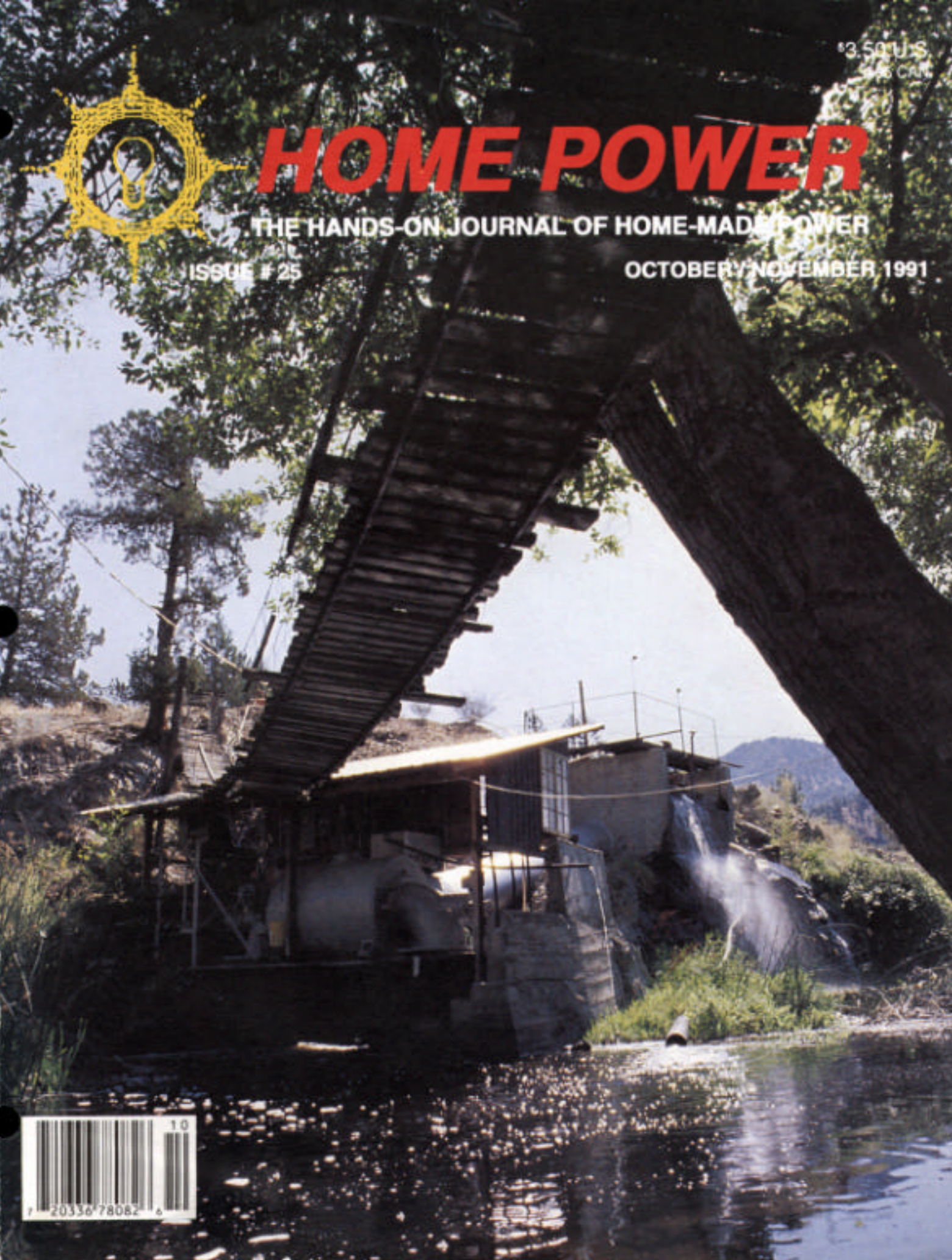
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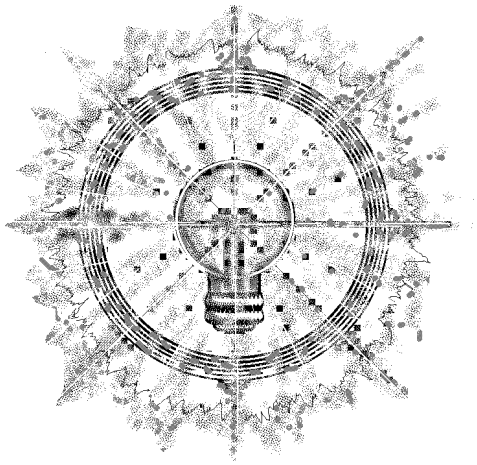
THE HANDS-ON JOURNAL OF HOME-MADE POWER
ISSUE # 25
OCTOBER / NOVEMBER 1991



HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Contents

Access

Home Power Magazine
POB 130
Hornbrook, CA 96044-0130
916–475–3179

Think About It

"Whatever you can do, or dream you can, begin it.
Boldness has genius, power, and magic in it."

Johann Wolfgang von Goethe
1749-1832

Cover

Rolling Thunder. This hydroelectric system provides power for two all-electric homes. Story on page 7.

Photo by Richard Perez.

From us to YOU

Turning the Corner

We are in a new world of renewable energy.

Right now, we are making the power we need to run our homes from the sun, falling water, and the wind. The technology has been ours for years.

Advances in photovoltaics, hydro runners, and improved wind turbines are just welcome refinements to tried and true renewable energy sources.

Right now, renewable energy is cheaper than 1/2 mile of new power line. Forget the endless monthly bills or the environmental impact.

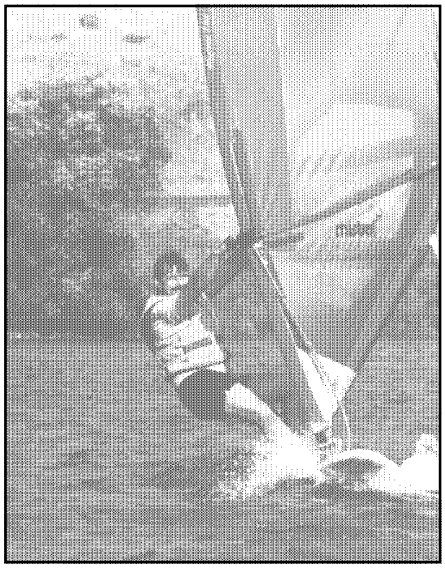
Right now, families are using sunshine for domestic hot water and space heating. Solar heat is making a dramatic comeback through new collector designs and honest, knowledgeable dealer/installers. The new geyser and evacuated tube collectors capture solar heat even on a cloudy day!

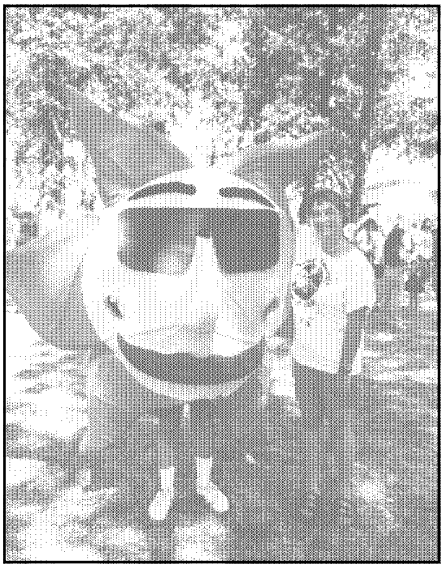
Right now, families are cooking with the sun. Sun ovens are safer and cleaner than electric or gas ovens. No matter what the season, we can use a solar cooker.

The production of hydrogen for cooking, supplemental hot water and space heating is just around the next bend. For folks using renewable energy systems now, hydrogen production will be a BONUS generated with surplus power. At SEER '91, the HP crew saw a normal-looking car powered by a newly developed, ultra-efficient, hydrogen fuel cell. Pollutants? Zero, zip, nada. The only emission at all is water pure enough to drink.

We are on the right road. We will turn the corner when the phrase "alternative energy" comes to mean "renewable energy" and oil, gas, coal, nuclear, big hydro, and even wood are the less desirable "alternatives."

Bob-O Schultze for Kathleen, Richard, Karen, Therese, Stan, and the Whole Home Power Crew.





Above Left: Bob-O has fun with wind power. Photo by Stan Krute.

Above Right: Kathleen and her old friend, Sol, at SEER '91. Photo by Richard Perez.

People

Pete Chiboucas
Sam Coleman
Jimis Damet
Jeff Damm
Dave Doty
Jim Forgette
Dan Freeman
Paul Hodgdon
Debby Jennings
Kathleen Jarschke-Schultze
Stan Krute
How Kuff
Tom Lane
Dan Lepinski
Chuck Marken
Kurt Nelson
Therese Peffer
Karen Perez
Richard Perez
Rick Proctor
Mick Sagrillo
Bob–O Schultze
Jeff "Smitty" Schmitt
Donald Scott
Michael Welch

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electron
connection
full page

LUNATIC FRINGE

Dan Freeman

I have always considered myself a member of the Lunatic Fringe. What is the Lunatic Fringe? "Those who believe in something so strongly they are ridiculed, shunned and on occasion laughed at. Their belief is so intense they will violate accepted norms of decision making to implement it."

Bringing in new members

A constant theme in Home Power is to win new converts to renewable energy (RE). This is the purpose of the magazine, its advertizers, and subscribers. Everytime there is another convert coming off the Grid you can almost hear the cheering of the subscribers. As with all champions of a cause, we must grow larger and stronger to lead the way.

Why choose renewable energy?

The primary decision is based on sound moral and environmental reasons. However, when making this decision, we were influenced by the economics or practicalities of a situation. For example: the utility company wants $20,000 to connect our dream house to the grid. This type of influence causes many of us to make our environmental decision. Now don't get me wrong, there are lots of us that use RE with the power poles running within economical ear shot. The point is that most need a "valid" reason for choosing renewable energy. A valid reason is necessary for us to live with our decision and make it understandable to others. Once we have made the transition to RE we find that it works and is better in all respects. This makes us feel good about ourselves and makes us want to spread the word.

Perspective

I was inspired to write this by a statement in Home Power #23. In his article on the Solar and Electric 500, John Takes says, "I must admit that I have some mixed feelings whenever 'solar' and 'racing' are used in the same sentence." John goes on to say that, "If people are to have an objective in transportation it shouldn't be how fast can I get from A to B, but rather for my REAL transportation needs, how can I get there consuming the least amount of the Earth's resources in the process."

