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HOME POWER
THE HANDS-ON JOURNAL OF HOME-MADE POWER
ISSUE # 23
JUNE / JULY 1991
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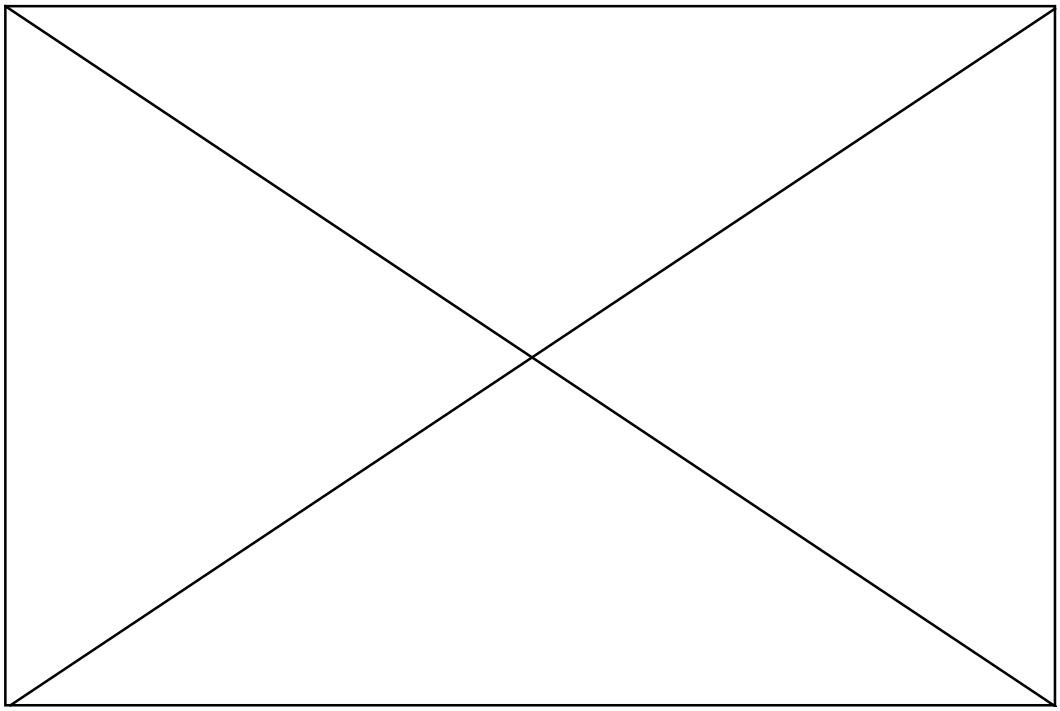

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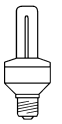

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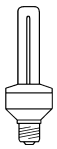

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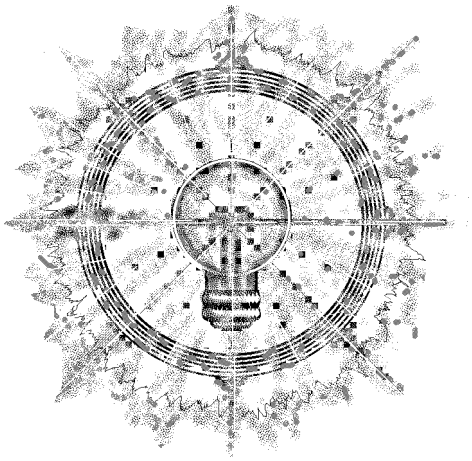

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Contents

- **From us to YOU– 4**
  Freedom direct from the source
- **From us to YOU– 4**
  People & Legal Stuff
- **Hydroelectric– 6**
  UltraLow–Head Hydro
- **Systems– 12**
  PVs, Yes. Seabrook, NO!
- **Fuel Cells– 16**
  Power source of the '90s
- **Photovoltaics– 20**
  How PVs are rated.
- **Health & Environment– 24**
  ElectroMagnetic Fields
- **Wind– 32**
  Wind Generator Towers
- **Photovoltaics– 37**
  How PV cells work
- **Photovoltaics– 40**
  PV Module Rating
- **Photovoltaics– 42**
  Pond Areation
- **Muscle Power– 48**
  Pedal Power
- **Energy Fair– 50**
  SEER '91, Willits, California
- **Subscription Form– 51**
  Subscribe to Home Power!
- **Inverters– 53**
  How inverters work
- **Things that Work!– 58**
  High Lifter Water Pump
- **Efficient Appliances– 61**
  Washing Machines II
- **Energy Fair– 64**
  Midwest RE Fair, Amhurst, WI
- **Electric Vehicles– 66**
  Solar & Electric 500
- **Homebrew– 69**
  Five projects from HP Readers
- **Code Corner– 74**
  The NEC and You
- **Good Books– 76**
  Renewable Energy Reading
- **Home & Heart– 79**
  Washer & Vacuum Stuff
- **Happenings– 81**
  Renewable Energy Events
- **the Wizard Speaks– 84**
  Free Energy Update
- **Writing for Home Power– 84**
  Share your info!
- **Letters to Home Power– 85**
  Feedback from HP Readers
- **Q&A– 91**
  A manner of techie gore
- **Ozonal Notes– 94**
  Our Staph gets to rant & rave…
- **Home Power's Business– 95**
  Advertising and Sub data
- **Home Power MicroAds– 96**
  Unclassified Advertising
- **Home Power Mercantile– 98**
  Advertising and other stuff
- **Index to HP Advertisers– 98**
  For All Display Advertisers

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Think About It

"We should all be concerned about the future because we will have to spend the rest of our lives there."

Charles Franklin Kettering.
1876 – 1958

Cover

A Trump hydro turbine operating at thirty-six inches of head. This turbine has been producing over 100 KWh daily since 1981. Story on page 6.

Photo by Cameron McLeod.

From us to YOU

Freedom's just another word for nothing left to burn…

We've been burning things for aeons. We were burning before we could speak. Our friend fire was a good servant, but has become a hard master.

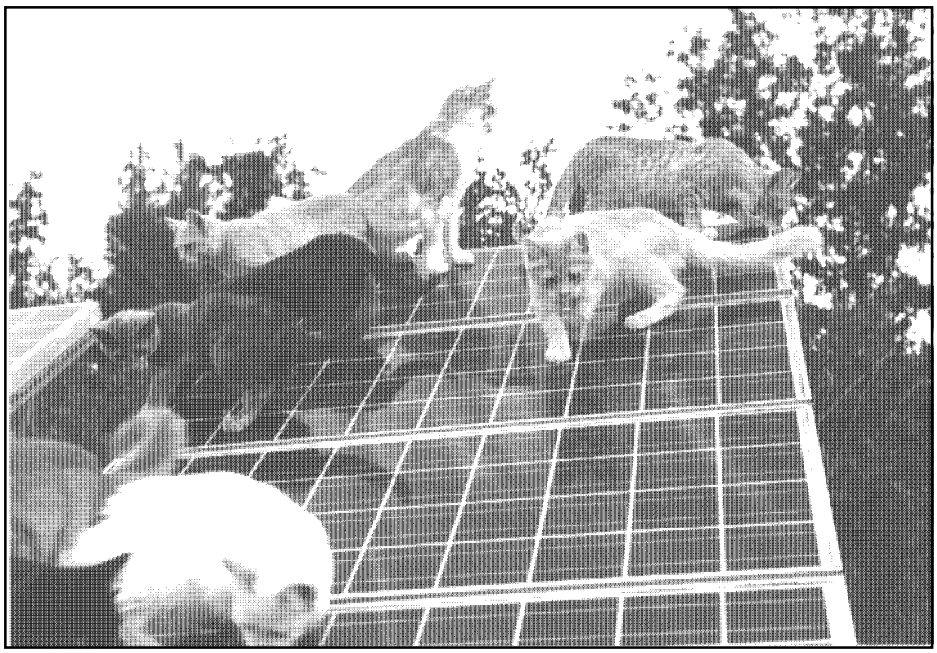
Burning is just releasing stored solar energy. Whether it is oil, coal, natural gas, or wood, it all started out as sunshine. Even wind and rain are fueled by sunshine.

Photovoltaics burn sunshine. Wind and hydro turbines burn sunshine. Solar heaters and cookers burn sunshine.

When we burn sunshine, we go directly to the source. We do away with the thousands of years needed to make oil, coal and natural gas. We do away with the hundreds of years to make a tree. We short circuit the entire energy chain and go directly and immediately to the source. By tapping the source, we bypass middlemen, pollution, and greed. Our friend fire has indeed shown us that dead dinosaurs smell after several million years. Energy is like many perishables, it's best used fresh.

Nature smiles when we accept her greatest gift, Springtime Sunshine, as she offers it.

Richard Perez



Above: different forms of solar energy meet and greet each other.

People

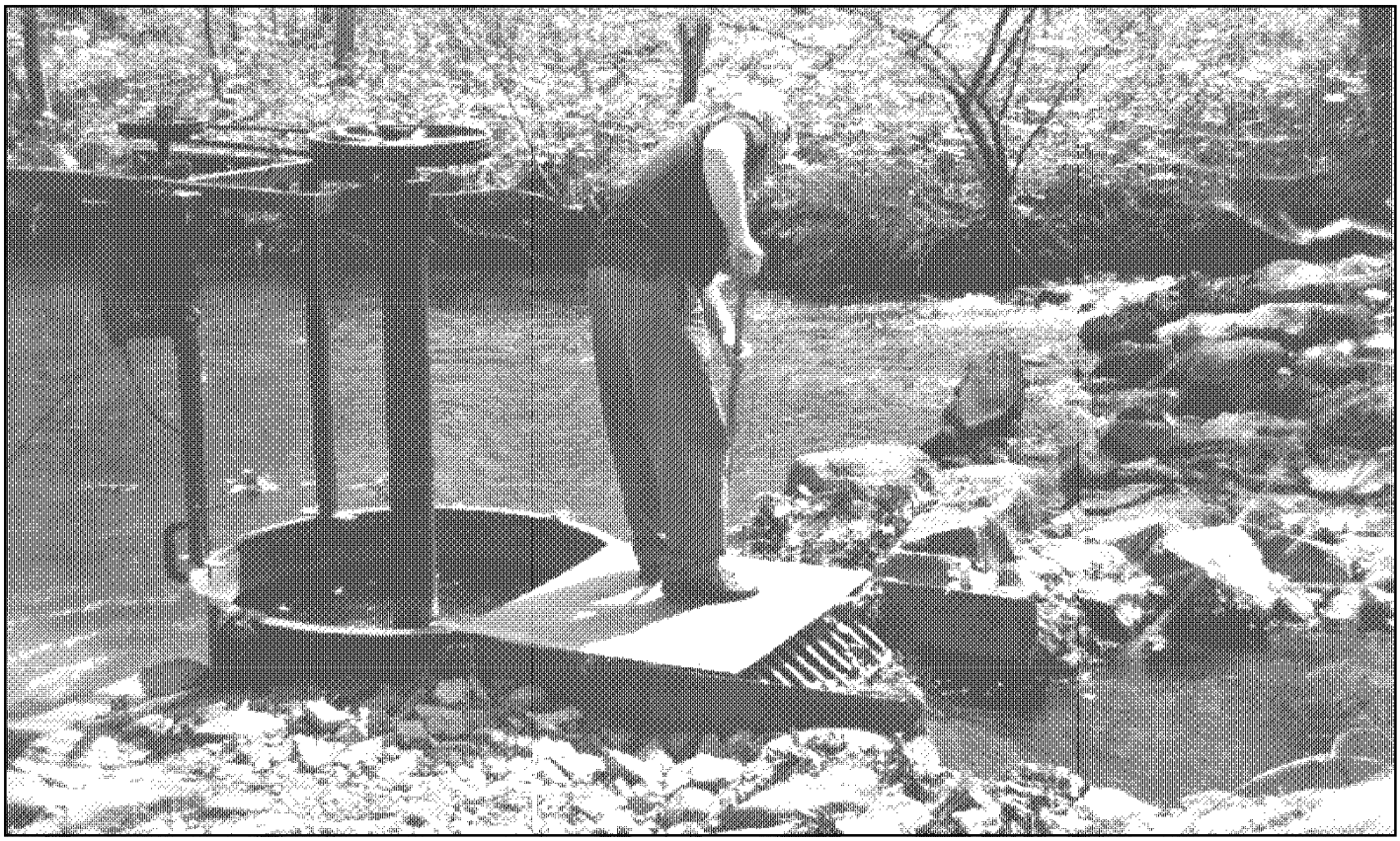
Dianne Burgess
Sam Coleman
Jeff Damm
Gerhard Dekker
Scott Ely
Jim Forgette
Chris Greacen
John Hill
Paul Hodgdon
Kathleen Jarschke-Schultze
Jonny Klein
Stan Krute
Crissy Leonard
Clifford Mossberg
Quintin Myers
Ken Olson
Cameron McLeod
Karen Perez
Richard Perez
Shari Prange
Mick Sagrillo
Tami Schneck
Bob-O Schultze
John Takes
Michael Welch
John Wiles
Robert Wills

Printing

RAM Offset, White City, Oregon

Cover 50% recycled (40% pre-consumer, 10% post-consumer), low chlorine paper. Interior is recyclable, low chlorine paper. Soybean ink used throughout.

TRACE
FULL
PAGE
AD



Above: Abe Lewisburger cleans out the trash racks of prototype "Portable" low head hydroelectric plant. Turbine Specs: 22 inches of head drives a 24 inch diameter C.M.C -Fitz vertical axis francis turbine developing 3 Amperes at 130 Volts DC or 9,360 Watt hours per day. This turbine discharges 520 cubic feet of water per minute at 70 RPM. Photo by Cameron McLeod.

Ultra–Low Head Hydro

Cameron MacLeod, N3IBV

One hundred years ago low-head hydro wasn't just an alternative; it was the best alternative. Unlike high-head sites, low-head sites are everywhere, and often closer to population centers where the power is needed. Power sources were valuable and sought after, because cheap power wasn't delivered through silent wires down every street. Local wars were fought over water rights.

The History of Low Head Hydro

Times have changed, but the weight of water and gravity remain the same. Once we had over two hundred makers of small water turbines in the U.S.A. Some of them built, by 1875, equipment that was 80% efficient. They built and inventoried turbines as small as four inches in diameter that made one horsepower on ten feet of head. Turbines that ran on two feet of head and made from one to fifteen horsepower were common. Some were excellent machines that ran with little maintenance for years. The know-how and hardware were everywhere. In the eastern part of America, the power of the small streams near populated areas was developed and put to work. All the way from the hills to the sea, this water was used over and over again wherever topography supplied enough head. One large stream in the east had dams and still has

pre-revolutionary deeded water rights wherever early settlers found three feet of head.

When ships landed on the east coast, surveyors and mapmakers headed inland to discover natural resources. All the old maps denoted power sites as "Mill Seats" long before settlers arrived. This was before the successful use of stationary steam engines, so we know that they were referring to hydro power. Later, towns grew because of this power. Virtually every sort of agricultural and industrial work was once aided by the water. It is sad that the water source of power is often blamed today for the mess that industry left behind. In this age of environmental awareness, we should not throw out the turbine with the wash water.

Back when power was valuable, men moved hundreds of tons of earth and rocks with just their backs, mules or oxen. Often they made this investment & did this work with their bodies for the sake of one or two horsepower. Wow! Think about it. Something was going on there. If you think they were nuts, then look at the size of the manor houses and mills that were energized with those one or two horsepower. Then think about what clean renewable power in your backyard is really worth to you - and your children - and your grandchildren - and on and on - forever.

Of course power has gotten cheaper and cheaper in the last hundred years. By burning non-renewable fossil fuels at the expense of the earth and our futures, they practically give it away. I can hear you now - what's this jerk talking about. The only ones that really know the value of power are the people who have tried to make power for themselves. If your goal is to supply your daily energy needs; you either know how cheap commercial power is or you're going to find out. My position is not to discourage you, just to warn you. Pursue your dream. If you can't visualize it it will never happen.

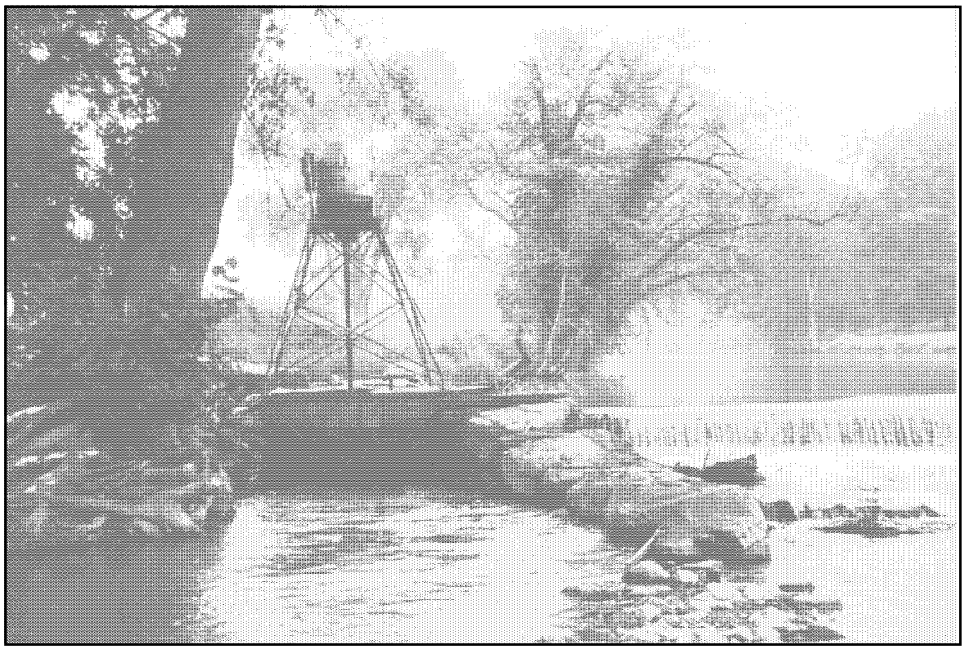
Over the past ten years, I've helped to develop twenty or so small hydro sites. I've gone on to bigger megawatt hydros now, because I need to make a living. The small sites range in power from 300 Watts to 100 kW. Almost all of this work has been under fifteen feet of head. The power has been utilized to run homes and small businesses or more commonly, large farms. All the projects were former sites with dams in one state of repair or other. The legal aspects of these undertakings have been handled by the owners and often represent the greatest problem.

Hydros and Red Tape

If your home power system isn't on federal land, doesn't hook to the grid, and doesn't make power from a navigable stream; then you may not need a federal license. There is no legal way to avoid dealing with a state agency. Watch out - often this destroys dreams. You had better base your work on an existing dam or a pile of rocks no more than 36 inches high called a diversion wier. Remember not a dam, but a wier. That diversion had better not be long in either case if you hope to stay within environmental laws. In all cases you had better own both sides of the stream. These problems will vary from state to state. You must learn through research. Have enough sense to keep your own council (keep your mouth shut about plans) until you figure out which way the water flows.

Low-Head Hydroelectric Turbines

My goal here is to let home power people know that under just the right circumstances low head hydro is possible. Practical - that's your judgement. It will depend a lot on what you consider to be valuable. That is to say, your values. How much your alternatives cost matters too.



Above: a 30 inch Trump turbine operating at 36 inches of head. This turbine produces 35 Amps at 130 Volts DC or 4,550 Watts of power. It has been in operation since 1981. Photo by Cameron McLeod.

Despite all this red tape nonsense many people have successfully established low-head hydro systems. I'll detail a couple of sites to whet your imagination. First, you should understand that very little has been written about low-head hydro in the last fifty years. By 1915, development had shifted from small diverse sources of power to large centralized systems based on alternating current and high voltage distribution. Giant government-backed utilities were beginning to carve up the country into dependent territories. Starting with the cities and industrial areas they stretched their wires out into the country. By the 1930s, rural electrification was well under way. Many utilities forced their customers to take down their wind machines and remove their turbines before they could hook up. Big customers were bribed with no cost changeovers from D.C. to A.C.. Along with the gradual loss of public self-reliance, the end result for the hydro power machinery business was that the market for small turbines disappeared. So did the manufacturers. Several companies made the transition to giant utility grade equipment into the 1950's. Now they are gone too. None of the biggies are U.S. owned.

There are a few crazies like myself who still build small machines. Most backyard operations concentrate on pelton and crossflow turbine which are only suitable for high head (depending on power requirements). I build Francis and Propeller type turbines. They are expensive, hand-built machines that don't benefit from mass production. They will, however, last a lifetime with only bearing changes. This is a tall order because everything must be constructed just right. I approve all site designs before I'll even deliver a turbine. I personally design most systems.

Often a better way to go involves rehabilitating old equipment. Some hydros were junk the day they were built. Other makers really knew their stuff. Their quality and efficiency are tough to match even today. These machines are usually buried under mills or in the banks of streams. Go look, you'll find dozens. The trick is to know which one you want, so do your homework before buying an old turbine.

A Low-Head Hydro System

One site that depends on a rehabilitated machine belongs to a farmer named George Washington Zook. George decided not to use commercial power in 1981. He had deeded water rights and the ruin of a dam on his property. Best of all he had lots of water, and incredible determination, common sense, and know-how. He only has thirty-six inches of head. I supplied him with a thirty inch diameter vertical axis Francis type turbine. This turbine was built by Trump Manufacturing Co. in Springfield, Ohio around 1910. One of the good ones. George was 25 years old when he finished the project.

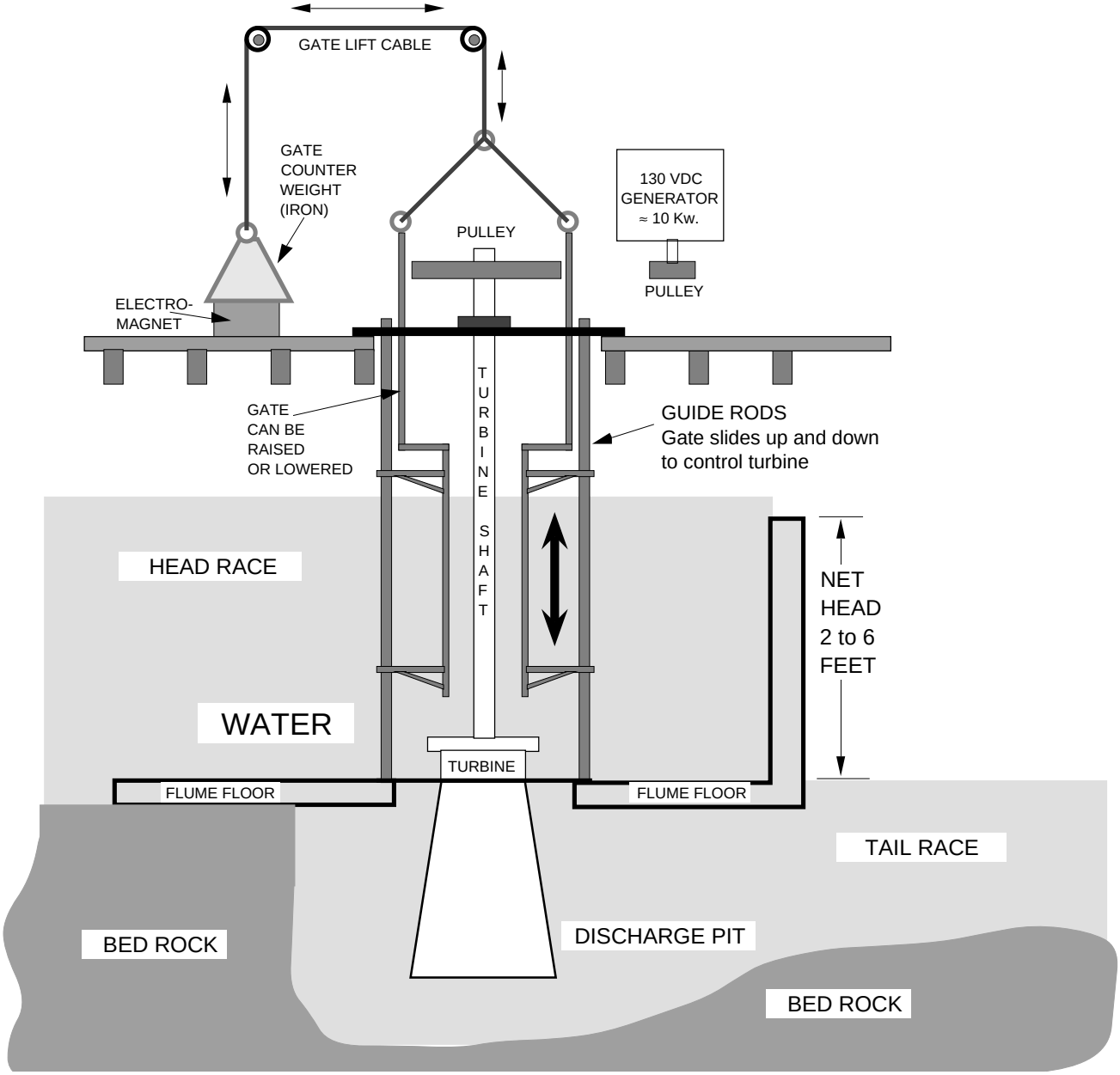
George got all the required permits and built a sixty foot long, 36 inch high, log dam with a wooden open flume for the turbine at one end. He installed the turbine with a generator mounted on a tower to keep it dry in high water (never underestimate high water). Four months later his dam washed out. One year later he re-built and started generating 130 Volt D.C. power. Yes, high voltage D.C.. His machine develops 35 Amps @ 130 Volts or 840 Ah/day or 109.2 kWh/day. Discharge is 2358 c.f.m. (lots of water) @ 96 r.p.m.. He has a 90 series cell, 240 Amp-hr. nicad battery pack. This represents an incredible amount of power for any home power system. That is 32,760 kWh a month. Hey, that's enough power to run three to five average American homes. All of this on 36 inches of head. Yeah, that's right, and his battery pack lets him meet 20 kW peaks. Here is what his load looks like : three freezers(two for the neighbors),a refrigerator, refrigeration to keep the milk from twenty cows cold, a vacuum system to milk these cows, two hot water heaters, all lighting in home, barn and two shops, occasional silage chopper use, wringer washer, water pump, iron and farm workshop machines. I'm afraid it still goes on, his nephews put in a complete commercial cabinet shop two years ago. They have all the associated equipment including a 24-inch planer. Well, now what do you think about low-head hydro?

There are a few key differences between George's system and most you read about. There isn't an inverter on the property. At 120 volts D.C., line losses are at a minimum (We have some 220 volt three wire systems operating). All of the equipment and machinery on the farm was converted to 120 volt D.C. motors, including refrigeration. The high efficiency of this approach makes all the difference.

AC versus DC Hydros

Stand alone A.C. is a possibility, but it requires a larger turbine and more year round water to meet peak loads. The cost of an electronic load governor and the inefficiency of single phase induction motors are two of the drawbacks to consider. Backup generator cost is also a factor. You'll need a big one to meet A.C. peak loads. With batteries to meet peak a small generator will suffice.

Remember, if you can meet 20 kW. peak loads with batteries it only takes one horsepower 24 hours a day to run the average American home. This is a tiny turbine that



uses little water when compared to the 40 horsepower turbine on the same head that would be needed to meet the same peaks on conventional A.C.. Forget it - there is no comparison. The big machine would cost a fortune and require massive amounts of water. Hey, it is possible, I've built them.

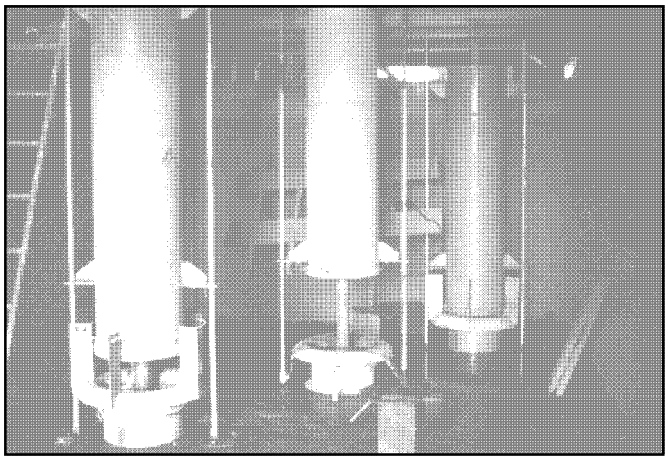
The best of both worlds would have the lighting and heavy motor loads on 120 Volt D.C. for efficiency. It would have a switching power supply running on 120 Volts D.C. putting out high-current 12 or 24 Volts D.C. to run an inverter for specialized A.C. loads like TVs and stereo systems.

Some Low-Head Hydro System Specs

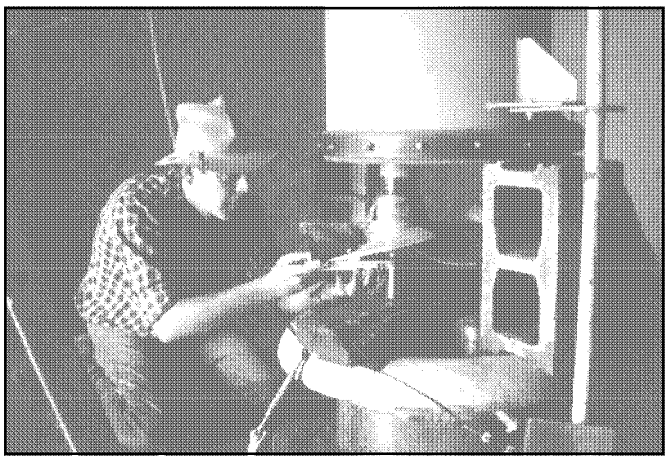
Here are the pertinent details on some-stand alone D.C. low-head hydro sites that I've been involved with:

System 1

5 feet of head - 8 inch MacLeod-built C.M.C. vertical Francis-type turbine develops 3 Amps @ 130 Volts or 72 Ah/day or 9.36 kWh/day. Discharge is 72 cubic feet of water per minute @ 335 r.p.m.. Note: The term vertical implies a vertical main and gate shaft which extends above flood level to protect generator and electrics.



Above: three Conastoga propeller turbines that operate on 7 feet of head. Each turbine produces 5,000 Watts at 470 RPM. This photo shows the head race which is filled with water when operating. Note the Gates and Gate Rods.
Photo by Cameron McLeod.



Above: Cameron McLeod inspects the propeller on one of the Conastoga turbines.

System 2
22 inches of head - 24 inch C.M.C -Fitz vertical francis develops 3 Amps @130 Volts or 72 Ah/day or 9.36 kWh/day. Discharge is 520 c.f.m. @ 70 r.p.m..

System 3
Three feet of head - 30 inch Trump Vertical francis turbine develops 35 Amps @ 130 Volts or 840 Ah/day or 109.2 kWh/day. Discharge is 2358 c.f.m.@ 96 r.p.m..

System 4
Fifteen feet of head - 8 inch MacLeod built C.M.C. vertical Francis turbine develops 12 Amps @130 Volts or 288 Ah/day or 37.4 kWh/day. Discharge is 130 c.f.m. @ 580 r.p.m..

System 5
Four feet of head - 27 inch S. Morgan Smith vertical Francis turbine develops 28 Amps @ 250 Volts or 672 Ah/day or 168 kWh/day. Discharge is 2190 c.f.m. @123 r.p.m..

System 6
Ten feet of head - 12 inch C.M.C. vertical Francis turbine develops 15 Amps @130 Volts or 360 Ah/day or 46.8 kWh/day. Discharge is 244 c.f.m. @ 320 r.p.m..

Low-Head Hydro Information
Getting info on low-head hydro isn't easy. Virtually nothing of any technical merit has been published since 1940. Watch out for crazies and experts who try to re-invent the wheel. It is un-necessary and wrong-minded. It has all been done and done well. Go find the data. Rodney Hunt Manufacturing published some of the best information between 1920 and 1950. They also built great machines. They no longer build turbines. Their books are out of print. Find them in engineering school libraries or museums that specialize in early industrial technology. Turbine makers catalogs from 1880 to 1920 were in fact engineering manuals, some better than others. Look for them. I haunt the old book stores. Go for it.

Books to look for :
Power Development Of Small Streams, Carl C. Harris & Samuel O. Rice, Published 1920 by Rodney Hunt Machine Co., Orange Mass.

Rodney Hunt Water Wheel Cat. #44 - THE BEST. Check out the Engineering section.

Any catalogs printed by : James Leffel Co., S. Morgan Smith Co. , Fitz Water Wheel Co., Holyoke Machine Co., Dayton Globe Manufacturing Co..

Construction of Mill Dams, 1881, James Leffel and Co. Springfield, Ohio. Reprint; 1972, Noyes Press, Park Ridge N.J.,07656.

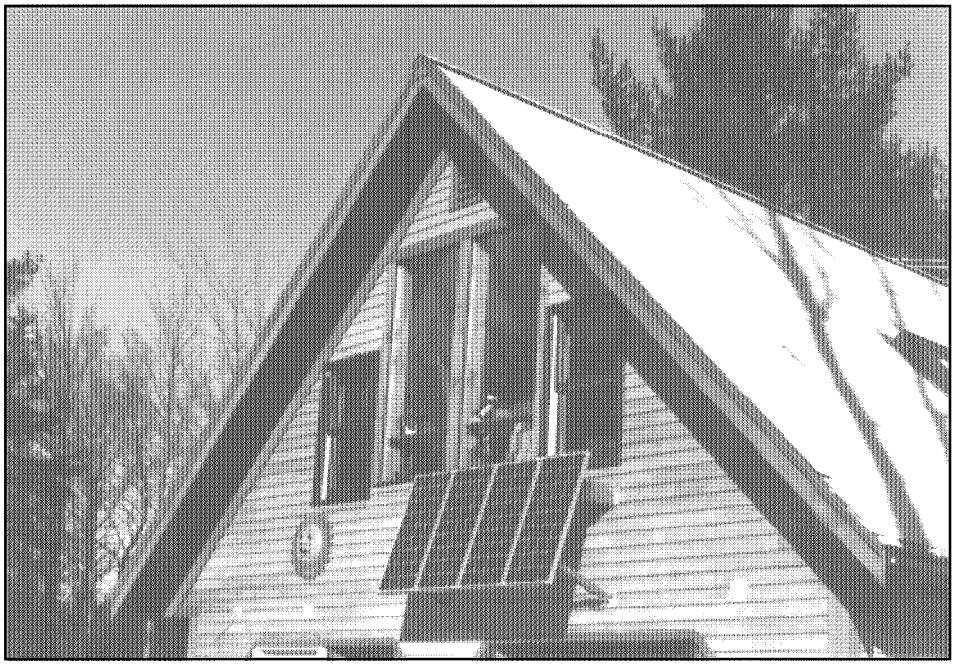
Some words of encouragement…
Well people, I hope I've opened the door to stand-alone, low-head hydro for a few of you. If you really want the details you've got some long hours of research ahead of you. If you are determined to get on line, I wish you the best. Watch out, it is harder than building a house from scratch. It can be a real relationship buster. I believe it has as much merit as any effort at self-reliance one can undertake. Good Luck!

Access
Author: Cameron MacLeod N3IBV, POB 286, Glenmoore, PA 19343 • 215-458-8133.

PVs, Yes! Seabrook, No!

Paul Hodgdon and Dianne Burgess

When I bought this land in New Hampshire, I knew that the house I'd build on it would get its electricity from the sun. The power line runs right by the driveway, but the Seabrook nuclear power plant is on the other end of that extension cord. I've known since the early 70's that I would use renewable energy, because too many spokesmen were saying solar energy "is not yet feasible."



The House

My wife, Dianne, and I built the house by ourselves– the only things we hired out were the excavation, plumbing, and well drilling. We made concrete forms for the footings and kneewalls, framed, roofed, wired, insulated, sheetrocked– you name it, we did it. In the beginning, what we were erecting was the 24' x 28' garage of our yet-to-be built house. I wanted to have the garage as storage and shop space for the house construction. We changed plans once we had the roof on, and felt the sun shining in the south end. We were living in a two-room, barely insulated apartment, and paying an additional $150/month to keep it at 55° F. with electric heat.

Our long-range plans still include an attached breezeway and house, but we decided to make the garage liveable and save some bucks. On the inside, you'd think it's a normal house. When the time comes, however, the downstairs will actually convert back to a garage quite easily. Until then, it makes a mighty comfortable home for the two of us– the most comfortable we've ever lived in.

Our System

We assembled our system over a two-year period, so I'll describe the components in the order that we acquired and integrated them.

Batteries

While living in Santa Fe, NM in 1983, I called Windy Dankoff and offered to volunteer for a few weeks at the Windlight Workshop. It was fun, but I got the better end of the deal because I got to pick Windy's brain each day. One of the many things he enlightened me about was the possibility of obtaining batteries from phone companies. I called a solar friend back in New Hampshire with this info, and put him to work asking around. To make a long story short, we both got our batteries cheap from a company that was switching over from rotary-dial to touch-tone, and replacing their batteries. My friend (and now neighbor) is, of course, indebted to me for life! Unfortunately, this great use of second-hand batteries has now become almost impossible nowthat EPA regs require phone companies to document the proper disposal of their batteries.

I ended up with twenty-four, 840 Ampere-hour, 2 Volt Exide lead-acid cells. I stored the cells at a friend's house and left a small automotive trickle charger on them. I would check them every few weeks and record the voltage of each cell. I saw great potential for these not-so-little cells (each one must weigh over 120 lbs.): they were the first acquisition toward our owner-built

home. When the time finally came to begin building, I then moved the batteries to the site, and put a tarp over them. Then came our next two purchases…

Inverter and generator
The Trace 2024 is a terrific inverter, and I highly recommend two options for it: The standby (charger) option is a natural choice if you'll ever need a 120 vac powered battery charger; and I find the digital voltmeter (DVM) indispensable. When pushed, four buttons on the front of the inverter will indicate: 1) battery voltage, 2) charge rate, to the tenth of an amp, 3) input cycles-always good to know how close the generator is to 60 Hz., and to adjust its RPM if necessary, 4) peak ac voltage of input.

I bought our Coleman 4000 watt ac generator with a Tecumseh 8 h.p. engine, at a department store for $400. It's a good no-frills generator for the money.

What a great way to have power at the site! Most of the time we worked in silence as the inverter ran the saws and drills. We started the generator as we left for the day and it would charge the batteries for two hours, until it ran out of gas. Of course, I'd run the generator if I was making frequent cuts, such as for the rafters. Once the roof was on, the batteries were moved inside. Time for the next addition to the electrical system…

Control Board
Next came the Square D load centers, fused disconnects, and other hardware for the control board. I was helped in the design and selection of disconnects by Peter Talmage of Talmage Engineering in Kennebunkport, Maine (you know, where George and Barbara Bush go to recreate. From his cigarette boat, George could see Peter's wind generator if he'd only slow down and look.)

