and TL1076 (2 amp, $5.85). These are 100kHz switcher ICs very similar to the National part Chris Greacen has been writing about lately. They are much cheaper. The main difference in using 'em is that the LT chip uses a capacitor (for control voltage) on one pin rather than the simple on/off function that the National part uses. Efficiency is right up there with the National part. Hopefully Chris can grab one of these and tell everyone how to use it as an alternative in his circuits.

2. LT also has some other switches; LT1070,1,2 (40 KHz models) that are designed for every other mode of switcher configuration you could want (flyback, inverting, step-up, boosted current, etc.). They are 5, 3 & 1.25 Amp respectively. I have used the LT1072 for an 80% eff isolated flyback mode converter to power my 12 VDC AT&T answering machine from 24V (must use an isolated version switcher because of the phone line connection). Another LT1072 is used as a constant current charger for 10 to 10 NiCads at currents up to 1.2 Amps and efficiencies up to 92%.

3. For more into on using these ICs try to reach: Linear Technology Corp., 1630, McCarthy Blvd., Milpitas, CA 95035 • (408) 432-1900

Ask for application notes AN35 for LT1074, 6 and AN19 for LT1070, 1, 2. The AN19 is excellent for giving you all the info you could want on the different converter styles, xfmr and diode selection, efficiency calculations ac/DC losses, etc. They give lots of good formulas and pretty straight forward text. They also have an IBM computer program called SwitcherCad which allows you to model these parts in different converter styles. (The program may cost some and you may need to use Chris's techniques for asking too.)

4. Keep your eyes open for the LT1149 IC to be available from LT. It offers synchronous switcher performance (uses a FET instead of the Schottky diode) to boost eff to 95%! It takes up to 49 VDC input and is rated for 2-3 Amp output. Normal use is stepdown converter.

5. Also wanted to point out that the current articles with the National part is missing the most important characteristic in selecting the inductor. You must evaluate the core volume needed to avoid saturation of the core material. This omission doesn't hurt the switchers any because they are pulse limited. It also may not show up in your eff calculations but the response of the switcher to load changes may be the pits! The other comment is a reminder that the Fluke 87 RMS accuracy is not rated for the 52 KHz switching frequency of the National part. There are also correction factors in the meter specs that should be used in your calculations to get accurate results for frequencies under 50 kHz. (Don't get me wrong; I'm not saying any of your data is wrong but beware it's easy to take the numbers shown as ideal results.)

Keep up the good work! Thanks for listening. Sincerely, Andrew Bean, 5867 W Countryside, New Palistine, IN 46163

Thanks for the component alert, Andrew. Homebrew has always been my favorite. The use of high frequency switching circuits such as you mentioned is revolutionizing home power components. — Richard Perez

To Go Power Fans

The latest issue of Go Power ("Regen!", *HP*#38 confirmed for me my conclusion that Go Power is the best thing going for good in-depth reports on EVs. I write for EV News and Solar Mind, and both of them are fun to get the latest in information about the grassroots industry, as are the EV clubs and EAA Current EVents, but Go Power is where it's at for in-depth coverage!

That's why I was particularly disappointed in Bob Brant's new book, *Build Your Own Electric Vehicle*. This is the first EV book "for the masses" to be published by a major publisher in over 10 years — and under $20!!! But they left out Home Power. Well, no matter — we'll just have to start a write-in campaign to have Go Power added to the list of "Addendum" that the publisher will surely have to add when 2,000 Home Power readers write to complain. The publisher, TAB Books, has its own zip code: TAB Books, Blue Ridge Summit, PA 17294-0850.

Beyond that oversight, it's a terrific book — and each of us can do our part to place it on the best seller list. How does a book become a best seller? The buying of books can't be pinpointed on one set of stores or locales. The bookseller survey crew calls Walden and B Daltons, as well as the independent book stores.

If each EV advocate reading this magazine buys two copies of Bob Brant's *Build Your Own Electric Vehicle*, one in March and one in April, we might see sales of 5,000 books each month.

Yes, it's a $36 investment ($17 each plus tax), but we'll spend that much on at least two pizzas (pick your favorite snack food) over the next 60 days. *Now — here's why we should do this:* By placing these orders , we will bump at least 10,000 copies off the book shelves and onto the book store's order sheets. If the book hits the bestseller list, Bob Brant will get on TV, and we'll *all* win — people who drive EVs will be local heroes, people who give up one Saturday each month to hold club meetings will find attendance is doubled, and schools will be ordering EV components.

I've been well-supported by the EV community — that's why *Why Wait for Detroit* is out of print. Naturally, my first reaction was envy — how did this Bob Brant succeed in getting a major publisher where I failed? And why didn't he include Go Power? But that diverse thinking has no place in the grassroots "let-get-EVs-on-the-road" movement. Do everyone a favor and help put Bob Brant's book on the best seller list. Steve McCrea, 1402 E Las Olas Blvd #904, Fort Lauderdale, FL 33301-2336

Thanks, Steve. I ordered two copies today! — Richard Perez

Way Out

I would like to request your comments on an article on solar energy that appeared in the December/January 1994 issue of *Mother Earth News*. For your convenience a copy is enclosed.

The article sent some mixed signals. While it conveyed an attitude that seemed generally supportive of solar energy, it also contained a few zingers. For example, the article quoted a user who claimed that a solar energy system can cost $300,000; it painted a picture that users may have to curtail seriously their use of appliances; and it mentioned possible damage to sensitive appliances such as stereos and computers.

Where I'm coming from: In about three years, I plan to build a new home in a rural area of northwest Texas; I planned to have Sunelco, Inc. design a solar energy system package to build into the home from the git-go.