This attitude is a prime reason that renewable energy is not in the main stream of American society. People who have chosen renewable energy have sacrificed many of the "finer" things to obtain energy independence. They assume others must pay their dues as well. This attitude causes renewable energy to be synonymous with sacrifice and simple rural life.

We must separate our chosen life style from the use of renewable energy. The masses (non-members of the Lunatic Fringe) are not interested in RE since it is associated with a reserved, non-exciting life style. Most people relate renewable energy to conservative living in a remote area, doing without, and separating themselves from main stream society. In short, becoming a member of the Lunatic Fringe. Mass conversion to renewable energy will never happen until RE is associated with such concepts as speed, luxury, convenience, style, economy, and fashion. I dream of the following articles in Home Power.

ELECTRIC DRAGSTER SETS SPEED RECORD IN 1/4 MILE

RE POWERED HOME WINS LUXURY AWARD

NEW GM ELECTRIC CAR GOES 0 TO 60 IN 5 SECONDS

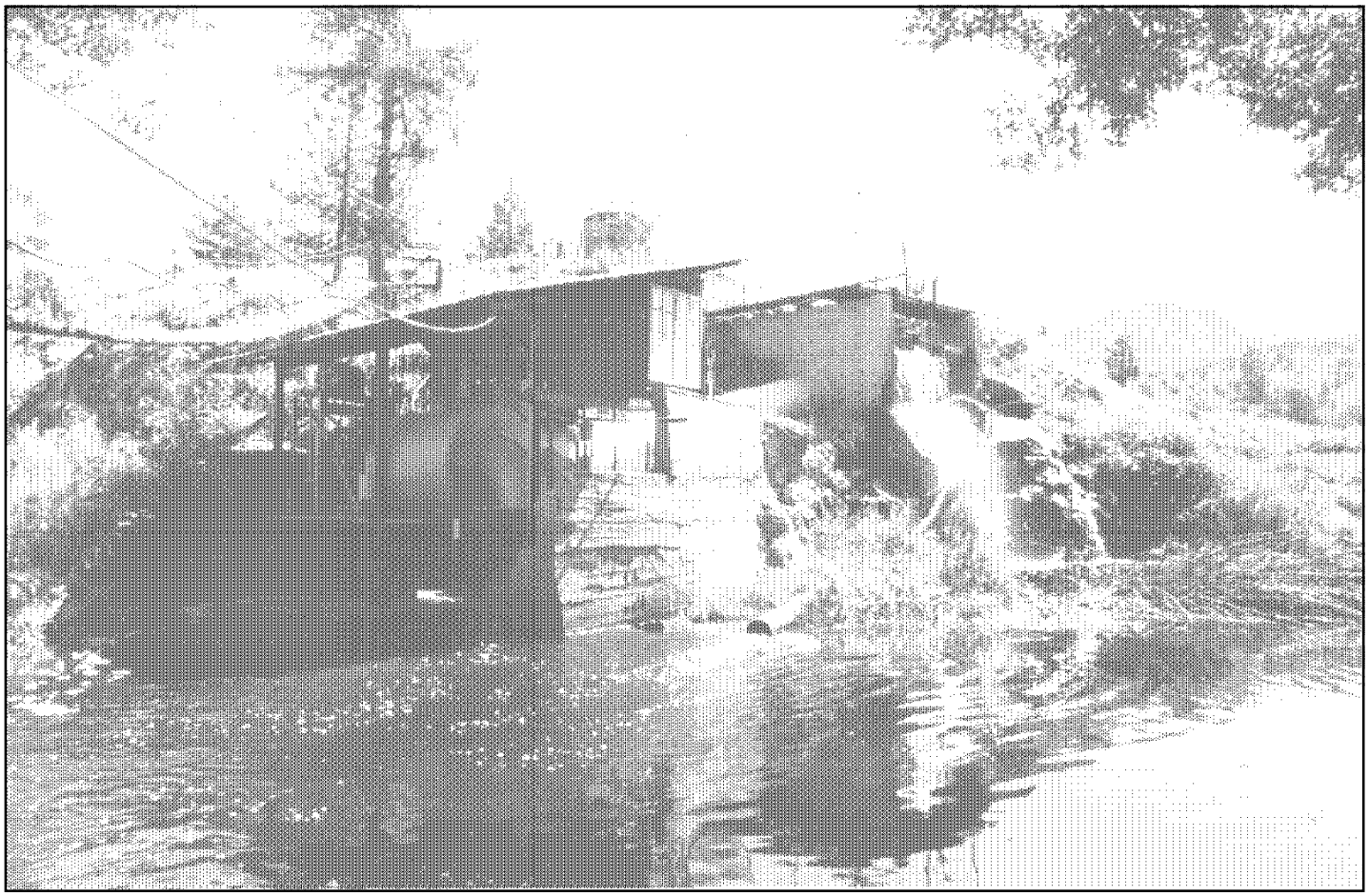
ROBIN LEACH TOURS THE 10 MOST EXPENSIVE SOLAR HOMES

Conclusions

Few people will choose renewable energy for ecological reasons alone. There are, however, millions who will spend money for stylish fast cars, big houses with lots of conveniences, and an enviable life style. The best way to bring about a renewable energy revolution is to think luxury, not sacrifice. If we really want to spread RE, then we must SPEND MONEY and NOT sacrifice amenities. I am not proposing waste, just not doing without. Remember the things which are not necessary, the things that are fun. If you want to bring in converts, make your renewable energy life style better, don't just get by.

If the sun is shining or the wind blowing and your batteries are fully charged, I maintain that YOU are wasting energy because you are not using it. So I purpose using all that wasted energy to have some fun. Race your electric car. Light up the outside of your house. Pump water through your fountain. Impress your friends with the luxury and sanity of renewable energy. Have some fun, you deserve it.

Access:
Author: Dan Freeman, 3008 W. Lupine, Phoenix, AZ 85029 • 602-993-8503



Above: Stuart Higgs' hydroelectric turbine generates power for two all-electric homes. On the left is the powerhouse holding the 30,000 watt alternator. To the right, overflow water spills from the fish guard. The day this photo was taken the turbine was producing 12 kw. (288 kwh/day) while cycling 770 pounds of water per second. Photo by Richard Perez

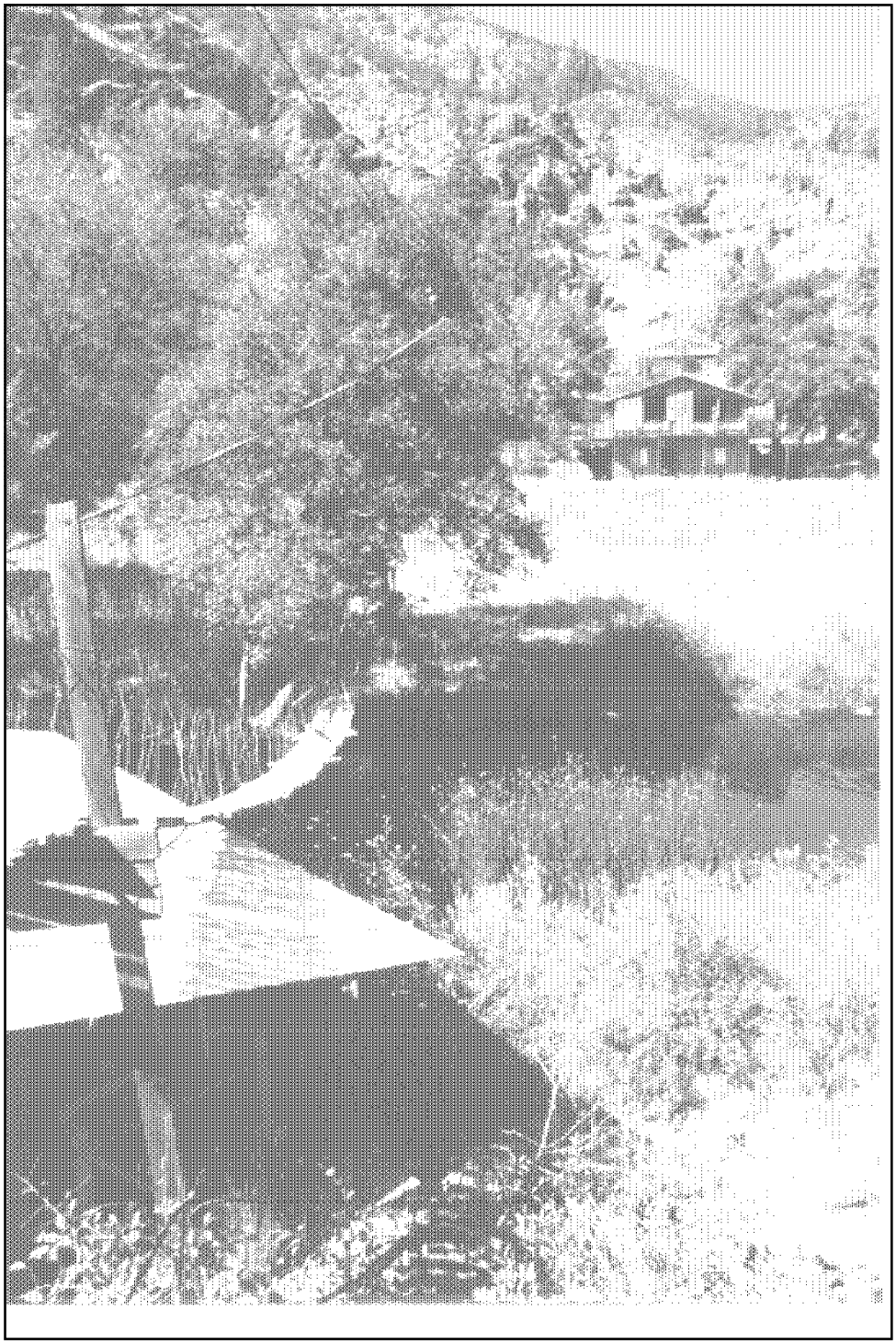
Rolling Thunder

Richard Perez

When Stuart Higgs visited Hoover Dam at age nine, he dreamed he would someday make his own electricity from flowing water. Now fifty years later, Stuart and his family operate the biggest home power system I have ever seen. Two families, both with all-electric homes, are supplied by Stuart's hydroelectric turbine. With a daily output of up to 720 kilowatt-hours, Stuart's hydro could power ten average American households, or over fifty energy-efficient households. And it cost about the same as an automobile, plus years of study, research, and just plain hard work by Stuart.