In particular, Peter set us up with the really neat fused disconnect (Square D Cat. #D-323N). This one box does three jobs: 1) 100 amp disconnect between batteries and inverter, 2) 100 amp disconnect between batteries and 24 VDC load center, and 3) 40 amp disconnect between batteries and array.

The 323N isn't cheap at $180, but using this one safety switch costs less than using three separate units. It also keeps the control board simpler in appearance. Peter adds a nice service: before shipping the box, he labels where each cable will go. That's a great idea and gives peace of mind that you're doing things correctly. We wanted the control board to be bright, neat, and orderly so that it's easy for visitors to understand as we explain our system. We plan on adding some graphics onto the white background to further help visitors (such as a sun painted behind the array wires).

House Wiring
I wired the house with 12-2 wire with ground. We don't use any DC items that draw more that a couple of amps, so 12 gauge was of sufficient size. Plus, with such a small house, there are no excessively long wiring runs. The AC outlets and switches were installed according to standard procedures. For DC I used an article in HP #7 as a guide. I very much like the idea of having both 12V and 24V available in one receptacle. However, I didn't like using the bare ground wire as a normal current-carrying conductor. I did it and it works fine, but when we build the house, I will use 12-3 wire instead (the difference being that all three wires will be insulated). However, I don't know of any four-prong plugs and outlets that aren't 1) humongous and 2) very expensive. The system can be easily converted to all AC should we ever sell the place and someone connects to the grid (I hope this never happens). It would just be a matter of replacing outlets and rearranging some of the wiring in the DC breaker panels. The house wiring itself wouldn't have to be changed a bit.

Before PVs
Believe it or not, we had no photovoltaic (PV) panels for the first eight months we lived here. Hey, let's face it– PVs are expensive! It took us awhile to save the bucks. It was during these eight months that we realized how nice it was to have large battery storage and a standby option on the inverter.

The large capacity meant we only needed to charge the batteries every four days or so. The standby option meant that all we had to do was start the generator - and I mean that's it! The Trace takes over from there: it senses the generator input, and charges the batteries while letting the generator power the AC mains panel.

PV Panels
This past fall we bought our first four panels for $1200. The Kyocera K-51s have performed right on their maker's specs (a little more with snow on the ground); just over 3 Amps per panel when charging our battery. We will install a charge controller when we add four more panels, which we hope to do next fall. Until then, our battery bank is big enough that it can't be damaged by overcharging.

Water
A 1/3 h.p. AC submersible pump, 100 feet down in our drilled well, fills our large pressure tank in the house. The tank has an 18 gallon drawdown. This system works well, but we should have used a more efficient pump. Our Teel, Model #3P614E, from W. R. Granger draws 10.4

amps- wish I'd seen HP#17's article on 120 VAC pumps before buying. The 2024 inverter can't start the spin cycle on our big ole' Maytag while the pump is on. This isn't a big problem, for we usually do the laundry (3-4 loads, once a week) while the generator is running.

A Paloma PH-6 provides hot water. An Aqualine 1.6 gallon toilet and water-saver shower head minimize water usage. We collect summer rainwater from the roof for the garden.

Refrigeration
A Sibir propane fridge keeps things cool while we dream of a Sunfrost… some day!

Electronics
Two portable AM-FM radios and a tape deck run on 12V DC. Hey, that Select-a-Tenna (Things that Work!, HP #18) really is great! Boston has some good talk radio now and then. We only watch 2 or 3 hours of TV per week. So when we do, we watch our Mitsubishi 20" remote control Diamondvision screen– who says AE is roughing it? The Trace runs it and our VCR perfectly.

Lighting
We use compact fluorescents for all room lighting: Twin 13 watt ceiling fixtures in both the kitchen and living room, two 20 watt floor lamps, and a 24 watt (very bright) PL fixture in the bathroom. A 12 Volt, Osram 5 watt Halogen mounted in a goose neck on the headboard makes a perfect bedtime reading light.

Richard Perez makes a good argument for AC lighting in HP #20, and for the most part, I agree with him. But, let me cast my vote for making your one or two most frequently used lights DC. We use 13 watt Osram bulbs run by Sunalex 24v electronic ballasts purchased from Talmage Engineering. The kits are $33 and the screw in unit is $42. So far, these ballasts have performed as well as the AC Osrams; quick starts, silent operations and no radio or TV interference. That we can change a bad bulb without throwing away a good ballast offsets the higher price. I feel better running a 13 watt PL straight from the batteries as I read my Home Power at 10 p.m., rather than make a 2,000 watt inverter do it - especially when I think of the inverter's output power vs. efficiency curve.

Free Ice Cream!
We live in North Sutton, New Hampshire which is located halfway between Concord and Hanover, just off Interstate 89. If you live close enough, and want to check out our system, or just say hi, please give us a call. We want very much to share our experiences with folks who are either doing similar things, or think they might like to in the future. As an extra incentive, here's a deal you can't refuse: we own a small ice cream shop called Arctic Dreams in nearby New London, NH. If anyone comes into our shop with an issue of Home Power Magazine or a Home Power T-Shirt, they'll win a FREE sundae, with their favorite flavor of Ben & Jerry's ice cream! We're open all year - just call ahead for our hours. By the way, the shop is lit with nine Osram 15-watt reflectors.

Conclusion
How much of a pain is living with home power? I suppose the best answer to that question is what Dianne told a friend recently, "A lot of the time, I forget we're not on the power line." I have to admit, moving those monster batteries got old, and starting the generator at -10° F isn't much fun, but I would never trade home power for the grid.

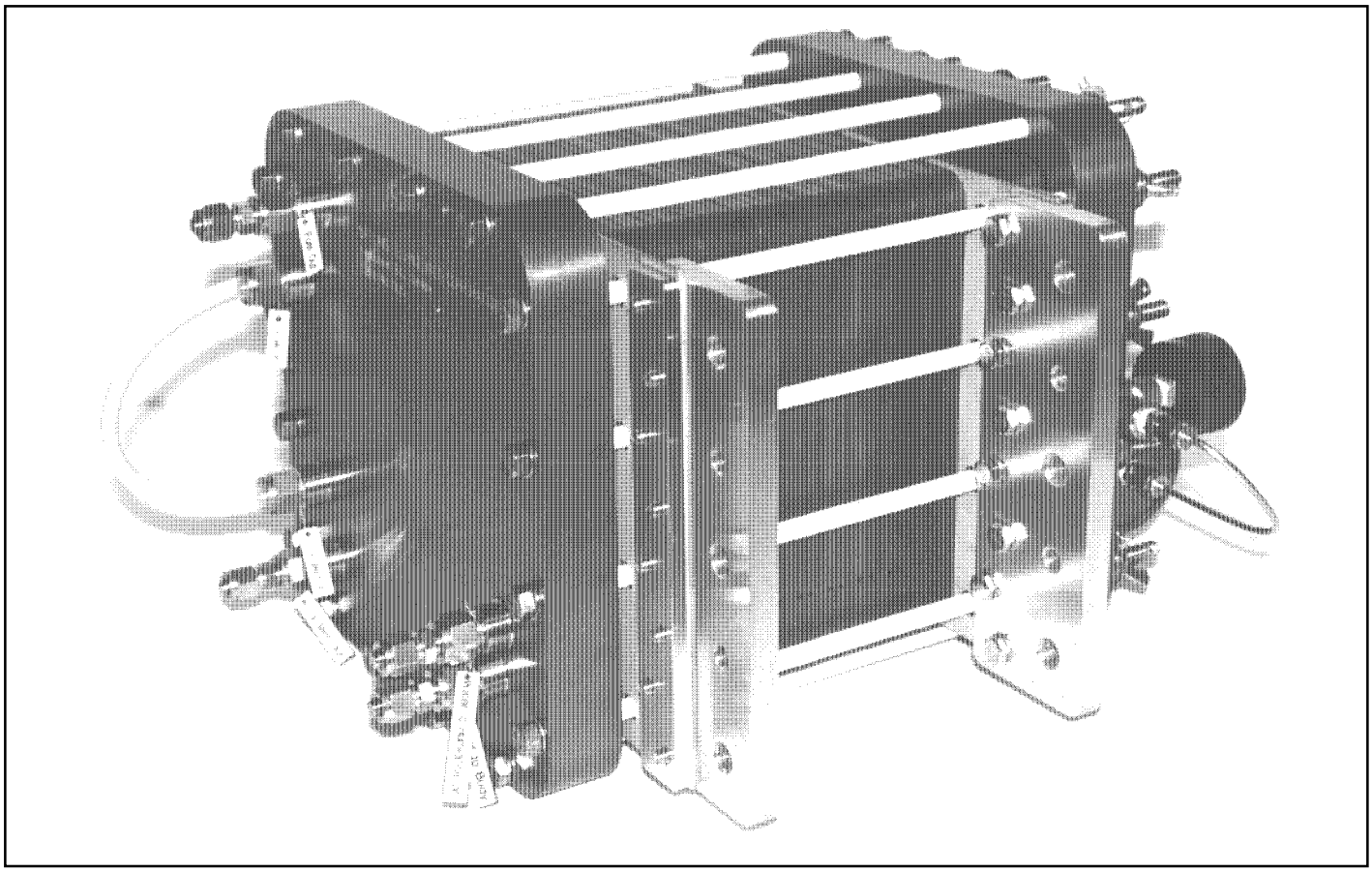
You know, once you've gone with gas for hot water, cooking and refrigeration, it really is not hard to minimize your use of electricity. As our system expands in the future, we would like to get a Sun Frost and solar water heater. Until then, we're mighty comfortable in our small home with the tiny bank payment. It's hard to describe to someone on the grid the satisfaction I feel when I see the ammeter's needle rise as the sun comes out from behind a cloud.

With the power lines running past our driveway, it would of course have been cheaper to plug in. But we want to show people that there is an alternative. Sure, it is expensive now. But as more people buy PVs and inverters, along with compact fluorescents, Sunfrosts, and other energy-efficient items, the costs will come down. Until then, people that care have to jump in and use these things. This house is our small contribution to that effort.

Access
Authors: Paul Hodgdon & Dianne Burgess, POB 43, North Sutton, NH 03260 • 603-927-4278.

Arctic Dreams featuring Ben & Jerry's Ice Cream, Main Street (across from the bandstand), New London, NH • 603-526-9477.

Peter Talmage, Talmage Engineering, Box 497A Beachwood Road, Kennebunkport, ME 04046 •



Above: This 1.7 kW prototype PEM fuel stack made by Ballard Power Systems is 20 inches long and weighs 81 pounds.

Hydrogen Fuel Cells - the power source of the '90s

Dr. Robert Wills

Imagine a car that can travel 300 miles without refueling, that performs as well as the gasoline cars of today, that uses one-half as much energy per mile, eliminates our dependence on fossil fuel and produces only water as a byproduct. Hydrogen fuel cells may make such vehicles a reality before the end of the decade. They could even cost less to run than gasoline cars.

What is a fuel cell

Practical fuel cells were first developed in the 1960s for the U.S. space program. A fuel cell is a device that converts a chemical fuel (generally pure hydrogen) directly into electricity. A fuel cell is like a battery that never runs down. The chemicals that are consumed (hydrogen & oxygen) are continually fed into the cell, rather than being a component that is used up.

Fuel cells may also be thought of as "reverse electrolysers". When two electrodes are put into a salty water solution and a current is passed, water is broken down into hydrogen and oxygen. This process is called electrolysis. Fuel cells perform the reverse action - they combine hydrogen & oxygen to form electricity and water.

Fuel Cell Vehicles

Battery electric vehicles can solve some of our transportation problems, but they have three major flaws, all related to energy storage: batteries are expensive, heavy, and even the best offer only limited vehicle range.

In the short term, hybrid battery electric vehicles with small internal combustion engine "range extenders" will be used to provide the vehicle range and performance that we are used to. By the year 2000, developments in fuel cell technology promise a cleaner, more efficient alternative to the internal combustion engine, & a new age of pollution-free driving.

The Key: Efficiency

Internal combustion engines are limited by the laws of thermodynamics to a maximum efficiency (the mechanical work output divided by the chemical energy in) of about 30%. Practical engines are closer to 20% efficient, and when stop-start driving is considered, efficiency drops to about 15%. Fuel cells are not limited by the thermodynamic Carnot cycle, and can convert fuel to electricity at up to 80% efficiency. Efficiencies of more than 50% have been demonstrated to date. This means that you can go three times as far in a fuel cell car as in a gasoline car, on the same amount of fuel.

Fuel Options

There are two ways of storing the hydrogen needed to run a fuel cell car. Either pure hydrogen can be stored in gas, liquid, or "metal hydride" form, or hydrogen can be generated onboard from hydrocarbon fuels such as compressed natural gas or methanol.

The "reforming" of methanol or other hydrocarbons to produce hydrogen and carbon dioxide has the advantage of easy fuel storage but the disadvantages of needing a small, onboard chemical processing plant, and still polluting the atmosphere with carbon dioxide.

Storage of pure hydrogen in cryogenic liquid or high pressure gaseous forms poses safety hazards that are unacceptable for general transportation. Storage in metal hydrides, where hydrogen atoms lodge in the atomic lattice of metals such as magnesium and titanium, offers safety and ease of use, but carries the penalty of high costs and much added weight (only 2-5% of the weight of the storage system is actually hydrogen).

When the system is looked at as a whole, however, this extra weight is compensated by the reduced weight of the drive system (the fuel cell, electric motor and motor controller) when compared to a gasoline engine and transmission, and reduced fuel requirements. Fuel cells capable of 10 kW continuous output and electric motors rated at up to 100 HP should be available at weights of less than 50 lbs apiece.

The safety of hydrogen as a fuel is often questioned. In fact, hydrogen is in many ways far safer than gasoline - it is non-toxic and disperses quickly. So little gaseous hydrogen is available in a hydride storage system (and heat is needed to liberate gas from the metal matrix) that such systems are inherently far safer than gasoline storage in today's cars.

A Hydrogen Economy

A hydrogen powered car needs a means to refuel. This could take the form of hydrogen refilling stations where hydrogen is piped or trucked from central generating sites. These "gas" stations will be worthy of their name. Hydrogen is produced in large quantities today from natural gas via a reforming process. This is the cheapest source at present. In future, we can look forward to large scale photovoltaic/electrolysis power stations in the southern U.S.A. producing hydrogen for the whole country. Pipelines, including the existing natural gas network, could be used for distribution.

Hydrogen can also be produced from water and electricity via electrolysis. This could be done actually at the "gas" stations, or alternately, small electrolysers could be installed in cars, or in home garages, to provide a means of refueling from grid electric power. In the short term, home or onboard electrolysers are the only alternative, despite higher fuel costs, as a network of hydrogen gas stations will take some time to evolve.

Economics

Dr John Appleby of Texas A&M University's Center for Electrochemical Systems & Hydrogen Research has calculated that a fuel cell car powered by hydrogen made from natural gas could cost as little as 1.5¢ per mile in fuel cost, compared to 4.4¢ per mile for gasoline. A fuel cell car could cost one third as much to run as the car of

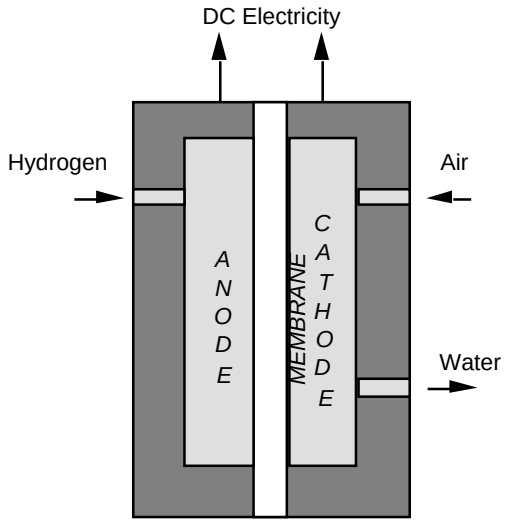


Diagram of PEM cell: The Proton Exchange Membrane Fuel Cell has platinum impregnated electrodes either side of a plastic film electrolyte.

today! Maintenance costs would be minimal with no engine oil changes, no spark plugs, no exhaust system, and with the regenerative braking reducing the mechanical brake wear. The fuel cell life could be as long as 100,000 hours. Appleby puts the cost of electrolytic hydrogen fueling at 5.6¢ per mile, and straight battery electric vehicles at 3.5¢ per mile plus 2 - 5¢ per mile in battery replacement costs.

The benefits of zero-pollution vehicles, such as the fuel cell car, should also be included in economic comparisons. Estimates of the social and health costs of burning gasoline in our cities range from $1.15 up to $4.50 per gallon of fuel.

Another researcher at Texas A&M, Dr. David Swan, has predicted that fuel cell system costs can drop to $272 per kW with mass production. He estimates a complete 75 kW peak, 25 kW continuous fuel cell/battery hybrid drive system would cost $8,550, about $1000 more than a conventional gasoline drive. Other estimates are as low as $4,450 for a complete drive system.

How long to Market?

While government and car manufacturers' predictions of fuel cell cars range from 2005 to 2050, recent advances have made practical cars possible within a few years. Many small companies are working on fuel cells for vehicles. Ballard Power Systems in Vancouver, B.C. plan to have a fuel cell powered bus on the road by 1992 and are also working with General Motors on automobile applications. Dr. Roger Billings of the American Academy of Science, Independence, MO, has developed fuel cells that are not only small, light and efficient, but can operate in reverse as electrolysers. He plans to deliver a demonstration fuel cell vehicle to the Penn. Energy Office in mid-1991.

We are about to leave oil behind, and enter the age of the fuel cell.

Access

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Fuel Cell Maker: Ballard Power Systems, Inc., 980 West 1st Street,-Unit 107, North Vancouver, B.C. V7P 3N4, CANADA • 604-986-9367.

Fuel Cell Maker: Ergenics, 247 Margret King Ave., Ringwood, NJ 07456 • 201-962-4480.

How photovoltaics are tested & rated

Richard Perez

Have you ever wondered how PV modules are rated for power output? How do those magic wattage numbers appear on the back of every module? Well, virtually every module is tested by their manufacturers. This article discusses how PV makers test and rate their modules. And how these power ratings may be different from actual module performance out in the sunshine.

A long and winding road…

This series of articles grew from our PV testing over the last three years. We found differences between the performance ratings printed on modules and their actual performance in the sun. We set out to find out why. This turned out to be a very long journey indeed. We got information from the modules' makers, we talked to the Solar Energy Research Institute (SERI), and we set up module "test jigs" for evaluating modules ourselves.

During the next few issues of Home Power, we will be printing the actual performance data of virtually every module, new and used, now available. This article defines the terms, standards and procedures used by PV makers and by us during our "in the sun" PV testing.

The Standards

All measurement depends on standards. Without using clearly defined standards, measurement is meaningless. Rating the power output of a photovoltaic module is done in a highly structured and standardized fashion. Here are the various measurement parameters & a schematic of our test jig.

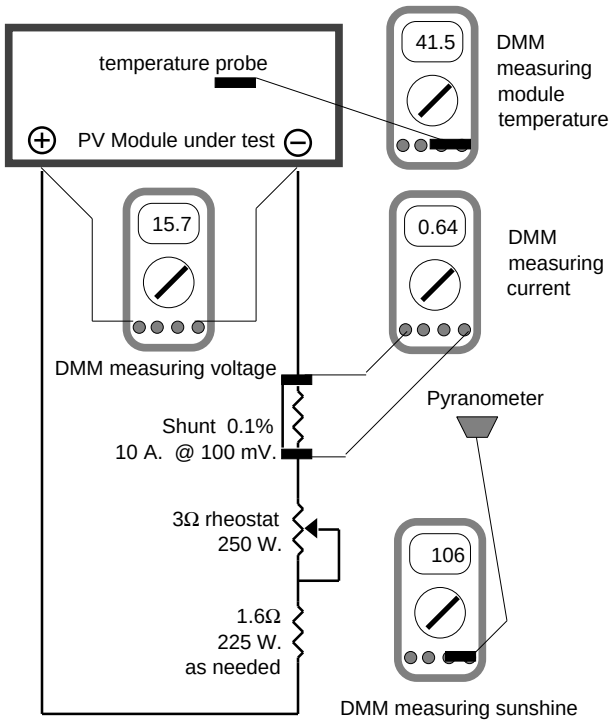
Voltage

Modules are rated at two voltage levels. The first is called "Open Circuit Voltage (Voc)" and is just that. The voltage output of the module is measured with the module disconnected from any load. The second voltage rating point is called "Voltage at maximum power point (Vmp)" and is the voltage at which the module puts out the most power. All voltage measurements are made at the module's electrical terminals on the module's back. These measurements are made with a highly accurate voltmeter. We use the Fluke 87s with 0.1% accuracy.

Current

Current is also rated at two important levels. The first is called "Short Circuit Current (Isc)" and is the amount of current that the module supplies into a dead short. The second current rating is called "Current at maximum power point (Imp)" and is the number of Amperes

Home Power's PV Test Jig



delivered by the module at its maximum power point. Current is measured with a shunt in series with one of the PVs' lead. The voltage loss across the shunt provides accurate current measurements. We use 10 Amp., 100 mV. Deltech shunts with an accuracy of 0.1%. We use a Fluke 87 in 4 1/2 digit mode to take these measurements.

Maximum Power and Maximum Power Point

Power is equal to Amperes times Volts (P=IE, or Watts=Amperes X Volts). Every module has a specific point on its power curve where the product of Amps times Volts yields the greatest Wattage. This is the Maximum Power Point, and the module's wattage output is rated at this point's voltage and current.

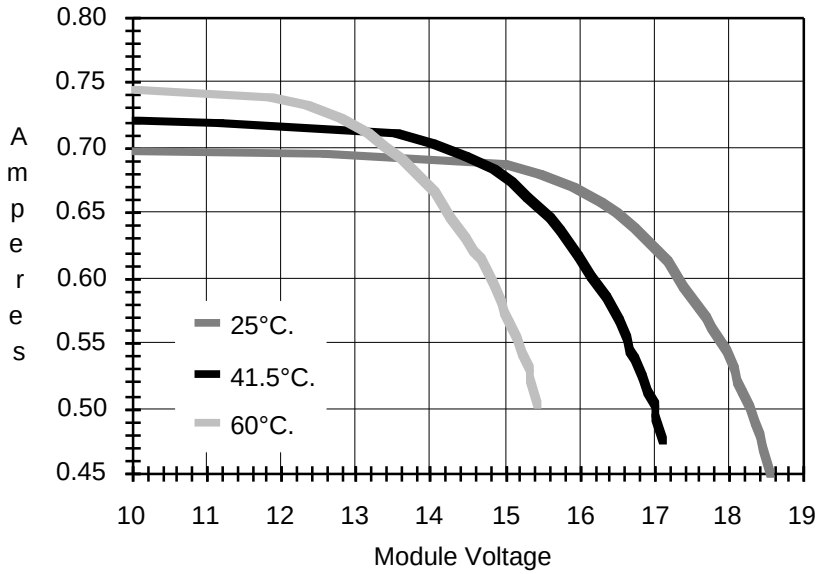
So to find the module's maximum power point we take data over the entire range of voltage and current. Because we have taken the modules voltage and current

Photovoltic Module Test

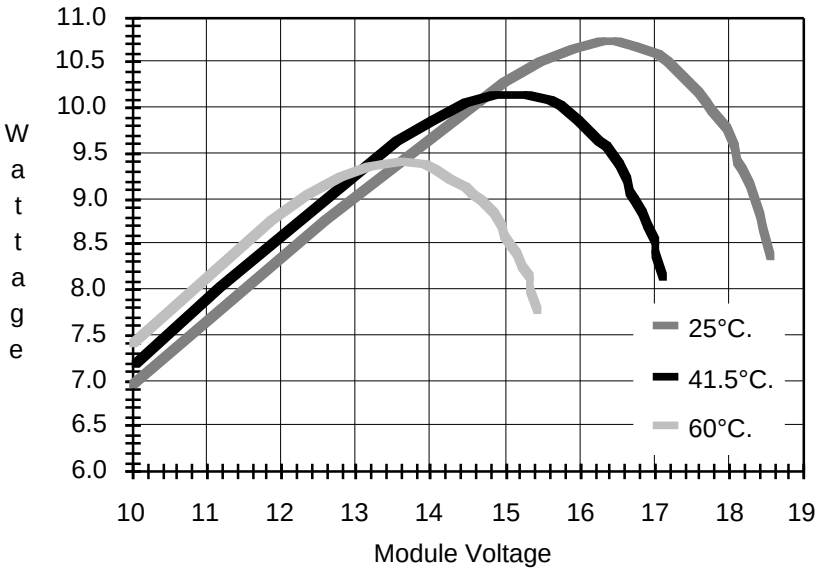
Date	5/27/91	
Time	10:03	AM PST
Air	23.10	°C.
Module	41.50	°C.
Insolation	106.00	mW/cm2
Rated W.	10.80	Watts
Rated A.	0.65	Amps
Rated V.	16.50	Volts

Volts	Amps	Watts
0.14	0.728	0.10
1.03	0.729	0.75
11.16	0.719	8.03
13.55	0.711	9.63
14.03	0.704	9.88
14.48	0.694	10.05
14.85	0.683	10.14
15.07	0.674	10.16
15.30	0.663	10.14
15.61	0.646	10.08
15.73	0.637	10.02
15.96	0.618	9.86
16.16	0.602	9.73
16.26	0.593	9.64
16.35	0.586	9.58
16.53	0.568	9.39
16.63	0.554	9.21
16.66	0.545	9.08
16.74	0.538	9.00
16.84	0.525	8.84
16.92	0.514	8.70
17.00	0.503	8.55
17.01	0.494	8.40
17.12	0.475	8.13

PV Module Current vs. Voltage



PV Module Wattage vs. Voltage



data, we can compute the wattage for each current and voltage data point. By doing this we can easily find the Maximum Power Point in the sea of Current versus Voltage data. The charts and table detail a single test run on a 10.8 Watt multicrystal PV module. All the data appears on the table. The graphs show the data as Volts vs Amps curves and Power vs Voltage curves. We took the data with a module temperature of 41.5°C. (104°F.). The curves of performance at 25°C. and 60°C. where derived from the 41.°C. data.

Effect of Temperature on PV Module Performance

As the temperature of a module increases two things happen. One, the voltage output of each cell decreases, and two, the current output of each cell increases very slightly. The graphs show the effect of temperature on module performance. If the module is at its rated temperature of 25°C., then the module will supply its rated power output. If the module's temperature is increased to 40°C., then its output drops to 94% of rated. If the module's temperature is increased to 60°C., then its output drops to 87% of rated.

This is why we don't see rated output from modules on hot days. The use of 25°C. as a temperature standard at which all other data is taken, leads to less than rated performance in the sun. When modules are doing their work, they have temperatures greater than 25°C. We

measure module temperatures as high as 76°C. (169°F.) on very sunny, hot (air temp 38°C. [100°F.]), and windless days. The point here is that, with the exception of cold winter days, the modules are always running at 40°C. or greater. We measure the temperature on the back of the module with a Fluke 80T-150U temperature probe. Air temperature and wind play a big part in the module's operating temperature.

Solar Insolation

Solar insolation is a fancy term for how much sunshine is an object receiving. All modules are rated using a standard solar insolation of 1000 Watts per square meter or also as 100 milliWatts per square centimeter. This standard insolation is rarely seen anywhere on the face of the earth, other than in laboratories. This is because solar radiation is never uniform and stolidly refuses to be consistent. Too many factors affect the amount solar radiation a body receives. Small items like weather, altitude, and reflection all make realistic standardization of sunshine impossible. So we do the best we can and measure the amount of sunshine hitting an object. There are two ways to measure sunshine. One is with a PV module that has been calibrated against a standard radiation of 1000 Watts per square meter. The second instrument is called a pyranometer. We are sending two PV modules to SERI for calibration and future use. Right now we are measuring solar insolation with a Li-Cor 200SB Pyranometer. This pyranometer produces 1 mV. DC per 10 milliWatts per square centimeter with an accuracy ±5%. We measure the pyranometer's output with a Fluke 87 DMM in 4 1/2 digit mode.

Flash Testing Modules

The folks who make the PVs test them under artificial light inside a building. These folks need reproducible lab standards that are not at the mercy of solar insolation and weather. Most manufacturers use what is called "flash testing". This means that the module is exposed to a short (1ms. to 30 ms.), bright (100 mW. per sq. cm.) flash of light from a xenon filled arc lamp. The output spectrum of this lamp is as close to the spectrum of the sun as possible. A computer watches the module's output and gathers the same data as we did above– voltage and current. This data is compared to a reference module located in the flash chamber with the module under test. The reference module has its power output calibrated to solar insolation by SERI or by Sandia National Labs. Flash testing is done at temperatures between 25°C. and 28°C., depending on the particular PV manufacturer. The results of flash testing determine the numbers you see printed on the module's back. Every maker we talked to, flash tests each and every module.

Testing Modules in the Sun

Testing modules in the sun produces different results than testing them with a flash tester. The main difference is caused by temperature. Manufacturers of PVs must test modules in artificial conditions because they mass produce their product. The flash test ratings are not what we will actually see in the sun. This is why we are testing most modules now available and will report on the results.

I think that the makers of PVs could better serve us by rating modules at between 40°C and 50°C. Just making this one change in standards would do much to bring manufacturers' rating into line with actual module performance in the sun. While gathering information for this article, I talked to many PV industry folks. Many of them expressed the same desire- to use standards that more closely reflect actual operating conditions. For example, here is an excerpt from a letter regarding ratings from Mike Elliston of Carrizo Solar.

"Carrizo Solar Corp. purchased the Carrizo Plains solar power plant in January 1990. In June of 1990, we begin taking down the ARCO M52, 4 V laminates from that field.

We devised a laminate rating procedure using the industry standard test conditions of cell temperature of 25°C. and 1000 watts/sq. m. of solar insolation. We have relied on a comparison to a "reference cell". This is a laminate that has been "flashed", i.e. rated under standard conditions by Siemens Solar. We compare the output of this reference cell to the output of a laminate under test.

This method gives us an output rating which is comparable to that of the other manufacturers. How useful is this standard rating? The standard rating is more optimistic than useful. 25° C. is not a typical cell temperature. If it is 25° C. and sunny, look for cell temperatures of 40° C. to 65° C. If it is 35° C. (95°), cell temperatures could reach 75° C. with no wind. The voltage and power drop 0.4% per degree C. A 40 watt (25° C.) module is only producing 33.6 watts at 65° C. and 15 volts sinks to 12.6 volts. Under these conditions this 40 watt, 15 volt rated module would no be able to charge a battery (where 14 volts are required).

What the module buyer needs is more than one 25° C. power curve. He needs 2 or 3 power vs. temperature curves to try and match his location to the appropriate curve. Only with accurate information on his charging system and the power curve for his location can an informed decision be made about modules.

Michael Elliston, Carrizo Solar"

Home Power's PV Testing Program
So we are setting up a large test bed out in the sun. We will test just about every maker's new modules and also the used modules now available. We will run all the modules side-by-side, under the same solar insolation and at the same temperature. We will report extensively on our results in the next issue of HP.

Meanwhile, if you would like to set up your own test jig & take data from your modules, please do. Please send us a copy of your data and we'll include it in the PV survey. The more data we collect about module performance, out in the hot sun, the better we can design, purchase, and/or use our systems.

Access
Author: Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

Info about PV testing supplied by these organizations:
Keith Emery, Solar Energy Research Institute (SERI), 1617 Cole Blvd., Golden, CO 80401 • 303-231-1032.

Michael Elliston, Carrizo Solar, 1011-C Sawmill Rd. N.W., Albuquerque, NM 87184 • 505-764-0345.

Al Panton, Kyocera America, 8611 Balboa Ave., San Diego, CA 92123 • 619-576-2647.

Ramon Dominguez, Solarex, 1335 Piccard Dr., Rockville, MD 20850 • 301-698-4468.

John Loveless, Siemens Solar, 4650 Adohr Lane, Camarillo, CA 93012 • 805-388-6254.

Joel Davidson, Hoxan America, POB 5089, Culver City, CA 90231 • 213-202-7882.

Instruments to test PV modules.
Pyranometers: LI-COR, Inc., Box 4425, Lincoln, NE 68504 • 402-467-3576. The model LI-200SB is $200.

Shunts: Deltech, 13065-H Tom White Way, Norwalk, CA 90650 • 213-926-2304. They make a 10 A., 100 mV., 0.1% shunt (MKA-10-100) for measuring current. $12.20

Digital Multimeters and Temperature probes: Flukes are available everywhere, check your phone book or HP ads.

Rheostats and high wattage resistors: Fair Radio Sales, POB 1105, Lima, OH 45802 • 419-223-2196. Fair Radio sells a 1.6Ω, 220 Watt resistor for

ElectroMagnetic Fields and Home Power Systems

Richard Perez and Bob–O Schultze

The energy that surrounds us is part of our environment. Recently we've been made aware that the electromagnetic fields (EMFs) made by electric power present a potential health hazard. This article begins a series of two articles about electromagnetic fields. This first article discusses the potential health hazards involved. This first article also defines an electromagnetic field, describes how these fields are produced by electricity, and tells how to construct an ac magnetic field meter to measure the magnetic portion of the fields around our homes. The second article, appearing in our next issue (HP#24), details how to reduce man-made electromagnetic fields and our exposure to these fields.

Life in Electromagnetic Fields

The reason we became interested in electromagnetic fields was medical information about their effect on humans. This information suggests that there may be links between prolonged exposure to electromagnetic fields and diseases, specifically cancer, nervous disorders, and birth defects. The medical community is far from agreement about how much EMF exposure constitutes how much of a health hazard. In fact, I've found the medical view of EMFs to be very confusing and contradictory. I have included a bibliography to some of the medical literature about this at the end of this article. Then you can read the literature & become as befuddled as I am about the hazards involved in EMF exposure.

The medical and electric power communities will be disagreeing about the biological effects of electromagnetic fields years from now. However everyone agrees on one point. This point of agreement is: "There is no minimum daily requirement for electromagnetic fields." Regardless of what medical view you may believe, everyone can agree that no exposure to electromagnetic fields will not harm you.

This article is not presented to scare anyone. In fact, home power users live in electrical environments that naturally have very low electromagnetic fields. This is because most of us don't have commercial power lines connected to our homes. On the other hand, we do make 120 vac power with inverters and generators. These devices do indeed produce EMFs, although much lower in intensity than say, living next to a power line. In fact, every living thing on this planet is constantly bathed in electromagnetic fields produced by the Earth itself. These natural fields are mostly DC in nature and life has evolved in their presence. The Earth's fields present no health hazard because we are used to them. It is the area of human created fields in the 50 to 60 cycle per second range (Hz.) that are potentially hazardous. And this frequency range is where electric power operates.

Cancer

If no one really knows if EMFs are a health hazard, then why be concerned at all? Because some studies have reached very disturbing conclusions. For example, a survey conducted by Nancy Wirtheimer and Edward Leeper in Denver, Colorado during 1979, published in the American Journal of Epidemiology, linked childhood leukemia deaths to prolonged exposure to EMFs. During the last ten years, twelve studies have been done inside the USA linking increased cancer rates to electromagnetic fields. These studies report a 140% to 320% increase in cancer among people with prolonged or intense exposure to electromagnetic fields. It seems that exposure to EMFs interferes with normal cell development by altering the action of RNA within individual cells. The electromagnetic field affects the operation of the living cell by "jamming" normal electrochemical activity and normal growth. This situation is analogous to power line interference on a radio.

Birth Defects

The effect of EMFs on the unborn were studied by Dr. David Savitz, Dr. Esther John and Dr. Robert Klechner and were reported in the May 1990 issue of the American Journal of Epidemiology. They found that the incidence of brain tumors among the children of pregnant women who slept under electric blankets increased two-and-a-half times. They also found a 70% increase in leukemia and a 30% increase in all cancers.

Nervous Disorders
Low-frequency EMFs affect the body's circadian rhythms by affecting the production of a hormone called melatonin which is produced by the brain's pineal gland. Melatonin is a hormone that regulates the biological rhythms of mammals. Research done by Barry Wilson and his co-workers at Battelle Pacific Northwest Labs has documented that prolonged exposure to EMFs causes reduction in the secretion of melatonin. Reduction of melatonin levels can result in psychiatric disorders like depression, shortened attention span, & inability to sleep.

The jury is still out…
For every study I have cited above there is also a study that says that EMFs pose no danger to living creatures. The point here is that we can live very well without exposure to the electromagnetic fields produced by electric power. So let's understand what EMFs are, let's measure our exposure to them, and finally let's reduce our exposure to EMFs to a minimum.

What is an Electromagnetic Field?
All energy which radiates is electromagnetic radiation. Radiant energy comes in many forms and is usually classified by frequency. Light is electromagnetic radiation of a very high frequency, and radio is electromagnetic radiation that is lower in frequency. All electromagnetic radiation is surrounded by what is called an electromagnetic field. Electromagnetic fields are composed of two components, one is electric and the other magnetic. These two fields are at right angles to each other and are inherent in all types of radiation. The illustration below graphically represents a moving electromagnetic wave with its electric and magnetic components.

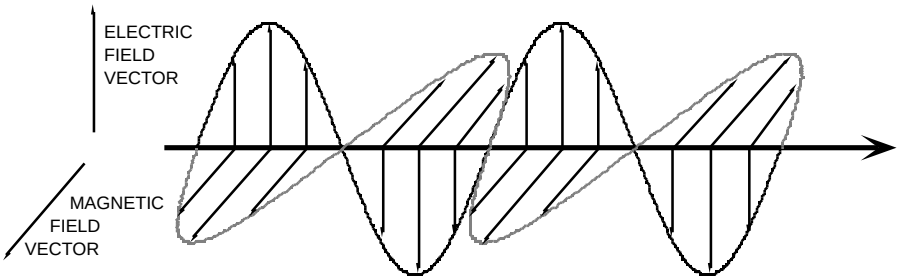
How are Electromagnetic Fields Made?
The electric portion of an electromagnetic field is caused by electric charge. The electric portion is usually called "the electrostatic field" and for our purposes is related to voltage. The magnetic portion of the field is caused by charge in motion. This magnetic portion is usually called "the magnetic field" and is, for our purposes, related to current (electrons in motion). In simple terms, voltage creates the electric component, while current causes the magnetic component.

The electric fields encountered at voltages lower than 440 Volts are very weak and do not present appreciable health hazards. Since home power users only use voltages below ≈220 volts, we don't need to be concerned with the electric fields within our homes. The same, however, cannot be said about magnetic fields.

The intensity of a magnetic field is directly proportional to the amount of current flowing. More amps means more intense magnetic fields. And it is the magnetic portion of the electromagnetic field that needs our attention.

Magnetic fields follow the inverse square law of radiant energy. This means that the closer you are to the field's source, the much intense the field is. If you halve the distance between yourself and the field, then the field is four times more intense.