I wanted the solar system to supply about 80% of my energy needs, with a stand-alone generator providing the balance. I planned to completely omit the closest utility company from my energy plans. I envisioned the entire solar package costing about $15,000, to include an ac converter and a bank of batteries.

The house will be nearly 4,000 square feet, and it will contain most "normal" modern appliances. I will substitute about a dozen ceiling fans for central air conditioning, wood heat for central heating, and use a gas stove.

However, the house will contain a conventional refrigerator, a freezer, a couple of televisions, a stereo, a home computer, a vacuum cleaner, ceiling lights (fluorescents), and other such "normal" amenities. Also, I'll probably put a few wood-working tools in a utility building. I'm not enamored with the prospect of constant brown-outs from turning on one too many light switches, nor my computer monitor exploding in my face because of power surges.

Was the *Mother Earth News* article misleading? Did I interpret it incorrectly? Are my concepts far fetched or unrealistic? At your earliest convenience, I would appreciate hearing your comments. Sincerely yours, Kenneth M Fletcher, 547 Oak Creek Dr, Brandon, FL 33511

Hi Kenneth, the only way that I can see the need to spend $300,000 for a PV system would be for an all electric home with no thought of conservation (and no backup power source). The size of your proposed PV system will greatly depend on the number of people in the home, how energy conscious the residents are, and how much sun your area receives. You seem to be making many of the right choices to keep your proposed system within budget: non-electric heat, gas stove, fluorescent lighting, etc. You might want to consider a very energy efficient refrigerator/freezer (such as a Sun Frost) or super insulating the ones you have. Being aware of energy usage goes a long way too. Putting plug strips on phantom loads and following the maxim "if ya ain't using it, TURN IT OFF" saves an incredible amount of energy. You've picked an honest and reliable company to help you with your system.

As far as certain appliances not working on PV, it really is a function of the inverter you decide on. Almost all appliances and computers run on modified sine wave inverters. The Mac LC III computer and most laser printers are some exceptions, but they run just fine on sine wave inverters.

This magazine and our home is run on a PV and wind system. We've never had a brownout and we sure didn't spend a tenth of $300,000. — Karen Perez

Well, Kenneth, I consider that article to be bogus baloney. Nuff said…. — Richard Perez

KTU with a DTU backup

Heidi and her three KTU(Kitty Thermal Unit) bed warmer. At "off" hours backup heating is provided by one DTU system (Jeremy, our Golden Retriever). The systems are not yet compatible. P.S. — Lighting is PV powered 12 Volt. Chris Pretlitz, POB 5024, Laguna Beach, CA 92652

Utilities Off-Grid

Two issues have been written about the utilities getting into the PV remote home market. No one seems to want this. The utilities are monopolistic, no one trusts them. But... what if a utility in New Mexico got so good at remote power systems that it began encroaching on other utilities districts and then an Oregon utility began underbidding the New Mexico utility. In other words, for the first time utilities could really compete. Still...would they know how?...would they not just divide up the market? Steve Baer, Zomeworks Corp., POB 25805, Albuquerque, NM 87125

Well, Steve, the questions you raise are just two of the many that bother me. Public utilities have had the soft monopoly for so long, I doubt if they could compete with each other much less today's lean operating RE dealers. RE systems are ideally suited to user ownership. I think the major problem with utilities is that they want to rent us power rather than empower us to make it on our own. — Richard Perez

I can't see utilities going into competition with each other, Steve. They long ago divided up the USA into "Service" territories. That's what gives them the monopolies. New Mexico horning in on Oregon's turf? The trespassers would be horsewhipped with a 69KV line! — Bob-O

Wooden Batteries!!

The articles on rechargable batteries and PV charging by Therese Peffer are exactly what I've been looking for. I've used a solar battery charger for about a year but wanted more specific information about batteries. I got it!

I participate in environmental exhibits and like to bring home the power of PVs in a direct manner. I built a solar fountain with a bilge pump hooked directly to a PV panel (Solarex MSX 30). This gets attention but is bulky.

For a smaller example of direct PV power I used my solar battery charger and a portable radio. These are connected using two "wooden" batteries. The batteries consist of half inch wooden dowels 1 $^{7}/_{8}$ inch long. A wire is attached to a small round head brass screw in one end of each dowel. The solar charger has a three volt takeoff so I attached the other end of the wires to a compatible plug. The "wooden" batteries are inserted into the radio like regular AA batteries, one making contact with the positive side and one with the negative side.

This works under an incandescent light so is useful at indoor exhibits. It also works great at picnics and on the beach. I'm sure your readers can find many more applications of this idea. Sincerely, Tom Atwater, POB 363, Collinsville, CT 06022

Great idea, Tom! Thanks — Therese Peffer

Useful Marine Equipment

Although it's extremely unlikely that you at HP would not already have this kind of info, it nonetheless caught my eye in Defender's *1993 Marine Buyers Guide*, (available from Defender Industries, Inc., POB 820, New Rochelle, NY 10801-0820, (914) 632-3001, Fax (914) 632-6544 for $4.50, 288 pages) originally purchased to access non-corrosive hardware and fiberglass and mostly just to see what they had. Well, there's PV panels, deep-cycle batteries, 12 VDC lights and water pumps (how about a 12 VDC sump (bilge) pump?) and various versions of the ultra-low flush toilets used with SunMar's WCM.

But I digress — the noteworthy aspects of the little wind/water generators are that (according to the graphs anyway) they would generate power in most any decent river current with minimal disturbance to the environment and that the convertible ones could be used seasonally in response to changing — wind power when water flow doesn't available (or frozen over), water power when conditions warrant the change over.

Having a site where 12 VDC power can be generated from both wind and water without long wire runs might be difficult for some, but many river valleys are located in low, flat, open country that has good wind potential also.