Hydromania in our back yard…

Late one evening, Bob-O called to tell us that the winner of an international hydro competition lived not thirty miles from us. The Yreka, California newspaper carried a story about a local man, Stuart Higgs, who had just placed first in an international competition to design and build the most effective hydro turbine runner. This competition, at the International Water Power Conference '91 in Colorado this summer, featured entrants from many nations and all large hydro players. A man in our back yard skunked all the big time operators and took home first place with his $12 home-made hydro runner.



Above: Stuart Higgs' home viewed from the powerhouse. The Shasta River is spanned by a suspension bridge.

As you can imagine, we were very interested in meeting Stuart. Since the newspaper didn't give any access data, we tried HP's Subs database. Sure enough, Stuart was a subscriber. Armed with his address, we quickly got his phone number from information. We called and set up an interview. Here's what we found out.

The Higgs' Homestead

To the north of Yreka, California, the Shasta River flows from the 14,000 foot bulk of Mt. Shasta into the Klamath River and then into the Pacific Ocean. Along the river's way to the ocean, Stuart borrows some of its water for about a quarter mile and then returns it. Stuart's site is about seven miles from downtown Yreka, and three miles from the nearest commercial electric lines.

Stuart has been a hydromaniac since his visit to Hoover Dam. He chose the site of his present home with hydro power in mind. Years of work finally became a hydro system on Christmas Eve 1989. Stuart's wife returned home to find their homestead brilliantly lit from top to bottom with Christmas lights. Stuart had switched the hydro on for the first time and everything worked!

All-Electric Homes

I am not going to dwell on the specifics of the appliances powered by Stuart's system. This data is meaningless and the list of appliances would fill pages. When a renewable source produces as much power as Stuart's hydro, there is no point in counting kilowatts.

Stuart powers up two all-electric homes. Everything is run on electricity. Everything. Included are appliances we do not normally associate with renewable energy systems– big time electric power slurpers such as: electric clothes dryers (two of them at 5.5 kw. each), electric space heating via many baseboard heaters, electric hot water heaters, air conditioning, electric cookstoves, multiple refrigerators and freezers,

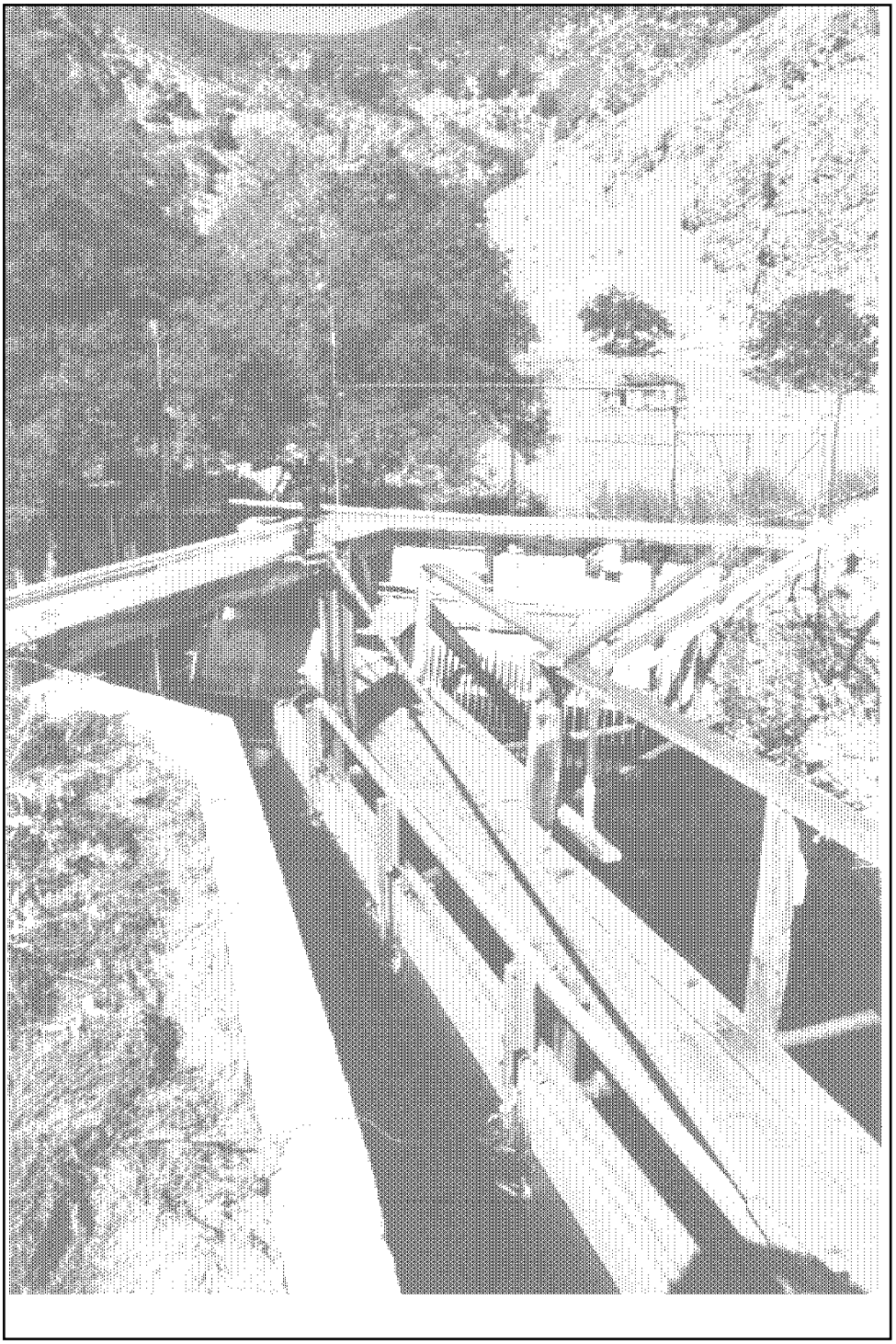
dishwasher, trash compactor, and myriad high-powered shop tools (like a 3 hp. air compressor). All this and more are powered by Stuart's hydro. I noticed a wood heater in the living room and asked Stuart about it. He said they installed it as a back up heat source and have never used it.

In terms of electric appliances, the Higgs Homestead has just about everything you could imagine. When you own the power company, why not?

Stuart's Hydro Site

Stuart uses 1,200 feet of ditch to deliver water to his turbine. The head (or vertical distance that the water falls) in the system is 17 feet. The turbine cycles between 10 and 30 cubic feet of water per second (between 5,000 and 15,000 gallons per minute), depending on the water level in the river. On the dry August day we visited, the turbine was cycling about 12 cubic feet per second (5,400 gallons per minute) and was producing about 12 kw. of power.

Stuart made sure of the water rights on his homestead before he moved. His homestead holds water rights for 50 cubic feet per second. He tore down the old wooden flume that delivered water to the site, and replaced it with a large ditch. This ditch required both blasting and heavy equipment to construct. Stuart did the work himself with his D6 Cat, a crane, and a backhoe.



Above: This electric-motorized fish screen keeps migratory fish and debris from entering the turbine.

The Fish Screen

The ditch delivers the water to the hydro through a fish screen. This fish screen is a marvel of design and function. A large area (about 6 feet by 20 feet), fine mesh, stainless steel screen prevents fish from entering the hydro. The screen is continually wiped by long brushes to keep debris from clogging it. Everything is automated and powered by electricity (what else?).

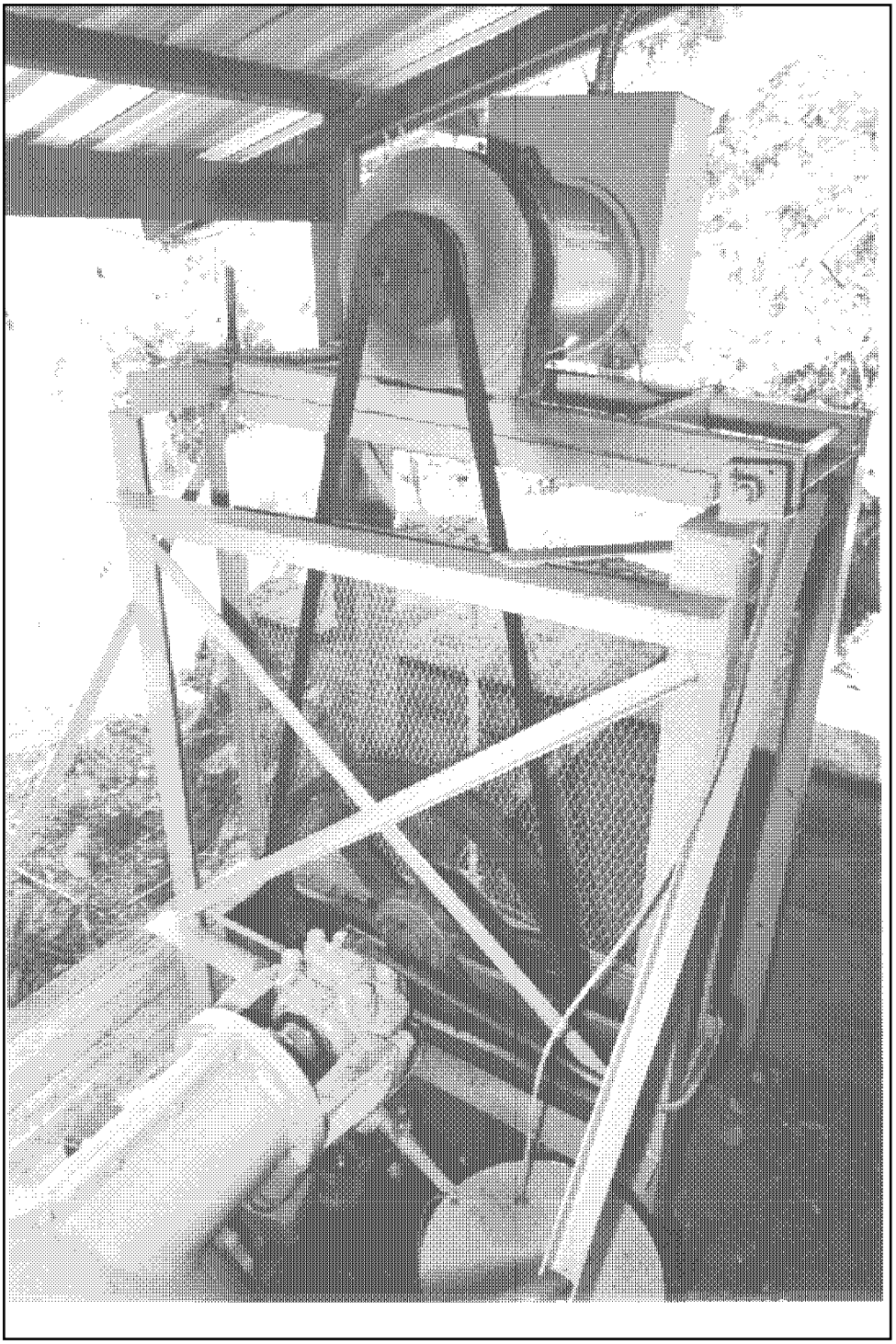
The Shasta River is sometimes full of migrating fish. Stuart's screen works so well that the California Dept. of Fish and Game often bring ranchers, and others using river water, to see it. Whoever claims that small scale hydro turbines are a threat to fish hasn't seen Stuart's fish screen. The fish screen feeds the river into the turbine via a four foot in diameter pipe.