How are ac Magnetic Fields Measured?
The intensity of a magnetic field is expressed in two units, one is called the Gauss and the other is called the Tesla. One Tesla is equal to 10,000 Gauss. In this article we will be using the unit called milliGauss, which is one-thousandth of a Gauss. To give you an feeling for the intensity of a magnetic field, consider the following data supplied by an electric power utility (the Bonneville Power Administration). If you stand underneath a 500 kilovolt power line you will be in a magnetic field which has a peak of 140 milliGauss. But since magnetic fields are related not only to current flow but also to our proximity to the current flow you don't have to stand underneath a power line to be in the presence of an intense magnetic field. Consider these household magnetic fields. The magnetic field for those who sleep under a 120 vac electric blanket are up to 100 milliGauss. The electric blanket is so dangerous because it is very close to the body for extended periods of time. At a distance of one foot, the magnetic field surrounding a microwave oven is about 40 to 80 milliGauss, and the fields around electric hair dryers and electric shavers range from 1 to 90 milliGauss. At a distance of one foot, fluorescent lighting and TV sets have fields in the range of 1 to 20 milliGauss. This is what electric power utilities are telling us. We are skeptical and decided to measure the fields in our environment ourselves. And the



remainder of this article details the instruments we constructed to accomplish these measurements and our findings.

So, how much is too much?
As we stated before, the health community and the power utilities are in radical disagreement on how much magnetic field exposure is too much. Suffice it to say that the state of Florida has set a 250 milliGauss maximum on the edge of their power line right-of ways.

The health studies we read state that fields over 100 milliGauss can most certainly produce health effects. Fields as low as 1 milliGauss can be dangerous if a body is exposed to them for long periods of time. We measure the intensity of the background ac magnetic fields outside in our "quiet" rural environment at less than 0.15 milliGauss.

So how can you find out the intensity of the magnetic fields in your home? Well, get a milliGauss meter and measure them. That's what we did. We built our own milliGauss meters and had them calibrated by an authority who does magnetic field work for a major utility. This person was of immense help in constructing and calibrating our meters. We'd give you his name, but he likes his job of convincing the power companies to clean up their act, and prefers to remain anonymous.

If you don't want to build your own milliGauss meter, then purchase one already made. A list of suppliers of already made milliGauss meters appears in Access at the end of this article.

Building Home Power's AC Magnetic Field Meter

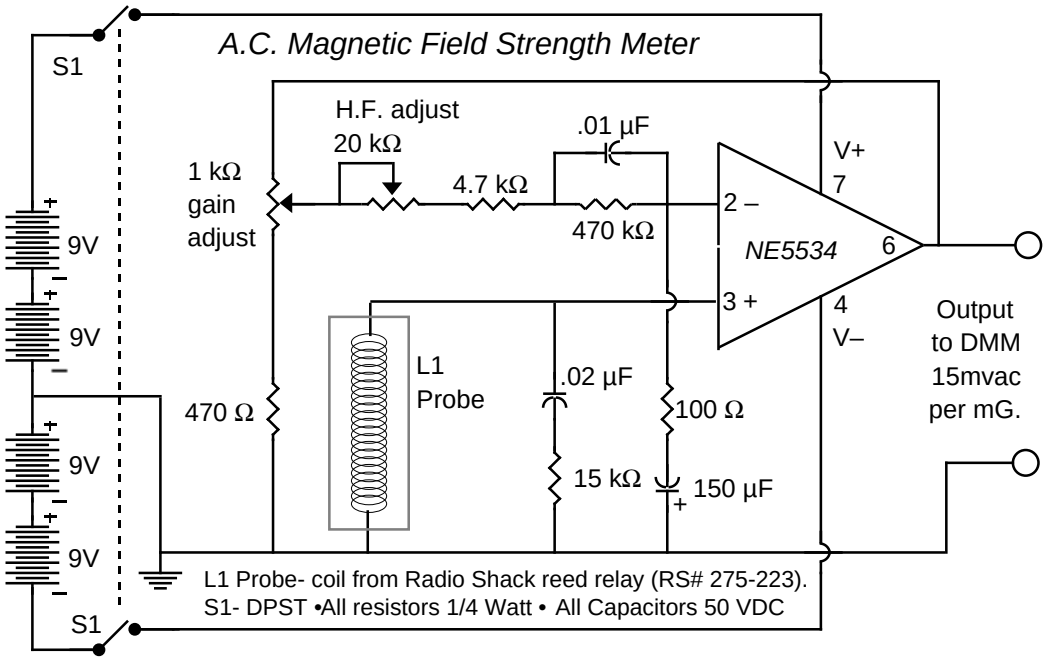
Bob-O Schultze-KG6MM

Don't build one of these units. Build two. There are a couple of good reasons to do this.

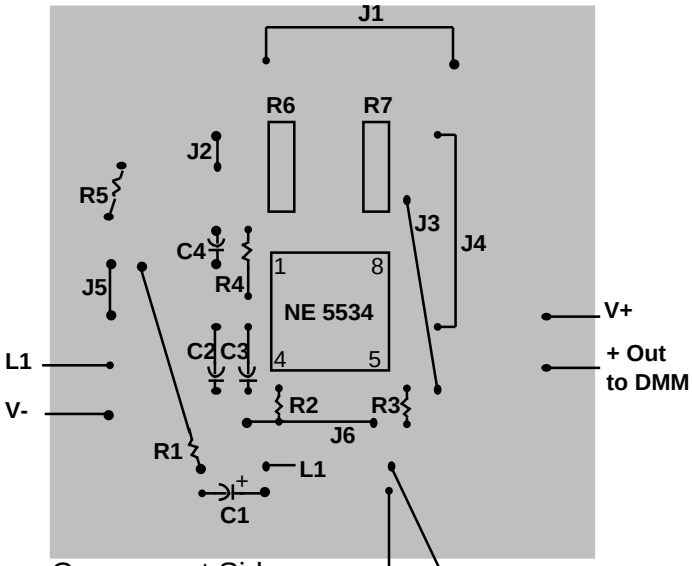
The first is purely economic. Unless you have a very well-stocked junque box, you'll likely end up buying the components from two or three mail-order suppliers. These places often have a minimum order amount (see access info), so buying enough parts to build two will most likely get you over that amount without having to purchase "fillers"-those neat little impulsively bought dodads which you'll never use. The shipping charges from these outfits seem to be about the same whether you buy $10. or $50. worth of stuff anyway, so buying enough parts for two circuits allows you to split those costs (hopefully) with whomever is sharing the cost of the parts.

The second reason is availability. Everyone in the neighborhood will want to use the unit, your DMM, and you to sniff their house for EMF. On the other hand, if you happen to be a bachelor who's tired of your own cooking, an EMF "map" of a neighbor's home might be worth a dinner invitation or...

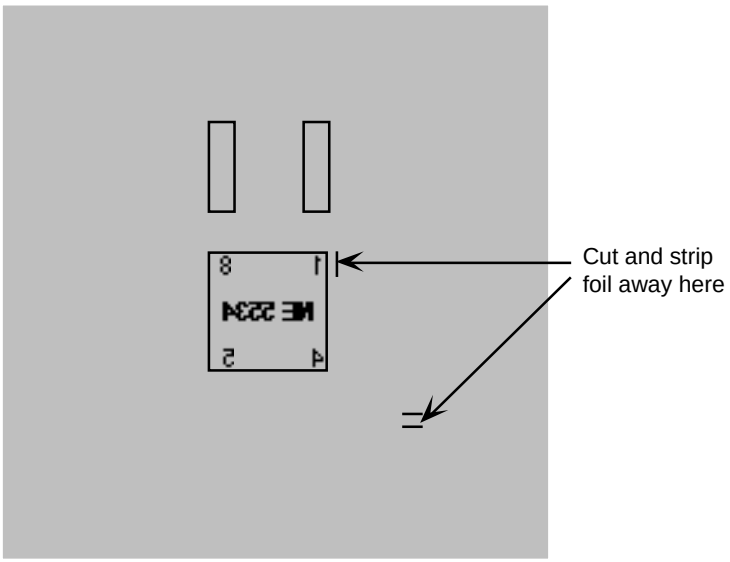
Kudos
The design of this AC Magnetic Field Strength Meter is the brainchild of a HP reader who does magnetic field work for a major utility. His generosity and assistance in making this available to all of us is beyond exemplary. Thanks!



The Circuit
The circuit is basically a high-gain, low-noise OpAmp design. The AC field being measured induces a very small current in the probe which is amplified by the circuit and output as AC voltage. While precise calibration is not possible without some minimum test equipment, we believe that by building this unit as shown with high quality components, it will perform as accurately as any unit available costing under $600. today.

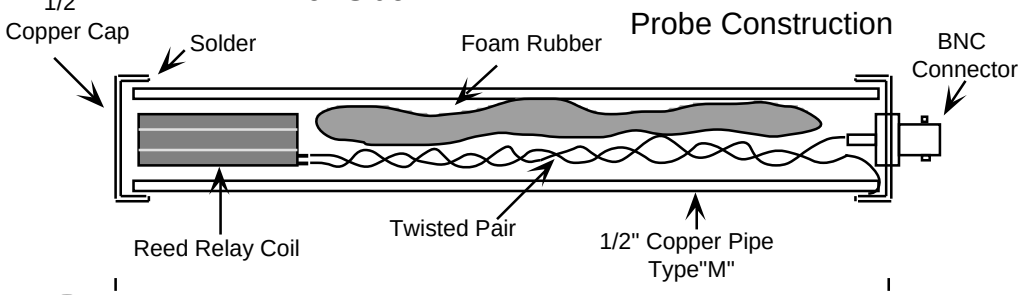


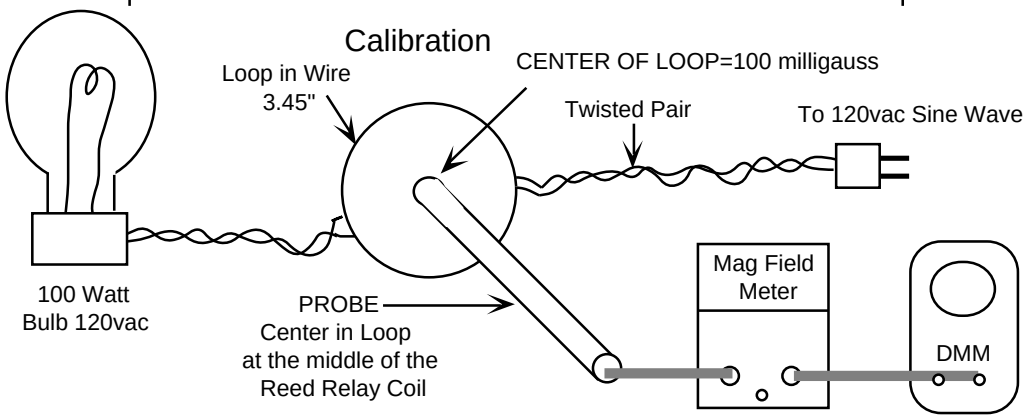
Component Side



Foil Side

Resistors	Capacitors
R1-100Ω	C1-150uF Tantalum
R2-15KΩ	C2,C3,C4-.01uF
R3-470Ω	
R4-470KΩ	J1-J5=Jumper
R5-4.7KΩ	
R6-20KΩ 15 Turn potentiometer	
R7-1KΩ 15 Turn potentiometer	





The Probe

The probe is an awesome example of engineering KISS. The inductor is the relay coil from a Radio Shack reed relay with the reed switch removed. The Radio Shack coil was chosen for its ready availability and to provide uniform response for calibrating the rest of the circuit.

The housing is made from 1/2" hard copper water pipe (Type"M"-thin wall) and two copper end caps. Any plumbing or hardware store should carry the pipe and caps. The Type M thin-wall copper pipe (as opposed to Type L thick-wall) is important to insure flat frequency response and eddy current loss at higher frequencies.

Any type of coax can be used between the probe and the meter, and RCA plugs and jacks can be substituted for the BNC ones.

Initial Adjustment

Set the high frequency response potentiometer (R6) to maximum and the amplifier gain (R7) to minimum. R6 will be at max when 20 KΩ can be measured between J1 and the upper side of R5. R7 will be at minimum when 1 KΩ can be measured between J1 and J3.

With these settings, the unit should yield a relatively flat frequency response from 50 Hz. to 15 KHz. Gain compression starts at about 130 milliGauss input at 50 Hz and 180 milliGauss input at 3 Khz. Sensitivity is 15 mv ac per milliGauss (±5%).

Cautions

If you build and use the calibration coil, center the probe

Quan. ONE Meter	Quan. TWO Meters	Part Description	Part Supplier	Supplier Part#	Part Cost Each	Part Cost ONE	Part Cost TWO
4	8	Alkaline 9V Batteries	Anywhere		$2.00	$8.00	$16.00
1	2	DPDT Toggle Switch	All Electronics	MTS-8	$1.75	$1.75	$3.50
1	2	1KΩ Potentiometer	Mouser	594-64W102	$2.20	$2.20	$4.40
1	2	20KΩ Potentiometer	Mouser	594-64W203	$2.20	$2.20	$4.40
1	2	Reed Relay Coil	Radio Shack	275-223	$1.89	$1.89	$3.78
1	2	NE 5534 Op Amp	All Electronics	NE5534	$1.25	$1.25	$2.50
4	8	9V Battery Snaps	Mouser	12BC106	$0.39	$1.56	$3.12
4	8	9V Battery Holders	Mouser	534-080	$0.25	$1.00	$2.00
1	2	8 Pin DIP Socket	All Electronics	ICS-8	$0.20	$0.20	$0.40
3	6	.01uF Capacitor ±1%	Mouser	140-PF2A103F	$0.38	$1.14	$2.28
1	2	150uF Tantalum Cap.	Hosfelt	15-238	$1.75	$1.75	$3.50
1	2	100Ω Resistor 1/4W 1%	Mouser	29MF250-100	$0.12	$0.12	$0.24
1	2	470Ω Resistor 1/4W 1%	Mouser	29MF250-470	$0.12	$0.12	$0.24
1	2	4.7KΩ Resistor 1/4W 1%	Mouser	29MF250-4.7K	$0.12	$0.12	$0.24
1	2	15KΩ Resistor 1/4W 1%	Mouser	29MF250-15K	$0.12	$0.12	$0.24
1	2	470KΩ Resistor 1/4W 1%	Mouser	29MF250-470K	$0.12	$0.12	$0.24
2	4	BNC-BNC Cable 48" long	Hosfelt	60-127	$3.00	$6.00	$12.00
3	6	BNC Male Chassis Mount	Hosfelt	#952	$1.00	$3.00	$6.00
1	1	Printed Circuit Board	Radio Shack	276-159	$1.49	$1.49	$1.49
1	2	Enclosure	Mouser	537-MDC642-01	$6.53	$6.53	$13.06
1	2	Banana Jack-Red	Hosfelt	#2349R	$0.35	$0.35	$0.70
1	2	Banana Jack-Black	Hosfelt	#2349B	$0.35	$0.35	$0.70
2	4	1/2"Copper Pipe Caps	Hardware Store		$0.30	$0.60	$1.20
1	2	1' Hard Copper Pipe- Type"M" Thin Wall	Hardware Store		$0.75	$0.75	$1.50
1	1	Standoffs w/screws	Radio Shack	276-195	$1.19	$1.19	$1.19
					Total	$43.80	$84.92

	For ONE	For TWO
Total Mouser	$15.23	$30.46
Total Hosfelt	$11.45	$22.90
Total All Electronics	$3.20	$6.40
Total Radio Shack	$4.57	$6.46

coil in the loop center for the most accurate measurement. Remember that the center of the loop is radiating 100 milliGauss! Keep your body parts away from it!

Parts Suppliers

Mouser Electronics, 12 Emery Ave.,Randolph, NJ 07869.For catalog 800-992-9943. Order 800-346-6873.
All Electronics Corp.,POB 567,Van Nuys, CA 91408. 800-826-5432.
Hosfelt Electronics Inc.,2700 Sunset Blvd.,Steubenville, OH 43952. 800-524-6464.
Digi-Key Corp.,POB 677,Thief River Falls, MN 56701. 800-344-4539.

Some Magnetic Field data from our neighborhood

After constructing two ac magnetic field meters, we decided to measure the fields in the RE powered homes in our neighborhood. What we found was not only surprising, but has also made us very wary of what we do with electricity.

We found that the ambient magnetic fields in our neighborhood are very low less than 0.1 milliGauss. We found that the fields inside our homes were also very low expect for some hot spots.

Places with High Fields

We measured high fields (over 100 milliGauss) in serveral places. One of the prime offenders is the inverter and its DC input cables. Fields here are between between 700 and 1000 milliGauss within inches of the inverter's DC cables. Since these fields decrease radically with distance, the fields about six feet from the inverter/cables was below 20 mG.

The other place we found high fields was in hand operated tools using 120 vac electric motors. In order to test the tool we placed the probe in our hand, and then gripped the tool and swtiched it on. Any tool which uses an ac motor or transformer will defineitly have intense ac magnetic fields surround the tool. We measured fields as high as 1000 milliGauss in kitchen hand mixers, circular saws, sanders, and soldering irons.

Computer Equipment

As you may imagine, we were very curious about the magnetic fields surrounding our computer equipment. The crew here spend hours, days, weeks, nay, it seems years in front of our computers. We measured fields about 0.3 to 0.9 milliGauss at a working distance from these computers. This level is low, but it is still three to nine times more than the background fields we measured. Both computers measured are Mac IIcx systems with Two Page monochrome monitors. The majority of the fields were being produced by the monitor. Computer use is basically the same as watching TV. The magnetic fields

are low unless you are right in front or directly to the side of the picture tube. We measured several TV sets and the fields surrounding the TV were directly proportional to the size of the screen. Here's a sample of some of the hundreds of ac magnetic field measurements we have taken in our neighborhood.

Measure your Magnetic Fields

Build the meter described here. Or get an electronerd to help you. Or buy a meter. Take data around your home and neighborhood. Write the data down so when it comes time to fix things, you'll know where to begin. That's right, we can fix this situation.

We've been experimenting on wiring techniques that greatly reduce the ac magnetic fields produced by our inverters or by any other ac power source. All this data will appear in the next issue. Meanwhile, measure your fields and do your homework about the medical effects of these fields. I am not a doctor, but hope that readers may have the information about how much exposure to these fields is dangerous. Until then I provide this reading list, so you can learn more about the health effects of these fields.

Access

Authors: Bob-O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044. 916-475-3401. Richard Perez, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

Already Made Mag Field Meters: Real Goods 800-762-7325.

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A.C. MAGNETIC FIELD MEASUREMENTS

LOCATION: Flett Home, Hornbrook, CA. Powered by PVs and inverter

#	Mag. Field milliGauss	Comments(i.e. field source, distance from field source, etc.)
1	0.07	All Off, including the inverter
2	0.07	Outside house by a good 50 feet
3	0.11	System not in use, but inverter running
4	0.14	7 feet from front of 13" color TV
5	0.22	in kitchen with twin tube fluorescent on
6	0.39	7 feet from twin tube fluorescent ceiling light
7	3.47	14 inches from kitchen mixer
8	8.33	Electrolux vacuum cleaner at handle
9	8.67	2 feet from side of 13" color TV
10	10.93	8 inches from operating Kitchen Aid kitchen mixer
11	18.13	directly on top of lightly loaded inverter
12	32.87	Electrolux vacuum cleaner by feet
13	37.47	directly on top of the Kitchen Aid kitchen mixer
14	284.00	directly on top of inverter loaded to 200 Watts
15	380.00	grip on Makita (120vac) hand-held sander
16	880.00	grip on Sunbeam hand-held mixer
17	934.67	inverter cable, inverter loaded to 300 Watts

LOCATION: Schultze Home, Hornbrook, CA. Powered by PVs and inverter

#	Mag. Field milliGauss	Comments(i.e. field source, distance from field source, etc.)
1	0.08	50 feet outside house
2	0.09	24 inches from Osram ER-15 compact fluorescent
3	0.09	8 feet from 19" Sharp color TV and VCR
4	0.29	18 inches from Mac IIcx system with 19" monochrome monitor
5	1.51	24 inches from Lights of America compact fluorescent
6	1.61	24 inches from Sylvania compact fluorescent
7	2.15	18 inches from twin-tube fluorescent light
8	2.85	18 inches from Lights of America fluorescent strip light
9	24.07	grip op battery powered 3/8 inch Makita drill
10	49.00	12 inches from operating 600 Watt Goldstar microwave
11	83.33	grip of Krups hand-held mixer
12	485.33	8 inches from operating 1/2 hp bench grinder
13	486.73	grip of Bosch sabre saw
14	638.67	grip of 3/8 inch electric drill
15	898.67	grip (left hand) of Black & Decker circular saw
16	1033.33	on inverter cables with inverter loaded to 500 Watts
17	1070.00	grip of 160 Watt Weller soldering gun

LOCATION: Perez Home, Agate Flat, OR. Powered by PVs and inverter

#	Mag. Field milliGauss	Comments(i.e. field source, distance from field source, etc.)
1	0.08	background field about 50 feet from house
2	0.32	2 feet from operating Mac SE with 2 hard disk drives
3	0.69	in main room with all computers operating
4	0.89	2 feet from Mac IIcx (2 hardisks) with 21" monochrome monitor
5	1.67	4 feet from operating 600 Watt Goldstar microwave oven
6	4.63	directly under a commercial 60 kV. power line- loading unknown
7	12.20	2 feet from operating 600 Watt Goldstar microwave oven
8	19.47	3 feet from inverter loaded at 250 Watts
9	92.00	6 inches from inverter loaded at 250 Watts
10	794.67	on top of inverter cables with 250 Watt loading

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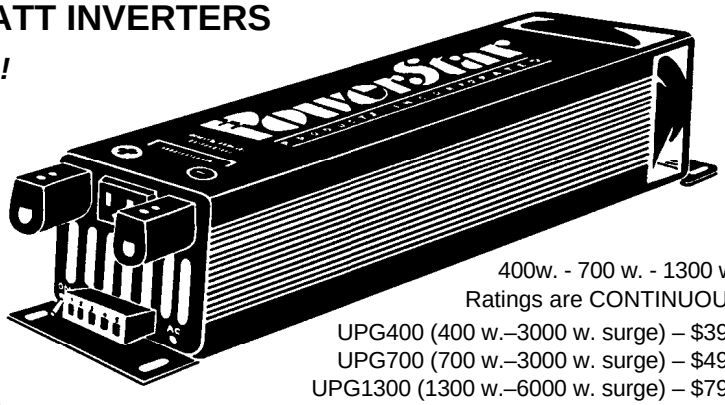

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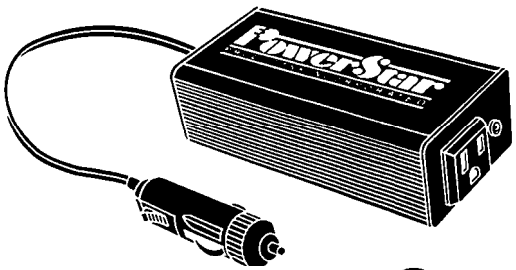

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Wind Generator Towers

Mick Sagrillo

Towers for wind generators come in a wide variety of shapes, sizes, heights, and prices. However, the often forgotten purpose of a wind generator tower is to get the wind generator way up there, and, most importantly, to keep it up there. "Keeping it up there" should, therefore, be the prime consideration in selecting a tower for a wind generator installation.

Styles

Towers for wind generators come in two basic styles: freestanding and guyed. A freestanding tower is just that; no wires or cables to help keep the tower in an upright position. They are self-supporting. These towers include the 3- or 4-legged lattice or truss-type of towers, and either metal or wooden poles.

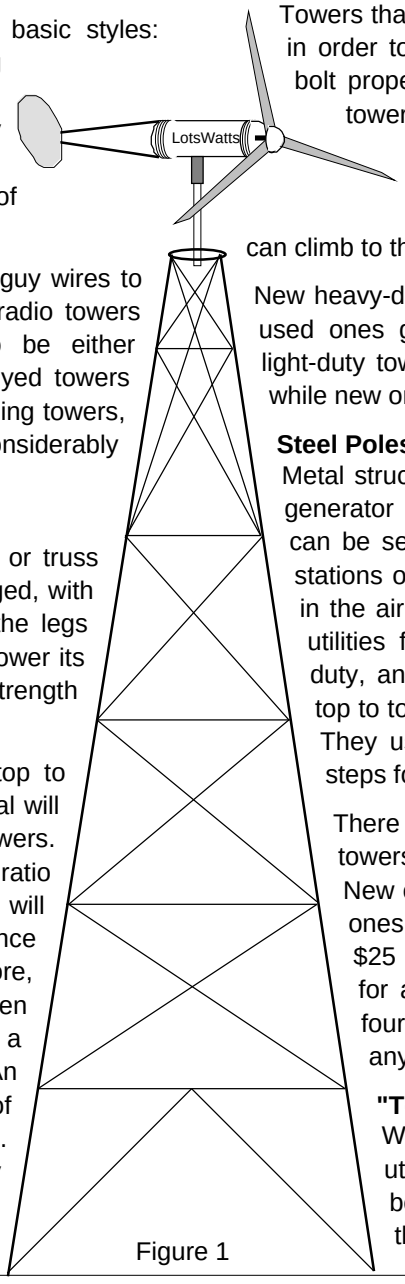

Figure 1

Guyed towers require the use of cables or guy wires to keep them standing. Most television and radio towers fall into this category. They can also be either lattice-type, or wooden or steel poles. Guyed towers are generally less expensive than freestanding towers, but, because of the guy wires, require considerably more space.

3 & 4 Leggers

Most freestanding towers are of the lattice or truss style (figure 1). They are either 3- or 4-legged, with diagonal and/or horizontal braces holding the legs together. These braces are what give the tower its lattice or truss look. They also provide the strength and rigidity to keep the tower upright.

Lattice or truss towers are tapered from top to bottom. Towers made with light gauge metal will be tapered more than heavy-duty towers. Light-duty towers will have a height to base ratio of about 4 or 5 to 1. This means the base will occupy, from leg to leg, one fifth of the distance of the height. An 80' tower would, therefore, have a span of from 16 to 20 feet between legs. Heavy-duty towers typically have a height to base ratio of about 9 or 10 to 1. An 80' heavy-duty tower would have a span of only about eight or nine feet between legs. The area that the tower base occupies only becomes important if space is a consideration.

Towers that use angle iron for the legs will be 4-legged in order to get the diagonal and horizontal braces to bolt properly to the legs. The legs of the 3-legged towers are usually made of specially formed 120 degree angle iron, or round pipe or tubing. Lattice or truss towers always have some sort of ladder built into them so that you can climb to the top and service your wind generator.

New heavy-duty towers sell for about $80 per foot, while used ones go for about $30 to $40 per foot. Used light-duty towers will sell for about $15 to $25 per foot while new ones sell for about double that price.

Steel Poles and Tubes

Metal structural steel tubes can also be used for wind generator towers. An example of this type of tower can be seen all along our interstate highways. Gas stations often use metal tubes to get their signs high in the air. These tubes are also frequently used by utilities for their high lines. They are very heavy duty, and usually taper from about one foot at the top to to three or four foot in diameter at the bottom. They usually incorporate some sort of removable steps for climbing to the top.

There is no hard and fast rule for prices on these towers. Used ones are very hard to come by. New ones are usually sold by the foot while used ones sell by the pound, like scrap steel. $20 to $25 per foot is not an unreasonable price to pay for a used steel pole, as they sell for three to four times that new. Get a second opinion on any price quote.

"Telephone" Poles

Wooden poles, the creosoted kind used by utility and phone companies, can sometimes be used for wind generators. Unless you guy the pole, you should only put a small wind

generator on one of these poles (more about this, and why, later). By small, I mean nothing larger than a generator with an eight or nine foot rotor. Larger rotor diameters will cause the wooden pole to sway. While this will usually have no effect on the pole itself, it can have a considerable impact on the wind generator and how it works. It can also be very unnerving!

Wooden utility poles are sold by class, the class indicating its strength. Get the strongest that you can afford. Average price for these poles is in the $1,000 dollar range for a 70-footer, depending on the class and the utility you're dealing with. Their one big advantage is that they can almost always be obtained locally, thereby minimizing shipping costs. A disadvantage is that they can be very tough, and dirty, to climb. Unless the pole was in excellent condition and came with a guarantee of some sort, I would never consider using a used wooden pole for a wind generator. Any internal cracks could prove disastrous!

Lattice/Guyed Towers

Guyed towers of the lattice style use considerably lighter materials in conjunction with supporting, or guy, wires to get the job done. A 10 foot section of Rohn 45G tower, the most commonly used guyed tower for wind generators, weighs only 70 pounds. A 20 foot section of a freestanding Rohn SSV tower will weigh in at between 500 and 800 pounds because its geometry.

The secret to the guyed tower's strength is the guy wires (figure 2). Cables stretch from several points on the tower to three different equally-spaced directions away from the tower. The top guys keep the tower erect, while lower guy wires keep the tower rigid and prevent oscillation or wobble. Ideally, the guy wires should reach the ground at a distance from the tower base equal to 3/4's of the height. For example, an 80' tower would have the guy anchors spaced 60' from its base. This distance can safely be reduced to 1/2 the height of the tower, if necessary, without upgrading either the cables or the footings. While the base of a guyed tower is smaller than that of a freestanding tower, they none-the-less take up considerably more space due to the guy anchor locations.

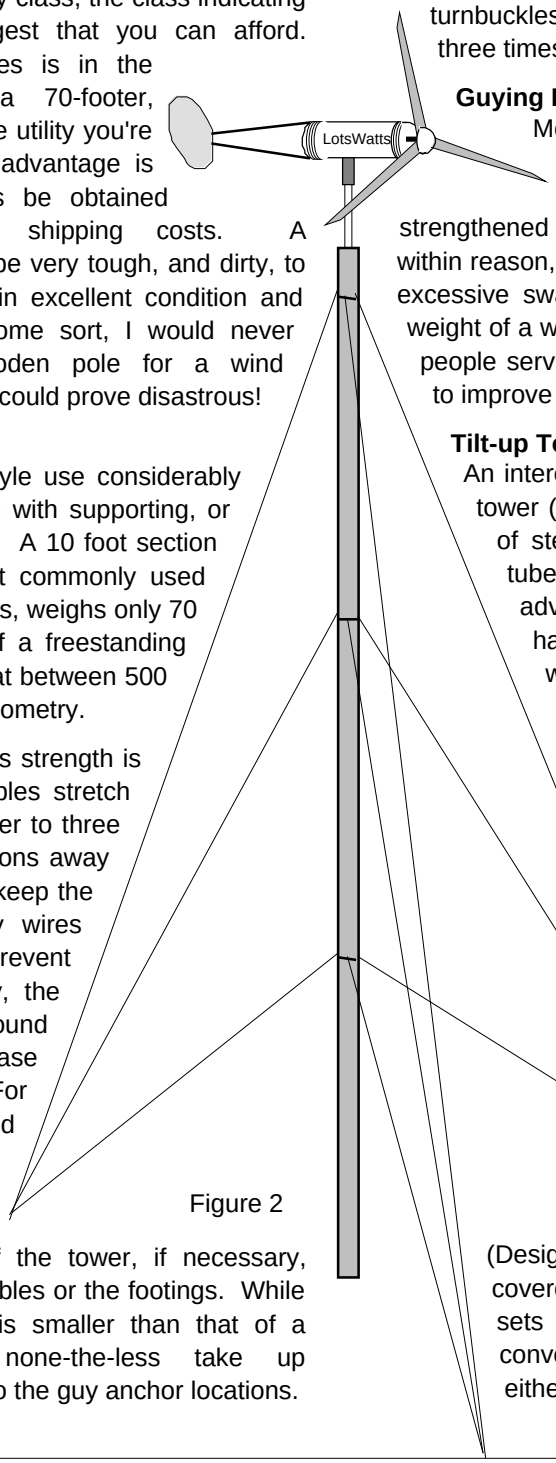

Figure 2

Lattice/guyed towers look like three-sided ladders. The three legs of the tower are parallel to each other, and in the case of the Rohn 45G, only 18" apart from base to top. Holding the legs together are evenly spaced horizontal and diagonal braces (figure 3). These braces make climbing this type of tower very simple. Used lattice-type guyed towers cost about $15/foot with all associated hardware: guy brackets, cables, turnbuckles, and anchors. New equipment runs two to three times used prices.

Guying Poles and Tubes

Metal tubes and wooden utility poles can also be installed with guy wires. By using guy wires, an otherwise light duty pole can be strengthened enough for use as a wind generator tower, within reason, of course. What we're trying to eliminate is excessive sway. If a tower will not support the static weight of a wind generator AND the weight of one or two people servicing the unit, then guy wires are not going to improve the situation.

Tilt-up Towers

An interesting variation of a guyed tower is a tilt-up tower (figure 4). Tilt-up towers are typically made of steel well casing, although any strong steel tube or wooden pole would work. The advantage of a tilt-up tower is that you don't have to climb it. You just tilt the tower along with the wind generator down to ground level. All service work can be performed safely on the ground. If you are deathly afraid of heights, then a tilt-up tower is just the ticket!

Tilt-up towers have a built-in hinge at the base for tipping up and down. The raising and lowering is done with the help of a tractor, truck, or 4-wheel drive car. Fancy set-ups have their own built-in winch to do the job of the vehicle. Tilt-ups have a shorter "tower", called a gin pole, attached at right angles to the tower that aids in raising and lowering. (Design and construction of a tilt-up tower will be covered in a future article.) They also have four sets of guy wires, rather than three sets like a conventional guyed tower does: one set is on either side of the tower to keep it from swinging

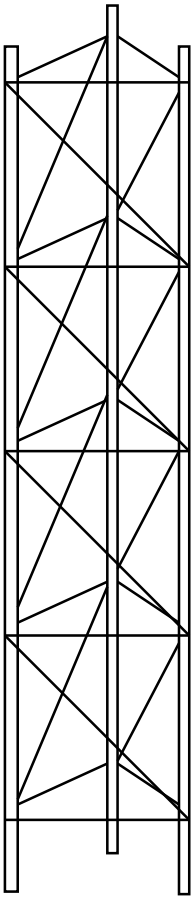

Figure 3

from side to side while being raised and lowered; one set is used to pull the tower in an upright position and lower it; and the last set is opposite the front set and prevents the tower from tilting too far forward.

While tilt-up towers are the most convenient to use, they do have a down side. Raising and lowering them can be a hair raising experience until you get used to it. If the tower, guys, and footings have been undersized, you'll find out during raising or lowering when the whole thing comes toppling down. Raising and lowering is rarely a one person job. There is just too much to keep an eye on. Also, there are some wind generators that don't work very well with tilt up towers. For example, a generator that utilizes a gearbox is going to pose a problem at any oil changing time. (The ingenious person can usually find ways around these problems.)

Loading on Towers

The emphasis on a well-built and strong tower should be obvious. We don't want it to fall down or blow over. How that is accomplished may not be so obvious. Let's take a look at how a tower is designed and constructed, and why.

Towers are designed to carry a certain amount of static weight, namely the wind generator and the associated bodies that dangle from the top to perform service work. This is the vertical, or downward, load on the tower, and is fairly easy to design for and build. If the legs won't support the weight involved, you just make them a little stouter.

The wind generator and tower itself also present a certain amount of resistance to the wind, especially when the blades are spinning. This is known as horizontal or lateral thrust, and is not as easily designed for. The reason is that as the velocity of the wind increases, the power available in the wind, and subsequently the thrust, increases exponentially. (see "Wind Generator Tower Height" in Home Power #21.) When the wind speed doubles, that is, increases by a factor of two, the power increases by the cube of the velocity, or a factor of eight! Also, remember that the surface area that rotor presents to the wind is a function of $\pi \times r2$. While a 14' rotor is only twice the diameter of a 7' rotor, it has more than four times the surface area. Lateral thrust can get out of hand very quickly!

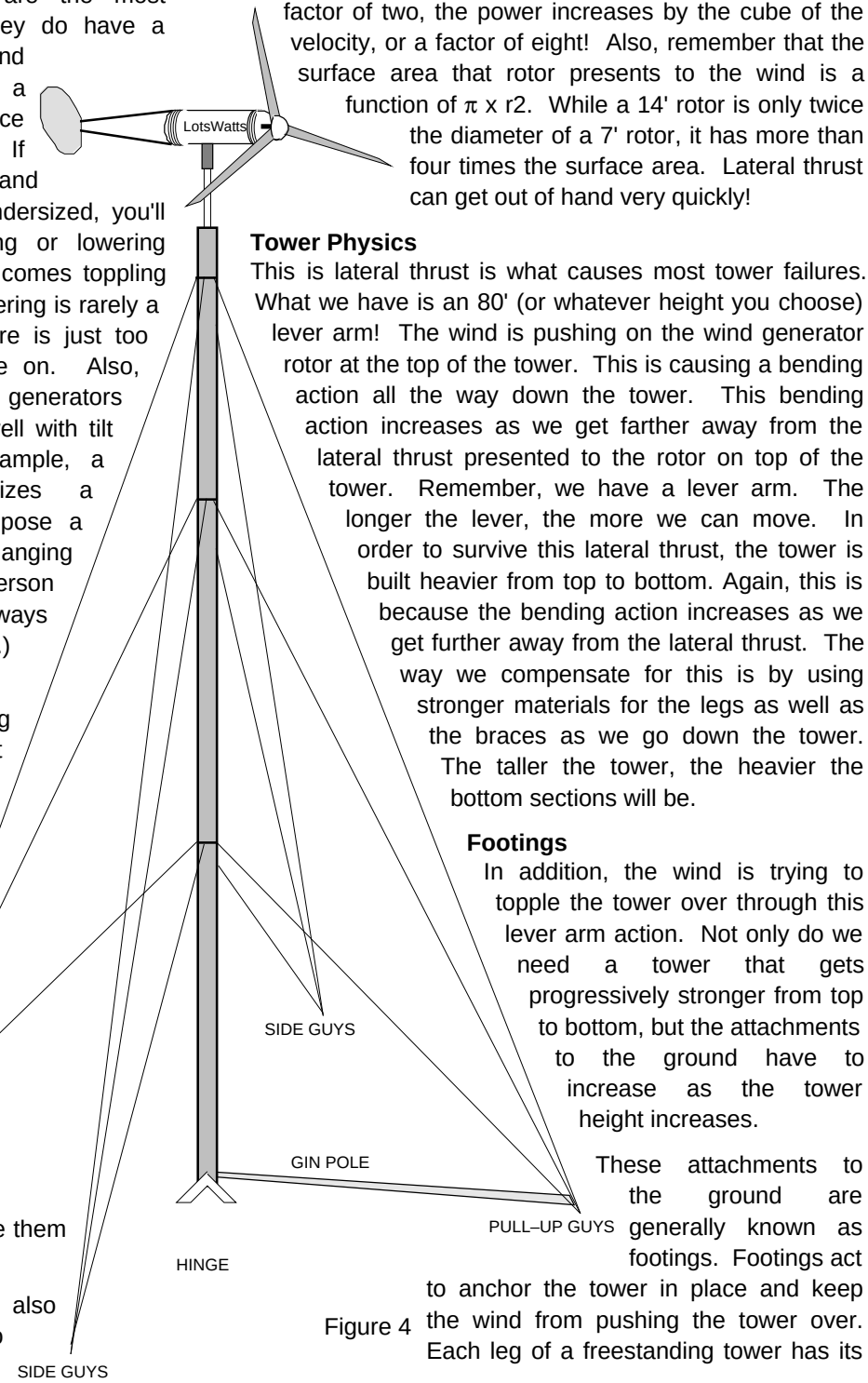

Figure 4

Tower Physics

This is lateral thrust is what causes most tower failures. What we have is an 80' (or whatever height you choose) lever arm! The wind is pushing on the wind generator rotor at the top of the tower. This is causing a bending action all the way down the tower. This bending action increases as we get farther away from the lateral thrust presented to the rotor on top of the tower. Remember, we have a lever arm. The longer the lever, the more we can move. In order to survive this lateral thrust, the tower is built heavier from top to bottom. Again, this is because the bending action increases as we get further away from the lateral thrust. The way we compensate for this is by using stronger materials for the legs as well as the braces as we go down the tower. The taller the tower, the heavier the bottom sections will be.