That said, I can only add that your presence and availability in the published world as actual users of the technology of AE and doers of great works in the process, can only be a great inspiration to us all. Steve Birkett, RD2 Box 2152, Vergennes, VT 05491

Aw, shucks, Steve. Thanks for letting us know about these marine products. I always figured that any device that works in a marine application would be loafing in home power service. The only thing that worries me about using "drag behind" generators in a stream or river is debris. Our seasonal "Skookum Creek" is only ten feet wide, but I've seen trees rushing downstream during periods of high water. — Richard Perez

Solaradobe

I've just returned from a fantastic class for owner-builders taught by Joe Tibbets of Southwest Solaradobe School. I'm not aware of the school being mentioned in *Home Power* during the two years that I've been a subscriber. Solar Power and earthen construction: it seems like a perfect marriage and Joe Tibbets, Director or Southwest Solaradobe, teaches outstanding classes on adobe, rammed earth and pressed block construction. Pressed block and rammed earth are especially suited to wet climates.

By choice (and soon by necessity), we are moving away from fossil fuels to produce electricity and heat. Construction can also be much less energy intensive. For more information about classes, *HP* readers can write to: Southwest Solaradobe School, POB 153, Bosque, NM 87006 or call (505) 252-1382. Sincerely, John Moore, 117 Miles St, Santa Cruz, CA 95060

Thanks for the review, John. Solar and adobe sounds like a great mix! — Therese Peffer

A World View

Finally bought a subscription. Heard about *Home Power* through Vancouver Electric Vehicle Association. I like the range of subjects you cover and the amount of technical detail you go into as well as the just-the-facts-no-preaching style. I also like the articles of RE doings in other countries and your personal involvement with some of those projects. It is vital that the developing countries move directly into the more environmentally benign 21st century energy sources and wise and frugal use of them. From the view of the global environment, it makes little sense for a quarter of a billion North Americans to clean up our act only to have four billion people in the developing world starting to belch out coal smoke to power their new-found middle class urban lifestyle.

China is presently going through this very transformation. A billion folks who have mostly been living without refrigerators, lights, or television are very quickly getting these things, not to mention cars. This is the fastest growing demand for energy on the planet. They also have abundant supplies of low grade, high sulfur, soft coal. Canadian businessman Paul Demarais of Power Corp. has signed a multi-billion dollar deal with China whereby his company, Ontario Hydro & Hydro Quebec supply China with a bunch of big coal-fired generating stations as well as the grid to distribute the juice. (Incidentally, the head of Ontario Hydro, Maurice Strong, was the chairman of the Earth Summit in Rio, where so much was made of CO_2 and global warming.) There are lots of business and political reasons why this is likely to go ahead. Power Corp. already has extensive dealings (none in energy) in the Pacific Rim; Hydro Quebec's massive Great Whale hydro development is on shaky ground, largely because of New York's unwillingness to buy cheap electricity at the expensive of the environment in Northern Quebec; Ontario Hydro is in a bit of a cash squeeze because they sunk a lot of money into excess nuclear generating capacity they have no market for and big interest payments to make, plus they have promised not to raise rates until the year 2000! (also eliminated their energy conservation program).

China is a great opportunity for the RE industry. Lots of sun & a huge population not easily accessible to grid & not used to unlimited energy. Is the RE industry not organized enough to pool resources and supply this new market? I see opportunities for joint venture plants in China, and the rest of the Pacific Rim producing equipment to supply the huge local demand. Imagine the unit cost of PV panels made by the millions in new plants by local labor! And these would be competing with expensive new generating plants carrying huge debt loads and still having to invest in the grid system to distribute the power. RE is really cost effective there.

So what's holding the RE industry back? It's great to keep plugging along in our own backyards, and great things have been accomplished, but the world is growing fast. Any ideas on influencing the direction of this new development? Keep up the good work.

P.S. The articles on Power Politics, Who Owns the Sun and The Grid Man were well researched and thought out. Here are a couple of international angles to consider. Canada supplies a lot of energy to the U.S. at very cheap rates, both in the form of natural gas and electricity. A lot of new generating capacity is being built to supply the U.S. market, at great expense to the environment, with the government bypassing the normal environmental assessment process. The Free Trade deal and NAFTA say we must continue to supply this energy to the U.S. even if there is a shortage at home. So look for lots of cheap energy in the foreseeable future. One of the big problems created by free trade is that it geographically insulates the consumer (in this case of energy) from the environmental consequences. Jim Palmer, 3746 Cambridge St, Burnaby, BC V5C 1G1, Canada

Hello, Jim. You are right, China represents an enormous market ripe for renewable energy. Many small rural Chinese villages are now supplied power by a single, under 10 kiloWatt, diesel engine/generator. Other areas in exactly the same situation are India and most of rural Central and South America.

Renewable energy sources, like PV, wind, and microhydro, replaced the engine/generator as a prime system power source over ten years ago. RE is simply cheaper and more reliable than running a generator. Domestic RE businesses are growing so fast that they can barely keep up with the North American market's demands. Any entrepreneur bold enough to bring RE to places such as China is in for an exciting time.

It really seems to me that energy should be home grown. Both in the business infrastructure that makes the hardware available, and in the consumers of the energy. There is really no need to construct centralized power stations to the detriment of everyone's environment. Energy can be made on our roof tops and back yards using natural sources. RE production takes the power monopoly away from the utilities. This change is as revolutionary as the development of radio or the automobile. We have yet to realize the impact on our lives and societies. May we live in exciting times! — Richard Perez

Lifestyle

Okay — Just a moment of my raving is all you must put up with.