The Turbine

Stuart's turbine uses a horizontal axis, Francis type reaction runner. The turbine was built by the Morgan Smith Company and rebuilt by Stuart. This unit is huge— about six feet in diameter, fifteen feet long, and has a main shaft diameter of four inches. Stuart rates its output at about 1 kilowatt of power for each cubic foot of water per second fed into the turbine.

The turbine is belted up to a 30 kw. 120/240 vac alternator. This alternator makes 60 cycle ac power directly. Stuart's system uses no inverters or batteries, but makes its power as it spins, hence the name, Rolling Thunder. And thunder it does. The feeling of being in the powerhouse is indescribable. Up to a ton of water is roaring through the turbine each second. The deck of the powerhouse shudders under the force. There is no doubt to the senses that rolling thunder is harnessed within the turbine.

A Thomson and Howe hydro control uses five, 6 kw. shunt heating elements to keep the frequency of the alternator at 60 cycles per second. Stuart says that the frequency output of the controlled turbine is accurate enough to run standard electric



Above: The turbine is belted up to a 30 kilowatt, 120/240 vac Kato Engineering alternator.

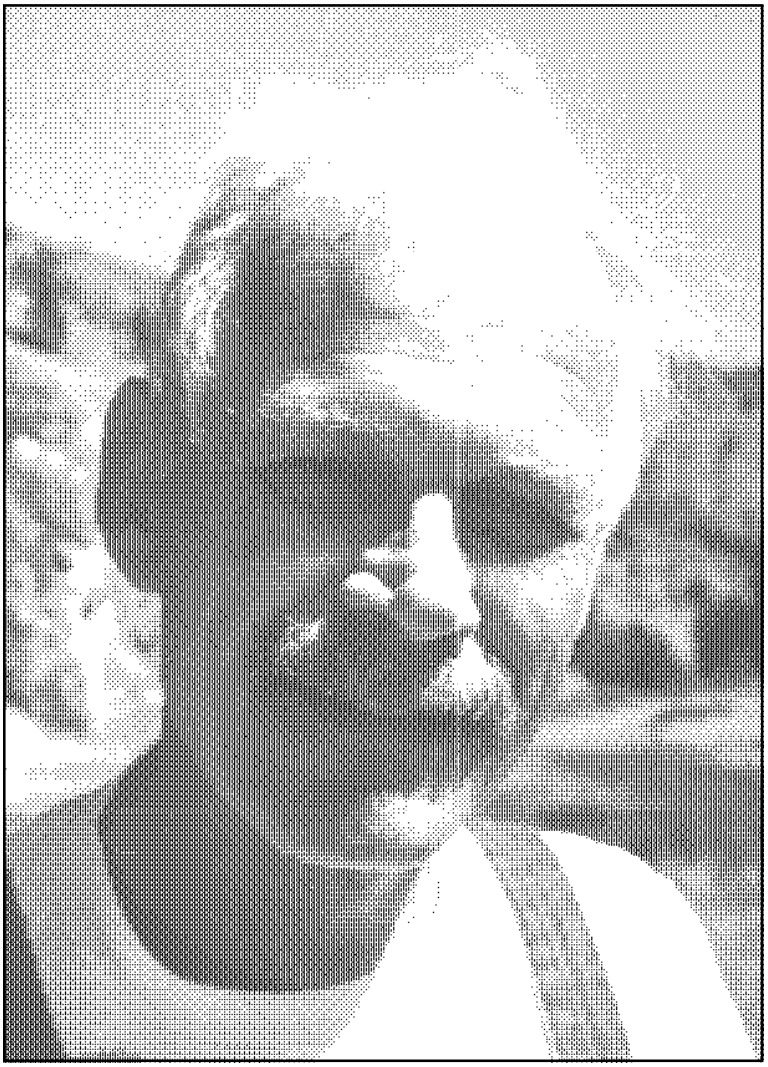
Left (on page 10): The turbine in its powerhouse. Note the discharge tube located beneath the turbine. Fish love to congregate in the oxygen-rich water discharged by the turbine. To give you an idea of the size of this beast, there are two 5 gallon buckets in front of the turbine.

A primer on hydro runners...

The business end of a hydro turbine is called a **runner**. The runner converts the moving energy of water into mechanical power by turning the output shaft. The runner is the interface between the world of flowing liquid energy and rotating mechanical energy. Hydro runners come in two basic types, those which operate in air and those that operate totally submerged in water.

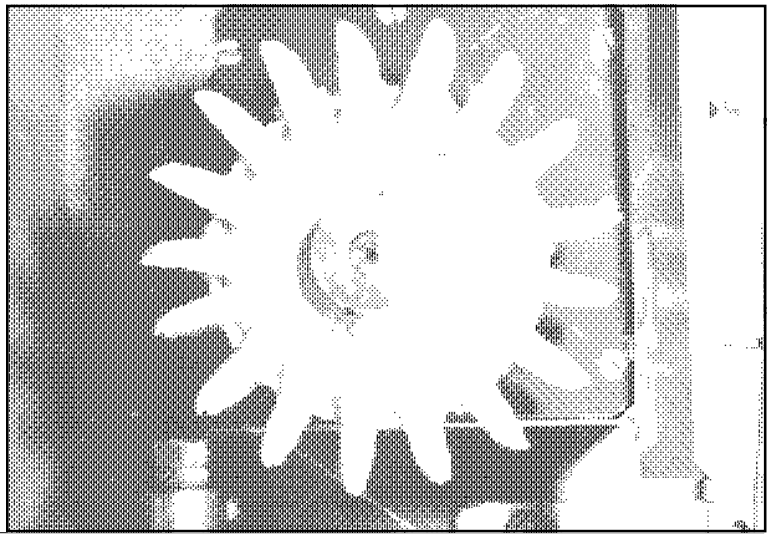
Turbine runners that operate in air have the water sprayed onto the runner through an **orifice**. The stream of water moves through air and hits the cups on the wheel This impact turns the shaft. This type is often called a **Pelton** wheel or an "**impulse**" turbine. This type of runner, one that operates in air, is most commonly used on microhydros like those made by Harris, Energy Systems & Design, and Lil Otto Hydroworks. Stuart won the competition with the impluse runner pictured on this page.

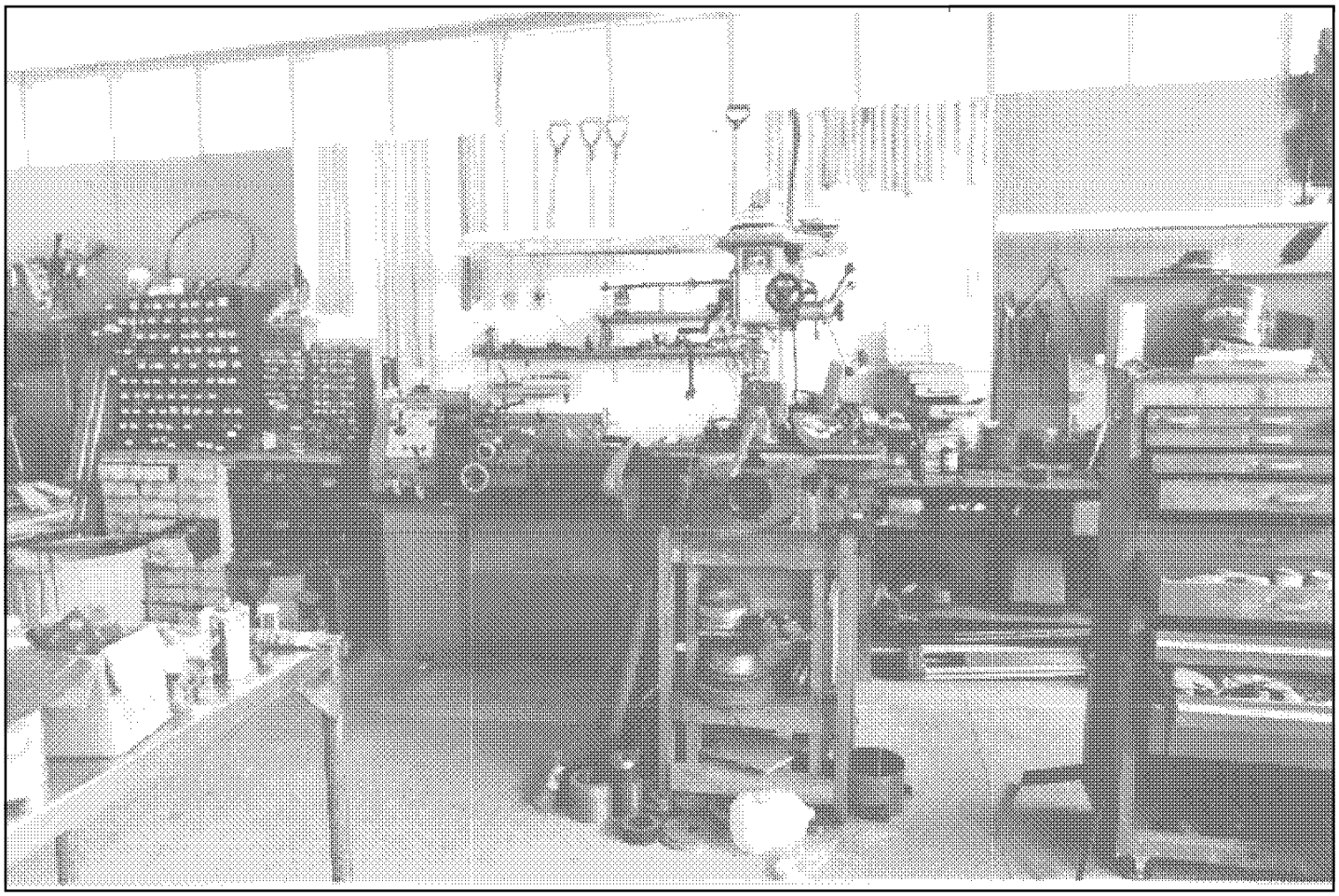
A second class of hydro runners operate totally submerged in water. These turbines are like propellers converting fluid motion into mechanical power. Like aircraft propellers, aircraft wings, helicopter rotors, and the propellers on wind machines they operate by using an **airfoil**. The shape of the runner's (or airfoil's) blades is such that the surface area of one side of the runner is greater than the other side. The fluid motion across the runner creates unequal pressure on one side of the runner. This pressure is created because the water must move unequal distances across the unequal surface areas of the runner. The net result is a force, produced by water flowing by the runner, that turns the turbine's shaft. And all this happens totally submerged in water. This type of runner is called a "**reaction**" runner. Reaction runners are found in the turbines made by Canyon Industries, Almanor Machine Works, and others. If you want more info, see a Physics book under



Above: Stuart Higgs.