Footings

In addition, the wind is trying to topple the tower over through this lever arm action. Not only do we need a tower that gets progressively stronger from top to bottom, but the attachments to the ground have to increase as the tower height increases.

These attachments to the ground are generally known as footings. Footings act to anchor the tower in place and keep the wind from pushing the tower over. Each leg of a freestanding tower has its

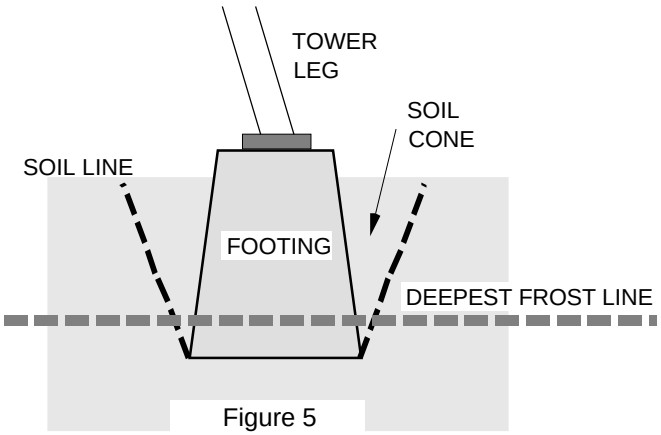

Figure 5

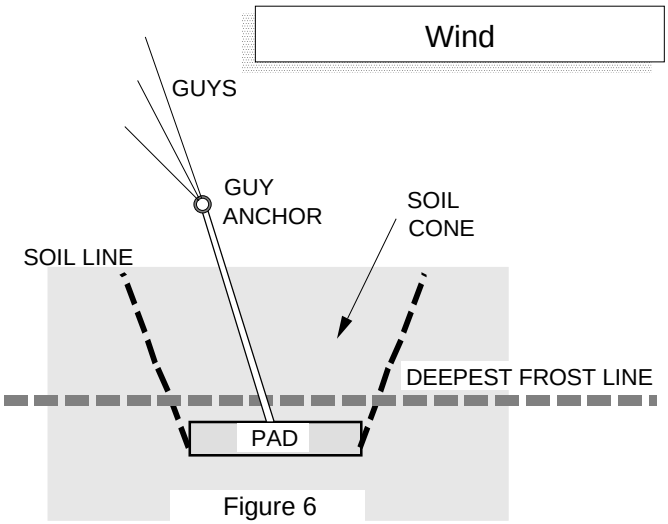

Figure 6

own footing. Footings are usually bell-shaped (figure 5). Guyed towers will have a footing under the tower itself, but individual guy anchors are usually imbedded in concrete pads (figure 6). Footings and pads are always set below the frost line.

Footings and pads are designed to use the soil itself to help work against the lever action of the tower and keep themselves in the ground. If you were able to pull straight up on a footing or pad with enough force to dislodge it, it would not come straight out of the ground. Instead, you would pull a certain amount of soil out of the ground with the footing or pad (figure 5 and 6). The shape of the remaining hole would look like an inverted cone. By being designed this way, the amount of concrete needed, and therefore the cost, can be kept to a minimum, while maximizing strength.

Vibrations

In addition to lateral and vertical forces, a tower also has to withstand a variety of vibrations. These vibrations are set up in the tower due to the spinning of the rotor, the yawing on the wind generator, the electrical hum of the generator, and the interaction of the wind with the tower itself. These harmonic vibrations may become so severe as to be audible to the human ear. Also, the tower may begin to sway in the higher winds. This swaying can easily become an oscillation in a steady wind if it is uninterrupted by yawing. All towers have a natural frequency at which they vibrate or resonate. However, if not accounted for in the design of the tower, vibration can actually destroy a wind generator or tower and, especially, their welds. For this reason, the nuts and bolts of wind generators should be assembled with a thread locking compound (such as Loc-tite). An alternative is to use self locking nuts or "pal" nuts.

One of my wind generators is mounted on top of a uniquely designed tower made of 3" thin-walled metal tubes. In about a 15 mph wind, the tower gives off an eerie low "moaning" sound when the generator yaws. It has put more than one visitor on edge on an otherwise quiet moonlit night.

Rooftop Mounts

Many people ask about mounting a small wind generator on a short tower on top of their house roof. My answer is always "don't"! Aside from the obvious problem of turbulence, the generator will cause the entire structure to resonate at some point. Rubber pads don't help at all. Smaller wind generators, which spin faster than larger units, are the worst offenders. Even if your house is structurally sound enough to hold the tower in place, the sound will drive you wild in short order.

For the same reason, towers should not be attached to the walls of houses, either. If we're talking about a garden shed or garage, then maybe, but you may still end up dismantling everything. I know of one guy that built a small greenhouse out of fiberglass sheeting between the four legs of his wind generator tower. It was designed so that the four legs were the corners of the greenhouse. After two days of running the wind generator, the police came and told him he had to do something about the situation. By that time he was convinced anyway; he couldn't work in the yard without ear plugs.

Final Caveats

I am occasionally asked about putting a wind generator on the top of a tree. Trees don't make good towers. They are hard to climb safely. They're even harder to climb with wind generator parts and tools cluttering up your hands. They sway too much. Dead trees rot at the ground and fall over. Enough said!

Finally, be wary of putting an oversized wind generator on an undersized tower. Many people learned this lesson the hard way in the mid- and late-70s. For a time, the rage was to buy up old waterpumper towers and put Jacobs or Wincharger wind generators on them. A Jake

with a 13 1/2' rotor has a swept area of 143 square feet presented to the wind ($\pi \times r^2$). A Wincharger with a 12' rotor has a swept area of 113 square feet. Most waterpumpers came with an 8' wheel. That's only 50 square feet. Virtually all of these installations came crashing down. If you're going to err with a tower, err on the side of safety: overdo it. Who knows. Maybe someday you'll want to put up a larger wind system on your existing tower!

Access

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How Photovoltaic Cells Work

Chris Greacen

Photovoltaics are indeed magical devices - who would think, really, that you could put a shiny blue flat thing out in the sun and get electricity from it? They do work. Moreover, they need not be mysterious. It does take a little patience (you may need to read over this twice or more to get comfortable with the terms) but you do not need to be a semiconductor physicist to understand qualitatively how PVs convert light into electricity.

Atomic Model for Semiconductors

Ninety-nine percent of today's solar cells are made of silicon (Si), and other solar cells are governed by basically the same physics as Si solar cells. Since it is helpful to be concrete, I'll explain solar cells with reference to silicon. A silicon atom has 14 electrons. Four of them are valence electrons, meaning they are available to associate with other atoms. In a pure silicon crystal, each atom shares these valence electrons with four neighbor atoms in covalent bonds. This fairly strong electrostatic bond between an electron and the two atoms it is helping to hold together can be broken by input of sufficient energy: 1.1 electron volts (eV) or more. This corresponds to a photon of light of wavelength 1.12µm or less - all colors in the visible spectrum, and well into the infrared. This freed electron now roams the crystals much the way an electron in a metal travels freely, not attached to any one atom. It is free to accelerate in the presence of an electric field; that is to say it takes a part in the conduction of electricity. In making this transition it leaves behind a "hole", a place lacking an electron. Neighboring electrons can leave their bonds to fill the hole, essentially switching places with it. Hence both electron and hole can move through the crystal. This is called the photoconductive effect.

If nothing is done, within a certain time **t**, called the minority carrier lifetime, the electron is expected to recombine with a hole, producing a photon (heat). This is not very exciting, and it certainly is not useful for creating electricity. Loosely, what is needed is a way to separate the electrons and the holes so that they won't recombine in the crystal, and a path to funnel these electrons out to do work on a load. The former is provided by a semiconductor junction between two semiconductors with different electrostatic charges. The latter, simply by metal contacts to the cell on opposite side of the junction.

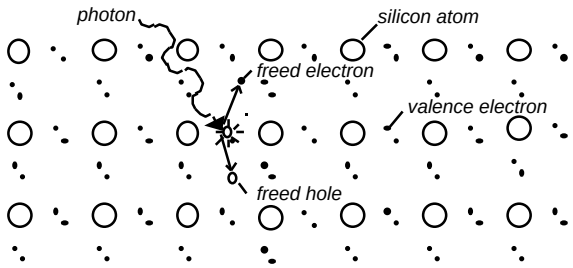

Figure 1 Photoconductive effect in silicon

Doping

If we add a small amount (on the order of one part per million) of phosphorous to the silicon crystal as it is forming so that the phosphorous atoms fill sites in the silicon crystal lattice, then we are said to have 'doped' the crystal with phosphorous. Phosphorous is group V on the chemical chart, so it has five valence electrons - one more than silicon. The phosphorous nucleus and inner electrons settle happily into the lattice site, and four of phosphorous's electrons participate in the covalent bonding with electrons from the four neighboring silicon atoms. But in the crystal the fifth electron is very loosely bound to the phosphorous atom, so loosely in fact that at room temperatures it is thermally excited into the wandering free state. Doping with elements like phosphorous with one valence electron more than the original atom is called n type doping (n for 'negative'), and the dopant is called a 'donor' because it easily gives up electrons.

Doping silicon with boron has exactly the opposite effect. Boron is group III, so it has three valence electrons - one less than silicon. It fills a silicon lattice site, but has enough electrons for only three covalent bonds with

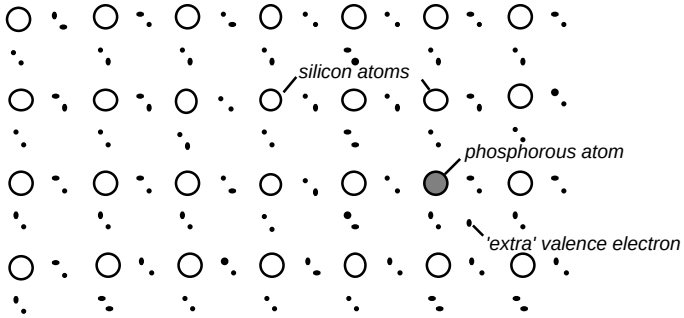

Figure 2 n type (phosphorous) doped silicon

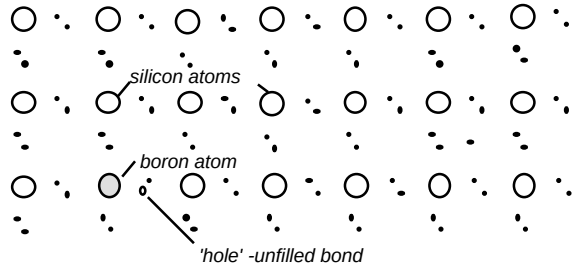

Figure 3 p type (boron) doped silicon

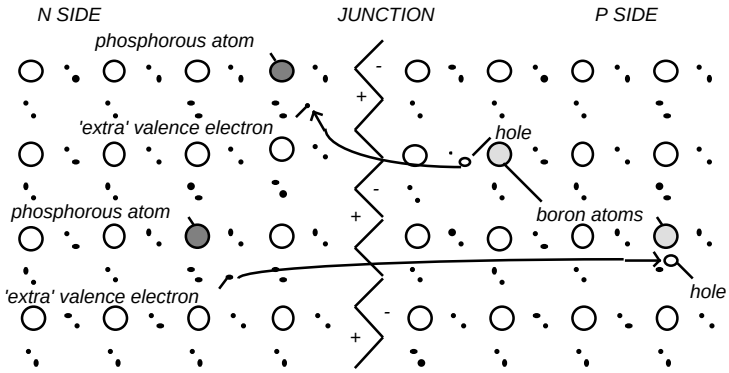

Figure 4 Junction forming

neighboring atoms, leaving a hole. This hole, identical to the photogenerated hole explained above in the discussion on photoconduction, is thermally excited at room temperature into freedom to roam about the crystal. For silicon, boron is a p type (positive) dopant, and called an acceptor because its unfilled bond (hole) readily takes in free electrons.

Diodes

Photovoltaic cells are diodes with a large surface area exposed to the sun. A diode is just an n - type layer slapped onto a p layer. The space where the two layers meet is called the junction. The instant the diode is formed, the billions of free electrons near the junction in the n-type material immediately rush over to fill the holes in the p-type material, leaving the n side (which had been electrostatically neutral) with a net positive charge. Likewise, holes on the p side migrate to the n type material, leaving the p side of the junction with a net negative electrostatic charge.

Within milliseconds the process reaches equilibrium as the statistical force pushing electrons on the n side to fill holes on the p side is balanced by the force from the electric field created by the electrons and holes when they have moved from their original materials. Loosely you can think of the n- side as having a high "electron pressure" and the p-side as having a low electron pressure. Forming the junction "opens the valve" for this electron gas to flow to the region of lowest pressure. The electric field of the junction presents a barrier to further crossover of majority carriers: in the n type material, electrons are the majority carriers, and in the p type, holes are the majority carriers. As figure 5 shows, the junction does not impede the flow of minority carriers; if there are electrons in the p side (and there won't be many because holes are so common there) and they wander into the junction they will be accelerated across to the n side. Actually this wandering is not entirely random: those electrons on the p side which make it to the junction are whisked across, and their absence on the p side near the junction encourages a drift of electrons from farther in the p side to take their place. This current is called a diffusion current. Vice versa for holes (minority carriers on the n side).

Sunlight into Electricity

Now recall the photoconductive effect: a photon hits an atom (a silicon atom most likely since there are millions more of them, but also possibly a phosphorous or boron atom) and frees an electron leaving behind a hole. Suppose this creation of an 'electron hole pair' takes place in the p type material. The electron and the hole wander around the lattice with a speed determined by a material dependent parameter called the mobility. An electron from such an electron-hole pair has a relatively short time that it is free because it is very likely to recombine with one of the numerous holes on the p-side. If the electron-hole pair is created close enough to the junction, chances are pretty good, however, that it will diffuse into the junction, and when it does it will be

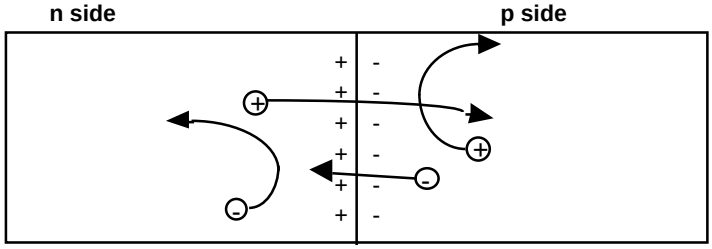

Figure 5 junction formed

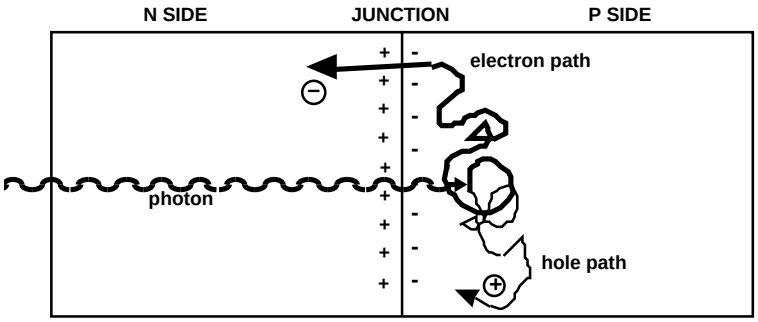

Figure 6 The junction in action

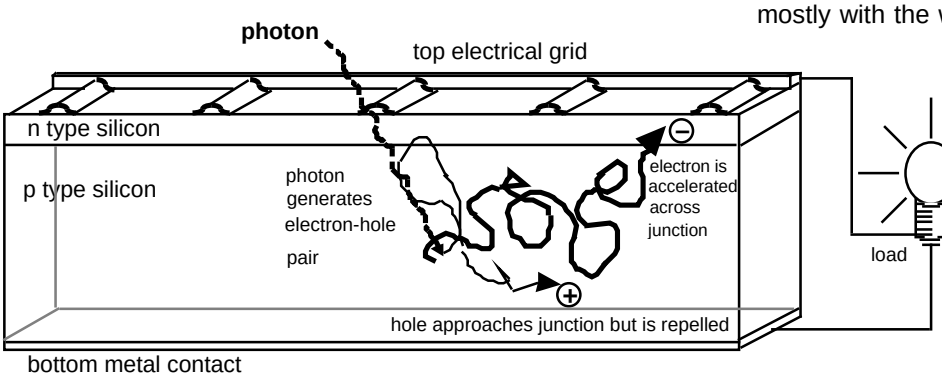

Figure 7 schematic of a pv cell.

accelerated across by the electric field. If the hole happens to wander into the junction, it will be repelled.

The electron, once it has gone across, will stay on the n-side since only rarely does it have the energy to climb the barrier back to the p side. It has little danger of recombining with a hole because there are very few holes on the n side. A similar situation occurs when the electron-hole pairs are created by light on the n side. In this case the hole, if it diffuses into the junction will be accelerated across to the p side where there are very few electrons. The only work performed by the light was the separation of electrons from the holes at some atom. As the electrons and holes wandered around the crystal, the minority carriers (electrons on the p side, holes on the n side) that came upon the junction were accelerated through to the other side by the 'frozen in' electric field of the junction. The charge imbalance in an illuminated cell (electrons piled up on the n-side, holes on the p side) creates a voltage difference, and if the two sides are connected by a wire, a current of electrons will flow from the n-side to the less electron crowded p-side doing work against an external load. Actually this last sentence is not rigorous enough to account for the current and the voltage of the cell. The electrons lose potential energy as they cross the junction, just as a ball loses potential energy as it rolls downhill. The electrons remain, however, free, and as such they have a higher potential energy than the bound electrons on the p side. Since most of the electrons on the p side are bound, and most on the n side are free, taking the material as a whole, the higher energy of n side electrons creates a voltage difference between the p and n sides. Connecting the two sides with an electrical load, the photogenerated electrons will flow from the n side through the load to the lower energy p side.

Further Reading

Physicists use other models to design and predict the voltage and current of a solar cell. They are concerned mostly with the ways electrons and holes can recombine, robbing a cell of its output. If you're interested, there are a number of more deeply into this. I recommend R. J. Van Overstraeten and R. P. Mertens, Physics, Technology and Use of Photovoltaics, (Adam Hilger Ltd, Bristol 1986) and Kenneth Zweibel, Basic Photovoltaic Principles and Methods, (Van Nostrand Reinhold Co.), 1984

Access

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PV Ratings

Jim Cooley

As one becomes involved in the design of a PV power system, be it large or small, a critical factor is the number of modules needed to supply the power. This is, in theory, a simple case of arithmetic, somewhat equivalent to balancing a check book. In reality, you need to put back what is taken out, plus the percentage lost to inefficiency. Basically, you figure your loads, and then use the module rating to estimate haw many are necessary to replace what is used. A PV module in southern Arizona in July will produce different curves than an equal module in Montana in July. One sees that the PV module rating is, and probably never will be, an accurate indicator of its actual output under ever changing real world conditions.

As in most things today, we are applying a certain amount of science to the output specs. This is where an understanding of how the ratings are achieved is very important to any design. If you purchase a 50 watt (manufacturer rated) PV module, it's a sure bet that when it's out in the sun, you won't always get 50 watts.

Among the many things affecting that spec are;
A) actual surface temperature of the cell
B) actual light intensity at the cell's surface
C) wiring resistance from module to application
D) angle of cell to sun
E) age and condition of the battery bank (when charging batteries)
F) quality and number of connections between the module and the load
G) age and condition of the module itself
H) accuracy of the instrument used for the measurement

It is fairly safe and somewhat optimistic to say that under the controlled conditions at which the module is initially rated, an accurate output would likely fall within reasonably close range of its factory spec. But the range of realities under which most PVs are utilized, leaves the end user with somewhat less than they paid for.

In the 10 odd years I have been involved with this science, I have been witness to both ends of the truth. In many cases a lack of spec'd output can honestly be attributed to the conditions of the atmosphere at the time, or one or more of the factors A)-H). And, in a few cases, I have actually seen the modules outperform the specs', under less than perfect atmospheric conditions (this can also prove to be a problem when the design thresholds are passed). But in other applications, I have been at somewhat of a loss to explain the reasons for low output and would draw conclusions of misrating on the part of the manufacturer, intentional or not.

But before we all run out to instigate litigation against the PV manufacturers, we should consider the many variables involved, the need for some type of logical base rating, and that when we consider all the pieces of the system (regulators, batteries, inverters, etc.) the fractions lost from errant PV ratings are, in most cases, the easiest to overcome. As it applies, simply add some additional input. The case of overkill is no stranger when choosing a generator, a battery bank or an inverter, (definitely when choosing an inverter). In the real world, PV overkill follows common sense.

At best, ratings and specs give us a base to start with, while actual experience under specific operating conditions is the only true critic.

Access
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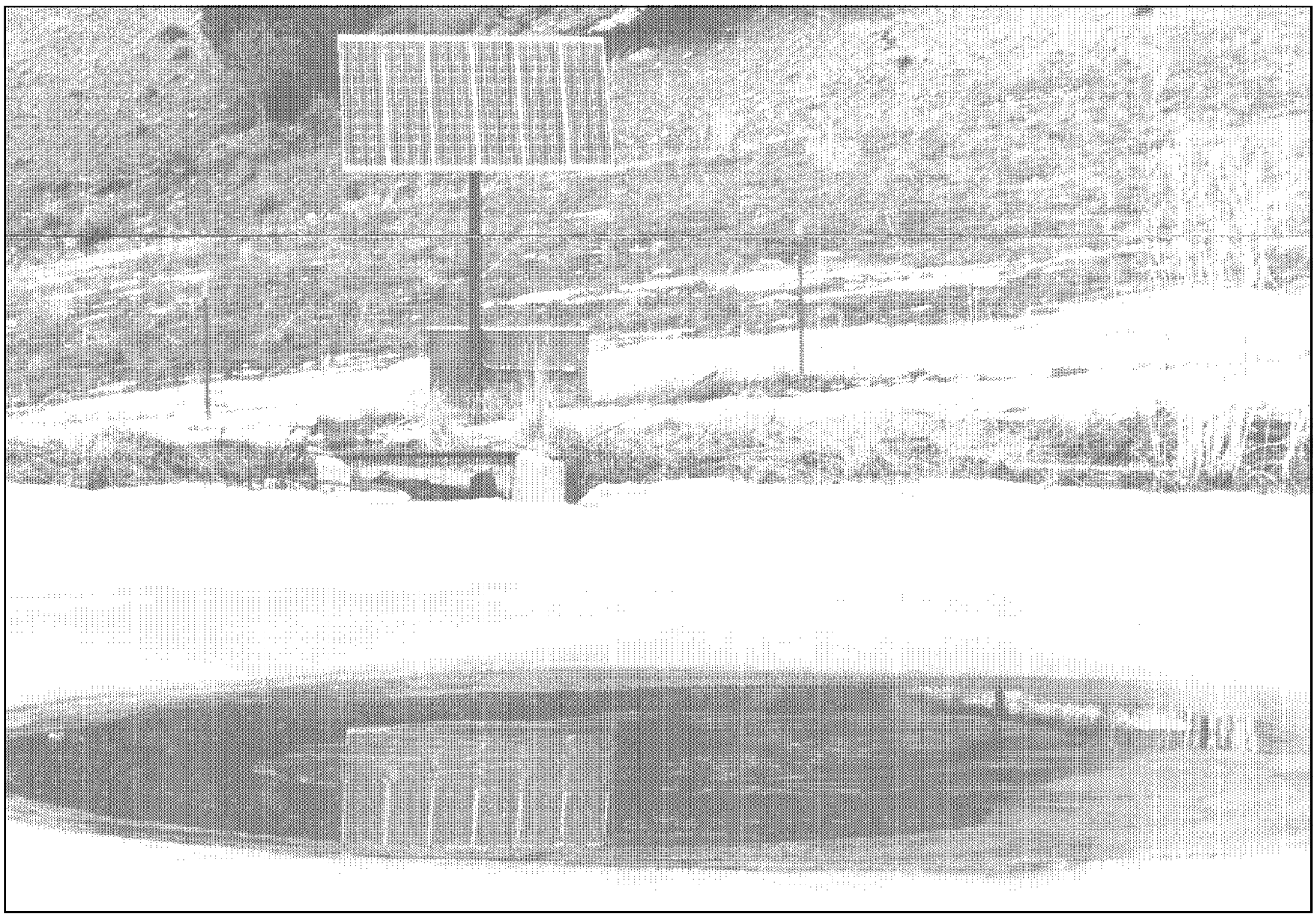


Above: PV powered pond aeration at the Danciger Ranch's trout pond near Carbondale, Colorado. Photo by Crissy Leonard.

Pond Aeration: Photovoltaic Powered

Scott Ely, Tami Schneck, and Ken Olson

Pond Aeration is a technology used by ranchers, recreationalists, scientists, and entrepenuers for improving water quality and fisheries management. The basic principle involves the pumping of air into the water column to increase the supply of oxygen. We would like to share with you our collective efforts and experiences with PV powered pond aeration systems.

Why aerate?

Pond aeration allows ranchers the opportunity to keep ponds free from aquatic vegetation which can clog watering and irrigation equipment. Recreationalists can better enjoy their fishing experience in a healthy pond or lake environment. Water treatment facilities utilize pond aeration in waste water lagoons to achieve water quality. Another common application for aeration is the business of aquaculture where aquatic life is cultivated for sale. Although the process has been used for many years, only recently have these systems been powered by photovoltaics.

Small Pond Applications

For our purposes, we will define a small pond as a body of water ranging up to 1–1/2 acres in size and 10 to 12 feet deep. Some examples of small pond environments which can benefit from aeration include:

1. Ponds that are plagued by algae and aquatic plant growth due to nutrient inputs such as runoff from fertilized

lawns and agricultural areas, etc. Excessive vegetative growth can cause water quality problems in terms of high pH levels and fluctuating oxygen levels. Oxygen depletions and fishkills typically occur in the summer when plant growth and water temperatures are highest.

2. Ponds that are located in areas where ice cover and heavy snowfall occur during the winter months. In such situations, sunlight can not penetrate into the water column, thus limiting oxygen production by plants. An oxygen depletion or 'winterkill' will typically result.

3. Ponds that are stagnant and may be low in oxygen because there is no flowing water.

4. Ponds that are affected by eutrification (the natural aging process of a body of water). Such waters are typically high in nutrients which cause an excessive growth of aquatic vegetation. The abundance of growth results in an accumulation of organic material on the pond bottom. This leaves little or no oxygen in the bottom water layers and inhibits the natural decomposition process.

If low oxygen conditions prevail, water quality may eventually deteriorate to the point where the pond environment will no longer support aquatic life. Aesthetically, the pond may become an eye-sore if aquatic vegetation is excessive. Low oxygen levels may also limit the natural decomposition process thereby causing odor problems.

Pond aeration will improve water quality by:

1. Increasing the circulation of water, preventing stagnation and stratification.

2. Oxidizing or breaking down organic material which tends to accumulate on the bottom of the pond.

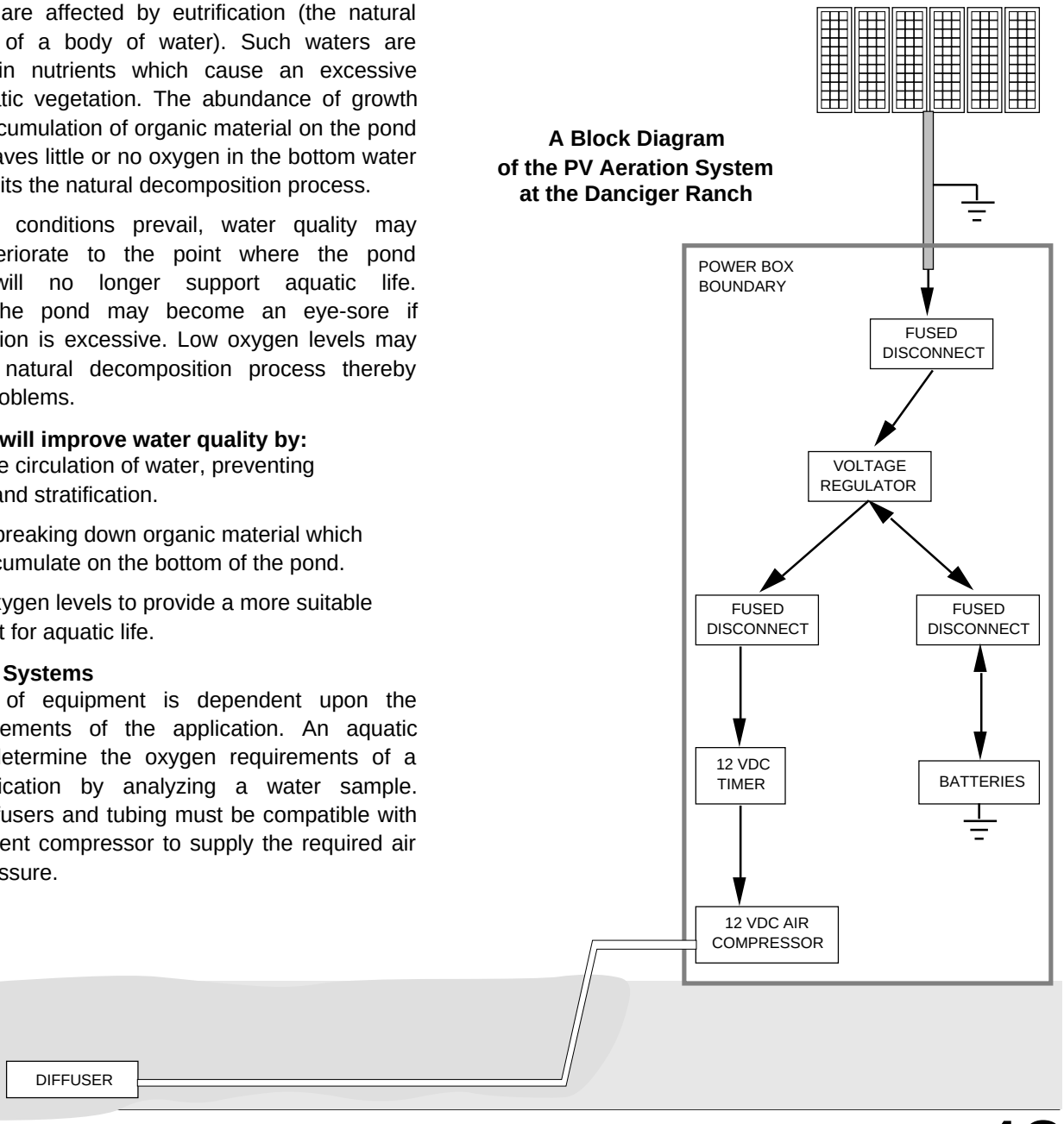
3. Increasing oxygen levels to provide a more suitable environment for aquatic life.

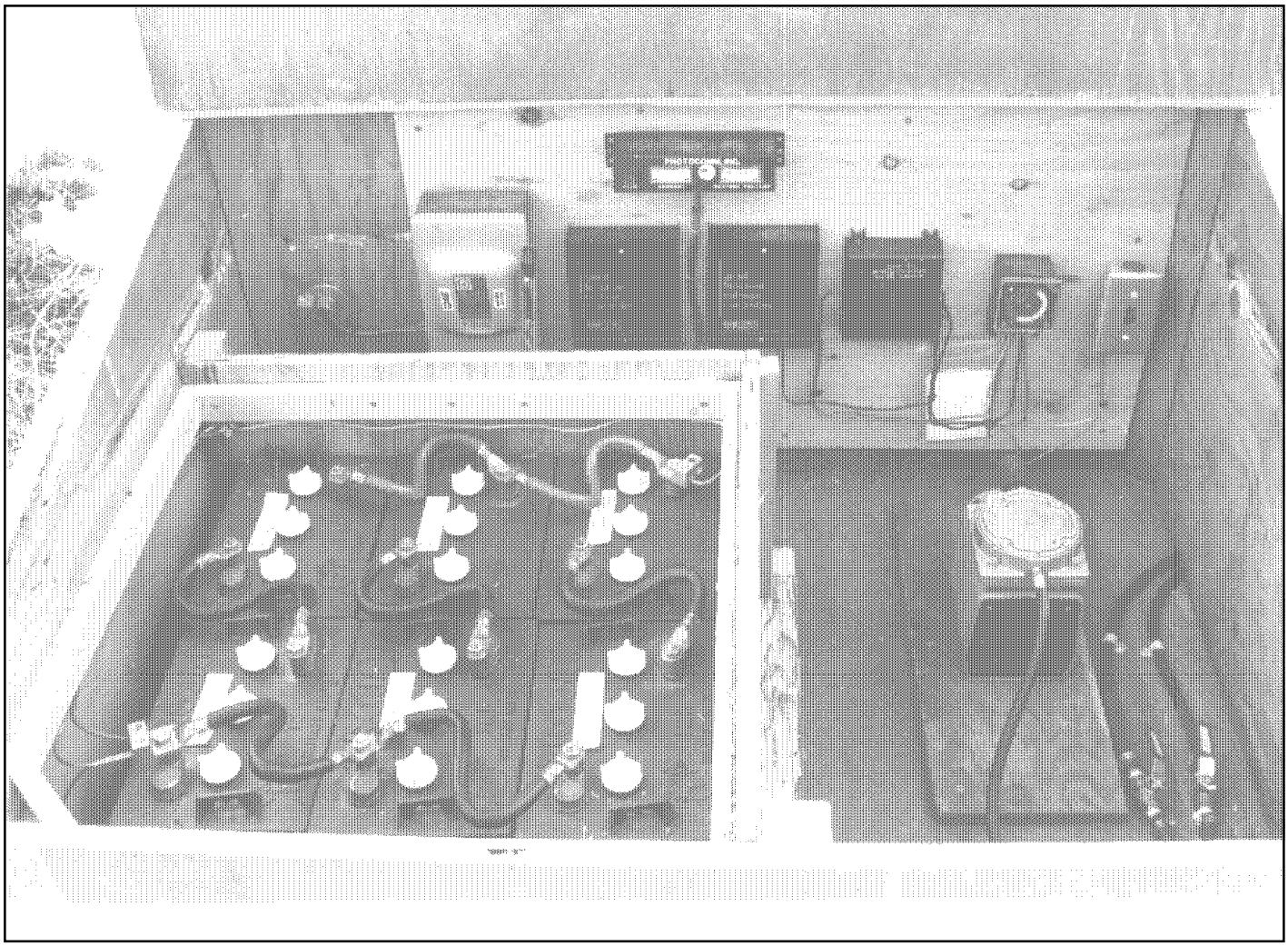
Pond Aeration Systems

The selection of equipment is dependent upon the aeration requirements of the application. An aquatic biologist can determine the oxygen requirements of a particular application by analyzing a water sample. Selection of diffusers and tubing must be compatible with an energy-efficient compressor to supply the required air volume and pressure.

A small diaphragm compressor is used to pump air through polyethylene tubing and into air diffusers strategically placed on the pond bottom. Air bubbles are released through the diffusers to oxygenate the bottom waters and the entire water column. Aeration efficiency can be increased by placing the diffuser(s) in the deepest water, thereby increasing the time length of the bubbling action. Smaller bubbles have a larger surface area to aerate the water column. Although these two factors of bubble size and depth increase aeration efficiency, consideration must be given to the resulting increase in power requirements.

A Block Diagram of the PV Aeration System at the Danciger Ranch





Above: the box housing the Danciger System's equipment. Inside are batteries, controls, fused disconnects, a timer, and the 12 VDC air compressor. Photo by Crissy Leonard.

POND AERATION EQUIPMENT

Compressors

Air compressors on the market today are generally appropriate for large aeration applications utilizing utility grid power. The selection of low voltage compressors for this application is rather limited. Typical pond aeration requires an airflow of .5 CFM at a pressure of 5 to 10 PSI. The compressor is selected to provide the required volume of air at the required pressure to be developed.

Choosing a compressor is a rather simple task since we've already established that there is a limited selection of low voltage compressors on the market. The challenge to the designer becomes selection of the proper diffuser and pipe to match the compressor's capacity. Pressure is determined by the type and depth of diffusers, and size and length of polyethylene tubing being used.

Tubing

For small pond applications, tubing size is normally limited to 1/2" to 3/4". The tubing is a lead–weighted polyethylene which is buried from the compressor to just below shoreline. From there it runs to the diffuser which should be located near the center of the pond where the depth is greatest.

Diffusers

There are three types of diffusers manufactured for pond aeration: airstone, venturi and perforated diffusion tubing. The airstone and perforated tubing are more efficient in terms of oxygen transfer because they generate a smaller bubble size. They also have correspondingly larger power requirements. The venturi is the simplest type of diffuser although it produces large, coarse bubbles which do not

allow for very efficient oxygen transfer.

Installation Of Aeration Equipment
The installation of pond aeration equipment is fairly simple. The compressor is generally located near the body of water in order to minimize length of tubing runs. The polyethylene tubing should be buried and enter the water below the water's surface. This will protect it from sunlight, animals and people. Consideration must be given to fluctuations in water level so as not to expose the buried pipe.

To install the diffuser, attach it firmly to the polyethylene tubing using hose barbs, hose clamps or other appropriate fittings. The installer floats out to the desired location and lowers the diffuser allowing it to settle on the bottom.

Power By Photovoltaics
PV-powered pond aeration is appropriate for small ponds where utility or generator power are impractical. Although maximum benefits can be expected from continuous operation, adequate results may be derived from a shorter duty cycle. An aeration system powered by photovoltaics is typically designed to provide a minimum of 4 to 6 hours of operation daily. The particular hours and length of operation will depend upon the site-specific needs of the water body as determined by an aquatic biologist.