Alternative energy is only a small part of the many changes that need to be made in the "average" American lifestyle. Those folks that choose to live on the land need to do so with the least amount of impact possible. As a matter of fact, I believe the impact could be positive as well as negative. (Humans can repair eroded riparian systems they find themselves near.) Our noise can be more akin to that of the birds than to that of the bulldozers. *We can walk*. We can dig with a shovel. We can utilize our excrement to nourish the soil, rather than foul the water. Cities can be designed humanly — for life, not cars. People can live amongst wildlife, forests and streams even in cities. *We can walk*. We can eat our food fresh — yes, cities can grow food for the people.

I enjoy a life without clicks & buzzes, without whirring motors. I believe people should walk their talk as much as (humanly) possible.

People want to live forever & don't know what to do with themselves on a rainy afternoon.

I've ranted to you before. I appreciate very much the contributions that espouse a simpler lifestyle. I shudder & my skin crawls when people speak of 3,000 sq. ft. houses with the "works". 5.5 billion people cannot have that lifestyle.Sorry, it is impossible. But 5.5 billion people can have a much better quality of life if the 250 million Americans that live opulent lifestyles (materially) realize how good it would be to have less and at the same time have less stress, less worries, less health problems, and have more love, time, community & spirit.

P.S. I believe part of the reason that there is so much crime, hopelessness, depression and fear in this country is because of our worship of material goods (greed) and because a great many young people (especially) are calling bullshit on the system. Burying your guns to protect what you got, doesn't change anything. Peace to you all, Bruce Brummitt, RT1 Box 413, Ponsford, MN 56575

And peace to you, Bruce. I can draw you a schematic of how to wire your system, but I've no schematic of how to wire up humans. Greed and fear have been with us since fire was passed from hand to hand lest it be lost. I don't expect techie marvels like the photovoltaic module to instantly change ten thousand years of habit. If a person makes a decision to work on himself, then he makes this decision within himself. There is nothing that you can say, or I can print, that will make anyone look inside. When it is time, it happens. While we can't work on others, we can most certainly work on ourselves. — Richard Perez

More on Utilities Off-Grid

I wish to comment on John Wiles open letter in your Dec/Jan issue and the various comments throughout the issue to the contrary.

The problem seems clear to me and so obvious that I wonder if you are all aware of it and need not declare it. The Power Politics Column, page 68 demonstrates my point. The utilities are looking for their next source of power generation — nuclear is going out and if the green's (no pun intended) have their way the rest are going down.

Although not mentioned in the column, hydroelectric is certain to suffer from the salmon problem. One future source might be, fusion power, as the news this week (December 11) may indicate a breakthrough for fusion. I can see the future with vast expanses of the desert covered with PV arrays hopefully camouflaged for visual impact instead of being similar to the environmental impact of the wind power farms. The PV installations will have to account for the flora and fauna that may be endangered. As a science fiction buff I can see a story of a future with a high percentage of the earth's surface covered with PV arrays and its impact on the environment of relocating the sun's thermal input to distant cities.

If that is the distant future goal of the utilities — to use PV as a major source of grid power, then the legal problem of their monopolistic basis is covered. I agree that they have no right to be in competition in the present market. In fact I would see a class action suit as a possible way to fight this tendency — first through the state(s), and then the Supreme Court. I don't see a problem with their use of PVs for remote grid purposes.

I suggest that the IPPP, in agreement with John Wile's open letter, proceed immediately to join the utilities as a team and work together.

Let me congratulate you on your magazine. The only other that I read cover-to-cover is *Time*. Even my computer magazines are only scanned. I have two comments on the present issue. In the Power Politics Column, I disagree with the impact of the NAFTA agreement which is colored very green. I believe strongly in regenerative braking in the feature on page 52, but as an electrical/electronics engineer I deplore the author's lack if agreement between text and schematics. He uses detailed terminal nomenclature in the text, but the same terminals are not identified on the diagrams! Thank you for an interesting magazine, Gordon K Greene, 6565 E Beach Rd, Port Angeles, WA 98362-9715

Well, Gordon, I expect that the utilities would like to keep their present monopoly on power generation. And since RE is the power source of the future, they would like to have a monopoly on this also. What we're here to say is you can own it! And we're here to show you how.

The battle between RE dealers and the utilities is just beginning. I don't see these two factions making nice and joining forces. I figure that the RE dealers are the people's champions. After all, they are the only ones insisting on your right to own the sun. — Richard Perez

PV Power Energizes Innovation

Dear Home Power: Thank you for printing the article in *HP*#31 by N. Bleecker Green. The article about his Photovoltaic (PV) Power Station started ideas flowing at J. L. Stanford Middle School here in Palo Alto. We decided to build one similar to his for our school. Our Industrial Technology teacher, Brad Booth, wrote a grant proposal for the power station and our program received the funding necessary to build our project.

We recently finished building a power station similar to Mr. Green's and we have set it up so we use the power from the PV panel to charge two 12 Volt batteries. The power station is used to operate a few halogen lights, a 12 Volt fan, and motors that we plan to use in future projects.

This power station will be used to educate students about electricity and alternative energy solutions. Students will learn the difference between series and parallel circuits and about volts, amps, and ohms by reading instruments that are part of the power station. Students will learn that volt readings differ through the year, with the panel set at different angles to the sun.

Working with our power station has inspired the writing of a grant to build two solar-powered go-karts. Students helped write the grant, which was approved, and now we are in the process of planning the designs and ordering the parts. Our plan is that these vehicles will be able to be taken apart and put back together in different ways, like an erector set.