Below: Stuart's award winning impulse hydro runner.





Above: Stuart Higgs' hydroelectric-powered workshop. Here Stuart builds more hydroelectric turbines. Major tools in the shop include an end mill, lathe, a plasma arc welder and a mig welder. With these tools, Stuart works stainless steel into low head, high flow hydroelectric turbines in the 4 to 8 kw. range.

clocks for months before they gain a few minutes. The Thomson and Howe control is capable to absorbing the full 30 kw. output of the turbine.

Stuart said that he is only using half of the turbine's runners because he is already generating more power than they can use. If the need should ever arise, Stuart could allow water to flow over the second runner in the turbine. If he does this, then the system would produce about 50 kw. or over one megawatt-hour of power daily.

A Hydro Breeder

After touring the turbine, we visited Stuart's machine shop. Stuart uses hydro power to build, what else but more hydros. Kind of like a breeder nuclear reactor without the glow in the dark features.

The turbines that Stuart makes are truly beautiful works of art. The reaction runner, shaft and other critical parts are constructed out of stainless steel and are finely finished. Stuart considers his home-built turbines to be his finest accomplishments, and is far prouder of them than his international first place award.

Hydro doesn't just happen

You don't just wake up one morning and realize that you have big time hydro potential. It's something that you plan and work a lifetime for. Just like Stuart did. Stuart's work has given his family energy self-sufficient homes that spare no convenience. And do no harm.

Stuart is a farmer. He has no formal training or experience in hydroelectric systems. He has no deeper pockets than most of us. His accomplishments spring from an intelligent and inquiring mind that isn't afraid of hard work.

Stuart didn't have any hard figures about how much his system cost. He did the construction work and built or rebuilt most of the hardware himself. He did say that his hydro has produced power at less than one cent per kilowatt-hour since it went on line 24 December 1989.

When I spoke with Stuart, I saw the spark in his eyes had become rolling thunder. He had nurtured a dream of freely flowing energy independence for fifty years and made it real. The world is his oyster. It's really hot today,

so turn up the air conditioning, get some iced tea out of the reefer, and find out what's on satellite TV. Nature is providing the power and Rolling Thunder is footing the bill…

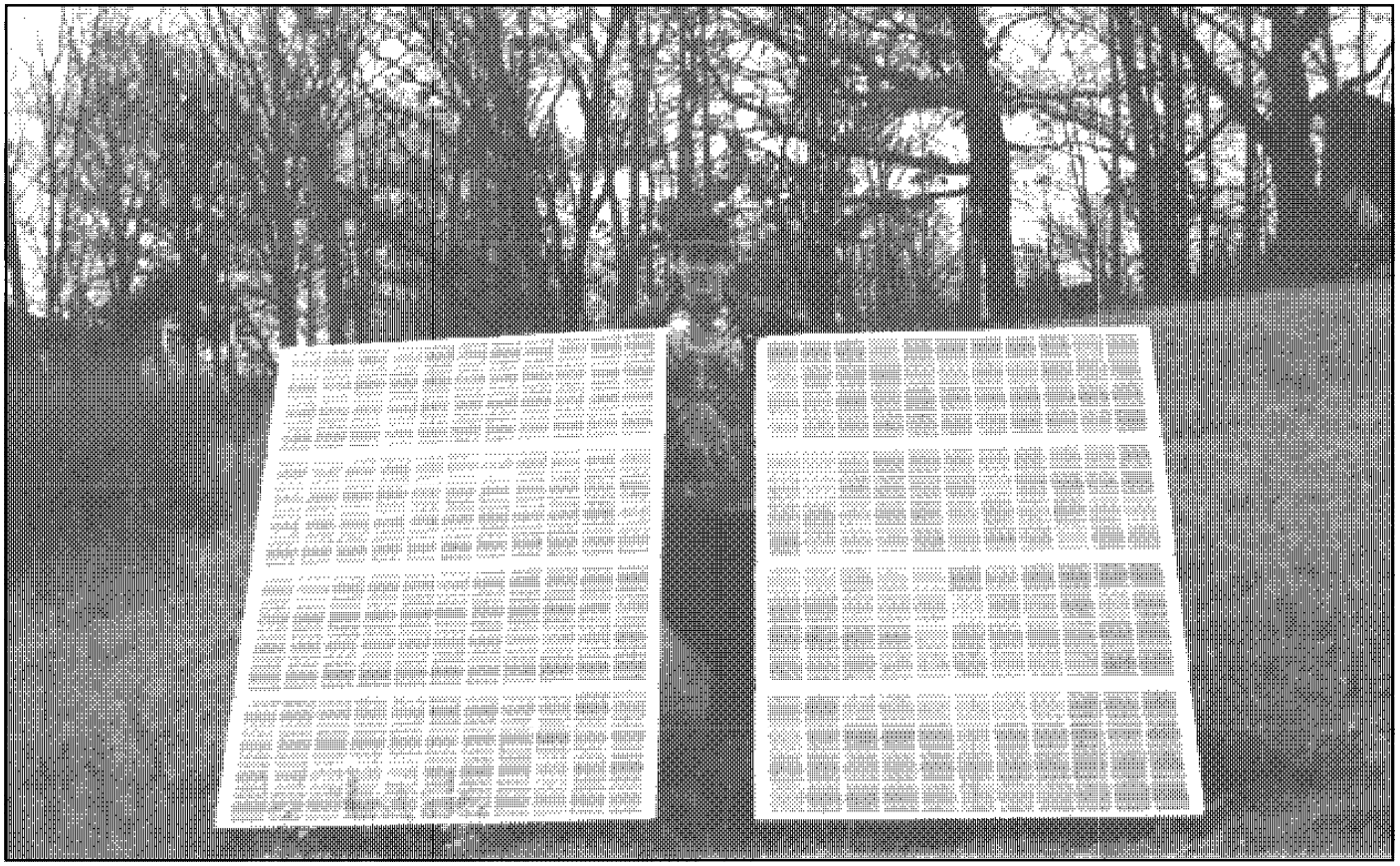
Access

System Designer, Installer, and Operator: Stuart Higgs, 7104 Old Shasta Road, Yreka, CA 96097 • 916-842-6921

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

Trace ad

KS Wind



Above: How Kuff and the long distance PV array.

Long Distance PV Power Transmission and the LCB20

How Kuff and Jimis Damet

The ideal place to locate a PV array is where it gets the most sunshine, keeps the array accessible, and minimizes the length of the wires running to the batteries. Here in the Arkansas Ozarks, the general conditions are not ideal. Though we get a good amount of sunshine throughout the year, the steep hillsides, bluffs and hardwood forests are ever-present obstacles blocking direct sunshine. This makes locating a PV array difficult. Most folks treasure the big shade trees keeping their house cool during the hot summer days. Cutting down big hardwoods in favor of letting in more sunshine is generally unacceptable, so getting a good swath of sunshine near the house is rare.

If the house is tall, the roof may provide ample sunshine for the array. Erecting a tower is another possibility, but towers are expensive and the thought of a 75-100 ft. climb up a tower makes one want to consider other possibilities first. The only other option is finding a suitable site for your PV array further from your house. This may be a garden site or pasture and may be hundreds of feet away.

Big Wire

Transmitting energy hundreds of feet from a good size home power array (400 Watts or more at 15 Volts), will require for a 12 Volt system: 1) enormous wire, (wire that is probably not available locally), or 2) the biggest wire that you can find and making multiple runs between array and battery. This will consume a lot of money and time.

In 1989 I helped our neighbors, How and Kate Kuff, set up a system that was one of the first of its kind using a Bobier LCB (Linear Current Booster) as a solution to the long-distance transmission problem. Here is his account of its installation and performance over the last few years.

A Users Account: Hot In The Sun While Cool In The Shade

Setting

Our homestead is nestled in the Ozark Mountains of northwest Arkansas just off the top of a ridge in a lush and shady hollow facing east. This is a region of large hardwood forests, steep mountainsides, high bluffs, cool hollows, and is the headwaters to many rivers and streams. We built our home down in the hollow among the large oaks, cherries, walnuts, and hickories. Ash, paw paw, and dogwood trees help to keep us cool in the shade and protect us from the late afternoon sun in the west. Among several springs surrounded by ginseng, bloodroot, orchids, irises, and goldenseal, we stay plenty cool even on the hottest summer days. However this site is not well suited to photovoltaic energy production or windpower systems, and the hydro potential is only seasonal. Despite this, we have managed to develop a photovoltaic system which provides us ample clean renewable energy for our family of four as well as providing enough energy to run a custom leather footwear business and an information management business.

A long way from home

Our PV array now consists of 8 Kyocera J59 59 Watt panels located 700 feet up from our house in the middle of one of our organic vegetable fields. The site has unrestricted solar access throughout the day and throughout the year. The panels are connected to our 1,680 Ampere-hour, 12 VDC battery bank at our house 700 feet away using 4 gauge aluminum triplex buriable cable. That's correct, DC transmission 700 feet using 4 gauge wire! This is accomplished by using the high voltage J59 modules (2.89 Amps @ 20 Volts), wiring them in series into 4 sets of series pairs, with each pair of panels producing 2.89 Amps @ 40 Volts. By increasing the voltage up to 40 Volts we have reduced transmission losses considerably. The extra high voltage J59s allow enough excess voltage to keep line loss at a tolerable level of 6 to 7%.