The photovoltaic components for a small pond aeration systems are very straight forward. Photovoltaic panels charge batteries through a controller which prevents overcharging. The controller should be set for proper charge termination corresponding to the battery type used. Temperature compensation is advisable for cold or very warm climates. Sealed, deep cycle, maintenance free batteries are suggested for most pond applications where access to the system for maintenance is a problem. A reliable, low voltage timer allows the compressor operating time to be set according to seasonal requirements. As with most photovoltaic systems, the modules require proper orientation and seasonal angle adjustments for maximum performance.

Case Study: Danciger Ranch Trout Pond
The Ty–Bar Ranch, Carbondale, Colorado, owned by Dave and Emma Danciger has two adjacent trout ponds totaling approximately 1–1/2 acres. Cold Colorado winters make it nearly impossible to keep trout from one year to the next. Ice and snow build–up over the winter deplete the pond's oxygen supply, killing the fish stock.

Students from the Colorado Mountain College's Solar Program installed a photovoltaic-powered pond aeration system (see photos) in April 1990 under the close guidance of Johnny Weiss and Steve McCarney, two of the Program's instructors.

The Danciger system has large oxygen requirements for a number of reasons: There are two ponds and two venturi diffusers. The location is at a low altitude (6300 Ft elevation) and warm climate. Seasonal drought conditions and lesser water inflow often contribute to warmer water temperatures.

Each of the two ponds has one venturi type diffuser located at the pond's bottom/center. One 12 Volt compressor supplies air to both of the diffusers. Aeration operation is set to operate from 6 AM ™ 8 AM and Noon – 4PM during the Winter months (Nov – Apr) and 5 AM – 11 AM during the Summer months (May – Oct). The system specifications and equipment costs are as follows.

2 – Venturi diffusers, Lead–weighted polyethylene tubing
1 – Compressor, Gast Model AG 244, 12 Volt, 14 Amp max
1 – 12V, 24 Hr Timer, Lumenite, Model DT 112–SR
6 – ARCO M–75 Modules
6 – Trojan T–105, Lead–acid batteries, 660 AH @12 Volts
1 – 30 Amp Safety Switch
2 – Trace C–30 Controls (One set to terminate battery charging at 14.5 Volts and one set to terminate battery discharge at 11.2 Volts)
1 – Photocomm Metering package, Array Current and Battery Voltage
Misc. Wiring, fuses and connectors
Total equipment cost approximately $ 4500.

Additional information on small pond aeration is difficult to find. There are resources in the waste water engineering field, but they are very complex and do not translate well into the small pond aeration systems. The application of photovoltaics in the aeration of ponds is a new technology and requires experienced biological input as well as qualified PV design assistance.

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Ken Olson is a founding Board member of the Solar Technology Institute, P.O. Box 1115, Carbondale Colorado 81623, 303–963–0715. The Solar Technology Institute is offering numerous practical applications workshops in renewable energy technologies. See

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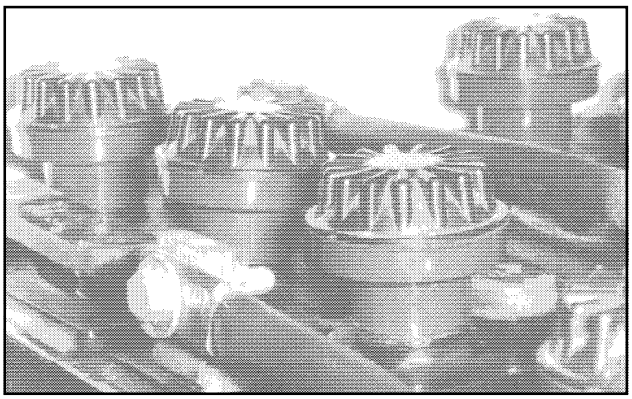

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Pedal Power

John W. Hill

You too can be a human power plant. A lot of folks have expressed interest in pedal power setups as backup or primary power sources. Here is a general perspective on the utility of this approach to greater independence.

Power Output

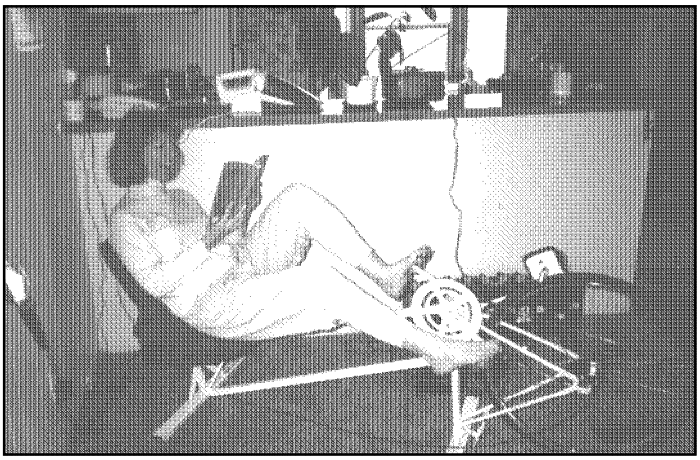
If you hook up a bicycle to a generator how much power can you generate? How practical is it as a home power resource?

The answer depends largely on your use and expectations. The first consideration is how much power can you generate. A fit olympic-class athlete may be able to generate as much as half of one horsepower for a brief time. At 746 watts per horsepower that translates into approximately 370 watts peak. A modestly fit person can expect to generate about one tenth horsepower (roughly 70 watts) for a brief period. For normal regular use a generator capable of producing 50 watts or more is quite adequate. If you are a cyclist interested in serious training, a generator capable of 100 watts or more is desirable. Permanent Magnet (PM) generators ranging in size from 60 watts to 200 watts are readily available and can be obtained with the bike generator options described below.

Compare this to the output from a 50 watt solar panel that runs 6 hours per day. If you could sustain a 50 watt rate for 6 hours, you could match the power generated by one solar panel, provided that you had nothing better to do with your days and nights. Clearly, a bicycle generator is not a competitor for solar panels, wind generators, or microhydro as a home power source.

For What?

Now look at it from another point of view. A high efficiency PL light will draw from 5 to 13 watts of power and a small DC television will draw from 15 to 60 watts of power depending on it's size and type. One hour of serious pedaling would provide enough power to supply a PL light for 3 to 10 hours depending on the size of the light. Or, it could power the TV set for 1 to 3 hours depending on it's size. So for such essentials as lighting, communications, or entertainment, a bicycle power system can provide adequate and useful power.



Above: exercise and battery charging all at the same time.
Photo by John W. Hill

Can Do

The next question is, "Can you pedal at a stiff clip for an hour?" The same question is, "Can you ride a bicycle for an hour?". If you ride a bicycle for transportation or regular recreation, the bicycle generator will prove to be a natural part of your lifestyle. If you can't ride a bicycle for an hour, perhaps you should add the bike generator to your lifestyle as a physical fitness and training aid.

How So?

"How do you use it?" To obtain the maximum efficiency, the generator needs to be a permanent magnet DC type. The PM generators produce voltage directly proportional to the shaft speed. Of the several generators available, output voltages can reach 40 to 100 volts or more if you set the bicycle into a high gear and pedal at a very fast clip. These voltages can burn up a 12 volt appliance in short order. There are two ways to handle the problem.

First, you can use a storage battery to regulate the voltage for the appliances. If you connect a generator spinning at a 40 volt rate to a 12 volt battery, the generator output voltage will drop to match the battery voltage. This occurs because the current from the generator has to flow through its internal resistance and produces a voltage drop that is equal to the difference between the open circuit generator voltage and the battery's terminal voltage. If you are charging batteries, you will need a few additional components. These include a voltmeter to monitor the state of battery charge, a blocking diode, and preferably a charge controller. You have to be a bit careful with charge controllers though. If you use a charge controller that was designed for solar panels, it may not tolerate the excessive voltages that the PM generators can produce. Some additional circuitry to protect the charge controller is desirable.

Batteries
A battery for use with a pedal power set up should not be too large. After all, you wouldn't want to have to pedal for two days solid just to charge the rascal back up, would you? Industrial pocket plate nickel cadmium batteries are ideal for this application because they have a relatively flat discharge curve and don't mind being deeply discharged and operated in a partial state of charge. This applies only to the pocket plate type of NiCad cell which has no memory characteristic. Unless several people are contributing regularly to the charging process, 20-40 ampere hours of capacity is very adequate. Larger capacities will work of course, or you can simply pipe the current generated into the larger battery bank of a complete home power system.

Voltage Regulator
The alternative to using a battery is to use a voltage regulator to buffer the variable output from the generator down to a constant 12.6 volts. With this arrangement, the lights and other appliances are on while you crank but go off when you quit. This offers a real education in the amount of power we drain from the system. Cranking a color TV and VCR is hard work while powering a reading light or two is so easy of a load that you hardly feel it. The advantage of having a regulator available is that you can get full use from the system even if your battery is flat dead. It also doesn't take up the space required by the batteries and it provides some discipline in the use of certain appliances. Some folks, for example, connect the TV set to their bike generator with a regulator and require the kids to carry their own weight when watching TV.

Bike Type
The next consideration is the type of bicycle setup to use. Most standard bicycle trainers can be fitted with an appropriate PM generator. Daniel Millton of The Power Company offers a relatively inexpensive conversion kit for converting your bicycle or exercise stand into a pedal power unit. He also makes a complete converted exercise stand, a recumbent pedal powered generator setup, and offers complete pedal powered systems with all electronics and system components.

The recumbent is a real pleasure to use. First, it is comfortable, and the recumbent design allows maximum use of leg strength. The seat is adjustable for any size person from 6 years old on up and it comes with a book holder for reading while pedaling. You can even sit in the padded seat and lean forward and turn the pedals with your arms. After tossing a log on the fire, and leisurely cranking away while the PL reading lights ignited and flickered to life, I realized that pedal power does indeed have a rightful place in the lives of people who defy slavery to the 60 Hz. umbilicals and all the economic, environmental, and resource waste that they represent. This reminded me of an old Amish farmer's comment on electrical power and telephones. He said, "It isn't that we believe that these things are bad particularly, it is just that we don't want to have wires binding us to the Englishman's world."

Security
During the winter storms a few months back, when the power lines were down, the wind generator was iced up, the solar panels were covered with snow, and the main battery bank was gasping up its last amp, the pedal power unit made a very nice addition to the home.

In summary, pedal power is valuable as a reliable emergency power source, as an auxiliary power source for driving small tools or appliances, and as a fitness aid. If you are considering pedal power, be realistic and don't expect it to compete with solar panels and other alternative power sources. Happy pedaling!

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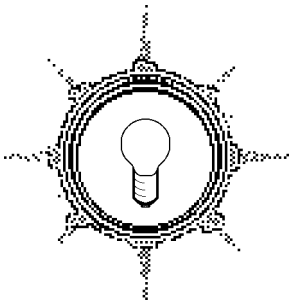

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How an Inverter Works

Clifford W. Mossberg

The process of converting low voltage direct current (DC) electricity into high voltage alternating current (ac) is not particularly "hi-tech" but it has several levels of complexity. The most complex levels use high tech solutions and are frequently employed because they make efficient and reliable inverters. In this article I will not try to explain the esoteric details of such "techy" stuff – I'm not qualified – but I will try to give the novice user a basic idea of what is going on inside that heavy box hooked up to the batteries.

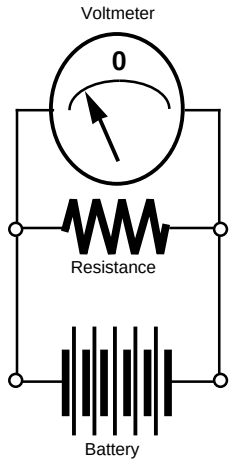
Inverting really means Switching Polarity

At the simplest level alternating current (ac) can be achieved by a simple switching device which just swaps connections to the battery leads.

In the very basic circuit and graph in illustration 1, a simple DC resistance is shown, for instance a light bulb. The "voltmeter" I have drawn is the type which registers zero in the center of the meter, so current flow in either direction through the resistance (bulb) will show up as movement of the needle to either the left or right of zero, depending on the polarity of the battery hook-up.

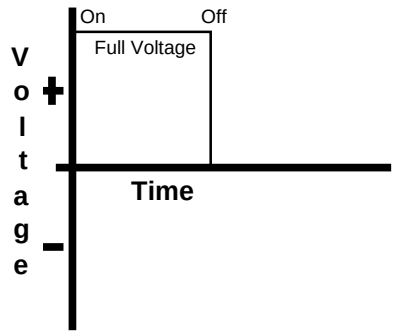
When the resistor is hooked to the battery, current will start to flow. The voltmeter will measure a voltage drop equal to the voltage which the battery can produce. If the battery was 12 volts and the resistance was an automotive tail light bulb the reading of the volt meter would be 12 volts. The graph shows that this would start the instant the resistance was hooked to the battery and would stop just as suddenly when the resistance was disconnected. The length of time the voltage shows on our voltmeter could be anything in this example, from milliseconds to hours.

In illustration 2 the leads from the battery to the resistor have been switched so the resistor is hooked up opposite what it was in illustration 1. You will notice that the voltmeter is now deflected to the same



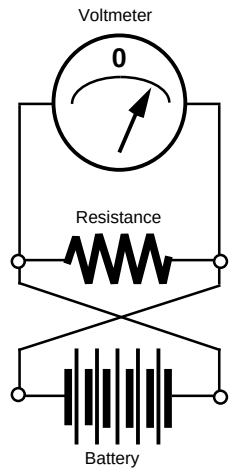
Simple DC resistance circuit

Illustration 1A



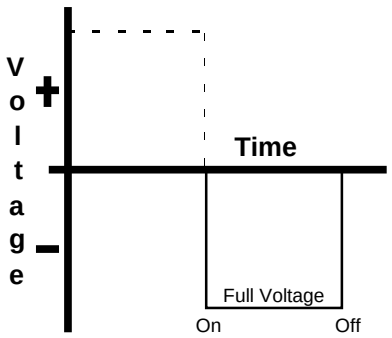
First half cycle of inverter opperation. Leads to battery are connected; voltage turns on, remains on for some period of time, and is turned off.

Illustration 1B



Simple DC resistance circuit with opposite polarity to 1A

Illustration 2A



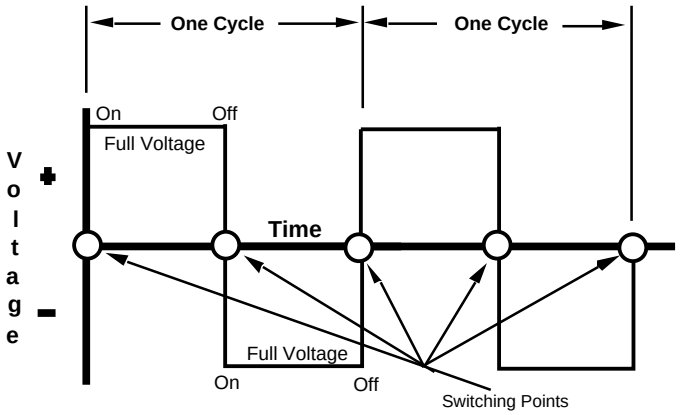
Second half cycle of inverter opperation. Leads to battery are switched; voltage turns on in opposite direction, remains on for some period of time, and is turned off.

Illustration 2B

reading (12 volts in our example) in the opposite direction. In illustration 2B I have extended the graph in 1B, drawing the new meter voltage reading as if it was turned on at the moment when the circuit in 1A was switched off. This graph (2B) is neatly drawn with both time intervals exactly the same length because in an actual inverter the interval that the electricity would be turned on would actually be the same, but in our crude example there is nothing which would necessarily make both periods of current flow equal. One of the necessary devices in an inverter is a timing mechanism that will make these pulses of electricity of about equal duration.

The same circuit can produce opposite effects electrically just by reversing the flow of electrons, or current. Here we have the basic principle of an inverter. Suppose for timing we hooked an electric motor to a simple rotating switch? For half the rotation of the switch current could flow as in illustration 1, for the other half of the rotation current flows as in illustration 2. This simple timing device would assure that the electrical energy in each pulse would be about equal. Here we have the simplest of inverters.

Each pair of negative and positive electrical pulses shown in illustration 2B would be one cycle. The number of cycles that occur in each second would be the frequency of the cycles. In this example, the frequency of this simple inverter would be controlled by the speed of the electrical motor, not a very elegant nor accurate method of controlling frequency, but--surprisingly--good enough in some cases. In actual fact I have only used this method to illustrate what is necessary and it is not a practical solution, however in some circuits a vibrating switch is used to reverse the current flow. While this is crude and does not produce an accurate frequency, it is good enough for some applications. For instance, old tube type car radios used a vibrator to invert 12 volt DC.



Graph of simple square wave inverter voltage. Every time leads to battery are switched voltage reverses polarity.

Illustration 3

The graph in illustration 3 shows two complete cycles of inverter operation. This type of current flow is known as a square wave for obvious reasons. It will repeat itself as long as the battery voltage is being switched. This repetition of full cycles is the frequency of the inverter and is given in "cycles per second" or "Hertz" in more modern terminology. Normal ac line frequency in North America is 60 Hertz (Hz.). (in some other countries it is 50 Hertz and in aircraft operation 400 Hertz is common). This 60 Hertz frequency is very important and it must be accurately controlled. A typical gasoline-powered small generator may control frequency to plus or minus 1 Hertz; that is, the frequency of such a generator might range from 59 Hertz to 61 Hertz. Anything much beyond this and electrical gizmos begin burning up. Commercial electricity is controlled much more precisely. For all intents and purposed there is no variation in the frequency of electricity from your power line for the simple reason that even minor deviations will cause the source of the offending power to be disconnected. Accurate control of frequency in an inverter is very important and as yet our crude inverter has no control.

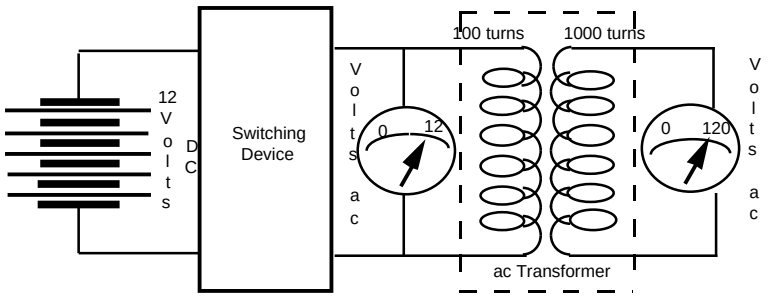
If we go back to our example we can determine that the speed of the motor running our rotary switch is what controls the number of times per second that our electricity changes direction. Speed up the motor and thus the rotation of the switch and the electricity will change direction faster, it will increase its frequency. It would be possible to accurately control the speed of the motor but the solution to do that best would probably incorporate solid state electronics and at that point switching and frequency could be more efficiently controlled by an all solid-state circuit which would eliminate the motor and rotary switch entirely. A circuit similar to "The Time Machine" circuit shown on page 79 of Home Power #21 would do well either to control the speed of our motor in the hypothetical example, or if we throw away the switch and motor the same circuit--with minor changes--would act as the switching device.

We have built a simple inverter now. It converts DC electricity into ac electricity of the same voltage. That's all very well if you have batteries that supply 120 volts DC but that's the exception not the rule. More commonly we will have 12 or 24 volt battery banks and so we will need to increase the inverter output voltage from some low value to the 120 volts which our ac appliances will require. However our inverter has made this easy for us. Once we have ac electricity we can use a simple

transformer to increase the voltage.

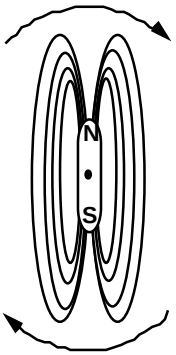
Enter the Transformer

A transformer in its simplest form is just two coils of wire placed close to each other. Alternating current flowing in one coil will generate electricity in the second coil, so without any direct connection between the coils we have electricity flowing in on one side and out on the other. The interesting thing about this is that the electricity can be changed in voltage as it passes through the transformer. Input and output voltage will be directly proportional to the number of turns in each coil. For instance if there are 100 turns of wire in the input coil and 1000 turns in the output coil the ratio of input voltage to output voltage is 1:10. If you supply 12 volts of ac electricity to the input coil of the transformer in this example you will get 120 volts out! This is not nearly as simple as I'm painting it to be but the principle holds. So all we need to do to finish up our inverter is attach the proper transformer to the ac output and we have it, 120 volt ac square wave electricity. There is one little problem though, our appliances don't like to eat square wave electricity.



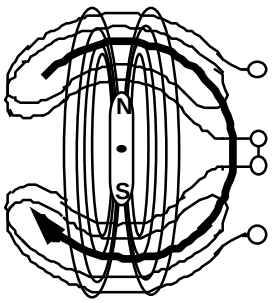
Schematic diagram of simple 12 volt DC to 120 volt ac square wave inverter

Illustration 4



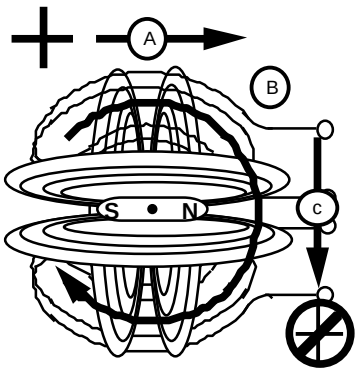
Magnetic field around rotating bar magnet (or generator armature)

Illustration 5A



Rotating magnetic field cuttingthrough coils of wire inside generator

Illustration 5B



Rotating magnetic field develops maximum voltage in coils when lines of force cut across wires, minimum voltage when lines of force are parallel with wires.

Illustration 5C

"Rolling Stock" or Alternators

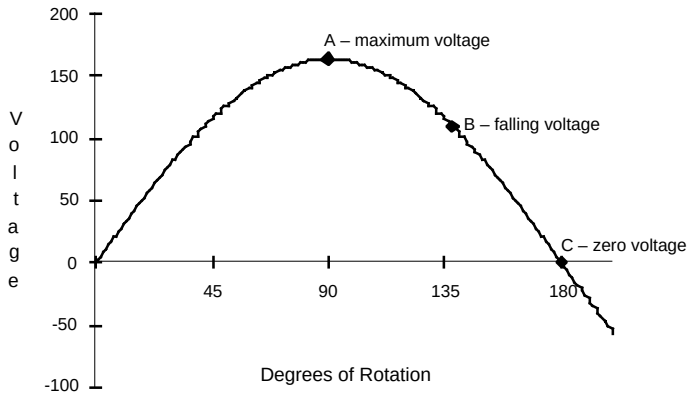
Most ac electricity is generated by rotating a magnet or an electromagnet between coils of wire. The electricity is generated as the "magnetic lines of force" cut through the wires in the coils. The process of a rotating magnetic field within coils of wire is used by engine/generators and by commercial utilities. Illustration 5 shows this.

The lines of magnetic force can be thought of as directional. As the magnet in the generator rotates, the lines of magnetic force are sometimes far away from the coils of wire and moving toward them and at other times they are very close to the coils and cutting directly across the wires. In the former case there is no voltage at all being produced while in the later case it is producing maximum voltage.

Sinusoidal, or Sine-Wave, Power

Illustration 6 is a graph of the voltage produced through one half of a revolution of the magnet in Illustration 5C. Points A, B, and C correspond with the labeled positions of the magnet. Compare this with the square wave graph for our crude inverter. Illurstration 6 is a sine wave curve and it is a "picture" of the electricity which your local power company produces. Electrical appliances with motors in them use coils of wire in the motors to make them operate and these coils of wire (called inductive

Illustration 6 – Sine Wave (Half Cycle)



loads) feel very comfortable with sine wave ac electricity. This is logical if you think of it. A rotating magnet inside a coil in a generator should be well matched to a rotating magnet inside a coil in a motor. Their electrical properties are the same.

Square Waves and Sine Waves

Illustration 7 is a graph comparing sine and square waves of the same size and period. The interesting thing about a graph like this is that (mathematically) the area underneath the curves in each graph is a proportional representation of power. Even a quick look can see that there is more power underneath each half cycle of the square wave (more area in the rectangle) than there is underneath each half cycle (hump) of the sine wave. This is the problem with a square wave inverter. Motors (inductive loads) don't know how to use that extra power in a square wave. They will go on using the same amount of power they would use if a sine wave was supplied, and with evil single mindedness, they change the remaining extra power into heat! This extra heat builds up until it burns the insulation off the wire in the motor's windings and a trip to the graveyard for that appliance. All ac appliances like the gradual and elegant changes made by the sine wave. Many appliances have problems digesting the abrupt changes offered by the square wave. Problem appliances may do anything from protesting with a load audio buzz, to frying and dying.

Modified-Sine Wave

Enter the modified-sine wave or quasi-sine wave. Keeping in mind that the area under each curve is power, if a square wave could be produced that had the same area (power) as a sine wave it would take care of the major problems. We could do this by reducing the height (voltage) of the square wave but reduced voltage means reduced motor performance. The trick is to keep the voltage up, but reduce the length of time it is on so that the two curves look about the same to a motor. Using silicon magic, this is now fairly easy.

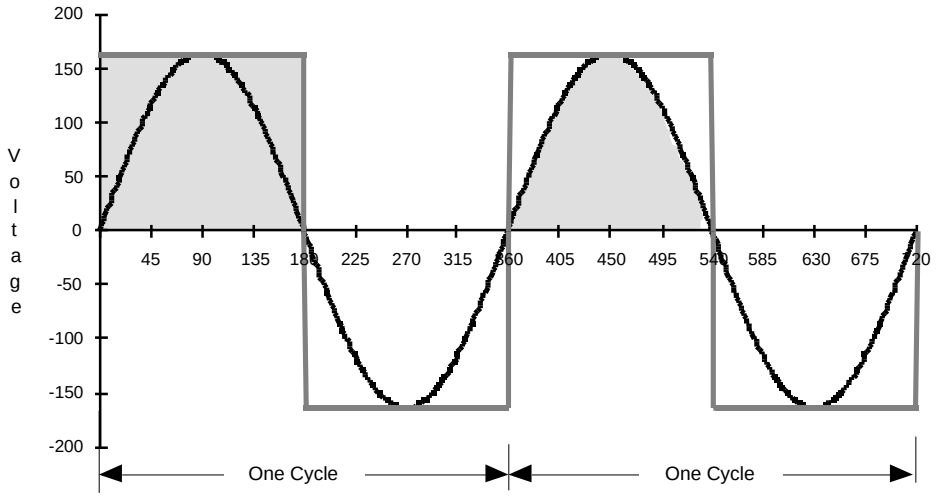
Our alphabetic friends, the ICs and the FETs

Instead of a simple on/off circuit the modified-sine wave inverter requires a timing cycle which has a variable "off "segment to it. Illustration 8A shows a quasi-sine wave while Illustration 8B compares this with a true sine wave. From this you can see that the trick is to turn off the electrical pulse of the square wave for a longer time. This is quite easy to accomplish efficiently with modern integrated circuits (ICs) and super efficient field-effect transistors (FETs). This is the method most often used in a modern inverter found in our renewable energy systems.

The Last Word? Not Likely…

I hope this makes modified-sine wave inverters a little clearer to those folks who use them but don't want to know too much about them. The truth is that I have left out far more than I've included.

Illustration 7 – Area Under Square Wave or Sine Wave is equal to Power



(One full revolution of magnet in Sine Wave)

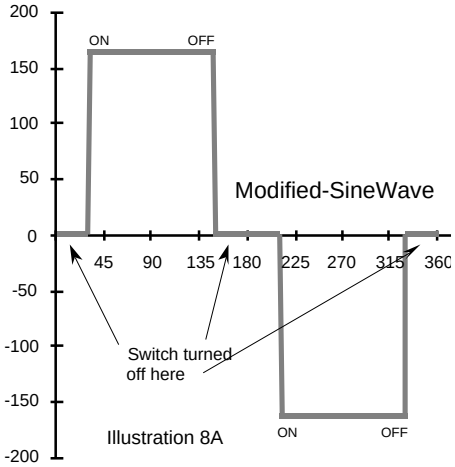


Illustration 8A

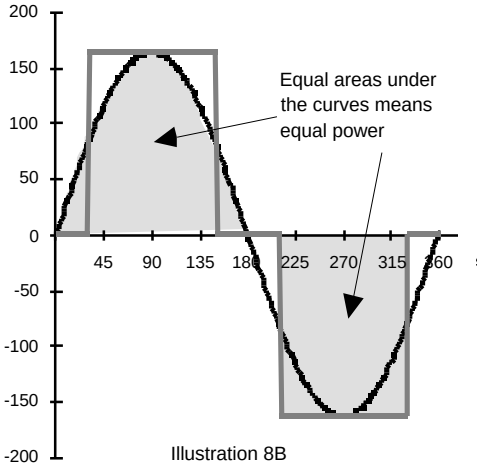


Illustration 8B

The modern quasi-sine wave inverters such as the Traces, or Heliotropes, and PowerStars just to name a few, are wonders of design and efficiency. They use the basic ideas offered here, but employ them electronically to custom-tailor the inverter's power production to the particular job at hand. This electronic magic gives us reliable inverters with phenomenal efficiency.

Inverters have done a lot to cushion the foibles of Ms. Nature in lonely places. I, for one, pray to the god Kilowatt every time I turn on my electric ice cream freezer and think of the complexity of the process that brings me this luxury from the sun, wind, and water.

Access
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SOLAR CAR CORP.

Things that Work!
Alternative Energy Engineering's High Lifter Pump

Things that Work!
tested by Home Power

Test Conducted by Michael Welch

Let me start by saying that I am completely sold on the High Lifter pump for my application. My High Lifter is pumping 240 gallons per day from a 6 gallons per minute spring that is 132 feet downhill from my water tank. The High Lifter is located 26 vertical feet below my spring.

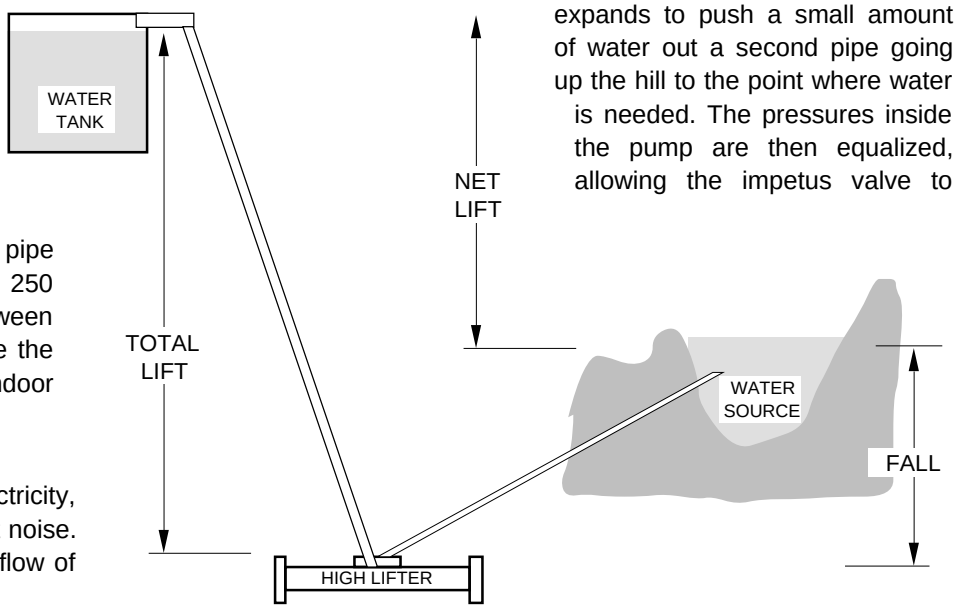
Shipping Container and Documentation

The High Lifter comes well wrapped in a 6 in. x 6 in. x 28 in.cardboard box. Alternative Energy Engineering uses recycled materials for packaging their products. The shipping weight is 10 pounds. Included with the pump itself is an inlet filter, an inlet pressure gauge, a hose for between the filter and the pump, an output pressure gauge, and a ball valve with a check valve for the outlet.

The Owner's Manual that comes with the pump is one of the best written pieces of documentation that I've ever seen. It is 23 pages long and includes: an introduction, typical applications, how it works, how to install it for various situations, an in depth section on maintenance and troubleshooting, performance curves, a trouble shooting flow-chart, an exploded view showing all the pump parts, and a specifications table.

The Test Site

My water system is comprised of a spring which flows into a large 480 gallon settling tank. From there, the water flows at 6 gallons per minute through 3/4 inch Schedule 40 PVC pipe 26 vertical feet to my pump site. The pump then pushes the water up 158 vertical feet through 1" black rolled drinking water pipe (only 1/2 inch pipe is required). The 250 gallon tank at the top is suspended between two sturdy conifers about 20 feet above the taps in my home to obtain sufficient indoor water pressure.



Pumping water without electricity

This pump works great without electricity, without internal combustion, and without noise. This pump will take a steady but small flow of water, and, with a short drop, pump a significant part of the water way up hill to the place it is needed.

Oh, if only all our water supplies were located above the point of use. Alas, it is an imperfect world. Well, then, if only we could afford some of the fine solar water pumping systems that are available. By the time you purchase the pump, wiring and the fair number of PV panels needed, your cookie jar will look like a bottomless pit.

I know two ways to use a downhill flow of water to pump a portion of the water further uphill. One is with the time-tested ram pump. The ram pump lets a flow of water in a pipe build up momentum until the flow causes an impetus valve in the pump to slam shut. The water, still wanting to exert its moving energy, is channeled into a chamber containing air, which is compressed by the force of water. The compressed air bubble in the chamber then expands to push a small amount of water out a second pipe going up the hill to the point where water is needed. The pressures inside the pump are then equalized, allowing the impetus valve to

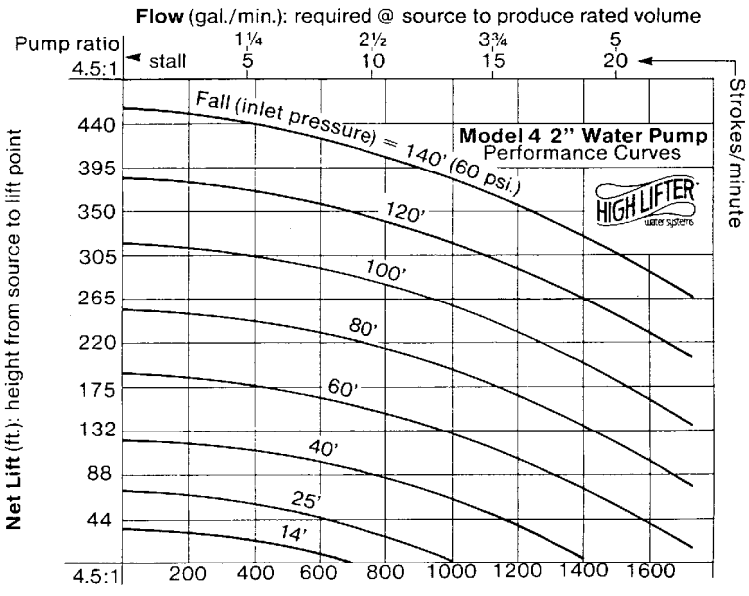
open again thus starting the downhill flow moving again, and the cycle repeats.

The second method is with the relatively new High Lifter. The High Lifter uses head pressure instead of momentum in a downhill pipe. It uses a larger volume of low-pressure water to pump a smaller volume of water at a higher pressure. A larger piston acts with a smaller one to gain mechanical advantage, a kind of "hydraulic lever." A collar inside the pump controls the inlet valve. As the pistons reach the end of their stroke, they contact this collar, pushing it until it directs a small amount of "pilot water" to the end of the spool in the pilot valve, thereby shifting it and changing the direction of the water flow in the pump. The flow moves the two-way pistons in the opposite direction until they again contact the collar, which shifts the pilot valve again, and the process repeats. Thus the pump's innards travel back and forth as it pushes water way up the hill.

High Lifter Specifications

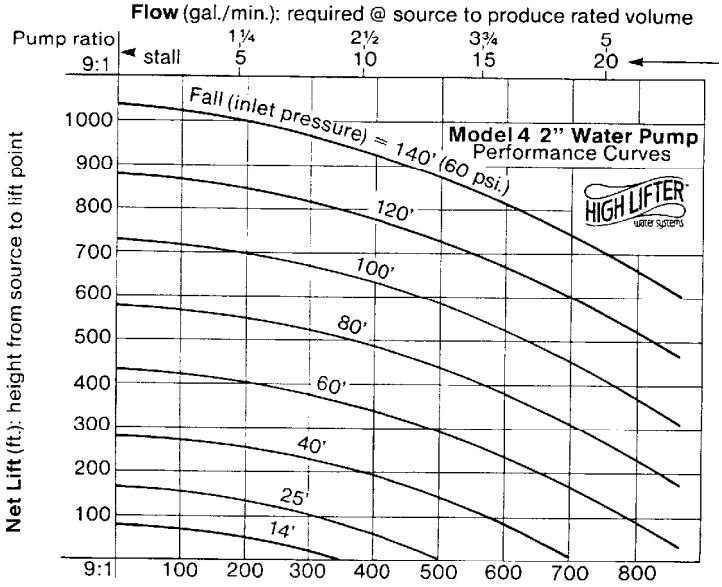
The cylinders are made of stainless steel, the valve body and head materials are machined from acrylic, and the pistons are made of high quality nylon. The total width is about 4 inches, length 26 inches, and the pump itself weighs about 5.5 pounds. The High Lifter is obtainable in two volumetric pump ratio models, 4.5:1, and 9:1, and changeover kits are available to switch back and forth. The higher the volumetric ratio, the greater the pumping pressure and the lower the output flow.

FOR 4.5:1 VOLUMETRIC RATIO PUMPS



1 psi = 2.3' **Delivery** (gal./day): assuming adequate water @ source

FOR 9:1 VOLUMETRIC RATIO PUMPS



1 psi = 2.3' **Delivery** (gal./day): assuming adequate water @ source

Typical applications

According to the Owner's Manual, the High Lifter can deliver up to 750 or 1500 gallons per day, depending on the model. It can be used with flows as little as one quart per minute. It can achieve net lifts of up to 1,100 feet, depending upon the circumstances. In situations of low fall and high lift, two High Lifters can be used in series.

High Lifter Performance

When I took delivery of my High Lifter, I had nothing but problems. I thought I would be unable to recommend the pump in "Things that Work" because my test site seemed to put to much of a strain on the pump, causing it to stall out with regularity. After trying "everything in the book", and some things that weren't in the book, I took the pump back to Dave Katz's pump experts at Alternative Energy Engineering. (I like going there anyway because they have so much neat renewable energy stuff to look at.) There we discovered that some of the earlier pumps had been assembled with too much silicone glue between the barrel and the valve body. The excess silicone had slopped over to partially plug the pilot valve holes. They gave me a recently rebuilt pump since they didn't have a new one ready to give me.

I installed the newly rebuilt pump, and 30 hours later I checked my previously empty tank. I was totally amazed to discover that the 250 gallon tank was completely full! At that point I began keeping track of the flow: it was an remarkable 240 gallons per day. Two weeks later the

flow had decreased to 218 gallons per day so I cleaned the inlet filter. Now that the pump was broken in and the filter cleaned, my flow increased to 294 gallons per day! It seems to have settled in at between 220 and 300 gallons per day, depending on how clean the input filter is.