Thanks again for the inspiration *Home Power* has offered. We will write back when we are farther along the road. Sincerely, Dave Fidler, Eighth Grader, J. L. Stanford Middle School, Palo Alto, California

Speaking of inspiration, Dave, you just made my day. I'm looking forward to hearing more! — Therese Peffer

Q&A

Battery Exercising

I have recently installed a solar electric system in a weekend cabin consisting of one set of Carrizo QuadLams charging six Trojan marine batteries. My cabin is wired for both 12 Volt DC and 120 volt ac. My inverter is a Trace 812 without the charging option, my charge controller is a Trace C30A, and I monitor the system with a Cruising Equipment Co. Amp-hour+ meter. I use the system on average twice a week. With all lights on (compact fluorescent) I draw a maximum of 19.5 amps. I typically use 30-40 Amp-hours per stay, but have on occasion tested battery voltage drops by leaving all lights on eight or more hours. My system has never been below 12.3 Volts. It has been six months since installation, and I have never equalized the batteries.

Q 1 – Am I exercising my system enough with such limited use? Is it beneficial to occasionally max out the system, and if so how far down should I take the voltage and how often should I do this? Is my system out of balance with regard to storage versus panels?

Q 2 – With regard to equalizing my batteries, I have a 3500 watt generator, but am unsure about the reliability of available chargers. I have been told it makes sense to build my own gas engine and truck alternator. Could I just shut down the charge controller on a sunny day this winter? If so how many consecutive hours would it take to properly equalize under the voltage conditions I have described? Respectfully Submitted, Peter Brown, 591 Lighthouse Ave, Pacific Grove, CA 93950

Hello, Peter. In answer to Q1, Yes you appear to be getting the system fully charged without any additional equalization or discharge exercising. Lead-acid batteries do not benefit from exercising. The less you discharge them, the longer they will last. Since you didn't mention your battery's capacity in Ampere-hours, I can't say if your system is battery heavy. A very good indicator of proper charging is the battery's appetite for distilled water. If you are adding more than four ounces of water (per cell) every eight weeks or so, then the battery is being routinely overcharged and further equalization is unnecessary. If you are adding more water more frequently, then lower the voltage on the PV regulator because you are chronically overcharging the battery and this will shorten its life. If you are not adding at least two ounces of water to each cell every eight weeks or so, then you are undercharging the battery and need to equalize with your PVs or generator.

On Q2. If you are using an engine to recharge batteries, then the car alternator version beats the 120 vac genny and battery charger route. The car alternator setup is more efficient and gives much greater control, especially for equalization charges. Since your system experiences only part-time use, reset your PV regulator to equalize every six weeks if necessary. In most part-time use systems, simply setting the regulator properly (≈14.2 VDC for 12 Volt lead-acid systems) will eliminate the need for any additional equalizing charges. If you decide to do a special equalizing charge, then set the regulator at around 16 VDC and let the battery gas for a good five hours. The evolution of hydrogen and oxygen by the battery's cells is a very indicator of the cell's state of charge. These gases are where the lost water in the cells goes. If you never use water in the cells, then they are being undercharged. If the cells are always thirsty, then they are being overcharged. — Richard Perez

Phantom Load ?

In a recent issue of Home Power it came to my attention that electronically ignited gas ranges draw significant amounts of power when they are not being used (*HP*#37). I have some concerns about the health effects of propane combustion products in our super insulated home. Since the pilot light represents a significant portion of the propane consumption and can't easily be vented, I had considered the possible advantage of electronic ignition. I was surprised to learn that electronic ignition on propane ranges were phantom loads because we have been using a propane gas dryer with electronic ignition for years on inverter power (Trace 2012). The dryer does not keep the inverter on when plugged in. The sensitivity setting is set so an 11 watt PL light will activate the inverter. Why is one appliance a phantom load and not the other? Are there any electronically ignited gas ranges that are not phantom loads? Peter N Allen, 3209 Military Turnpike, West Chazy, NY 12992

Hi, Peter. Only some electronically ignited gas appliances are either phantom loads and/or major power consumers. It all depends on how the manufacturer designed the product. Consider an electronically ignited range. Some use a power supply to drive a transformer which makes the high voltage spark for gas ignition. Here the power supply is a phantom load, but at under 40 watts, not a major power consumer. Simply put the range on a switched power strip. Consider another range that uses a resistive glow bar (600 watts) to keep the oven lighted.

This range is not a phantom load, but is a major power consumer. Consider an electronically ignited range that uses solenoids and piezoelectric crystals. Such a range is not a phantom load, and is a miniscule power consumer. For such a piezo ignited stove contact the Peerless Premier Appliance Co., 119 South 14th Street, Belleville, IL 62222 • 800-858-5844 • 618-233-0475 • FAX 618-235-1771. Kathleen Jarschke-Schultze got one for Christmas. She loves it and Bob-O says it loves his PowerStar inverter. He measured a power draw of about 2 Watts during ignition which included the digital clock/timer.— Richard Perez

Regulating Panels

I have an ARCO M-65 self regulating PV panel. If you look in each J-box there is a diode. It looks like each end of each diode runs back inside the panel. Are these PVs wired different than the 30 cells in series? Can this panel be changed so it won't self regulate so much? Can this panel be paralleled with other non-self regulating PVs and still put out what it is rated at?

By the way, you put out a cool mag. The only thing I don't like about it is.....Well, I can't think of anything! Thanks, Steve Nagel, POB 343, Babbitt, MN 55706

Well, Steve, you are already getting all you can get from those modules. The diode you mentioned is a bypass diode and has no effect on the modules output. The bypass diode is just there to protect a single module if it is wired in with others in a high voltage array. The bypass diode does nothing in your 12 Volt system. The module has 30 series wired cells and that's that. Consider buying modules with 36 series cells next time. The higher voltage module is much more effective. You can parallel other full sized (36 cell) modules with your M-65s. While the M-65s will dog it on hot days and when the battery approaches full, they will still crank out the amps. — Richard Perez

Properly Grounding a Trailer

I keep thinking I should write and tell you how great your magazine is, how much it has helped me, and to please keep it coming. I have had these thoughts for years but never got around to it. Thank you, it's been extremely helpful, keep it up. So much for conscience!