The energy arrives at the house via the aluminum cables and connects to a device called a linear current booster (LCB) which was designed and manufactured by Bobier Electronics. The LCB is a load matching device that senses load requirements and adjusts incoming voltage and amperage in the proper combination to power the load. In our case we use an LCB20 (20 Amps max input), and the 'load' is the battery bank. The majority of applications for the LCB are water pumping and DC motor control when running the load directly from a PV array. The LCB is capable of repackaging the incoming energy to match the high load requirements of starting a motor which may require more current than the panels are capable of producing. In our application the LCB essentially cuts the input voltage in half and more than doubles the input amperage. Using the tuning knob on the LCB we can fine tune the process for maximum output. We have an ammeter wired inline between the LCB and the batteries and we regularly measure a charging current of 24 to 30 Amps (the panels are rated at 2.89 Amps. x 8 modules = 23.12 Amps). The extra charging amperage that we measure is a result of the higher voltage J59 panels. This system has been in use for over two years with no problems or difficulties.

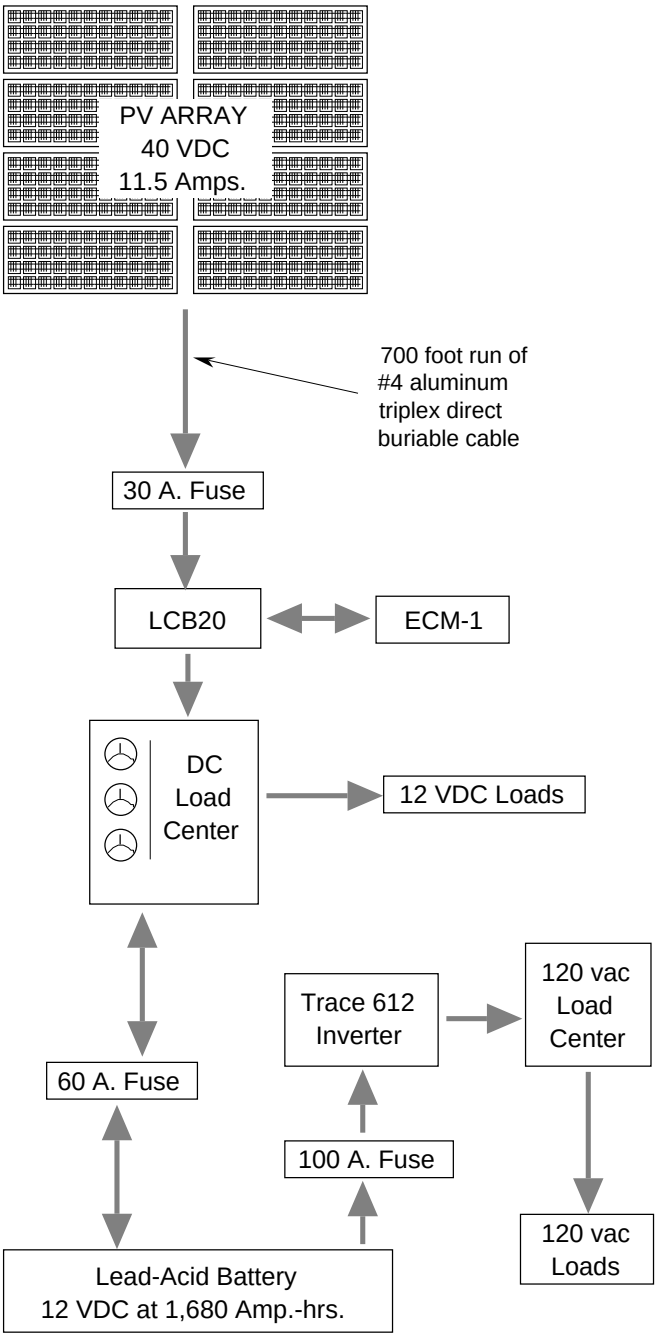
Protection

To protect the batteries from overcharge we use a very efficient electronic control module called an ECM-1 also from Bobier Electronics. In the past we had used a standard type charge controller, but found that the controller sitting in line between the LCB and the batteries offered substantial resistance and that our charging current suffered by an Amp or two when using the controller. The ECM-1 uses the remote option on the LCB20 to shut down the LCB's output at a user-defined maximum battery voltage. The resistance of this device is so low as to be negligible. Battery protection consists of dialing the desired cutoff voltage on the ECM-1 on a scale from 14 VDC to 16 VDC (or 28 VDC to 30 VDC for 24 Volt systems). If you want the battery to reach 14.5 Volts, set the ECM-1 at 14.5 Volts and the LCB cuts off the charging current when the battery voltage reaches that level, then automatically reconnects when the battery voltage drops to a threshold voltage.

A busy house

Our house and offices are wired with dual 12 VDC and 110 vac circuits. A Trace 612 inverter powers our 120 vac lights, 2 IBM compatible PCs, a MAC SE, several printers, industrial sewing machine, Pioneer stereo system, 19" color TV and VCR, vacuum cleaner, Nicad chargers, and numerous kitchen appliances. DC circuits power lights, a wringer washing machine, and a small stereo. Our lights consist of a combination of DC PL fluorescent, DC incandescent, DC quartz halogen, 120 vac incandescent and compact fluorescent lights. We try to conserve energy as much as possible, but quite often the batteries

Kuff PV System



are fully charged and we have excess energy. During some usually short intervals during the winter our system voltage drops, and we supplement the PV power with a Honda 1600 watt generator. Our future plans include the installation of a microhydro system for backup power during those dark times. We also plan to develop a DC freezer/refrigerator system and will probably purchase 2 additional Kyocera J59s to power the compressor.

The big picture

Our property is part of a larger farm that is also primarily RE powered. Our organically maintained vegetable and fruit gardens are watered using two Flowlight slow pumps, two LCB3s, four Hoxan 48 Watt PV panels, a holding pond, and a series of gravity feed irrigation lines. There is no grid access to the farm, and the closest power lines are about a mile away. We have managed to install all this RE equipment for about the price of the grid connect charges… except that this is clean energy, is mostly maintenance free, and there are no energy bills!

Wrapping up

Most of the comments that we received regarding the design and installation of this system, advised us to install the batteries in a shed next to the PV modules and use an inverter to supply 110 vac for distribution to the house. After examining a deep well pumping system using the J59 panels and an LCB, we began to suspect that this arrangement could be adapted to battery charging. By consulting with some experts and our local PV consultant, Jimis Damet of Rocky Grove Sun Company, we determined to experiment with this configuration. Jimis offered us onsite product and technical assistance and soon got everything working fine. I suspect that we have actually improved the performance of the panels via the dynamic tuning mechanisms of the LCB20. Had we gone the route of using the inverter for distribution, our entire system would shut down if we had an inverter problem. As it is now, if we have inverter problems we still have all DC circuits available (which can actually power most of our equipment with some modification). I would heartily recommend this type of system to anyone trying to create solar potential from a primarily shaded site.

TECHNICAL CONSIDERATIONS:

120 vac vs Low Voltage DC:

The alternative to long distance direct transmission of PV power was to power the home with 117 vac from an inverter located far away with the PV array and batteries. We found that this system had several disadvantages: 1) the heart of the system would be remotely located, keeping the user out of touch with monitoring and regulating functions, 2) all of the energy use would be dependent on the inverter, thus necessitating a backup inverter, 3) all loads will be 120 vac with subsequent inverter inefficiencies, 4) getting full power out of a 2000 watt inverter will still require sizeable wire for the long distance transmission (for 700 feet, #2 gauge or larger). The one advantage to an all 120 vac system is low house wiring costs.

12 VDC vs 24 VDC

Advantages for keeping system voltage at 12 instead of 24 Volts are: 1) though the LCB20 could improve performance for a 24 Volt system, it works best when the input-output voltage ratio is 2:1, 2) a 12 V system requires the least amount of healthy lead-acid cells in the battery bank– six. The 24 V system requires 12 cells which shortens the expected interval between cell failures. Also I think it is ideal to have two parallel sets of batteries in your bank. Two parallel sets double the capacity, and in the event of an accident or cell failure, the system need not shut down. 3) 12 Volt inverters are generally more available and cheaper per watt while being just as efficient, 4) 12 Volt appliances are easier to find, and 5) in this particular system, budget dictated component choices. The addition of six more cells to make a 24 V bank would have increased costs by at least $360. At the time, there were no 24 V inverters at less than $550. The Trace 612 provided all of the 120 vac requirements for this system and was within budget.

Wire

The wire that we chose for the PV transmission circuit was #4 gauge Triplex direct buriable aluminum cable. Aluminum wire is considerably cheaper than copper and in readily obtained in an outdoor direct burial grade. For array circuits that run a good distance on the ground outdoors, I have used aluminum cable extensively for the past 6 years and have had no problems. Special mechanical connectors must be used to join aluminum to copper wire at the array and the controller connections. These are usually a split bolt type and have an alloyed separator that keeps the aluminum and copper from direct contact and subsequent oxidation. Lightly coating the

Kuff System Cost

Item	Cost	%
8 Kyocera J59 PV Modules	$3,000	51.2%
Honda 1600 W generator	$750	12.8%
Trace 612 Inverter	$550	9.4%
700 ft. #4 aluminum triplex cable	$350	6.0%
1680 A-h, 12 VDC battery	$330	5.6%
Bobier LCB20	$250	4.3%
Misc. wire & expenses	$250	4.3%
2 PV Mounting Racks	$180	3.1%
Control Center	$125	2.1%
Bobier ECM-1	$70	1.2%
Total System Cost	$5,855	

Below: the Kuff family, from left to right: Lenni, How, Heron, and Kate.

connection with petroleum jelly, torquing the nut sufficiently, and a good quality electrical taping make a long term connection possible. These connections should be accessible, preferably in a weather tight junction box. Buying this cable in triplex is cheaper than buying two single conductors, and the third conductor comes as a bonus. We connected this #6 gauge ground wire on the negative side to decrease overall transmission resistance. Seven hundred feet of #4 triplex costs about $350, just under the price of a J59 module.

Powering up

We sized the wire originally to handle the power of four to six J59 modules keeping the line loss around 5 to 7%. We figured that another run of cable would be necessary when the array was increased from four to eight modules. We were amazed when the line losses only increased to about 8%, and the LCB more than doubled its output amperage (up to 30 amps). The 1,680 Amp-hour telephone cells easily bubbled up to 16 Volts when the ECM-1 was set at that point. This verified that the LCB20's output was providing sufficient charging voltage.