High Lifter Advantages

The advantages of the High Lifter over the ram pump are numerous. The pump is more efficient in that it uses less water to pump a given amount uphill. Additionally, it is a far piece quieter than the constant and very noisy KA-CHUNK of the ram, and it is quite a bit lighter and easier to move around than the ram. Last, but not least, the High Lifter will operate with relatively thin wall pipe in the input, whereas a ram, because of the intense and constant hydraulic hammering caused by the sudden closing of the impetus valve, requires solid mounting and steel pipe to keep from breaking apart joints.

The High Lifter is not without its disadvantages, though. It has a complex array of pilot valves and check valves, and relies heavily on close tolerance seals. Unlike the ram pump, water must be completely free of sand and grit lest the barrels and seals become scored allowing leakage. The High Lifter comes with a filter which takes out much of the harmful sized particles which may flow from your water supply. The filter must be cleaned regularly to avoid loss of inlet pressure. If a lot of foreign matter flows with your water, then the High Lifter may not be for you.

The Owner's Manual states that there is a danger that a hard knock to the valve body could cause a misalignment, but personal experience proved that it takes 2 large, strong people to successfully dislodge the glued and strapped valve body from the barrel.

Conclusions

The High Lifter has far exceeded my expectations, and definitely lives up to its promises. It is worth the $750. price tag, which includes access to the manufacturer who is willing to go the extra distance to help their customers.

Access

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Carlson
Communications

Washing Machines II

Jim Forgette

If these water saving methods were employed to their fullest, up to three times less water would be wasted on doing laundry. If you used a washer that's also been "converted" (uses three times less electricity: see HP#22), this "major appliance" would no longer be so major. Smaller home power systems could then afford to support one. Having a full-sized, automatic washing machine at home is wonderfully convenient, and having enough water/electricity to "feed" it brings a larger sense of pride in one's energy independence.

Stop that water-waster - washing machines

Last issue we discussed a way to reduce electrical consumption of standard, full-sized washing machines. This time, a washing machine's WATER-consumption is the topic. Washers can be needless water-guzzlers as well as watt-hogs. Alternatives are available that use up to three times less water than is considered "normal"....giving far more "wash for the slosh".

For water efficiency, which type of washer?

Water is a valuable commodity. Warm water is even more valuable. Until "ultra-sonic" washers or something equally as revolutionary is massed-produced and affordable, we'll have to work with what's available. With good strategy and a water-thrifty washer, much less water can get the job done. As a general rule, front loading washers use less water than top loaders. But some newer top loading designs (newer "extra-large capacity" Kenmore, Whirlpool & Kitchenaid brands) compete very well in water efficiency, and are able to wash larger loads than today's consumer-type front loaders. At present, newer front loaders are all made by the same company (even under different brand names), their tub size is smaller, they cost about $200 more, and tend to need repairs much more often than a typical top loader (Independent tests and surveys: see "Consumer Reports" Feb. 1991 magazine.) These shortcomings need to be considered before choosing a front loader for its superior water efficiency. Furthermore, if the options explained below are employed, a front loader's water efficiency edge all but disappears.

A great water saver

A very small number of washers have what is called a "suds-saver", which can reduce hot water consumption with no noticeable degradation in cleaning ability. It's been around for decades but has unfortunately lost popularity. Here's how it works: "Suds-saver" allows you to actually save wash water and re-use it for a second (or even third) load of clothes. The final rinse water (cold) is always new & clean for each load. A good strategy with "suds-saver": do a first load of less soiled, lighter colored laundry that needs warmest water - bed sheets, towels, etc. - then save the wash water & re-use it for further loads of progressively dirtier, darker, colored laundry -- work jeans, muddy clothes, throw-rugs, etc. My household of five has washed laundry on home power for seven years now, with and without "suds-saver", and I can testify it really makes a difference in hot water consumption. With it, our solar/wood hot water system is adequate; without it, I can never get a hot shower in edgewise! Our laundry is washed in warm, not hot water (soaps aren't very effective unless water is at least 50°F). Sad but true, "suds-saver" is one of the best kept secrets for gaining hot water efficiency. Part of the reason "suds-saver" is now almost extinct, a large laundry room sink must be present (or any 25 gallon vessel) to store the "grey" wash water. The washer automatically stores then later pumps the soapy wash water back into the washer when the next load is started. Add more soap each time the water is re-used (and please use an eco-friendly, low or no phosphate soap, even if the clothes don't match the "whiter & brighter" advertising bull----). For best hot water efficiency, use a fiberglass type sink (or insulate the container) -the stored water will stay warmer longer. The washer's controls let you choose whether to "save" or not. A small number of Kenmore/Whirlpool models have come from the factory with this option for many years. A "suds-saver" model will have two drain hoses coming out (the bigger hose, not the one or two smaller, water supply hoses), whereas a non-suds saver model will have only one drain hose. Sometimes the former owner has taken the second hose off. So for these brands, also look at the washer's controls to see if it says "suds-saver" anywhere. I know of only two new models that still come from the factory with this water saving option: Kenmore (Sears), catalog #26R29791N ($480); and Whirlpool, #LA5705XTW1. The factory tells me a retrofit "suds-saver" kit was recently discontinued for newer models (bummer), but may still be available at Whirlpool parts dealers for about $70 (#387172). My neighbor & I are developing a similar water saving "retro-kit" to fit most washers - I'll let you know.

Using rinse water for plants

Using rinse water for plants is an old trick, but many folks don't know about it. Do you want/need to be a water miser? Consider channeling the washer's final rinse

water (it's barely soapy) out to water trees, lawns, etc.--it's 20 or so precious gallons of high-quality grey water that can be used! Before the final rinse ends, you'll have to manually switch the washer's drain hose into a separate drainpipe before starting a new load. I don't recommend that you use the soapy wash water for special trees/plants: soap-salts etc. build up & harm/kill them. Soapy water ends up in the environment somewhere, so please do your part and use eco-friendly soap.

Updates from Watt-Guzzler story (HP#22)
Restrictions for some pre-1985 Kenmore/Whirlpool washers: In my last article, I suggested an easy-to-convert washer you can do from scratch; an older Kenmore/Whirlpool washer. Well, I have run into a small number of these washers that have an extra large wash tub, and the stock efficient motors are too long and will hit the floor. I have found a quality motor that fits many "un-convertible" washers and other ac appliances with similar 1/3 to 1/2 horse motors. They also "bolt right in" without needing adaptor plates or different drive pulleys. These shorter motors sell for the same price as most standard efficient motors ($250) that don't fit! They have the same 12 month warranty. With the correct custom setup, many more top loading brands are now good converting candidates, including all Maytag, newer Kenmore, Whirlpool, Roper, Capri, Kitchenaid, and newer Speed Queen/Amana washers.

Inverter life-span vs. heat
In HP#22, I presented a watt-hour graph, and for it I tested an "ordinary" washer on three different large inverters. After washing just one load, all three inverters were hot to touch (even ones with cooling fans). The outside temperature was only 75°F. Heat is a major inverter enemy, it shortens their life. This is why you'll find cooling fans in better quality inverters (a $100+ option in some). All inverters get old sooner or later, and heat pushes it toward "sooner" rather than "later". I tested the same inverters with the same washers & load of clothes, this time the washer had new efficient motors, the inverters ran cool (even 115vac versions) for the entire time. So if your full-sized washer is inverter powered , a converted washer not only uses three times less electricity, it also helps your inverter stay younger longer. Also noteworthy: In most cases, even a smaller, 400 watt inverter (with induction motor starting ability) is big enough to power a converted washer!

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"I've worked with Ken and Johnny. Not only do they know their stuff, but they effectively and quickly teach their hands-on knowledge to others. STI offers the most comprehensive, intensive, and practical training for using renewable energies. Whether you are on a degree track, interested in getting into the business, or just want to do your own system properly, STI is your best source for training." Richard Perez, Editor – Home Power Magazine.

Midwest Renewable Energy Fair 1991–

Friday, June 21, 1991

10:30 AM	12:00 Noon	1:30 PM	3:00 PM
PV & Wind for Developing Countries	PV for Educators	Building Electric and Hybrid Vehicles	Innovative Renewable Energy Applications
Ground Water Pumps for Heating & Cooling	Small Scale Hydrogen Production	Air/Water Combination Solar Systems	Solar Demestic Hot Water Systems
PV/Hot water Hydrid Systems	PV/Hot water Hydrid Systems	Solar Energy and International Development	The Physics of Solar Cells and Innovations
Solar Water Pumping	Introduction to Sustainable Agriculture	PV/Wind Hybrid Systems	Home-Sized Wind Systems
Do-it-yourself Solar Air Collectors	Site Analysis for Renewable Energy	Construction Techniques for Super Insulation	Energy & Economics of Sustainable Agriculture
Everything about Batteries	How to Orgainze and Operate a Home Business	Home-Sized Hydroelectric Systems	Stirling Engines
Passive Solar Architecture	Sunseeker: Solar Powered Race Vehicle	Planning for a Remote Home Power System	Efficient Water Use in the Home
How to Design & Build a Wood Gassifier	Introduction to PV Systems	The Attached Solar Greenhouse	Superinsulation: The Enercept Homes
POWER: Options for Energy Regulation	How to Build & Use a Solar Oven	Community Environmental Activism	A New Generation of Wood Stoves

Saturday, June 22, 1991

9:30 AM	11:00 AM	12:30 PM	2:00 PM
Pyrolysis Co-generation: Alternative Incineration	Introduction to PV Systems	The Attached Solar Greenhouse	Passive Solar Architecture
Solar Demestic Hot Water Systems	How to Build & Use a Solar Oven	Innovative Renewable Energy Applications	Solar Air Collectors
The Physics of Solar Cells and Innovations	Home-Sized Hydroelectric Systems	Home-Sized Wind Systems	PV/Wind Hybrid Systems
Methane and Ethanol Production and Use	Stirling Engines	Planning for a Remote Home Power System	Alternative Energy in Europe
RENEW: Development of Renewables in Wisconsin	Solar Energy and International Development	Building Electric and Hybrid Vehicles	Introduction to Sustainable Agriculture
Ground Water Pumps for Heating & Cooling	Construction Techniques for Super Insulation	Do-it-yourself Solar Water Collectors	Do-it-yourself Solar Water Collectors
Everything about Batteries	How to Orgainze and Operate a Home Business	Energy Economics and the Environment	Solar Water Pumping
Fundamental of Energy, Electricity and Electronics	Fundamental of Energy, Electricity and Electronics	Farm and Residential Water Systems	Farm and Residential Water Systems
Superinsulation: The Enercept Homes	Community Environmental Activism	Air-to-Air Heat Exchangers	How to Design & Build a Wood Gassifier

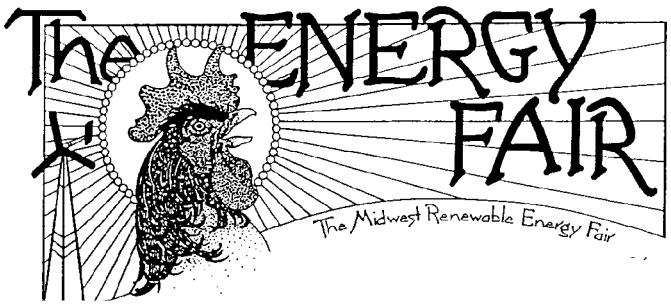
Sunday, June 23, 1991

10:30 AM	12:00 Noon	1:30 PM	3:00 PM
Passive Solar Architecture	Introduction to PV Systems	Planning for a Remote Home Power System	Advanced PV Systems
Small Scale Hydrogen Production	PV & Wind for Developing Countries	Building Electric and Hybrid Vehicles	Air/Water Combination Solar Systems
Alternative Energy in Europe	Site Analysis for Renewable Energy	Solar Air Collectors	Methane and Ethanol Production and Use
Do-it-yourself Solar Water Collectors	Do-it-yourself Solar Air Collectors	Home-Sized Hydroelectric Systems	Home-Sized Wind Systems
RENEW: Development of Renewables in Wisconsin	Introduction to Sustainable Agriculture	Everything about Batteries	Energy & Economics of Sustainable Agriculture
Solar Water Pumping	Energy Economics and the Environment	PV/Wind Hybrid Systems	The Physics of Solar Cells and Innovations
Inverters: A User's Guide to Stand-Alone Inverters	Stirling Engines	Efficient Water Use in the Home	Sunseeker: Solar Powered Race Vehicle
Energy, Electricity and Electronics	Energy, Electricity and Electronics	Farm and Residential Water Systems	Farm and Residential Water Systems
A New Generation of Wood Stoves	How to Build & Use a Solar Oven	Utility Conservation Programs	Superinsulation: The Enercept Homes

Workshop Schedule, Amherst, WI

Friday, June 21, 1991

4:30 PM	5:30 PM	6:30 PM	8:00 PM
Methane and Ethanol Production and Use	RENEW Steering Comittee Meeting	Address: Freedom's just another word for nothing left to burn. Richard & Karen Perez	Music Randy Sabine Quartet
Solar Air Collectors			
RENEW: Development of Renewables in Wisconsin			
Alternative Energy in Europe			
Do-it-yourself Solar Water Collectors			
Inverters: A User's Guide to Stand-Alone Inverters			
Energy Efficient Lighting			
Advanced PV Systems			
Utility Conservation Programs			



Saturday, June 22, 1991

3:30 PM	5:00 PM	6:15 PM	8:00 PM
Sunseeker: Solar Powered Race Vehicle	Advanced PV Systems	Address: The Politics of Energy Douglas La Follette	Music The Bone Tones
PV for Educators	Small Scale Hydrogen Production		
Air/Water Combination Solar Systems	Energy Efficient Lighting		
PV & Wind for Developing Countries	Energy & Economics of Sustainable Agriculture		
Site Analysis for Renewable Energy	Do-it-yourself Solar Air Collectors		
PV/Hot water Hydrid Systems	PV/Hot water Hydrid Systems		
Efficient Water Use in the Home	Inverters: A User's Guide to Stand-Alone Inverters		
Electromagnetic Pollution	Electromagnetic Pollution		
POWER: Options for Energy Regulation	A New Generation of Wood Stoves		

Sunday, June 23, 1991

4:30 PM	6:00 PM
The Attached Solar Greenhouse	Fair Closes
Ground Water Pumps for Heating & Cooling	
Energy Efficient Lighting	
Construction Techniques for Super Insulation	
How to Design & Build a Wood Gassifier	
Pyrolysis Co-generation: Alternative Incineration	
How to Orgainze and Operate a Home Business	
Electromagnetic Pollution	
POWER: Options for Energy Regulation	

1991 ENERGY FAIR HIGHLIGHTS

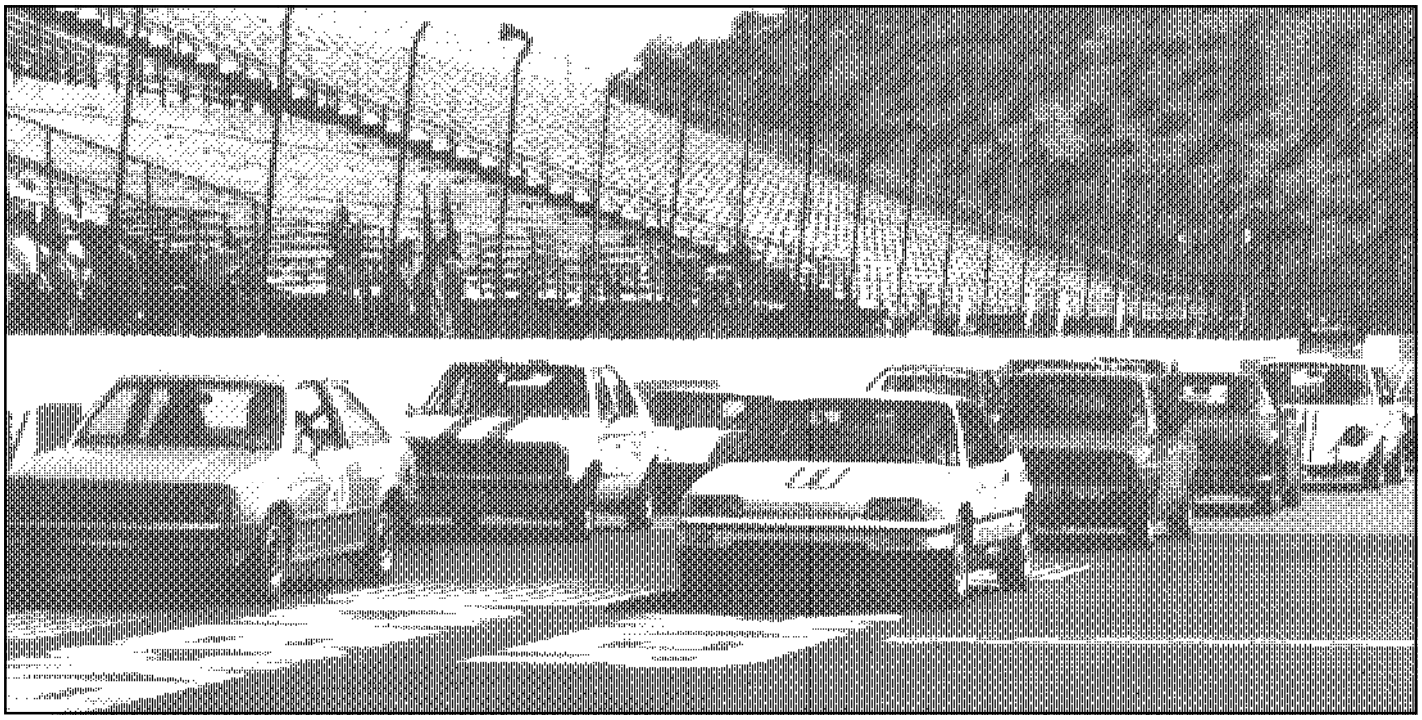
With the 1991 Energy Fair only days away, we look forward to meeting many new people and welcoming back old friends. The Fair will provide the public with an opportunity to see and purchase the latest in renewable energy and energy conservation technology, to talk with experts from across the country and to relax in the festival atmosphere.

- 50 different workshops
- Sunseeker: A solar powered race car from the GM Sunrayce USA
- Electric Vehicles & Hybrid Electric Vehicles
- Model Home demonstrating solar and wind power, solar heating, energy conserving appliances, and efficient construction techniques.
- Display Booths demonstrating displaying and selling energy related products.
- The Fair's PV array is for sale! ARCO 16-2000 PV Modules for $5 per watt! Call 715-824-3982 now to reserve your modules.
- Activities for children and child care.
- Daily admission-$3. Weekend Pass- $6. Evening concert-$5. Children under 12 Free (except concerts).

Midwest Renewable Energy Fair

116 Cross St., POB 249, Amherst, WI 54406

715-824-5166



Above: Starting line-up for the Electric Stock Car 200 race at the Solar & Electric 500 in Phoenix, Arizona. Photo by Shari Prange.

Solar and Electric 500

John Takes

In many ways, the Solar and Electric 500 was the first of its kind. Solar electric vehicle races have been held across open country for long distances. The Tour de Sol, Australian Solar Challenge & GM Sunnyrace are typical examples. The Solar and Electric 500 was held at Phoenix International Raceway's one mile closed circuit track. The vehicles were divided into two categories, solar electric vehicles and late model four wheel passenger electric cars. The solar electric portion of the event was to cover 186 laps (186m/300km) in two sessions. The electric car event was 124 laps (124m/200km).

Something to behold

The solar electric races were something to behold. Elegant streamlined shapes with precision engineering and high output solar cells gliding quietly around banked corners and straightaways. Everything about these vehicles is geared toward efficiency. It was fascinating to observe the crews working on these vehicles in the garage area inspecting, modifying and preparing their cars for the race. In a flurry of activity, whole bodies with integrated solar cells were removed so that motors, controls or drive gear could be dealt with.

The Solar Electric Winners

Examining the inside of the Swiss entry "Spirit of Biel" one gets the impression that every fastener, lever, and bracket has been thought out in terms of its function and fabricated accordingly. The vehicle carries 1,300 watts of photovoltaics (17% efficient cells) and utilizes silver-zinc batteries (129 volts -@ 24ah). The "Spirit of Biel" turned in a flawless performance finishing first in the solar category. The vehicle recently won the Australian Solar Challenge, finishing one day ahead of the nearest competitor.

Another very impressive solar electric vehicle was the

M.I.T. (5X). Computer analysis determined that the onboard solar array was losing more energy due to drag than it was producing electrical power so the cells were disassembled and placed in the vehicle since the race rules required that they be onboard. An exciting moment occurred for everyone when the car blew a tire at high speed and did a 360° in the turn. That evening at the driver meeting track officials expressed some degree of relief that this had proven the safety of solar cars.

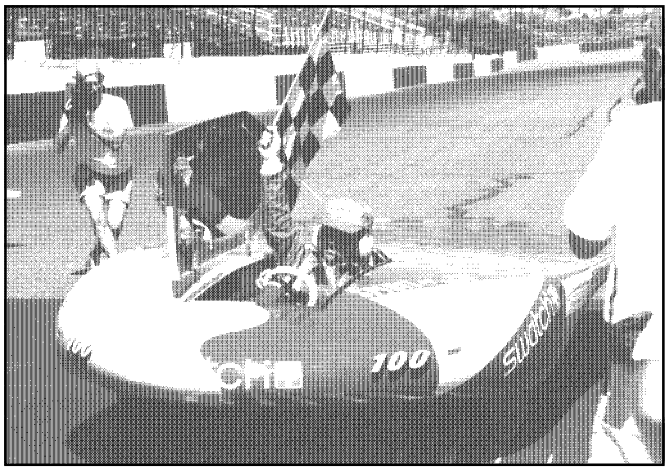
The Mauro Solarelectric was a study in what can be accomplished in a limited amount of time. When I arrived at the track on Thursday I noticed what looked like the beginning of a chassis. On Friday the vehicle had evolved considerably. It seemed like every time I passed by the garage area the vehicle was more complete. By Saturday it was competing on the track. What an inspiration for hands-on folks.

The Electric Cars

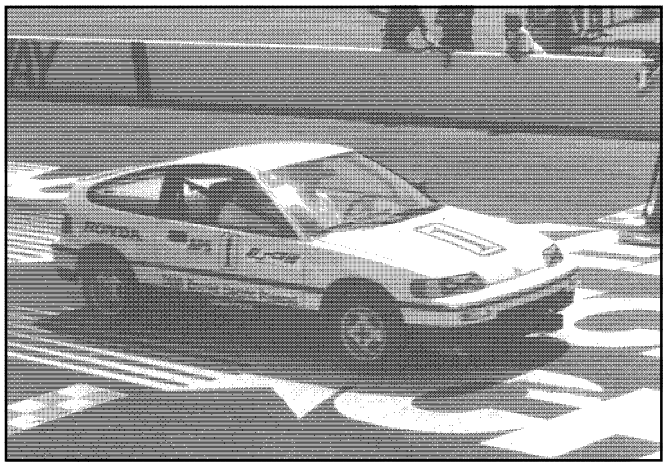
There was quite a variety of equipment and strategies in the electric car class. The very advanced Honda CRX was sponsored by Southern California Edison Company and Arizona Public Service Company (APS) and was designed by Dreisbach Electromotive Inc. (DEMI) of Santa Barbara. Utilizing a DEMI zinc-air battery it won the event and set new records with sustained speeds of 62 miles per hour and traveled 108 miles in two hours. This zinc-air battery technology is able to carry up to eight times the energy of other batteries of comparable weight and uses "environmentally friendly" materials. Besides the DEMI zinc-air battery pack the vehicle also uses a nickel-cadmium battery pack for passing and sprints above 65 mph. In an actual 1991 test, 215 miles at a nominal 45 mph was observed. APS feels that the new zinc-air battery allows electric vehicles to approach gasoline powered vehicles performance and represents a major step towards putting non-polluting electric vehicles on the road. DEMI plans to continue research on the battery and hopes that a U.S. or Japanese auto manufacturer will be interested in the manufacture of the battery.

Solectria's two entries looked good and performed flawlessly. Although they started in eighth and tenth position they finished second and fifth competing 104 and 84 laps respectively. James Worden has been working at producing practical electric and solar electric vehicles for awhile and it's great to see his success.

Michael Hackleman (to many of us one of the Grandfathers of electric vehicles) brought a resurrected Dept. of Energy car (a 1982 Ford Fairmont station wagon) which became known as the "lead sled" and used a very



Above: Swatch "Spirit of Biel" takes the checked flag in the Solar 300. Photo by Shari Prange.



Above: Honda CRX entered by DEMI, winner of the Electric Stock Carr 200. Photo by Shari Prange.

innovative ten minute (pit stop) recharging technique. As I watched from the pits Michael's' #27 car pulled in and up to a pallet of charged batteries. Battery covers were removed from the vehicle, a quick connect was plugged in and presto, the quick charge was happening! I noticed one of the crew members poised with cable cutters around one battery series interconnect and I began to refer to him as the "manual circuit breaker". The recharge technique worked well and Michael and team placed sixth.

One vehicle on display with particular interest for me was the Doran #43, a build-it-yourself vehicle composed of wood and fiberglass. Although this vehicle wasn't allowed to compete in the Electric 200, it was allowed to use the track during practice/qualifying and turned in an impressive 66 miles per hour. Plans for building a Doran are available and body part kits will be available this summer.

Overall, the Electric 200 demonstrated that efficient practical, and less polluting electric vehicles are appropriate for the needs of most people. Consider that 90% of our driving is usually trips of 25 miles or less.

The rest of the show

Other events were held in conjunction with the S & E 500. The environmental expo was open to the public for all three days of the event. Electric vehicles were on display and environmental and government organizations provided information on solar energy and ways that people can reduce the amount of energy that they use for transportation.

The Junior Solar Spirit is an annual, national event involving seventh and eight grade students and is intended to stimulate interest in service and engineering. Awards were presented for innovative design and overall performance. Students build solar model cars as class projects and compete against other schools. The finals are to be held in Washington, DC.

The "Kids Mini Solar & Electric 500's" was an event for 2-6 year olds with qualifying events held at Phoenix area supermarket parking lots. The twelve solar and electric mini cars saw speeds of 2-4 mph on a 30 foot long race track. Participants and their families received free tickets to the Solar and Electric 500.

Friday was Education Day at the raceway and was described as the world's largest science class. Arizona schools (grades 5 through high school) were invited to the track so that students could witness solar and electric vehicle technology in action. Teachers were provided with educational materials on solar power to prepare the students for the event.

Perspectives

I must admit that I have some mixed feelings whenever "solar" and "racing" are used in the same sentence. Americans' love affair with fast, competitive vehicles might mean that calling something a "race" is a way to bring people in to re-educate them and share a vision of quiet, non-polluting vehicles. If people are to have an objective in transportation, it shouldn't be how fast can I get from point A to point B, but rather for my REAL transportation needs, how can I get there consuming the least amount of the Earth's limited resources in the process.

Let's face it, in our culture it is very easy to become fascinated with any number of new exciting technologies. Let's choose technology that is compatible with survival of the planet. I believe that the Solar and Electric 500 was a display of that technology. See you at SEER 91!

Solar 300 Final Results

No.	*Driver*	*Entrant*	*Laps*
100	Paul Balmer Kurt Vogel	Spirit of Biel	186
5	Peter Rexer Thomas Massie	M.I.T	171
19	Jeff Silverstone Reicardo Espinsoa	Cal State Los Angeles	157
77	Rob Hamelink Mark Ely	W. Michigan Univ Jordan Energy Instit.	150
74	Chris Kabrick David Bailey	Rose- Halman Instit. of Tech.	133
101	Shan Daroczil Satoshi Doi	Cal Poly San Luis Obospo	109
7	Suzanne Myhaz Lenko David Chau	Arizona State Univ.	99
6	John Cochoy Keith Vanhouten	Virginia Tech.	97
12	Larry Mauro Tim Considine	Mauro SPA	48

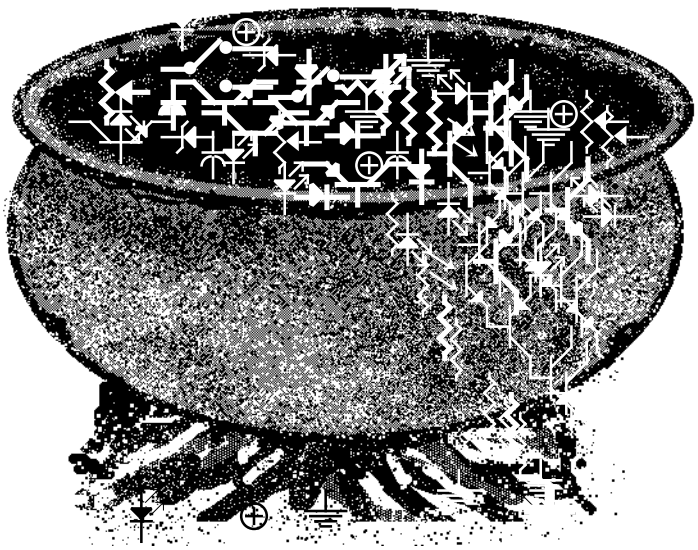
Electric Car 200 Final Results

1	Chris Smith	AZ Public So Cal Edison	108
99	James Worden	Solectria	104
43	Gary Jackson	Jackson Racing	95
49	Darrell Clark	Calif. Electric Cars	86
91	Ed Trembley	Solectria	84
27	Tim Considine	Michael Hackleman	74
30	Lealand McSpadden	Max Clawiter	73
90	Scott Cornell	Cornell Racing	64
20	Ron Shuman	AZ Elec. Auto Assn.	61
7	Bruce Mabrito	Reliable Battery Co. B.F. Goodrich	52
10	Mike Allen	Pacific West Supply Popular Mechanics	34
11	David Twine	Lectric Leopard	26
1x	Jim Creech	Gasless Carriages	18

Access

Author: John Takes, 1258 North Main St., Unit B2B, Fort Bragg, CA 95437. John is the owner of Burkhardt Turbines and a partner in Suntools. He is presently converting gasoline vehicles to electric power.

Homebrew



Constant Current Battery Charging

Jeff Damm

Battery charging systems can be constructed from very simple to extremely complex circuits. Many people learning how to make electronics work for them with charging systems only need a few components to get the job done. The general rule is that charge controllers will increase their user friendliness as they get more complex. In this article we will learn about some basic techniques for accomplishing the task of battery charging.

Figure 1 is a block diagram of a typical charging system for use with NiCads (Nickel Cadmium), Gel cells (Gelled Sulfuric Acid electrolyte, lead acid type, mechanically sealed) and standard Lead-Acid batteries.

The voltage source represents any one of many different energy sources: an alternator in a hydro, PV panels, an electronic power supply, or even another battery that is fully charged. The fundamental assumption behind all of the diagrams in this article is that the voltage source terminal voltage must be greater than the terminal voltage of the battery to be charged. The "extra" voltage difference can be anywhere from about 5 to 15 volts. Typical applications will require a voltage difference of around 5 or 6 volts. This means that charging a single 1.2 volt AA NiCad would only require a source of 6 to 7 volts. Charging a 12 volt battery will require between 17 and 20 volts.

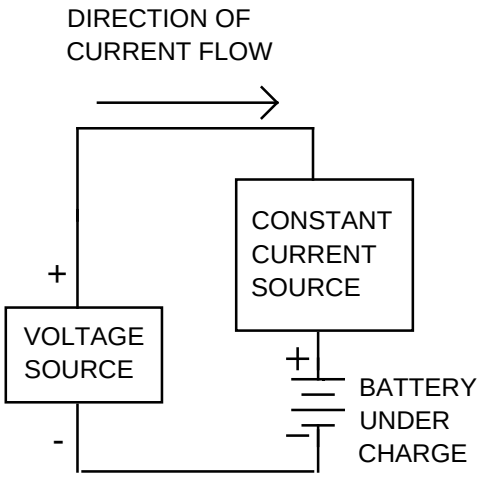


FIGURE 1

The constant current block represents whatever circuitry is used for the purpose of charging the battery of interest. The constant current block will force a predetermined current through the battery, independent of the terminal voltage at the voltage source.

A simple constant current source is shown in figure 2. The components are non-critical in nature. The devices inside the dashed line box represent the essence of the constant current source. Transistor Q2 can be any small signal NPN of the 2N3904 or 2N2222A variety. Almost any junkbox NPN will work as Q2. R1 can be any value from 220 ohms to 1000 ohms.

A series diode is included to prevent any possibility of battery discharge if the input power fails or if the input voltage drops below the battery voltage. The series diode must have a current rating greater than what will flow through it. A good generic diode for 1 Amp or less is the 1N4000 series devices. These are listed as 1N4004, 1N4005, 1N4006 etc. Silicon rectifiers are a better choice than the smaller "signal" diodes due to their higher current ratings.

Transistor Q1 can be almost any silicon NPN device that has a power dissipation rating greater than the power it must dissipate. Two choices to start with would be the TIP31 or the 2N3055. Currents beyond a few amps with the 2N3055 may require a Darlington connection to replace the Q1 function. This value is calculated by multiplying the voltage difference between the source and "load" battery and the charging current. Remember that a heat sink will usually be necessary for helping to keep Q1 cool enough to operate safely. A good rule is that if you cannot keep your finger on the metal case of Q1, then it needs a heat sink. Remember that Q1

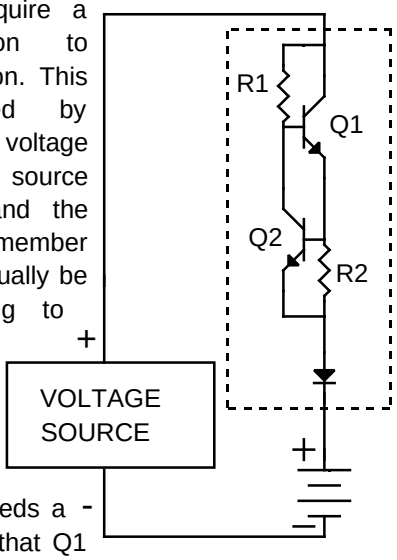


FIGURE 2

can get very hot very quick if it needs a heat sink and does not have one. I usually perform this test with a wet finger so that the moisture will be vaporized instead of getting a burnt finger!

Resistor R2 is the real magic element in this circuit. The value of R2 is what determines the constant current value. It is calculated as the ratio of the base-emitter voltage drop of Q2 divided by the current that we want to flow through the circuit. This can be simplified by assuming that the diode drop is about .68 volts. We can express this equation as:

R=.68/I where I is in amps.

For example, to establish a constant current of 50 mA to charge AA NiCads at C/10 we would use R=.68/.05=13.6 ohms. Since this is not a standard resistor value, we would want to use either 12 ohms or 15 ohms. A 1/4 watt (or greater) power dissipation resistor would work well. Remember that the R2 dissipation must be greater than it's actual power dissipation.

Figure 3 is a simple variant of figure 2 using a power FET (Field Effect Transistor) as the "pass transistor" element. Circuit operation is essentially the same as that of figure 2. A very good choice for the FET would be the IRF511 (International Rectifier) or IRF530. Almost any N channel Enhancement FET will work in figure 3.

Another constant current source that can be used instead of the circuits in this article was presented in Home Power #21 on page 82.

The real benefit of using constant current charge controllers is that you can get more use out of your PV panels. A classic example is the ability to charge different voltage batteries at different currents simultaneously. The only restriction is that the total current drawn from the panel must be such that the panel terminal voltage stays about 5 volts (or more) above the voltage of the battery we want to charge.

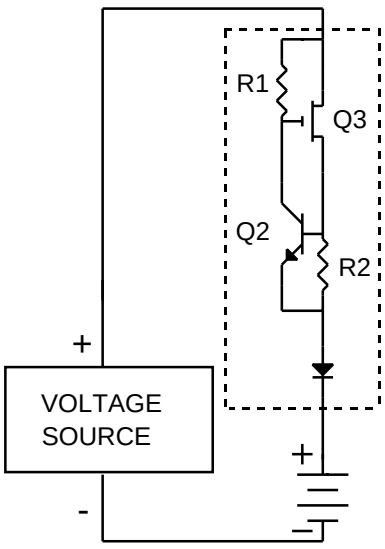


FIGURE 3

Access: Jeff Damm 6565 S.W. Imperial Dr., Beaverton, OR 97005 •

12 Volt Smart Night Light for under $4

Gerhard Dekker

Those of you living with small children can appreciate the convenience of a low power light source in the bedroom, bathroom, or hall that stays on all night. The design presented here draws only 25 mA., will turn off at dawn and on at dusk, further reducing power consumption and extending bulb life because the bulb never sees the higher line voltage when your solar modules are active. Power consumption over a typical 12 hour night will be replenished in 6 minutes by one 3 amp solar module.

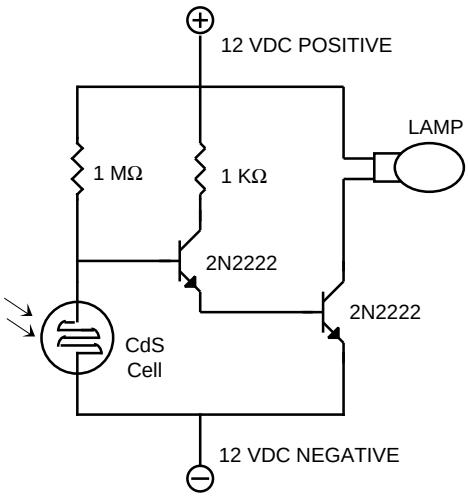
The parts are available at Radio Shack stores and construction of the circuit is very simple. I stuck the parts through holes poked in a 1" by 1" piece of light cardboard and soldered the appropriate leads together. The power supply wires can be very thin (#30 AWG) or whatever you have. Care must be taken that the CdS cell doesn't see the bulb, or any light reflected by it from within 24", as this will decrease the light output. With the bulb stuck in a little tin foil reflector there is a surprising amount of light, more than adequate for night light duty. I've had one of these going for 6 years now, still on the original bulb!

Parts List:

Two resistors- 1M and 1K Ohm, 1 each
Two transistors- NPN type 2N2222
One CdS photo resistor- 500 to 1M Ohm (RS#276-1657)
One bulb- 25 mA, 12 Volt, with leads, (RS# 272-1141)

Access

Gerhard Dekker, Box 689, Steinbach, Manitoba, Canada R0A 2A0 • 204-434-6143.