What got me off my duff and onto the keyboard is this constantly nagging question that has bothered me from the first day I hooked up my solar panels. I've read everything you have written about the importance of proper grounding and am in full agreement with you for attached housing. Here's my snag. I live in a fifth wheel trailer. Since a trailer is insulated from the earth by nature of its rubber tires, is it a good idea to attach a ground to it, thereby making it an object to be attractive to lightning? Or should it be kept as insulated as possible? I have been attempting the latter by putting lumber under the leveling jacks. Nothing touching the earth is a conductor, therefore no path to ground.

I'm sure there is a "right" answer to the situation and am probably not the only person who wonders about these points. If you disagree with me, then you will also have to answer the "how do you ground a home that moves around"? P.S. I have been buying the magazine off the stand because it's cheaper than mail forwarding. It is much easier to find now. Thanks for your help, Edwin J Watts, POB 120, Cotati, CA 94931

It's a real problem, Edwin. It all depends on where you are and how long you are going to be there. If electric hookups are used, then they will be grounded and you will be too (through the 120 vac circuit). If the RV is attached to water hook-ups, then consider a water pipe as better ground than none. Use a heavy battery charger alligator clip and cable for temporary connection to the local plumbing. If you are going to be parked awhile without any hookups, then consider driving a ground rod and pulling it up when you leave. The most important place to ground inside the RV is the 120 vac distribution panel. A good ground in the proper place here will ensure safe grounding throughout a code-wired RV. Grounding an RV, aircraft, or boat is very different than grounding a home. What really counts is common grounding within the RV. If a good earth ground is available, then by all means use it. If not, then be comforted by the fact that grounding really doesn't protect you in the event of a direct lightning strike. It just lessens the probability of taking a direct strike. — Richard Perez

Schematic Help

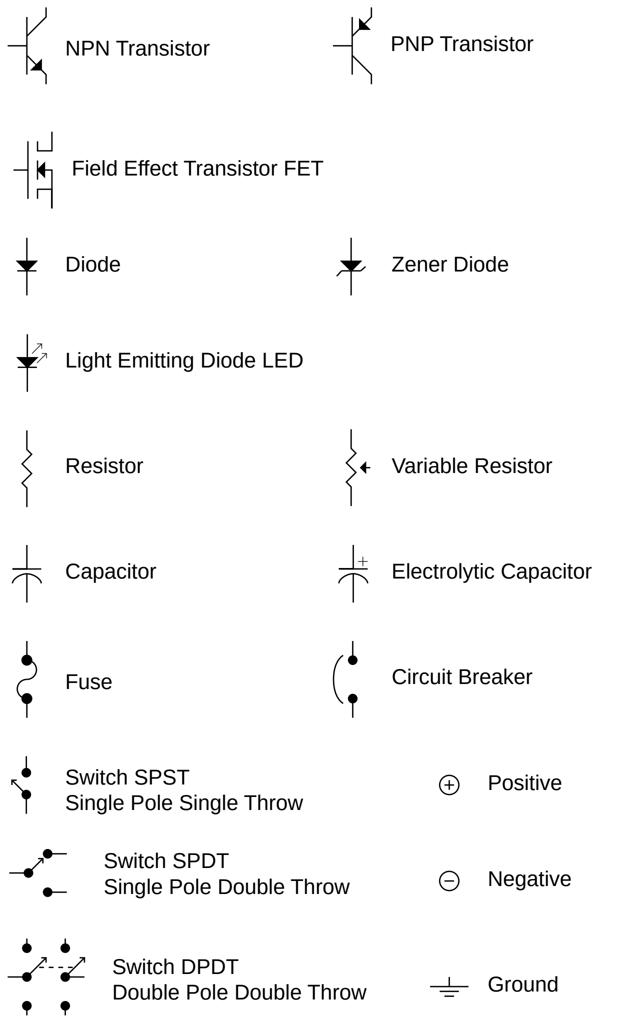
I decided to build a high voltage detector (Homebrew HP#33, pp. 80) to run a muffin fan to exhaust hydrogen from my battery room. I need help in ordering parts as I am not familiar with modern electronic components. I have a DigiKey catalog to order from.

Would you be willing to identify components by common name? For instance what is a 1N4001, LM 723, NE555, etc.? While I do recognize the symbols for resistors, capacitors and switches, I have no idea what the arrow with a curved line at its point is. Also, what is a MOSFET?

I think I will be able to wire up the unit following your schematic if all the parts were identified. Your help will be greatly appreciated. Lee Blake, HC30 Box 924, Prescott, AZ 86301

OK, Lee here is a graphic that identifies most of the schematic symbols. I also suggest anything that Forest Mimms ever wrote about homebrewing electronics. Most of his stuff is still available in any Radio Shack

Electronic Schematic Symbols



store. A 1N4001 is a silicon rectifier diode. An LM 723 is a voltage regulator integrated circuit. The NE 555 is a electronic timer integrated circuit. The curved line diode is a zener diode which is a special diode used as voltage references and to protect transistors from voltage transients. MOSFET means Metallic Oxide Semiconductor Field Effect Transistor. Don't be snowed by the electronics jargon. The average car is made with over 1000 different parts. The average electronics circuit is made from less than 20 different parts. Electronics homebrew is really much easier than it seems, and lots more fun than working on the gas guzzler. — Richard Perez

A Formula?

Congratulations; your magazine gets more informative each year.

The information from David Haaren in #31 about the amount of energy that is lost as heat was an eye-opener. I had read somewhere that car alternators were relatively inefficient. I suppose this is because so much energy is lost as heat.