Conclusion

The LCB20 is an ideal device for those who have particularly long distance PV transmission situations and want to maintain a 12 Volt system. By wiring PV modules in series-parallel and doubling the voltage (open circuit voltage limit is 50 VDC), the wiring requirements can be greatly reduced. The LCB20 takes this higher voltage PV energy and repackages it to very efficiently charge a 12 Volt battery bank with the bonus of 'netting' up to 25% more amperage than the sum of each module's rating! The ECM-1 is the ideal charge controller for the LCB20. It is user adjustable and consumes a negligible amount of energy. We recommend the higher voltage modules for best results with this kind of system. Also the LCB20 has proven to be very durable as there has not been a failure in the field to date. The low cost of the LCB20 and the ECM-1 provides an efficient and cost-effective solution for 12 VDC home power systems requiring long distance PV transmission.

Access

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A Talk with Sun Frost's Larry Schlussler

Paul Hodgdon

My wife, Dianne, and I were vacationing in California last winter, and stayed with friends in Arcata. I remembered that Sun Frost, maker of super-efficient refrigerators, was based in that very same metropolis (having seen their ads for years), and called them about a visit by a couple of off-the-grid New Englanders. It seems most folks on AE either own a Sun Frost or are wishing and saving for one. We're in the latter category, and wanted to meet the crew of talented folks that will someday make a fridge for us. Larry Schlussler and Crew were very kind and accommodating, and we thought Home Power readers would enjoy a vicarious visit to Sun Frost, and a conversation with Larry.

How did you first get started building efficient refrigerators?
About ten years ago, I got an Appropriate Technology grant to do a student project unrelated to school study. With that grant I built a chest-type unit.

What convinced you there was a market for super-efficient refrigeration units?
It was a combination of meeting a lot of people here in Humboldt County that were on PVs and needed refrigeration, and the fact that research grants became difficult to obtain when Reagan came into office.

Why do Sun Frosts keep veggies fresher longer?
Moisture condenses on a cold surface, and the colder the surface the greater the amount of condensation. In a conventional unit the refrigerator section is cooled by the freezer's cooling coils. Circulating the air in the refrigerator section past the cold freezer coils lowers the humidity to about 10%, causing lettuce to wilt and carrots to become

Left: The Sun Frost Crew.

from left to right, back row: Leif Christian, Elias Hesse, Travis Dyer, Mark Peterson, Jon Lewis and Thad Garbarino. From left to right, front row: Pete Barger, Greg Bean, Larry Schlussler, and Rebecca Schuett. Photo by Paul Hodgdon.

rubbery. In effect, water in the stored food is transferred to the freezer coils where it must then be manually or electrically melted.

In a Sun Frost, there are no air passages between the freezer and refrigerator sections. The separate 33°F cooling surface for the refrigerator section maintains high humidity storage conditions and allows vegetables to be stored a surprisingly long time without the use of crisper drawers.

What are the prospects for ozone-friendly refrigerant?

Danfoss, the company that makes our compressors, is based in Denmark. Over the next two years, they will change their Europe-bound compressors to ozone-safe, and U.S.-bound units should be switched shortly afterwards.

However, the amount of freon a refrigerator uses is very small. Conventional refrigerators use about 12 oz., and a Sun Frost only uses 4 oz., and that freon will be in use for several decades. Compare this to the air conditioners in automobiles. On a nationwide basis, auto air conditioners consume 30 times more freon than the cooling systems in domestic refrigerators.

What are the prospects for more effective insulation? Glass manufacturers are talking of windows with R-100 in the future. Is there any material or technology on the horizon for fridge walls— thinner, higher R-value?

Speaking of insulation, more freon is in the foam in our fridges than the cooling unit. We should have freon-free foam in the next 1-2 years. We like foam because it is multipurpose. In addition to insulation, it provides structural support as well, both for the box and the copper tubing. There are high efficiency insulations currently being researched; however, their commercial application is a number of years away.

The Solar Energy Research Institute (SERI) is currently developing evacuated panel insulation and we are looking into the possibility of incorporating this type of insulation into our refrigerator. This fall we may experiment with supplementing the insulation in a vaccine storage refrigerator with these panels--the Sun Frost R-1 should then run on a single 25 Watt panel.

Are there government requirements for R-value in refrigerators? If so, what are they?
There are government specs, but to be honest, I don't know the exact numbers. We're so far above the specs, we don't have to consider them when making design changes. Sun Frosts are 3-4 times more efficient than government specs require.

Then I'm curious - what thoughts went through your mind as President Bush announced his Energy Policy?
I really don't understand why he doesn't see conservation as an effective and necessary part of an energy policy.

If you were, say, Secretary of the Department of Energy, how would you convince the major manufacturers to produce more efficient refrigerators and freezers?
Some utilities now realize the savings potential in refrigerators and in the near future may help bring pressure on the manufacturers to produce more efficient units.

In terms of the government, I like the idea of a penalty/rebate system. Set a benchmark efficiency rating. Any fridges not meeting that level would be penalized with a $150-800 'tax.' Any fridge exceeding the benchmark would be entitled to a rebate of $150-800. The rebate money would be obtained from the penalty money, so little or no government money would be used.

Has your business been affected by the slumping economy?
No, the poor economy seems to be balanced out by an increase in environmental awareness. Previously, 80% of our sales had been to photovoltaic systems, but the percentage of AC units we ship is increasing.

Have you encountered any resistance from consumers to the top-mounted compressor?
No, only on rare occasions. We went to Earth Options, a fair in San Francisco, and people on the grid liked the Sun Frost...

Then what's your guess as to why the major manufacturers haven't moved the compressor back on top, where it started out?
Residential refrigeration is a static market. About 9 million units are sold annually. That number doesn't change much, so changing refrigerator design won't sell more units. And so far, the general public hasn't shown that higher efficiency is important to them when selecting a refrigerator. Once again, I think a rebate system might help.

Could Sun Frosts be mass-produced?
Sure, I don't see why not.

Any guess as to how much the cost would come down if they were mass-produced?
Well, it all depends on what kind of numbers you're talking for production. But figure in the neighborhood of 20,000 - 100,000 fridges per year. As a rough guess, I think a $2,300 Sun Frost would go for $1,500. They are actually very simple and straight-forward units.

If every fridge in the U.S. were as efficient as a Sun Frost, how would that affect our energy consumption?

There are many ways to answer that depending upon which analogy you chose to use, but here's some numbers I worked out recently: A Sun Frost uses 8 gallons of oil less than a comparably sized conventional refrigerator— every month! There are 125 million residential refrigerators in the U.S....8 times 125 million = 1 billion gallons of oil saved every month. To give you some perspective, that is 40% of the output each month of the Alaska pipeline.

Access

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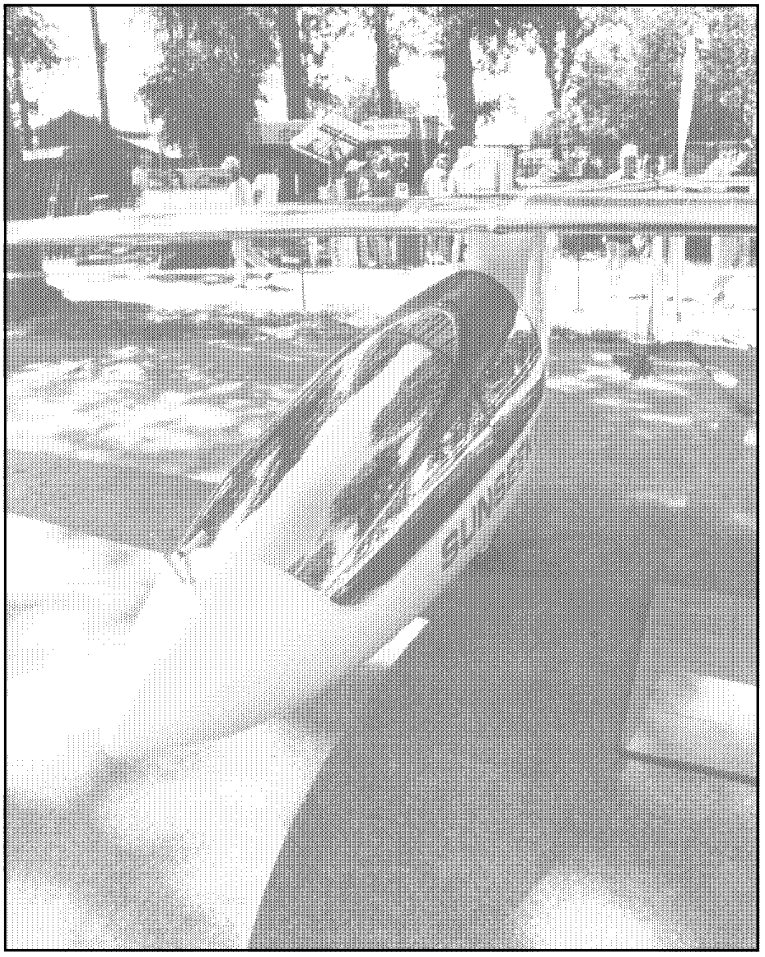
Zero Emission Vehicles (ZEVs) in California

Karen Perez

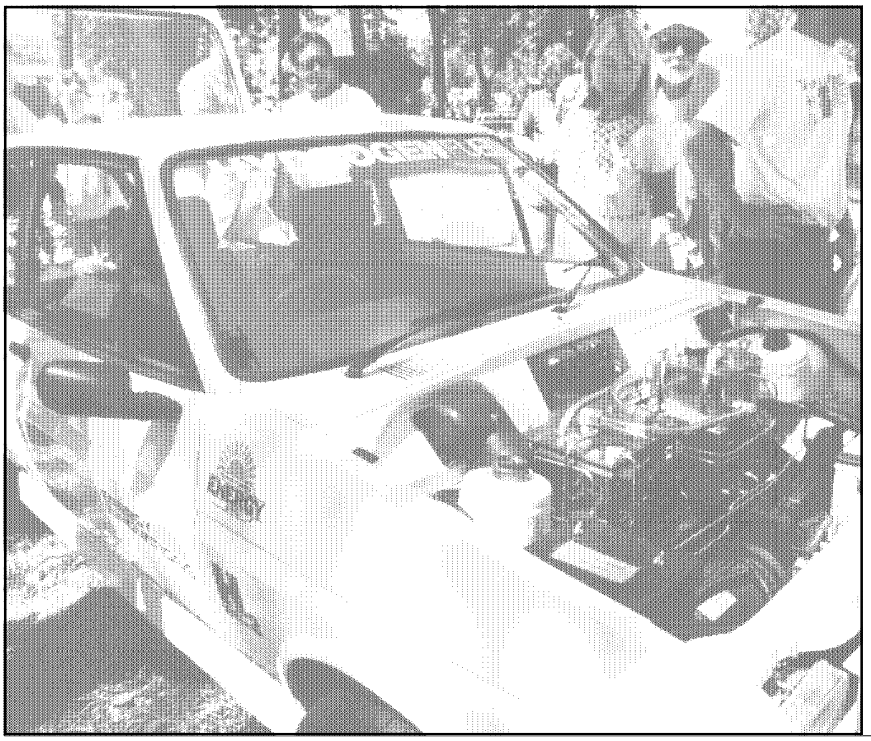
California has passed legislation to reduce auto emissions by forcing major passenger and light truck manufacturers (35,000+ sales per year) to build and sell zero emission vehicles (ZEVs). Beginning in 1998 2% of the "BIg Boys" sales must be ZEVs. The legislation goes even further by forcing all manufacturers of over 3,000 cars per year to produce and sell 10% ZEVs by 2003. Manufacturers say that the costs of producing an electric vehicle won't be feasible until at least 3000 electric vehicles (EVs) per year are built.