Simple NiCad Charging

Jonny Klein K7JK

Like Jeff Damm (Build a Constant Current Source, HP #21, pg. 82), I've been charging nicads with a constant current source for many years. But being very lazy I didn't spend many hours tinkering. I just used an LM317 in the data book constant current configuration:

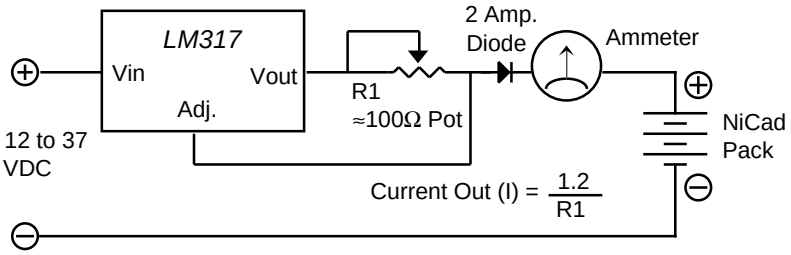
Since a regular old LM317 in the K or T package can source at least 1.5 Amps it can charge most nicads at the C/10 rate. I have a cheap digital multimeter I put in series as an ammeter to adjust the resistor, and I put the whole gadget on a timer. I set the current for C/10 and the timer for 15 hours and let er' rip. To keep your batteries at their greatest capacity, discharge them to about 1.20 volts before recharging. Don't forget a series diode so the batteries won't discharge through the circuit when the timer kicks off.

You can use this circuit for any number of batteries of the same capacity aslong as the power supply voltage is great enough; and it will work equally well from your car's with the same stipulation. I've been charging my batteries this way for many years with excellent results - some are up to 7 years old and still have full capacity.

I have several different batteries with different numbers of cells- this constant current charger does fine regardless of the number of cells in the pack. You can even charge two packs at the same time (in series) if you have enough supply voltage. Make sure you don't exceed the maximum voltage drop of 40 volts across the LM317. Make sure that the pass resistor is heavy duty enough to carry the current and dissipate the power (= I^2R). I got some heavy duty pots from Hosfeldt or Fair Radio Sales.

Access

Jonathan D. Klein K7JK, Talsalsan Farm, 12330 Takilma Rd., Cave Junction, OR 97523.



Commodore 64 Fiddling

Quintin Myers

I know you like to hear of unusual projects related to PV power, so here is a new one for you.

During these long winter evenings I decided to fiddle with my trusty old Commodore 64 (actually a SX-64 portable with built-in disk drive and color monitor that I modified to work on 12V). First I took the Bat-O-Meter circuit from HP#10, removed the LEDs, and plugged the leads into the joystick ports. Then I took some telephone wires, hooked them to the "USER" port data lines, and put IRFZ-30s at the other end. Then I wrote a simple BASIC program to take advantage of these new inputs and outputs. Now I have a programmable load controller/regulator.

The computer uses about 7 watts with drive and monitor off. It senses voltage in 1/2 volt resolution. It records voltage records throughout the day, displays them graphically on the screen, stores this data on disk, prints graphs, etc.

I use it to control a ceiling fan, pump, and resistive load, so far, for voltage regulation. It can control up to nine loads without any additional logic circuitry. This summer I plan to use it to control a swamp cooler, fan, open and close vents, and control an active tracker. I'm sure more uses will come to mind.

Access: Quintin Myers, 19344 Kiowa Rd., Bend, OR 97702, 503-382-4633.

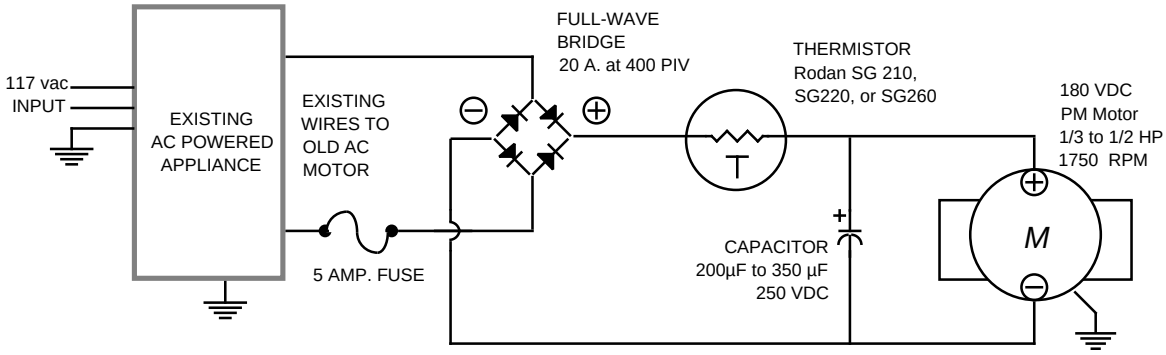
Soft–Starting Electric Motors

Jim Forgette

Important Caution

The permanent magnet motors used for converting washers and other machinery produce an usually strong, abrupt starting torque-- more stress than many were designed to withstand. In the older washers with belt-drive and metal gears, a 12 or 24 VDC conversion seemed to to handle this excessive starting torque, although over the years it will shorten the transmission's service life. The 115 vac conversions can produce an even more severe, sudden start than the 12 or 24V. Most newer washers use plastic type gears instead of metal. Direct-drive washers do not have a drive-belt to help dissipate this sudden jerk. The worst-case-scenario is a plastic-geared, direct-drive washer converted to 115 vac. This example could produce severe damage, in the short term, to the transmission gears. Other detrimental effects from this strong start: 1) It prematurely degrades contact points of any relays (arcing); and 2) it can prematurely weaken (de-magnetize) the permanent magnets in these motors.

In certain industrial appliances using these motors, a "Soft-Start" is included, which mellows this high amperage jerk start. Machinery you convert should also have this protection. I've researched this and put together a simple, effective soft-start module using Rodan SG220, SG210 or SG260 thermistors. Two should be used for reversing-type washer/machinery designs. You must know the motor horsepower rating and full load amps (common info on motor I.D. plates).



Summary

This circuit can reduce power consumption of many 115 vac appliances & machinery in the 1/4 to 1/2 horsepower range. Even though the new motor is DC, the appliance's power input is still 115 vac. The existing ac supply/wiring can still be used. Improved efficiency will vary with application. Be sure to ground the DC motor's case to the frame of the appliance. Before removing the old ac motor, turn on the appliance and note direction that the motor turns. If the new DC motor runs in the opposite direction, simply reverse its DC power wires. If the new DC motor's RPM is low, then increase the value of the capacitor to 350 µF. Be sure to disconnect the power source from the appliance before working on it, otherwise you can get a nasty shock. Under load, the DC side of the circuit is about 145 VDC. If a newer motor's horsepower rating is the same or slightly higher than original ac motor, these circuit specifications will yield an RPM very close to the original 1750 RPM ac motor. This allows the original motor pulley/gear size and any drive belt to be re-used in the conversion.

In a washing machine expect a 3-fold increase in efficiency. The circuit can also be used in most conventional dryers, wringers, pumps, shop machinery, swamp-coolers, large attic fans, etc.

Access

Jim Forgette, Wattevr Works, POB 207, San Andreas, CA 95249 • 209-754-3627. Wattevr Works sell these soft-start thermistor modules for $22 each for 12V, $18 each for 24V and $14 each for 115V. The 12 & 24V modules are wired into a NON fuse holder and have

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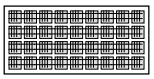

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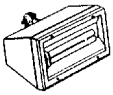

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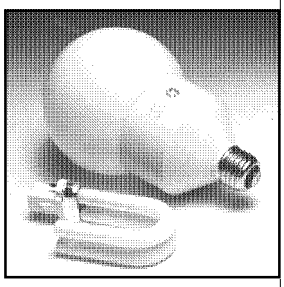

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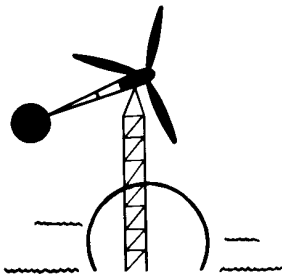

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The National Electric Code and You

John Wiles

In my trips around the country testing photovoltaic systems and presenting seminars on PV and in the numerous phone calls I get, I am frequently asked: "Does the National Electric Code (NEC) apply to me and my alternate energy system?" My response is: "It depends." Applicability of the NEC or other codes varies from state-to-state, county-to-county, city-to-city, and rural area-to-rural area.

NEC -- Just Paper, But....

The National Electric Code is merely one of many "codes" published by the National Fire Protection Association. It was developed and is maintained by volunteers from the electric power industry which include representatives from the utility companies, the public sector, the electric equipment manufacturers, and others. The PV industry is represented by a member on Panel No. 3 (where our PV Article 690 is discussed) who is sponsored by the Solar Energy Industries Association.

The NEC was developed to provide a standardized, country-wide set of guidelines for connecting and handling electric power safely at the final destination after it leaves the utility power distribution system. The utility companies are provided guidance in their power generation and distribution system operation by the National Electric Safety Code (NESC), a document published by the Institute of Electrical and Electronic Engineers (IEEE). Both of these codes assume and require that standardized devices be used to handle the power and make the connections so that a specialized, custom engineering effort is not required every time electrical power is used. The utility companies have very high, industry-established standards on the equipment they use. The term "utility grade" usually means very high reliability, durability, safety, and cost. After the power leaves the utility distribution system, the NEC provides guidance on the manner and method of connecting the power handling and generating equipment (including alternate energy system). The NEC requires that electrical power be handled by equipment that is designed, tested, and approved to national standards by a nationally recognized testing organization.

Most, if not all, of the ac electrical equipment used in households and commercial businesses throughout the United States has been tested, listed, labeled, or otherwise approved by Underwriters Laboratories (UL). UL has been around almost as long as the NEC and tests many other categories of products such as the fire rating of roofing products. Local electrical inspectors are familiar with UL approved products and readily admit they do not have the time, knowledge, or funding to determine the suitability of testing done by the manufacturer or other laboratories. In some metropolitan areas, certain fabrication shops are recognized by local electrical inspectors as building equipment such as custom panel boards to UL standards. UL not only tests and approves products, they more importantly establish the material, construction, and interface standards that apply to electrical equipment.

The Code and You

The NEC is "just" a document. However, in most states, many major cities, and a large number of counties and other jurisdictions, the NEC has been legislated into the construction codes as a law. This means that if an electrical power system is installed in a manner that does not conform with the requirements of the NEC, then it does not meet the requirements established by law. There are numerous variations on this basic tenant. Many jurisdictions have local codes that supplement the NEC -- in some cases in a more restrictive manner. The local code may be the previous edition of the NEC. For example, the 1987 NEC may still be the legal code in 1991 in Podunk USA. In some areas, landowners having 40 acres or more do not have to comply with electrical or sanitary codes. In other cities, the electrical or building inspectors have gone on record that direct current or PV power systems are not going to be inspected. In some states, the inspectors are examining every PV-powered billboard, water pump, and stand-alone installation. A few states allow homeowners to do their own wiring, others require a licensed electrician. A telephone call to your local building inspector or electrical inspector will quickly reveal the requirements in your area and whether your system comes under a city, county, state, or possibly no code at all.

Guidelines and Suggestions

The National Electric Code provides safety guidelines for power systems used by the general public -- that's you and me. If these guidelines were followed in the installation of PV systems and the equipment carefully chosen, the PV system reliability and safety would in most cases increase significantly as would the durability, and performance. While your alternate energy system may never be inspected and your local laws may not even require code compliance, it may be to your benefit to follow the guidelines in the NEC. You can buy a copy of the NEC from the local electric supply company, look at a few houses being wired, make friends with an electrician, and review the suggestions in these Code Corner articles. They are just that -- suggestions. I do not attempt to interpret the NEC, I just paraphrase it and highlight the material that appears to be associated with our alternate energy systems. The local inspector, if any, has the final say.

Access

John Wiles, Southwest Technology Development Institute, P.O. Box 30001/Dept 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105

Solar Electricity Today– The 1991–1992 Renewable Energy Resource Directory

from PV Network News

Reviewed by Richard Perez

This is a vastly updated and expanded listing of most every manufacturer, distributor, and dealer in the field of renewable energy. It contains over 800 listings spanning the topics of publications, dealers, manufacturers and specific hardware by type (like batteries or controls, for example). Names and complete addresses, most with phone numbers, make this resource directory essential for anyone in the biz and anyone purchasing components or services. Editor Paul Wilkins deserves the Medal of Excellence with PV clusters for the great work he's put into this new directory.

Solar Electricity Today contains 16 pages in an 8.5" by 11" black and white format. Cost is $7.00 from PV Network News, 2303 Cedros Circle, Santa Fe, NM 87505 • 505-473-1067. At less than a penny per listing, Solar Electricity Today is a fantastic information bargain.

In Pursuit of Adventure and Freedom - A Sea Gypsy's Handbook for Living in Paradise

By Fritz Seyfarth

Reviewed by Kathleen Jarschke-Schultze

The title alone intrigued me. All those buzz words - adventure, freedom, sea gypsy, and paradise conjured up visions of every ocean-going movie I had ever seen. No, I've never been sailing, but this book made me consider what a life "under a spread of sail" would be like for me.

Here are the real and important considerations of anyone thinking of escaping their present life for "the sailboat as an island retreat". Fritz works right on through all the points of this sea gypsy lifestyle with honest advice, warnings, temptations and humor. He covers choice of a boat, renewable energy options afloat, the working sea gypsy, contrasts in lifestyles, and the golden years. Not only does he write from his years of experience but he has also included the advice and opinions of other sea gypsies he is acquainted with. His 'reading list' and 'other information resources' are a must for anyone contemplating the life of a sea gypsy.

He goes on to relate several stories of he and his cronies just to tempt the wishful reader further. My favorites were The Pirate's Leg and Salad Girls Can Cause Problems, Skippers Say. If I were a bit younger and knew how to swim I would be tempted to be a Salad Girl on Captain Fritz's boat.

Other books by Fritz Seyfarth and available from Spanish Main Press: Tales of the Carribean, Mavericks in Paradise, Pirates of the Virgin Islands, Memoirs of Anne Bonny-Lady Pirate and Adventure-Under Spread of Sail

In Pursuit of Adventure and Freedom by Fritz Seyfarth is available for $9.25 postpaid from Spanish Main Press, Red Hook Plaza - Suite 237, St. Thomas, US, VI 00802

Mavericks in Paradise

by Fritz Seyfarth

Reviewed by Bob-O

Sixteen all too short stories about modern day "Caribbean rascals, renegades, adventurers and thieves..." Exciting and uproariously funny stories based more or less on the experiences of Mr Seyfarth and his sea gypsy friends living an "adventure under a spread of sail" in paradise. Argh, matey!

The booklet's dedication gives us a clue to the author's philosophy and what lies ahead:

"For some, the expedition through life seems to be somewhat of a long and exciting pirate treasure hunt. So I dedicate this book to various swashbuckling acquaintances in the hope that somewhere along the voyage each of these life-loving rascals will find his own personal treasure and by the end of the passage will have escaped hanging..."

Ahhh. To sleep, perchance to dream... You'll laugh, you'll cry, you'll kiss $6. goodbye... On the other hand, every man-jack and lady among us have been fleeced for lots more and gotten less. Much less.

Available from Spanish Main Press, Red Hook Plaza-Suite 237, St Thomas, US, VI 00802. $6.25 ppd. A deal.

The Solar Electric Independent Home Book

by Fowler Solar Electric, Inc.

Reviewed by Bob-O

The Solar Electric Independent Home is a well-written book aimed at those folks who are thinking about building or refitting a home with photovoltaic electricity.

It shows how to calculate the number of PV modules necessary to support your electrical needs based on "ballpark" insolation estimates and actual electrical usage. The book contain fairly detailed explanations of those PV modules, batteries, controllers, inverters, and other equipment that the folks at Fowler are familiar with. It contains good installation guidelines and diagrams for sample systems. The chapters on basic electricity and maintenance of a PV system make worthwhile reading for anyone wanting to learn about owning your own "power company". Their advice about finding a good dealer/installer to help you set up your system is well taken. The last 40 pages are devoted to useful wire loss tables, a good glossary, a huge listing of questionably useful solar insolation data, and the now obligatory Section 690 of the NEC.

It should be mentioned that other devices and equipment than those mentioned in this book are available and should be investigated before installing a system.

Available from: Fowler Solar Electric Inc.,POB 435,Worthington, MA 01098. 413-238-5974. $16.95.

Sowing The Wind– Reflections on the Earth's Atmosphere

by Louise B. Yound

Reviewed by the Wizard

This is a book about the space in which we live and breathe– the atmosphere. Among the many interesting and well covered topics are: history of atmospheric exploration, atmospheric dynamics, weather patterns, atmospheric evolution, long and short term climate cycles, solar atmospheric effects, effect of human activity on the atmosphere, and solutions to atmospheric problems.

There are 14 pages of references at the end of this 200 page book. At first I thought I would not like this book. I was wrong. It is entertaining, interesting and easy to read. The science parts are geared to both layman and initiate. If you are interested in the atmosphere and its effects on life & ecology, read this book.

Sowing the Wind is published by Prentice Hall Press, 15 Columbus Circle, New York, NY 10023. The book is a 5.5" by 8.5" black and white paperback and its ISBN# is 0-13-083502-1. Cost is $9.95.

Efficient Washing Machines for Home-made Electricity

by James F. Forgette

Reviewed by Richard Perez

This booklet is an A to Z manual for the transformation of standard, watt-guzzling, washing machines into power sippers. It contains information about converting virtually any washer with high efficiency DC motors. Conversions are to 12 VDC, 24 VDC, and even high efficiency conversions for 120 vac from an inverter. See Jim's article in Homebrew this issue for a sample of the swell techie info in this booklet. This manual is extremely thorough and detailed, covering all aspects of washing machine conversion.

Some of the most useful and hard to find information is about selecting the best washer for conversion to a super-efficient DC motor. This manual represents Jim's extensive search for the perfect washing machine. He's tried them all and shares his extensive, hands-on experiences easily with the reader. That's right, the manual is fun to read and filled with funky, hard-won wisdom.

This manual is 40 pages in an 8.5" by 11" black and white format. Cost is $10.00 from Wattevr Works, POB 207, San Andreas, CA 95249 • 209-754-3627.

Wildfire Across America

by Trooper Tom

Reviewed by Bob-O

If you are part of a rural fire fighting organization, or planning to start one, you need this book. If you are considering employment with a state or federal agency as a wildland firefighter, you should read this book. This book also contains very useful information about fire protection for the rural homeowner, you'll just have to dig a bit to find it.

The author's basic technique for residential fire protection is constructing two relatively small fire breaks in concentric circles around the dwelling. Between the fire breaks you remove, by burning or clearing, most of the "kindling" type of fuels that carry a fire along. The real beauty of this method is that it can be done with very little

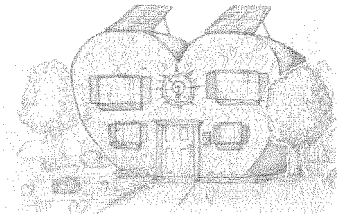
or no long-term visual impact. The visual landscape is one of the reasons that folks live in the country in the first place, so more homeowners are likely to use such a technique to get fire-safe than the classic wide and ugly firebreak.

The only thing I totally disagree with is the author's recommendation against the use of chainsaw chaps. A chainsaw is a useful but dangerous piece of gear. Any operator, whether he/she be professional or not, in an emergency situation needs all the protection he/she can get. Do-do happens.

Overall, this is a very worthwhile book. The rural homeowner's best insurance against wildfire is his/her own efforts to make their home fire-safe. Wildfire Across America will help with these efforts. Where else can you get a good fire insurance policy for under $20.00?

Available from: Trooper Tom's Fire Protection Company, POB 669, Selma, OR 97538. 503-592-2135. $17.95 ppd.

Home & Heart



Kathleen Jarschke-Schultze

In response to my comments on washing machines, Maytags in particular, I have heard from Lance Linfoot. Lance lives in Dos Rios, CA and called me to see if I knew what the problem was with Maytags on inverter power. His Trace 2012 and a Maytag would not work right.

Maytag Upgrade

I did not know why they didn't work well, only that they didn't. He had a Maytag repairman come out and reported to me all that he did to the Maytag to make it work for Lance. It took four things:

1. The addition of a capacitor, Maytag part #2-6103.
2. Check to make sure the belt surface is not sticky. To fix this, replace belt.
3. Lubricate motor rollers with silicon, not oil & clean track.
4. Check pump belt for over tightness. You should be able to just pinch the belt together in the middle.

I hope this helps the RE people out there having problems with their Maytag washers. This seems to be mostly for the newer Maytags. According to Jim Forgette (see Slaying a Watt-Guzzler, #22), the older Maytags already have a capacitor. Now the only machines to get a factory installed capacitor are those destined to be sold in Europe. Even with these checks and changes there is no guarantee that your Maytag will work without a hitch.

I also heard from Billy Barr of the Rocky Mountain Laboratory in Crested Butte, CO. He has been running a heavy duty Maytag washer for years, on a Trace 2012, without a problem. He has a moderately small battery system, using six 100 amphour lead-acid batteries (rated for 3 years- now in their 11th year). His Maytag has performed excellently and has been as dependable as they advertise. This is good for Billy as the repairman and/or any parts would have to be skied in most times of the year. As an added bonus, Billy says Maytag is easily the most socially responsible of the appliance companies.

Vacuum and Suction

Lance also told me that he uses a Eureka Vibra Broom II to vacuum his New Zealand sheepskin carpets, with complete success. His mother still uses an old Kirby that she got when he was a child.

This was interesting to me as I had just been sent an older Kirby vacuum by a fellow Sol Sister, Katcha Sanderson. Boy, is it cute! It has a red plaid cloth bag, red bumper strips and red attachments. Its polished aluminum body has a headlight that shines right on the area you are vacuuming at the time. It reminds me of old bulbous fendered Buicks. Yes, I like old things, but only if they work well.

This is a Kirby 505 (3 amp) and it is amazing. After shuffling along with my PortaPower for a year, I didn't realize how much dirt I was missing. After assembling the Kirby, we had a heyday vacuuming every carpet and floor in the place. We removed pounds of dirt. I kid you not! We estimated that about 2 1/2 pounds of dirt came out of our house. I was horrified that we had been living with that much dirt and gratified that now I was removing it.

Attachments & Options

As we were trying out the plethora of attachments that complement the Kirby I had a thought. Kirby must have been Scottish, maybe that's his family tartan on the cloth bag. He was sitting around one day, playing his bagpipes, listening to his wife complain about her broomstraws falling out, when the vision struck him. A vacuum cleaner that not only vacuumed any type of floor but also performed a myriad of other tasks. The variety of attachments bear me out. There is the Spray & Suds-O-Gun, the Handi-Sharpener, the Power Polisher, the Massage Cup, the Suction Coupler, the Blower Coupler, the Crystalator and The Handi-Butler to which other tools attach for use. This is in addition to the usual mundane vacuum tools we are used to (crevice tool, extension tubes, duster brush, etc.). I just wish I had seen one of those old door-to-door salesman pitch this machine way back when.

Recycled Value

I'm going to let Katcha and Bill Sanderson tell you why they've chosen the older Kirbys to recycle.

"For us Alternative living not only means independence energy-wise, but having a cottage industry which allows us a measure of economic independence too. Rebuilding and reselling vacuum cleaners has turned out to be our means to obtain this lifestyle.

We are happier yet to be able to blend both elements of energy and economy by offering to sell quality "recycles" to very energy efficient minded users. The best vacuum we have found that meets both of these criteria is the Kirby, whose older models were made with 3, 4, and 5 amp motors in the smaller head style before they became larger, heavier and more "juice" hungry.

Our house has wood floors with area rugs. In the course of "testing" out several other cleaners, I finally selected a 3 amp Kirby because it came closest to my ideal for these needs: 1) floor or carpet cleaning, 2) dependability, 3) lightweight and maneuverability, 4) easy canister/tool usage, and 5) options available for carpet or floor cleaning, painting, ETC.!

One of the newest "small" canisters came our way and the Kirby's 3 amps out performed that Eureka's 8 amp "Mighty Mite" in side by side comparisons. One other thing I like is cost savings in not having to buy the replacement paper bags the other cleaners need. I even have the option to donate the dust to my compost pile (while watching for metal or plastic items to be removed). This machine has also solved the cobwebs-in-the-15'-ceiling problem. Some extra light weight wands (tubes) reach up and still have suction to spare as I make homeless spiders.

Availability
Since the 3, 4, and 5 Amp Kirbys were manufactured some years ago, the availability of these machines are chancy at best. These fell out of favor due to "bigger is better" thinking. Many have been either junked or recycled for their aluminum. Most need plenty of TLC and work to restore them to to productive daily use, but they are up to it! We have been stockpiling the few we have come across, and in between other cleaner rebuilding have slowly and carefully got these ready for our "alternative friends".

Our price for a 4 or 5 Amp machine is $150, the 3 Ampers will be "premium" priced at $175. We guarantee these machines for the first six months. All should be able to run on any 600 Watt or larger inverter.

Tools
It is very seldom that we get the original tool sets with these machines, so we offer them (used/serviceable) as available for an additional $25. The cost for a new replacement set of genuine Kirby tools is $75, but we are researching and soon hope to be able to offer a "generic" replacement set in the $25 range. Other options include converting the pocket-dump bag over to a cloth bag which uses standard disposable paper bags for people who want that emptying method.

Eureka
As a less expensive, but still serviceable option, we offer 3.35/3.5 Amp rebuilt Eureka uprights ($45). These have a 3 month guarantee and tool set option ($10). Shipping is extra on all items."

Conclusion
The upshot for me is that I bought the Kirby Katcha and Bill sent me to test. I was afraid to let it go. It works so well. I have one of those sculptured-shag carpets (who ever invented it should be beat with it) where all the dirt goes to the short places and all the long shag folds over on top of that. Since I have been using the Kirby it looks like a newer carpet. I tried to find Kirby in the encyclopedia, to see if I was right about their heritage, but no go. I'm still curious, though.

Access
For more information/ordering CALL (408) 628-3362 (7AM-9PM Mon-Fri, 7PM-9PM Sat & Sun) or write - Sanderson's, 20295 Panoche Rd., Paicines, CA 95043

Jim Forgette, POB 207, San Andreas, CA 95249

Kathleen Jarschke-Schultze, C/O Home Power, POB 130, Hornbrook, CA 96044 (916) 475-3401.

HAPPENINGS

LMW&S/JEI Wind Workshop

Mick Sagrillo of Lake Michigan Wind & Sun, Forestville, Wisconsin in conjunction with Jordan Energy Institute of Grand Rapids, Michigan is offering a one week intensive, hands-on wind generator workshop from July 22 to 27, 1991. The workshop will include site analysis and system sizing; safety considerations; wind electric generators and alternators; rotor configurations and aerodynamics; tower designs; battery stand-alone and utility interconnect systems; and PV/wind hybrid systems. Installation and maintenance will be covered and in-field service work on an existing system will be performed. The cost of the six day workshop, which includes textbooks and printed matter, is $280.00 Three hours of college credit is available for an additional fee. Registration is limited due to safety considerations. For registration information contact: Mick Sagrillo, Lake Michigan Wind & Sun, 3971 E Bluebird RD, Forestville, WI 54213.

Hands-On Solar Workshops

The Solar Technology Institute is offering the following summer Photovoltaic and Solar Energy Workshops.

Photovoltaic Design and Installation, July 8-19, Carbondale, CO. Technical details of solar electric systems; practical engineering, hardware specification; & installations.

Solar Energy for the Developing World, August 5-9 in Willits, CA. PV and solar thermal systems for improving life in developing countries.

Solar Technology for Rural Health Care, August 26-30, in Carbondale, CO. This workshop focuses on the technical skills needed for using solar technologies in developing countries. Included are: vaccine refrigeration, lighting, communication, and water pumping.

The cost of a one and/or two week program is $350. per week.

Solar Home Program 1991-1992. This series of How-To and Hands-On workshops is about designing and building state-of-the-art solar homes that are self-reliant, thermally efficient, healthy to live in, and environmentally conscious. Photovoltaic Design and Installation, Sept.9-20; Advanced Photovoltaics for Remote Home, Sept. 23-Oct. 3; Micro-Hydro Power Systems, Oct. 7-10; Solar Home Design and Construction, Oct. 14-24; Energy Efficient and Solar Remodeling, Oct. 28-Nov. 21; Passive Solar Design for Professionals, Jan. 13-23; Heating the Energy Efficient Home, Jan.27-Feb.20; Solar Building Skills, Mar.2-May 1.

For detailed schedules and descriptions, costs, and scholarship information write, Solar Technology Institute, POB 1115, Carbondale, CO 81623-1115 or call Ken or Johnny at 303-963-0715.

Independent Power & Light Workshops

David Palumbo and Independent Power & Light of Hyde Park, VT will hold intensive one-day workshops in the summer of 1991. The workshops will include solar, micro-hydro and wind selection, battery choices - NICAD vs. lead acid, Charge controls, inverters, protection devices, wiring, and estimating loads for system design. Tours of state-of-the art systems will be made.

The workshop will be on June 29, and July 27, 1991. They will run from 8 A.M. to 5 P.M. Cost for each workshop will be $55.00 which will include "The Solar Electric Home Book" by Paul J. Fowler, "The New Solar Electric Home" by Joel Davidson and a three ring binder full of product descriptions, reviews and catalogs. Lunch is included.

The books will be mailed on receipt of each registration. Participants will be expected to read the books prior to the workshop. A deposit of $35.00 is required for registration as workshop size is limited. For more information contact: Independent Power & Light, David Palumbo or Kathleen DeCalle, RR1 Box 3054, Hyde Park, VT 05655, or call 802-888-7194.

Backwoods Solar Summer Workshops

Backwoods Solar will be holding several one day workshops on photovoltaic equipment and installation. Each workshop is limited to ten people. The cost is $40.00 per person, non-refundable pre-paid, which includes lunch and a text book ($30 per person if 2 people share the text book). The workshops will be held on the first Saturday of each month, July 6, August 3, & September 7, 1991. For more information contact: Steve or Elizabeth Willey, Backwoods Solar Electric Systems, 8530-HP Rapid Lightning Creek Rd., Sandpoint, ID 83864, 208-263-4290

Hands-On Workshops in Maine

The Maine Solar Energy Association has started a series of hand-on solar workshops all around the state of Maine.

The purpose of these practical, one day events is to de-mystify solar energy by showing the participants that it is practical today to use the sun to heat your home, make your hot water, furnish your electricity, and even cook your food and grow your vegetables out of season. In the past year we have had a very successful passive solar architecture workshop in Bangor, a solar greenhouse & sunspace workshop in Falmouth, and two photovoltaics workshops. The participants of the photovoltaic workshops actually constructed solar cell modules that they could take home for the cost of the parts. Some people made small solar battery chargers. Several participants assembled large 35 watt power modules.

In the coming year the expanded schedule of workshops will include; solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch.

For information on sites and dates contact Richard Komp, Maine Solar Energy Association, RFD Box 751, Addison, ME 04606, 207•497-2204

Electric Vehicle Club for Oregon

Lon Gillas of Pacific West Supply Co. in Amity, OR is organizing an electric vehicle club to promote electric transportation in the Pacific Northwest. Those interested in participating please contact Lon Gillas at P.O. Box 347, Amity, OR 97101, 503-835-1212.

Florida Solar Energy Center

Workshop Schedule for 1991 (subject to change). The Photovoltaic System Design Workshop will be held at the Florida Solar Energy Center on, Oct. 22-24, 1991. This workshop will cover solar electric technology and the design of stand-alone and utility interactive PV systems. Cost $150, in-state, $300 out of state.

Energy Efficient FL Home Building: the newest ideas on designing & building an energy efficient home for home builders, inspectors & those thinking about building. 9/19 (Orlando) 1991. Cost $45.

For more information contact JoAnn Stirling, 300 State Rd 401, Cape Canaveral, FL 32920-4099 • 407-783-0300

NE Sustainable Energy Assoc.

October 26 & 27, 1991 - SOLAR AND ELECTRIC VEHICLE SYMPOSIUM, Boxborough Host Hotel, Boxborough, MA. Just off RT. 495, west of Boston. CONTACT NESEA: 413-774-6051

Minnesota Energy Council

The MN Energy Council will hold a number of conferences on new technology in energy and environmental management for housing, small buildings, small business and municipal buildings, aimed at professionals and business people. For more information contact: Roger Peterson, Minnesota Energy Council, Box 8222, St. Paul, MN 55108 • 612-378-2973

Solar World Congress

The Solar World Congress of the International Solar Energy Society will be held on August 17-24, 1991 in Denver, CO. Contact: American Solar Energy Society, 2400 Central Ave. Ste. B-1, Boulder, CO 80301 USA, 303-443-3130, FAX 303-443-3212.

Sunnyside Solar Seminars and Workshops

"Photovoltaic Home Electric Systems - Seminar and Workshop" is a one day program given at Sunnyside Solar, Inc. in Brattleboro, VT. It provides an introduction to independent solar electric systems and includes a hands-on workshop assembling a four module system. Each program is complete. The 1991 schedule is June 29, July 27, September 28 and October 19, each on a Saturday, 9 am to 4 pm. Advance registration, with a $35 deposit for each person, is required. The balance of $95. per person is due on the day of the workshop. Registration for each session is limited to the first eight deposits received. Included in the day's program is lunch, a packet of product information and related articles, and Joel Davidson's "The New Solar Electric Home".

For additional information and registration, contact Carol Levin, Sunnyside Solar, Inc., RDF4 Box 808, Green River Rd, Brattleboro, VT 05301, 802-257-1482

Fowler Solar Electric Traveling Solar Workshops

Fowler Solar Electric Inc. will be offering a series of solar electric workshops during the summer, and fall of 1991. These workshops will teach potential PV homeowners to size, site, install, and live with a PV system.

All workshops will be held Saturdays. Jeffrey and Lea Fowler will teach the workshop from 9:30 AM to 2:30 PM. From 2:30 PM to 4:30 PM there will be comprehensive

product display, as well as a question session. To register, please send $25 per person. If you are attending as a couple, you will pay only $35 for you and your spouse. Send your address and telephone number with your registration. We will respond by mail about 3 weeks before the workshop with a confirmation, instructions, directions, and complete information. Please bring your lunch.

Dates of Workshops: Saturday, June 22, 1991, 9:30 AM in Plattsburgh, NY; Saturday, July 20, 1991, 9:30 AM in Keene, New Hampshire; and Saturday, August 3, 1991 in Montpelier, Vermont.

CALSEIA SUN-DAY

A statewide solar electric car race, ecological exhibits and demonstrations of solar and other forms of alternate energy will be featured at the First Annual Sun-Day, sponsored by the California Solar Energy Industries Assoc. (CALSEIA).

The event will be held June 23rd on the grounds of the California Museum of Science and Industry, 700 State Dr., Los Angeles, CA from 10 AM to 5 PM and is free of charge.

SUN-DAY will also be the site of the finish line for the California Clean Air Race, a race of solar electric cars from Sacramento, through Palo Alto, Fresno, San Luis Obispo, to Los Angeles. The 760 mile car race will highlight the development of alternate energy vehicles, and is the first of its kind in California.

For further information, contact Peter Cowles, Executive Director, 800/225-7799 (outside California 415/621-8426).

Solar Energy in Sweden/Finland

A two week study tour (or one week option) of community scale renewable energy projects, research labs, and technology exhibition centers in Sweden and Finland, including solar, wind, and biomass. Both countries have major national initiatives to develop renewable energy. Opportunity to attend 1991 International Symposium on Energy and Environment in Espoo, Finland, August 25-28. Option to depart USA on August 22 for a one week tour to exhibition centers and symposium only. Full tour (two weeks) will include a visit to production plant for highly-insulated building components, and ferry across the Baltic Sea from Sweden to Finland with a seminar held on board. For more information on the Sweden/Finland tour or the 1992 Denmark/Germany tower contact the Minnesota Energy Council, POB 8222, St Paul, MN 55108, 612-378-2973

Environmental Protection Information Conference

EPIC, a leading edge exposition to demonstrate the latest technology, products, and services with the greatest promise for improving the environmental performance of the business community. EPIC is specifically intended to establish and strengthen business-to-business relationships that promote cleaner, less toxic processes, technologies, and products in the marketplace. "EPIC presents a unique opportunity for the public and private sectors to showcase and examine the products, technologies, and services that are available to meet the environmental challenges facing the United States," said Senator Gore EPIC's keynote speaker. The event will be held on Oct. 22, 1991 at the DC Armory in Washington, DC. For more information contact Mark Flemister or Bob Frederick at EPIC 301-309-0700.

Lightwheels 1991

Lightwheels is a not-for-profit group formed 2 years ago to encourage alternative modes of transportation. by promoting the development of solar, electric and human-powered vehicles through exhibitions, contents and education.

The summer long Lightwheels exhibit opens at the Municipal Art Society's Urban Center on June 26. The Expo will highlight economically and environmentally sustainable transportation and energy resources. Along with solar, electric and human-powered vehicles that will take part in the Lightwheels Festival, many innovative, energy efficient technologies and products will be displayed. For more information call: Lightwheels 212-431-0600.

the Wizard Speaks…

FREE ENERGY UPDATE

A new free energy magnet motor is coming on the scene. Troy Reed of Tulsa, OK has developed a permanent magnet device that produces free energy. It has two sets of stationary magnets and two sets of magnets mounted on freely turning disks. Spring-type injector pins are used to keep the motor turning at a constant RPM (about 500) as well as to overcome magnetic attraction. The device is started using a normal starter motor and then runs freely and continues to produce energy. For more information contact Reed Magnetic Motor, Inc., POB 700395, Tulsa, OK 74170, or call 918-743-1112.

Another device that has been around for awhile is the N-Machine. The N-Machine was invented by Dr. DePalma, formerly of MIT. It has been tested by a variety of people and seems to work producing free energy. This device uses a magnetic field from permanent or electromagnets to produce voltage and current in a rotating disk. The disk is driven continuously by a normal high efficiency motor. A 90 page book is available describing the N-Machine. I haven't personally seen it yet, but it is available from For The People, POB 15999, Tampa, FL 33684. The cost is $9.95 plus $2 for shipping.

I have also been informed by an HP reader that the For The People radio show and Radio Free America do a free energy show every Friday on shortwave radio at 7.520 MHz. The times are 8 AM to Midnight eastern time.

Writing for Home Power Magazine

We specialize in hands-on, practical information about small-scale renewable energy production and use. We publish technical material in an easy to understand and use format.

Informational Content
Please include all the details! Be specific! Write from your direct experience- Home Power is hands-on! Please include full access data for equipment mentioned.

Article Style and Length
Home Power articles can be between 500 and 10,000 words. Length depends what you have to say. Say it in as few words as possible. Use simple declarative sentences- short and to the point. Use Sub-Headings to organize the information. Check out articles printed in HP to get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

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

Photographs
We can work from a color or black & white photographic print. If your photo is for the color cover, then send a color transparency (color slide).

Line Art
We can work from your camera-ready art. We can also scan or redraw it. We can generate tables, charts, and graphs from your data.

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Send your article on disk if possible. We use Mac computers. Please format all word processor files in ASCII "TEXT" format. We can read text files on 3.5" IBM disks. Format all graphics as PICT. Use 10 point Helvetica for all text embedded within graphics.