The articles on hydro power are very interesting. I did some rough calculations comparing the overshot wheel system discussed in #37 and the "Stream Engine" in #30. Assuming that they both have the same head of water the overhot wheel seems to develop a lot more energy per cubic foot of water used. Unfortunately I realize that if I had to pay for a new overshot wheel and all the step-up pulleys and lay-shafts the cost would be much greater. This is a real pity as the overshot wheel is so beautiful to look at!

Keeping David Haaren's article in mind, could the efficiency of the "Stream Engine" be increased by using a different type of generator?

I have heard that any permanent magnet DC motor can be used as a generator. Is there any formula that would enable me to calculate the voltage and wattage output from the figures that are supplied with the motors? I have in mind using one, two or more automobile fan motors as generators, driven from the rear wheel of my bike (like the cover illustration of #31). Yours Sincerely, J. S. Marks, RR1, Woodslee, Ontario N0R 1V0 Canada

Hiya J.S., You are correct...sorta. The overshot, in THAT situation, does develop more energy per cubic foot of water than the turgo runner used in the Stream Engine™. An overshot wheel is designed and built (usually on site!) for a specific Head/Flow combination. The turgo runner in the Stream Engine™ will work (at varying degrees of efficiency) from 5 feet to 200 feet of head. At either end of that range, you gotta figure that your efficiency drops off quite a bit. Like most things, you have to use the right tool for the job.

If there's a formula to calculate the voltage and current output of a perm-mag motor run as a generator, I'm not aware of it. In any case, the formula would have to include the rpm the motor spun at. If you're looking to experiment, use a motor with a higher voltage rating than you are looking to get out of it. 40 to 70 VDC or even higher wold be a good place to start. Have fun! — Bob-O Schultze

Paralleled Batteries

I have a question concerning paralleled strings of storage batteries. What prevents circulating currents between the strings due to battery voltage variations from discharging the batteries? It would seem that a "weak" string would load down a "strong" string. This could be tested by removing the charging source and the load from the battery array and placing a current meter between strings. If in fact there is loss due to circulating currents, perhaps isolating diodes should be used to isolate the parallel strings. Battery isolators have been used to parallel batteries in marine and RV applications. What has been your experience here? Is this a problem? If this is not a problem then would parallel-series wiring each individual cell in a grid, as shown for solar panels on Figure 6 of *HP*#27, page 23 provide more output current?

Is Bobier Electronics the only manufacturer of a buck switching battery charger (LCB)? This technology is the no-brainer best way to go, as it converts otherwise wasted output voltage into additional charging current. It is equivalent to adding more solar panels without the added line loss. Linear chargers dissipate that energy as heat, and pulse width modulated chargers waste that energy by disconnecting the charging source.

I'd like to add a couple of thoughts on the tracked solar panel versus the 40% larger untracked solar panel debate that gives some advantage to the tracked array. Assuming that both configurations will provide the equivalent power, the tracked panels will do so at a lower peak current. Since, power losses due to wire resistance are proportional to the square of the current, a 40% increase in current results in double the wire loss! Also, since the tracker will provide a more constant current output over time versus the untracked panels, perhaps, more daytime load would be powered direct from the panels, avoiding the charge/discharge inefficiencies of the storage batteries. Thanks for your help, J Robert Warden, 4 Planet Ct, Fairfield, OH 45014

As far as I know Bobier makes the only LCBs. See Chris Greacen's homebrew in the last issue if you want to build your own LCB.

Weak cells can and do discharge healthy cells within a battery pack. Additional parallel wiring at like voltage points within the battery can reduce this problem, but the real solution is to replace weak cells.

When it comes to tracking, I'm sold. Most of the modules here at Agate Flat are tracked. Your analysis of the situation with regards to peak current is correct. — Richard Perez

Glossary

ampere: The ampere is the standard unit used to measure electrical current. Physically, the ampere is a measure of the number of electrons passing a given point per unit time.

ampere-hour: The ampere-hour is the unit of measurement of the electrical capacity of a cell or battery. Physically, it represents the number of electrons available from the cell or battery.

anode: The anode is the electrode within the cell which undergoes the chemical process of oxidation. Electrically, the anode is the cell's positive terminal.

battery: A battery is a group of interconnected electrochemical cells. Single cells are considered to be a battery if they are used alone.

capacity: Capacity is the amount of electrical energy a cell or battery contains. The ampere-hour is the unit of this capacity.

cathode: The cathode is the electrode within the cell which undergoes the chemical process of reduction. Electrically, the cathode is the negative terminal of the cell.

cell: The cell is the basic unit used to store energy in the battery. The cell contains an anode, a cathode, and the electrolyte.

charge controller: A device which modifies the current flowing from a power source to the battery to prevent overcharging.

current: The flow of electrons measured in amperes. Direct Current (DC) refers to a constant flow of electrons in one direction. Alternating current (ac) refers to a flow of electrons that reverses direction at regular intervals.

cutoff voltage: The voltage level at which a cell is considered to be empty, and the discharge process is terminated.

cycle: A cycle is one complete charge/discharge sequence of the battery.

cycle life: Cycle life is the number of cycles a cell or battery will undergo before being considered "worn out". This point is usually defined as when the battery's capacity has reached only 80% of its initial rated capacity.

deep cycle: A battery or cell is said to be "deep cycled" if 80% or more of its energy is withdrawn before recharging.

depth of discharge: The amount of energy withdrawn from a battery or cell expressed as a percentage of its rated capacity.

electrolyte: The electrolyte is the medium of ion transport within the cell. The electrolyte provides a path for electron transfer between the anode and cathode of the cell. Electrolytes are usually liquids or pastes, which are either acidic or basic.

end of charge voltage: The voltage level at which a cell or battery is considered, while under charge, to be full.

equalizing charge: The equalizing charge is a controlled overcharge of an already full battery to restore all the individual cells within the battery to the same state of charge.

float service: A battery is in float service when it is continually charged at a very slow rate, and only occasionally discharged.

gassing: Gassing is the evolution of hydrogen and oxygen gases at the cell's electrodes. These gases result form the hydrolysis of water in the electrolyte during the charging process.

hydrometer: The hydrometer is an instrument for measuring the density of liquids in relation to the density of water. The hydrometer is used to indicate the state of charge in lead-acid cells by measuring the specific gravity of the electrolyte.

ion: An ion is an electrically charged particle or molecule.

inverter: An inverter is a device which converts a direct current input (typically 12 or 24 Volt DC) to alternating current (in the U.S., 120 volts ac at 60 cycles per second).

phantom load: An appliance or load which appears to be "off" when not in use, but is actually consuming power is called a phantom load.

photovoltaic module: A PV module consists of series-wired "cells" made from layered silicon crystals that convert light energy to DC electricity.

primary cell: A primary cell is an electrochemical cell which cannot be recharged. The chemical process within the primary cell is only one way — discharge. When a primary cell is discharged it is discarded.

rate of charge: The amount of energy per unit time that is being added to the battery. Rate of charge is commonly expressed as a ratio of the battery or cell's rated capacity to charge duration in hours.

regulator: A regulator is a device used to modify the input of power from the power source (photovoltaic, wind, or hydroelectric) to the battery so that the battery is not overcharged.

resistance: Resistance is the property of materials to impede a flow of electrons through themselves. All materials have some resistance. Those of low resistance are known as conductors, while those of high resistance are known as insulators. The unit used to measure resistance is the Ohm (Ω).

rest voltage: The voltage of a cell or battery that is neither being charged or discharged.

secondary cell: Secondary cells are electrochemical cells which are rechargeable. The chemical reaction within the secondary cell is reversible, allowing the cell to be recharged many times.

self-discharge: Self-discharge is the tendency of all electrochemical cells to lose energy. Self-discharge represents energy lost to internal chemical reactions within the cell. This energy is not and cannot be used from the battery or cell's output terminals.

shunt: verb: to divert electrical current to a parallel load. noun: A resistive load through which electricity is diverted. A device with precisely known resistance used to measure current. Since the resistance is known, the voltage measured across a shunt will accurately describe the amount of current moving through a shunt using Ohm's law (current = voltage/resistance).

state of charge: State of charge is a ratio, expressed in percent, of the energy remaining in a battery in relation to its capacity when full.

sulfation: Sulfation is the formation of lead sulfate crystals on the plates of lead-acid cells. Some of these crystals are bonded in a covalent manner and are impossible to re-ionize during recharging. As such, they represent a loss in capacity to the cell.

volt: The volt is the unit used in the measurement of the electromotive force. A standard electrical definition of the volt is: an electromotive force of 1 volt is necessary to move a current of 1 ampere through a 1 Ω resistor.

watt: The watt is the unit used to measure power. In electrical terms, it is a volt-ampere.

watt-hour: The watt-hour is the unit used to measure energy. A watt consumed or produced over one hour equals one watt-hour of energy.

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Alternative Energy Engineering — 1
Alternative Power Renewable Energy Center — 70
American SunCo — 85
Ample Power — 61
Ananda Power Technologies — 43
Aprotec — 91
Arizona Public Service Co. — 25
ATN Back Issues — 93
BackHome Magazine — 57
Backwoods Solar Electric Systems — 52
Bergey Windpower — 31
Brasch Labs — 66
C. Crane Company — 90
Carrizo Solar — 24
Cloud Software — 70
Cruising Equipment/Heart — 5
Direct Power & Water Corp. — 51
Electro Automotive — 96
Electron Connection — IBC
Energy Outfitters — 88
Energy Systems & Design — 76
Exeltech — 56
Florida Solar Energy Center — 89
Fowler Solar Electric — 67
Fran-Mar Alternative Energy — 73
Go Solar — 88
Grass Valley Solar and Wind — 104
Harris Hydroelectric — 57
Heaven's Flame — 91
Heliotrope General — 60
Hitney Solar Products — 30
Home Power Back Issues — 93
Home Power Biz Page — 81
Home Power Sub Form — 81
Hydrocap — 83
Kansas Wind Power — 77
KTA — 61
Kyocera America — 30
Lake Michigan Wind & Sun — 91
Lil Otto Hydroworks — 80
Marlec Engineering — 72
Midway Labs — 70
NESEA — 89
Northwest Energy Storage — 85
Offline — 67
Ozark Renewables — 90
Photron — 57
PowerStar Products — 73
PV Network News — 12
Read your mailing label — 31
Remote Measurement Systems — 92
S&H Alternate Energy — 80
Sanderson's — 69
Simmons Handicrafts — 91
Skyline Engineering — 30
Snorkel Stove — 73
Solar Depot — 13
Solar Electric Inc. — 91
Solar Energy International — 76
Solar Pathfinder — 67
Solar Tech — 66
Solarex — IFC
Solec — 19
SoloPower — BC
Southwest Windpower — 66
Star Power Solar Energy — 56
Statpower — 39
Sun Frost — 80
Sun Selector — 12 & 18
Sunelco — 47
Tecnologia Solar — 89
Tek-Tron — 24
Trace Engineering — 60
Trojan — 39
Vanner — 52
Wattsun (Array Tech Inc.) — 70
Wind Baron — 61
Windy Dankoff, PVSS — 73
Winter REading Special — 97
World Power Technologies — 85
Zomeworks Corp. — 67