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Got any questions?
Give me a call at 916-475-3179. This saves everyone's time. *Richard Perez*

Letters to Home Power

We Print 'em Unedited.
Selected & Entered by
Kathleen Jarschke-Schultze

Homebrew Anemometer

Dear Richard and the HP Crew, I enjoy seeing more information in HP about wind energy systems. I think your idea of installing a small wind generator to check a site's wind energy potential (#21, P. 78) is really good. After living with a small wind system for thirteen years, I've got a couple ideas to share.

My first wind machine was a homemade unit. If you want a good, reliable, efficient unit homemade is definitely NOT the way to go. But if you want a good, hands on education in wind energy, the homebrew will really give you that. Just don't expect it to perform like a factory model and be prepared to give the project plenty of time.

Another possibility for low cost site analysis is a homemade anemometer. I made one by attaching three sheet metal cones to a hub which is mounted on a small permanent magnet generator. Most any PM motor will work for the generator, though its best to use a slow speed unit. Remember too that it will be spinning day and night so one with ball bearings will probably last longer. Surplus Center and Fair Radio Sales Co. are two good sources of PM motors and Fair also has a good selection of meters.

The output from the generator is connected through a series resistor to a milliammeter. If you use two different resistors and a switch you can have a high and low range. Ours reads 0-25 on low and 0-70 on high. You'll need to make your own dial for your meter, so one with a removable face is handy. Just flip it over and mark on it the wind speed scales you want. Determine the proper resistors by experimentation.

I calibrated our unit by clamping it on the front bumper of our car, high enough above the hood to be in "clean" air. Note your readings as you drive at different speeds (this is a two person task). Do your calibration run before marking the meter as described above. Another way to calibrate would be to mount your unit next to a factory made one and note the readings. This would really be preferable to the car method. I calibrated ours using the car method though (did it on our way to church on a calm Sunday morning) and the readings correlate very closely with what is reported by the National Weather Service in our area.

If you're looking for one more reason to buy a Fluke 80 series digital multimeter the anemometer project is it. By putting the Fluke in parallel with the milliammeter and switching to the min/max/avg. recording mode you now have some of the functions of a full blown recording anemometer. It will tell you the minimum windspeed, the peak gust, and calculate the average windspeed over the entire day. You'll need to make a conversion chart to convert your Fluke numbers to windspeed. I also made a cardboard face that lays over the Fluke's face so one can read windspeed directly from the bar graph.

Hope this might be helpful to someone. Below is a

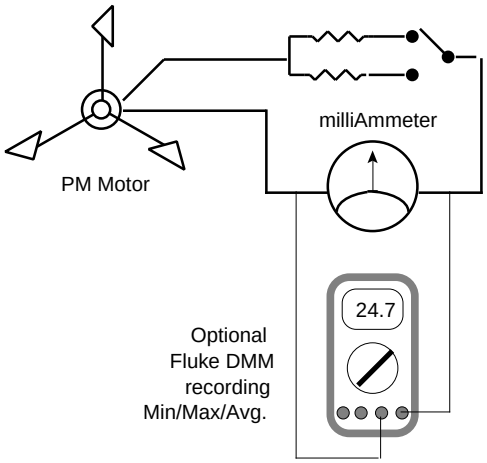


diagram to show what the setup looks like.

Fair Radio Sales, POB 1105, Lima, OH 45802 Tel. (419) 223-2196

Surplus Center, POB 82209, Lincoln, NE 68501 Tel. 1 (800) 228-3407

P.S. Thanks for the "Time Machine" in #21. Exactly what I was looking for. How did you know? I plan to build several. Just need more time for all these HP inspired projects.

Bruce Johnson, 7605 N. Post Rd., Spencer, OK 73084

Hi, Bruce. Thanks for the flowers and the easy to build anemometer. I built one like you described and used old panty hose containers for the anemometer cups. Only problem was that the plastic used to make these egg-shaped containers is photosensitive and they fell apart in about a year. Bob–O and I buy a lot of parts from Fair Radio Sales. They have great stuff, excellent service and bargain basement prices. Glad you liked the Time Machine. Feedback from readers on this circuit has been hot and heavy. We're glad to be of service. Richard.

Outback Bucks

Dear Home Power, I am interested in receiving copies of your design newsletter about the OOZIE backwoods electric vehicle project. Please let me know about any costs involved.

You may be interested in the incentive which New South Wales State Energy Authority provides for remote power

systems. Under a scheme known as the Remote Area Power Assistance Scheme anyone who is more than a $20,000 connection cost to a main supply is eligible for a 50% grant for the costs involved in providing remote power from renewables like sun, wind and water.

We recently installed a $24,000 system including installation costs and an equipment room for which we received a grant of $12,000. Major components (solar panels, wind generator, water turbine, batteries, inverters and chargers) have to be Australian made.

The Energy Authority decided it was to their financial advantage to do this as the average country consumer in N.S.W. costs the Authority about $3,000/annum in maintaining distribution lines, even though the consumer has to pay for their initial installation.

Maybe this example can be used to persuade American Utilities to do the same. Write if you want more info and/or a contact. The State of Victoria have also recently introduced a scheme similar to N.S.W. but with a max grant of $3,000.

You may also be interested in an Australian magazine called Soft Technology. c/o Alternative Technology Association, 247 Flinders Lane, Melbourne, Victoria 3001. Australia Cost $15.00 They would probably swap a subscription. Regards, Brian Woodward, Earthworks, Wollombi, N.S.W.2325, Australia

Hello, Brian. I very pleased to hear that the government down under is supporting renewable energy technologies. Wish we could convince the White House to do the same. I've entered a free sub for Soft Technology in our international database in hopes they will return the compliment. Karen and I would dearly love to visit the outback of Australia and some day we will. We see that many countries without an extensively developed commercial power grid are surpassing what is being done here in the USA. I salute the gov't of NSW for their far-sighted support of RE. I'm slowly working on the OOZIE project, but nothing really has been accomplished yet other than design and dreams. I need the assistance of an electrical engineer who can design 5 to 10 horsepower electric wheel motors. Our design calls for a gross vehicle weight in the neighborhood of 3,000 pounds. Our current design holds twenty-four 51 Watt PV modules (12 on the roof and 6 on each flip-up rack covering the left and right sides). We're planning on driving the four wheel motors with high voltage via two inverters. OOZIE is tentatively scheduled for ≈ 800 pounds of sintered-plate aircraft nicads. Wheelbase from front to back is 118 inches (about the same configuration as a Toyota pickup). Since OOZIE is a real powerhouse, we designing it to interface with a home power system. Batteries, PVs and inverters can be shared with a building when OOZIE is parked. How about it EV nuts, want to get in on the fun? Richard.

Hiding HP

This is our favorite magazine. Sometimes I wish we had two subscriptions because we fight over each new edition when we receive it. I get it and hide it in the bathroom so he doesn't take it away from me. Keep up the good work. And I hope there are some workshops this year close to us. Liz Ewell, POB 23, Silver Lake, OR 97638

Gee, Liz, it's great to hear we are so popular in your home. But instead of getting two subs just learn to share gracefully and get another year on your existing sub. Right, Kent?-Kathleen

Hi. Liz. The HP crew will be at the Oregon Country Fair's Energy Park on July 12th-14th. Oregon Country Fair is located in a small town called Veneta, just outside of Eugene. Come and join in the fun! Richard.

Plain Truth

To Whom, Etc., Great magazine - just keeps getting better. Since the Iraq/Kuwait crisis began, increased attention is being directed toward alternative and renewable energy. Maybe now the utilities will factor in societal and environmental benefits and pay a rate that will sustain current and future installations.

Meanwhile, we continue to dismantle the world's largest PV utility scale power plant (originally rated at 6.5 MEGAWATTS!)

Lance Pierson, Assistant Plant Manager, Carrizo Solar Corp.,Star RT Box 3013, Carrizo Plain, CA 93453

Gee, Lance, the thought of all those PVs frying in the sunshine makes me shiver. I get dreams of electric heat and air conditioning. The utilities are slowly getting the message about renewables. Utilities can either change they way they make and distribute power, or they can go the way of the dinosaurs. The utility involved in Carizzo was PG&E which is one of the most forward thinking in the nation. While I'm sorry to see the project terminated, I know that those panels are finding their way into home power systems. Their loss is our gain. Richard

Fixated Tracker

Dear HP, I'd like to see you folks do an article on trackers. We live in cloudy western Washington, and I've been trying to figure out the hot set-up for areas like ours.

I've got a basic concept, with a lot of fuzzy areas in the picture. According to some local sources, light levels on a typical cloudy day average about 15-30% of maximum. The logic goes like this: The light is so indirect and such a small fraction of max that you may as well simply mount PVs facing south at the proper tilt. Zomeworks track racks, which depend on the heat of the sun, may very well never fire up, remaining in a morning position. This would be worse than no tracker at all! I'm not clear on Robbins

trackers, but my guess is that most if not all electro-mechanical trackers rely on direct sun.

Which brings me to my next point: Not EVERY day is cloudy around here, contrary to what you may have heard. I'm sure that with a drill and some bits of metal, a person could come up with a device for pinning a Zomeworks at a noon-time position, then remove the pins on days which promise to be clear. Would this result in damage to the trackers internals?

As you can see, one question leads to another. I've been told that your money would be better spent on more panels rather than a tracker, and I wonder how many people have and/or will make the wrong decisions in cloudy climes like ours?

Bill Barmettler, POB 1462, Chehalis, WA 98532

Hi, Bill. Pinning the heat activated tracker in a south facing position is a fine idea and we've done this to a thermal tracker in our neighborhood. The site is high on a mountain in a windy location. During the deepest winter months the tracker doesn't get warm enough to work effectively. Check out the new two-axis, electric-activated Wattsun trackers. At this point in time, it is not cost effective to track any less than eight 50 Watt modules, with the exception of array direct water pumping. It's a matter of bucks for the tracker versus the extra power supplied by the tracked modules versus just spending the money on more modules. In order to be a candidate for a tracker, a site must have dawn to dusk sunshine. Richard

Ground Loop

Allow me to share with you a solution to the hum-m- audio problem in operating DC powered stereo hi-fi equipment on the same battery with an inverter. While my exact problem has not yet been described, anyone familiar with big ticket auto-sound equipment interfacing will be familiar with the problem - GROUND LOOP - and its solution: Radio Shack #270-054 audio system ground loop isolator.

I hate Radio Shack products with a passion, but this item WORKS. I was running a DC powered VCR into a DC powered "mobile stereo receiver" (Radio Shack #STA-7M that has line-in and even mag. phono input). Every time I turned on the inverter (to run a color TV) an awful hum pounded through the woofers. I suspected magnetic pickup - whenever you run a square-wave inverter, you generate big pulses of EMF fields especially where the + and - conductors are separated - unavoidable at the battery (even a puny 50 watt inverter on 1080 A/H of battery). See CURRENTS OF DEATH by Paul Brodeur, 1989. I tried opening the ground connections of the audio leads at the VCR. This lowered the hum but now made a buzzing (electrostatic pickup of the 60 cycle fields). Physically separating the amp. from the VCR (which generates magnetic fields from its logic) and from the TV (generates magnetic fields at 60 cps and 15 kc from its deflection coils) gives some relief, but the longer audio cables pick up more noise if ungrounded.

I saw this "audio system ground loop isolator" and when I read on the back of its card a description of the classic ground loop in interconnecting auto sound equipment, I knew it would work. It cured the problem 100%. It is designed for a high-impedance hi-fi stereo line input and has RCA plugs and jacks to go right into your amplifier's line inputs. I haven't tried it yet on magnetic phono input, but it may help there also. DC powered turntables need to have their green ground wire connected to the ground terminal of the amplifier to remove the high-pitched tone from the TT motor. Peaceful Sounds,

S. Marshall, RD3 Box 30-A Dover-Foxcroft, ME 04426

Hey, great! The right tool for the right job, eh. I love it when something works like it's supposed to. This will make for easier listening in a lot of RE households. Thanks. -Kathleen

Opinion vs Fact

I would like to take exception to John Wiles column. As Chief Engineer and Installer for "Solar Energy Resources" here in Westcliffe, we deal with the NEC and Colorado Inspectors (Statewide) on a daily basis. We are not encountering the same situations he describes. It appears his column is both fact and opinion concerning the Code. As a service to your readers his column needs to be edited to include only fact and not opinion. Otherwise keep up the good work. Dale Haberkorn, 440 Bear Peak RD, Westcliffe, CO 81252

Well, Dale, Mr. Wiles is wholly responsible for the contents of his column, we do not edit it, nor do we always agree with it. -Kathleen

Shedding Light

First let me add my own kudos to all that you receive... your publication is of great value to me. I live in Puna, Hawaii, which I have been told is the largest community in the US that is off commercial power and water (about 40,000 souls).

I own a home with rain catchment as a water source, about 200 watts of solar voltaic, four Trojan T-105s, a Honda 2200 for backup, and a Heart 600 watt inverter; propane stove and refrigerator; both propane and 120v fluorescent lighting. I'm writing to relate my experience with compact fluorescents, and to ask a few questions of

LAMP	120 vac ma.	120 vac watts	equivalent light watts	Cost
Panasonic 15W. Compact	230	28	60	$24.00
Lights of America 22W.	253	30	100	$9.00
Incandescent 15 W.	128	15	15	$1.50

you and your readers: I recently tested my 120v lighting system, with an eye to efficiency and cost. The results were:

The Panasonic was a compact "light capsule"; the Lights of America was a common ring-type fluorescent purchased at my local hardware store (price here could probably be reduced by 30 to 50% for mainland buyers). Both units came complete with ballast, and that is how the measurements were made. The "LoA" unit was definitely a more "fluorescent" color (i.e., not pleasing); it's lifetime is hard to determine from the "8 years" on the package. But... where is the greatest value? The "watts" were measured with my Heathkit DVM (it has a 2 amp AC current range), assuming I had 120VAC from the inverter (actual measured was 128VAC... is this an artifact from the "modified sine wave" of the inverter?). The real point seems to me that, for about $9, the cheap ring lamp put out more than half again as much light as the expensive compact fluorescent, and the power usage was increased by less than 10%.

To put things in perspective, I rarely need the large light output of the 22w ring fluorescent, and have just ordered $150 worth of smaller wattage compact fluorescents...but it is something to think about.

I would also like to know if any readers have experience with very low scale hydroelectric power generation... I get around 200 to 260 inches of rainfall per year ; ten or even twenty inches of rain a day are not uncommon, and one to two inches per hour are not rare... I've calculated that, at one inch per hour, I am getting over 600 gallons per hour runoff from my roof, which has a height (head) of twenty feet above ground level... the power equivalent is about 30 watts... is there a practical way to convert this for charging my batteries? Looking forward to my next issue... Aloha e Mahalo Nui Loa

Joel Aycock, POB 1659, Keaau, Hawaii 96749

How about it, readers? Anyone have low head, low flow hydro info? Richard

PicoPower

Dear Folks, I've read your magazine off-and-on for several years and have thoroughly enjoyed it. I especially appreciate your hands on approach and humor.

If there is MICROpower and NANOpower there must be PICOpower! During my fourth year (winter) in the tipi, I hooked up a small automobile bulb to a motorcycle battery and the seed was planted. This was to be my last winter living only by firelight and one kerosene lamp! I made up a small system that has worked perfectly for a year now. It consists of two Arco G 50/6 (six volt) panels wired in parallel - more about this later. This array puts out a whopping 2/3 amps at 7.3 volts, approx 5 watts. These are 'self-regulating' so I only usually see around 3 watts. I found a couple of hundred feet of 12/2, cut it in half and wired each panel separately to the control panel. I designed the control panel to be functional, a learning tool and fun, and it works! There are two 6v 10AH sealed gel batteries behind the panel. The batteries are individually switched and fused, the Arcos are also individually switched. The three meters are 0-500 milliamps (that's where most of my action takes place!), 0-3 AMPs and 0-15 volts. With these I can measure the voltage and current of each panel separately and power drawn by each 'appliance'. I have five of six switched outlets used - 1/2 watt, 1.2 watt and 5 watt car bulbs, 6 watt fluorescent/flashlight from Radio Shack and AM/FM/Cassette player.

Now to the answer - why a six volt system? My car is six volt (1961 Volks Bug) so I already had the three bulbs. The fluorescent from Radio Shack cost $15 (made to work from 4 'D' cells, it already had a jack for external power input). The cassette player was free (a belt was broken - a local store had one for $4). It was made to run off of 5 'C' batteries and also came with an external jack. Interestingly, the jacks on the radio and flashlight were the same but in the radio the center contact is positive and in the fluorescent/flashlight the center is negative. Whew! I use both of these in the car sometimes so I used one plug with a polarity reversing switch marked appropriately. The panels were about $120 total, tripod mount free and easy, wire $0, batteries $40 total and the panel cost me around $75. So I've got a no-maintenance system that satisfies my needs perfectly. Thanks for your inspiration!

The panel mounting tripod is simply three poles roped together. The angle of inclination is easily changed and it is very stable. My tipi works the same way - its called a 'three pole tipi' since the tripod is the foundation.

The solar cooker has been a LIFE SAVER and is highly recommended for any alternative liver (and even non alternative ones). I recently added the mirrors and plywood top to my cardboard cooker for a little extra heat - now I get about 320° full sun. I've probably used it close to a hundred times and still going strong - just worn around the edges. I cook soups, stews, breads, cobblers, grains, beans and heat water in it. I use clear quart jars (wide mouth) so I can see the food bubbling away - always a thrill. Do you know of anyone with plans for a parabolic dish? Thanks.

Mark Heinlein, POB 1764, Bend, OR 97709

Although I have heard that there are plans for parabolic dish cookers out there I don't have any specific leads or addresses. Sorry, Mark. It always is a thrill to cook solar. If more people tried it I'm sure more people would do it regularly. -Kathleen

Under Spread of Sail

Dear Folks, I will start with the usual thought that I do

enjoy your publication and have used many of the ideas and suggestions that have been explained in the pages of your very informative magazine.

I will shortly be moving aboard a cruising sailboat in the 35' to 40' length range. Many of the concepts that have been espoused by you are very applicable to marine use and I intend to use PV and Windpower for my electrical needs on board, including: refrigeration, fresh water maker, and inverter circuits for repairs and maintenance.

Outside of a story about Mary Duffield and windpower on board her 35' boat, Agua Alegre, I have not seen any stories about marine applications of Alternate Energy. There are special problems with using electricity at sea but they can be solved with intelligence and patience. I hope that I have enough of both to be equal to the task but I do not have the research abilities that you folks exhibit with your survey of ideas, products and "Things That Work".

I need your help and advice regarding a sewing machine useable for repairs, new "stuff" for the boat and her crew and probably for use as a money maker in out of the way ports for those sailors who do not possess such a useful tool.

I would like information regarding power consumption; 100VAC (inverter power) and 12VDC. I have considered hand or foot power but that does not seem too practical for my circumstances. Any information that you or your readers can pass on will be much appreciated and used. Aloha, John L. Alton, POB 341, Pearl City, HI 96782

Smooth sailing, John. We do not get submissions about marine RE so we have not had many articles on it. I recommend Fritz Seyfarth's book 'In Pursuit of Adventure and Freedom' that is reviewed in this issue. Also , now any readers afloat can write directly to you with any info they have. When you get settled onboard and your system is working submit an article, you never know. -Kathleen

Spread the News

I was lucky enough to receive Home Power #1 and returned the subscription form along with an inquiry as to Home Power people in the Northeast. My letter was printed in HP #2. Also in it was an ad for Fowler Solar Electric in nearby Mass. With Jeff's help we have a system which powers our new log home. All our friends take the PV power as normal now, but they all went through the sudden realization that these lights and music and yes, even the washing machine, are all powered by the sun. It's a mind blower at first. Home Power is an excellent tool. Every issue I open answers some question for me. I attended the Solar Technology Institute's 2 week Solar Workshop at David Palumbo's Independent Power and Light, put on by Ken Olsen and Johnny Weiss. It was great. In fact, I even got my back in the photo on page 37 of HP #20 (I'm the one with no shirt). I was happy to see the article on Ken and Johnny in HP #21. They are good teachers.

So any way, please renew my subscription for 2 years and send a gift sub. to the Mason Public Library for me. HP just keeps getting better. Keep on Shining! Thanks for all the help and inspiration.

Dave Morrison, Jeds Ln, Mason, NH 03048

Thank you, Dave. We can't help but get better cause we have readers like you. There is nothing like being needed to make an idea/people/philosophy excel. -Kathleen

I would like to second the praise for Ken Olson and Johhny Weiss of the Solar Technology Institute. These fellows offer the finest hands-on PV training anywhere in the Galaxy. Richard.

Solar Wheelchair

Dear folks, Nice magazine, saw it on the newsstand for the 1st time and it definitely piqued my interest. I work for a project promoting the use of adaptive equipment by persons with disabilities. A good portion of that equipment relies on batteries. I have a personal mad scientist vision of enabling wheelchairs to "go solar". I'm enclosing a check for the available back issues and a subscription to see what I've been missing. Keep up the good work.

MaryAnn O'Toole, 5 Alicia Rd, Dorchester, MA 02124

To echo your own words, MaryAnn, keep up the good work. We salute you! -Kathleen

Overconsumption

Dear Home Power, Your magazine is excellent. As a Journeyman Electrician, in the trade for over ten years, I have seen the industry change a lot, from modest (grid) availability to massive overconsumption. Electric this, electric that, etc. The future holds much change for us humans as a species on this planet, if we do not change our greedy, overconsumptive ways, we will soon, go the way of the dinosaurs, extinct. Solar photovoltaic and other forms of Alternative energy hold much promise and the only REAL solution to SURVIVAL! This is not some new fad, some scheme, some joke, some speculation, it is reality! Alternate power is THE ONLY WAY WE ARE GOING TO SURVIVE! But, I don't have to tell you that. Life can be so ironic, I spend all day installing grid-connected systems, with up to 600 Amp capacities, on homes for God's sake, and come home to my 6 Kyocera 51 watt panels, and smile, for the changes all start with each one of us, as individuals. Keep up the excellent work! PS Do you accept pix? Sincerely,

Scott Jochim, Box 1224, Sandpoint, ID 83864

Yes, Scott, we do accept pix. There is no guarantee they will be published, of course, but we like'em. As for your other comments, I believe you have said it all. -Kathleen

Hand in Glove

Letters to Home Power

Dear Friends, We'd like to order back issues: #4 & #16. Enclosed find $4.00.

I'd like to encourage you to include info in small systems as often as possible, so that more people thinking of adding power to an "off the grid" lifestyle, see that small warp is possible. I remember seeing a mini-review of a mini system whose owner commented on the wonderful quality of life and light after graduating from kerosene to a one panel and DC electric system. He was really right - that transition is glorious - a day and night change to everyday reality.

We've been living in an 18' canvas yurt for twelve years. I really remember when we made our first 6V system and had ELECTRICITY! We've slowly added to our system, but still our life goes on with one panel. And it's enough for us. We use up 5 gallons of propane every six weeks or so for our Paloma water heater and everything else we do with wood. I'm still washing clothes in buckets, but I wouldn't trade my lifestyle for another in America. (Where can I get a pair of those elbow length rubber gloves?).

Anyway, my point is that off grid electricity can be available to lots more people if they think small, small. Small is not only beautiful, its simpler too.

So keep up the good work. We think you're great and we read every issue as soon as it hits the table. God bless you always, may your missions be accomplished. Yours,

Anne Shirako, POB 1004, Upper Lake, CA 95485

We salute you. It is a rare life that is uncomplicated in this day and age. The best that Bob-O can remember, he got the gloves from Industrial Safety and Supply in Lima, OH. We don't seem to have their catalog anymore. - Kathleen

Q&A

Basics

Home Power, We have a few questions and would appreciate any info you might have:

-a good book on basic electronics

-a plan to build a regulated power supply that utilizes 12 volts DC from the battery bank and has an output of approximately 0 to 20 volts DC and 0 to 5 amps.

Again, we think your magazine and philosophy is terrific!

Allen and Renee' Cook, Bozeman, MT

I am hard put to give you the title of one good basic book on electronics. I didn't learn from a book, but from a breadboard and a pile of parts. Any high school Physics book will deliver the science you need to work the wonders of electronics. As to the specifics of circuit design, there are hundreds of books each about a special facet of this enormous area. Here's my favorite: Electronic Design With Off-The-Shelf Integrated Circuits by Meiksin and Thackray (Parker Publishing Co.). Also good is ANYTHING written by Forrest Mimms. The manuals used by the US Air Force and US Army are simple, straight-forward and strictly functional- they teach quickly and well. I have no specific plans for the power supply you mentioned, but several companies produce DC/DC converters that will do as you wish (for example,. Tamura, 1150 Dominguez St., Carson, CA 90746 • 213-638-1790 or Abbott Transistor Labs, 2721 S. La Cienega Blvd., Los Angles, CA 90034 • 213-202-8820. Richard

Crying Radio

Karen Perez; Please renew our subscription for three more years. Your magazine is the most informative for those of us AE people in the USA and the world. Keep up the good work - Peace - Love - Harmony to you all.

Two questions. When listening to AM radio and a fluorescent light is turned on, what causes the radio to make that strange crying noise? How can it be eliminated other than turning the light or radio off? Thank you.

David Benedict, Native Self-Sufficiency Center, RD1 Box 375 Coldbrook, NY 13324

There is no simple, sure fix. What you are hearing on the radio is radio frequency interference (RFI) emitted by the fluorescent light. If the light and radio are powered on DC directly from the battery, then use capacitors to filter out the noise. Add a .001µf capacitor across the power leads at the battery and another at the light. Or use coaxial cable for the light's power wiring, and still add both capacitors. Or use an incandescent lamp (all incandescents are RFI quiet) if all the above fails. If the light and the radio are powered by the same inverter, then the situation is entirely more sticky. In this case, try every sort of 120 vac interference and noise filter you can get your hands on. Most won't totally silence the light. If you are really into noise-free radio, shut off the inverter and all fluorescent lights (either DC or ac), and listen. The inverter or fluorescent that is totally RFI quiet has yet to be invented. Richard

Interfering Inverter

Dear Home Power, I'd like to know if there is anyone out there who has knowledge of inverter interference with telephone lines. We have a Power Pal 1200 watt inverter and it seems when it is on there is a definite static on our phone line. I'm wondering if other Power Pal users have had this experience, and if any other inverters have presented similar problems to users.

I'm also wondering if this interference could pose a problem with modem communication? Right now I have the use of an Apple IIe with modem. I don't seem to have any problem communicating with MCI mail; but when I try to directly communicate to someone in Spokane with an IBM system, I received a line but was sending gibberish. Now I suppose the problem here could lie in not having exactly the right set up between us. I wondered if the inverter could be the culprit, as it must be on to run my system.

Any info would be appreciated. Our family enjoys your magazine immensely. We are off grid and totally solar powered here in the land of sunshine in Eastern Washington. Long live Mother Earth,

Terri Reed, RT3 Box 72-R, Davenport, WA 99122

Hi, Terri. Your problem is very common to many inverter users. The problem is that the modified-sine wave of the inverter is being coupled to the telephone wiring. The interference is creeping in where the 120 vac power wiring and the telephone wiring are close together. Rerouting of your phone wiring will most certainly stop the problem. Avoid running the phone and power wiring parallel to each other and within 24 inches of each other. If a phone line must cross a power wire, then let it cross at right angles and proceed perpendicular for at least two feet before turning parallel. Consider that your power wires are broadcasting antennas and your phone wires are receiving antennas. Do your best to see that these antennas talk to each other as little as possible. The best fix is to increase the physical distance between power and phone wiring. The problem with data transfer sounds to me like protocol problems (software smütz) and not line noise. In general modems will function on very noisy lines. Richard.

Solar Food Dryer
In reference to the letter from Pat Lambert in HP#22, Pat and other Home Power people may like to know a few sources for plans for solar food dryers.

The January 1979 issue of Popular Mechanics had an article entitled "Build PM's Solar Food Dryer" with complete plans and a few references.

In 1981 Rodale Press, 33 E. Minor St., Emmaus, PA 18049, published a book, Solar Food Dryer, ISBN 0-87857-333-X. Included were very complete plans and instructions for drying foods. Probably out of print, but library may help. Undoubtably there are other sources for plans also. Does take a bit of digging.

Bear, Bodega, CA

Thanks again, Bear. This comes just in time to get one built before the crops are ripe. - Kathleen

EDTA Report
Last year I purchased a used mini-motorhome. It is parked 51 weeks out of the year - and when I used it I found the aux battery that powers the interior lights, pump, etc. when motor is off, would power things for up to four hours, but the next morning had lost its charge completely.

Before a short trip I planned to fill it with EDTA dissolved in water but when opening the battery found all cells completely full, so I put in about 1/2 tsp. per cell powdered EDTA on the tip of a butter knife dipped into the bag.

After driving about 150 miles I camped for the night - next morning the battery powered lights and pump. Returning home the camper is parked - 3 days later the aux battery will run the lights but not quite enough power to run the pump. Next time I use it I will put in more EDTA. I imagine battery was empty and was filled just before I bought it.

Question: On "zapping" Ni-Cad batteries - I have several square Ni-Cads out of rechargable lights - Hitachi HP21 - 6 (6MI.2) and Panasonic LCR6 (rest obscured) 7.3-7.5V/20 hr. battery - can they be "zapped" - and please give exact instructions to zap off of 12V battery! Thank you.

Pat Weissleader, Desert Hot Springs, CA

You can zap these packs. Be careful, wear glasses and gloves. Hook up a 14 ga. wire between the negative pole of the 12 Volt battery and the negative pole of the nicad pack. Hook up a similar wire to the positive pole of the 12 Volt battery and VERY GENTLY AND VERY QUICKLY brush this wire's end across the positive terminal of the nicad pack. You will see a large spark and feel the nicad pack get warm. You have just zapped about a hundred Amperes of current into the nicad for a very short (less than 1/2 second) period of time. This zap of high current vaporizes the dendrites that tend to form within sintered plate nicads and create shorts. It also heats the hell out of the nicad and can damage or even explode the cell if zap too often or for too long a period. So give the nicads the shortest possible zap and let them rest for at least 24 hours before zapping again. If the nicad doesn't respond to two of these zap regimes, then the battery has problems that cannot solved by massive doses of high current. Such is life… Richard.

Low Head
Good Morning! We currently live in an old building whose electrical power is supplied entirely by the local commercial electric utility. We must replace this and plan to begin building a new home this summer. Our plans include alternative energy and we need help and information about options viable in our situation.

Our building site lies next to one of our three spring-fed ponds. The water flow is approximately 85-90 gallons/minute and the drop is one foot. Our research of water power leads us to conclude that the drop is insufficient, yet the flow is adequate. Is water power an option for us? Any suggestions? Any back issues of your magazine that address water power variables? We appreciate any additional help and information you may have! Thank you.

Wendy Koljord & Ralph Zerbe, RR1 Box 144, Houston, MN 55943

I refer you to the low head hydro article in this issue. Good luck. -KJS You have a fair amount of water, but 12 inches of head is low even from the low head systems on page 6 of this issue. Talk to Cameron McLeod and ask him if he can build ultra low head machines that produce say a hundred Watts instead of a thousand Watts. Richard

Picture Perfect
I'm trying to conduct a photography (landscape and wildlife) business here from my AE home. I've had much success and some frustrations, i.e. my Beseler Duel Dichro Color Head on my 120V enlarger blows the 24V 250W quartz halogen bulb every time I try to run it on my Trace 2012 inverter. Trace has suggested a pure sine wave filter (transformer). I'd like to hear from other running businesses on AE power, especially those utilizing sensitive electronics. Anyone have any experience with pure sine wave filters? At $250 for a 250W model I'm reluctant to experiment!

John Senser, 16000 Old Oak Ranch Rd., Sonora, CA 95370

Your problem lies in the power supply in the enlarger. This supply makes 24 VDC from the incoming 120 vac from the inverter. I'll bet dollars to donuts that this supply is not regulated. Any techie worth his salt can either regulate this supply, or reduce its output via a series resistor, or limit its starting surge via a thermistor (see Jim Forgette's Homebrew in this issue.) The sine wave filter

may work, and then again it may not, I have not direct experience with this enlarger. How about readers? Help this fellow out and he may send you a ultrafine photo! Richard.

Cheap PVs?

In response to dozens of letters from readers, I did some research into the new PV making process recently revealed by Texas Instruments. Here's what I found out…

Texas Instruments (TI) and Southern California Edison (SCE) recently announced a new photovoltaic manufacturing process that could make PVs America's favorite form of roofing.

TI's Spheral Solar cell is billed as an extremely simple, low-tech process with about an 8 to 10% conversion efficiency. The cells are made using approximately 17,000 spheres of low-purity, metallurgical-grade silicon, bonded in round holes in a 100 mm x 100 mm square of aluminum foil. During the process impurities in the silicon are pushed to the surface.

Sphere formation is done in a furnace and uses surface tension phenomenon. Impurities are etched from the surface of each sphere. An aluminum sheet is embedded and etched into a wire frame and the spheres are bonded to it with a heat/pressure bond. An insulator and another sheet of aluminum with no holes is applied, so that each sphere becomes a p-n junction between the two layers. The cell is flexible and should be extremely robust. If any individual sphere fails, the output of the cell only diminishes by 1/17,000th.

Over the last six years TI and SCE have each contributed $5 million toward development costs. Prototypes of the Spheral Solar cell are fully functional. Field tests are scheduled for late 1991. If a viable manufacturing process can be developed, PVs could drop from an average $8 per watt (25¢-30¢ per kilowatt hour) to as low $1.50 to $2.00 per watt (10¢-20¢ per kilowatt hour). If all goes well, Spheral Solar cells could be available by the first part of 1995. Karen Perez

Access:
Texas Instruments Inc., Materials and Controls Group, 1-800-336-5236, Ext. 700 (PV-91001).

Southern California Edison, Action Line, 1-800-952-5062

Ozonal Notes

Energy Fairs 1991

We going to as many Energy Fairs as we can. We will be at the Midwest Renewable Energy Fair in Amherst, Wisconsin on 20 to 23 June. We'll be at Energy Park in the Oregon Country Fair, Veneta, Oregon on 13 to 15 July. We'll be at SEER '91, Willits, California on 9 to 11 August. Last year we met thousands of HP readers at these events and we're looking forward to meeting many more this year.

These Energy Fairs are fantastic opportunities to see everything renewable. There are displays, workshops, speakers, live music, solar cars, and thousands of people who aren't afraid of sunshine. The best part is meeting everyone and marveling at the numbers. All too often, we home power people start feeling like the lone stranger. Mostly we live in the outback. Mostly we don't get out much anymore. It's easy to feel alone, like there are only a handful who feel as we do. Energy Fairs are the perfect cure for these blues. To get together with thousands of sunny people and share our dreams is an experience not to be missed.

So we'll see you at the Fairs!

The mechanics of Home Power's distribution

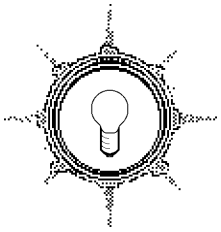
When we receive a subscription to Home Power we start that subscription with the next scheduled bi-monthly issue. Our second class mailing of Home Power is done in one big mass. After an issue goes to the Post Office, we must wait until the next to start a subscription. To those of you who resubscribed late after HP21, we're sorry that you missed HP22. We'd like to be able to start subscriptions with back issues, but labor and the Post Office won't allow this. If you want a copy of HP22, then it's available as a back issue for $3.50 mailed First Class, as are all back issues.

We don't send out separate renewal notices. We figure that this is a waste of paper, postage, and time. We print your last issue number on your mailing label. If the issue you are receiving is your last issue, then the mailing label will say, "THIS IS YOUR LAST ISSUE" just above your name. We figure that if you are interested, then you'll keep up.

Richard Perez

Home Power's Business

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



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Back issues through 20 are $2 each ($3 each outside U.S.), while they last. Sorry no more Issues # 1, 2, 3, 5, 6, 7, or 8 are available. Back Issues of #21, #22, & #23 are $3.50 each ($5 each outside U.S.). All back issues shipped ASAP via first class mail in an envelope or box.
Home Power Magazine, POB 130, Hornbrook, CA 96044

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Quantities of Home Power Magazine are now available for resale by newsstands, bookstores, energy businesses, and others. Please write or call for the specifics.

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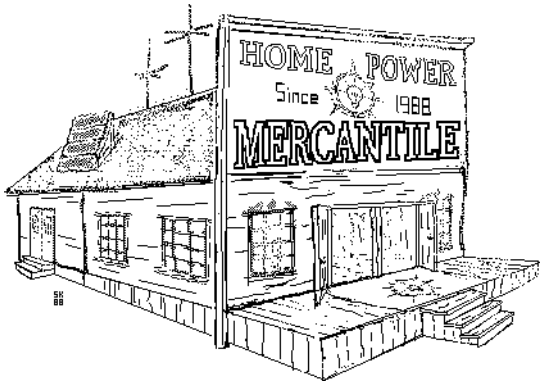

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Index to Advertisers

Active Technologies - 41
Alternative Energy Engineering - 100
Alternative Power & Light - 94
Alternative Transportation News - 71
Ample Power Company - 57
Atlantic Solar Products - 15
Back Home Magazine - 41
Backwood's Solar Electric - tear out insert
Bergey Wind Power - 36
Bobier Electronics - 47
C. Crane & Company - 78
Carlson Communications - 60
Carrizo Solar Corp. - 30
Cimarron Mfg. - 40
Electron Connection - 2
Energy Depot - 19
Energy Specialists - 57
Energy Systems & Design - 93
Folk Water Ram Pumps - 93
Fowler Solar Electric - 47
Harding Energy Systems - 73
Harris Hydroelectric - 46
Heaven's Flame - 90
Home Power Magazine - 95
Hydrocap Corp. - 47
Hydrogen Wind, Inc. - 78
Independent Energy Systems - 68
Integral Energy Systems - 62
Jordan Energy Institute - 60
Kansas Wind Power - 73
Kyocera America - 23
Lake Michigan Wind & Sun - 73
Lil Otto Hydroworks - 94
Midwest Renewable Energy Fair - 64
Offline - 75
Pacific West Supply - 19
Photron - 41
PowerStar Products - 31
PV Network News - 72
Real Goods Trading Co. - 31
SCI – 46
SEER '91 - 50
Simmons Handcrafts - 84
Skyline Engineering - 18
Solar Car Corp. - 57
Solar Spectrum - 73
Solar Technology Institute - 63
Solar Works - 80
Solarex - 99
Sun Frost - 47
Sunlight Energy - 75
Sunnyside Solar - 78
The Power Company - 75
Trace Engineering - 5 & 36
Utility Free - 49
Wattever Works - 90
Wattsun Corp. - 39
Wm. Lamb Corp. - 11
World Power Technologies - 15
Zomeworks Corp. - 41

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ENERGY
ENGINEERING
FULL
PAGE

BACK
COVER