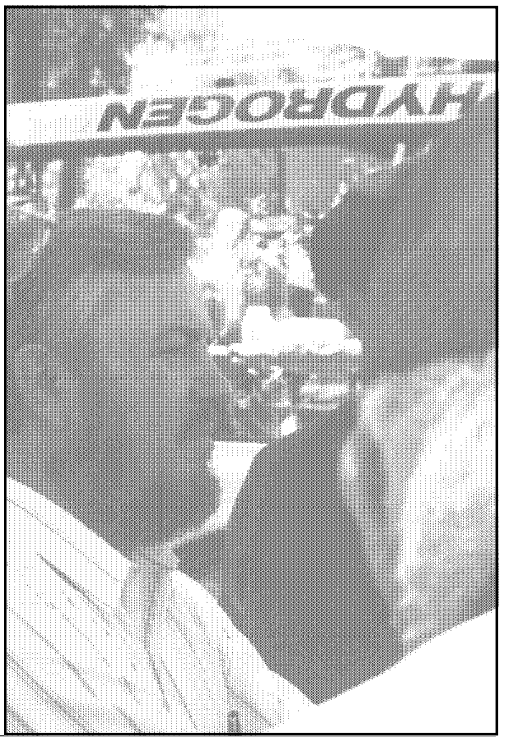
The legislation has built in steps to the 2003 ten percent ZEV goal. The law requires 1994 transitional low emission vehicles (TLEV) sales of 10%, and goes on to low emission vehicle (LEV) sales of 75% by 2003, and ultra low emission vehicle (ULEV) sales of 15% by 2003.

We applaud California for taking the first step on a very long road. We have heard rumors that New York, Massachusetts and Florida are considering similar bills. Kick your state and federal movers and shakers in the butt so that your state will do it too. Then we can all breathe easier.



Above Left: Eric Raymond's Sunseeker PV powered aircraft. Above Right: Phil & Gigi Jergenson tour the Fair in Phil's EV. Below Left: Roger Billings' hydrogen-fueled Festiva. Below Right: Dr. Roger Billings discusses hydrogen fuel with SEER '91 fairgoers.





SEER '91

Richard Perez

The 1991 Solar Energy Expo & Rally (SEER '91) in Willits, California was a nonstop festival of renewable energy in action. From solar airplanes to solar cars to solar lemonade, this year's SEER brought the reality and fun of solar power to thousands of smiling attendees.

My trip

In the short three days of SEER '91 it was impossible to see everything and meet everyone. I hardly slept and I easily missed half of the amazing stuff going on. I can only report on what I saw and did, so this is necessarily a personal view of SEER '91.

People

Energy Fairs happen by the crew's hard work. The SEER '91 Crew outdid themselves. Everything ran as smooth as the face of a PV module. Special thanks and appreciation go to Wayne Robertson, Phil Jergenson, Dave Leverett, Heidi Barthelemy, Keith Rutledge, and Kathy Griffin. This hard core crew worked their butts off.

Transportation

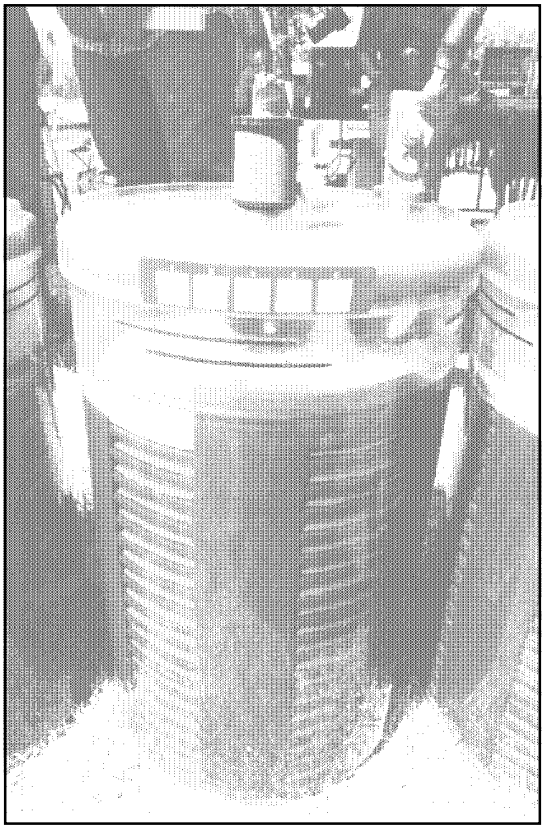
The two major attractions in the transpo scene were Eric Raymond's Sunseeker, the PV powered aircraft (see HP#19 for the techie details), and Roger Billings' hydrogen-fueled Ford Festiva. These two transpo machines are glimpses of the future of travel.

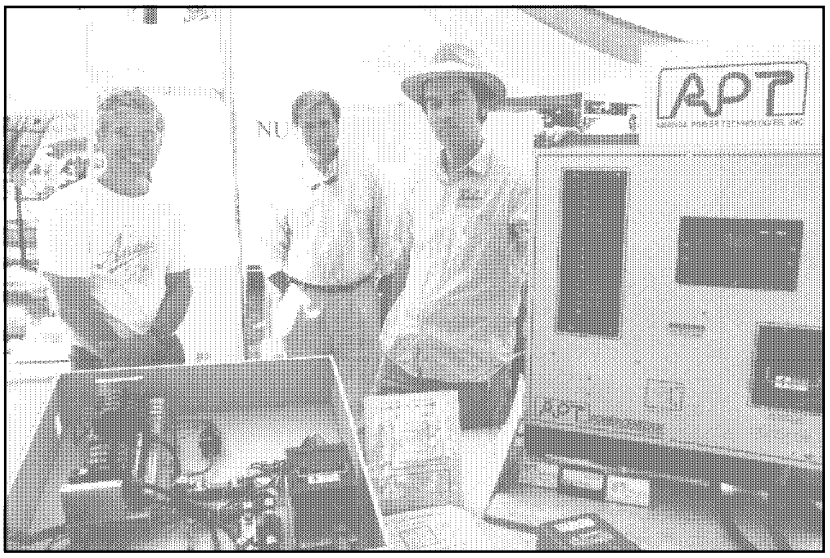
Eric Raymond was the first to fly America from coast to coast using only sunshine for power. Meeting Eric & Aida Raymond, and seeing the Sunseeker aircraft was the high point of my fair. Ever since I can remember, solar-powered flight has been a constant dream.

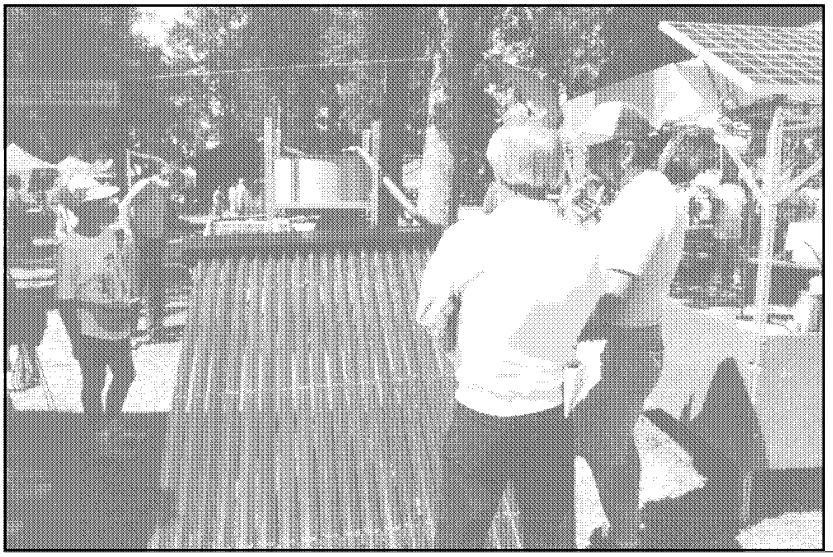
A little more down to earth was Dr. Roger Billings' hydrogen-powered automobile. Of the myriad electric vehicles at SEER '91, Billings' EV was unique. This auto stores hydrogen as metal hydrides and retrieves the energy through a fuel cell to power this electric vehicle. This machine was

Above: we took milliGauss meters for a ride in this Electric Rabbit made by Electro Automotive. The magnetic fields in this EV were lower than in front of a TV set.

Below: All types of vehicles competed in the rallies at SEER. With sunshine making the power, there were only winners in all categories.







Top Right: a 1,680 Ampere-hour lead-acid cell. Rob & Jean Shappell of Northwest Energy Storage are selling these huge used cells.

Top Left: David Booth of AEE explains hydrogen production to SEER folks. David is using electric power produced by PV modules to make hydrogen in electrolyzer cells. He is storing the hydrogen in large volume, low pressure (1.5 PSI) containers. The hydrogen gas is then burned in high level heating appliances like cook stoves.

Center Left: Jack Knowles and the Ananda Power Tech Crew show off their ultrafine power panels.

Bottom Left: Bob-O Schultze of Electron Connection explains the operation of the Thermomax solar heat collector.

beautifully crafted with obvious perfection shining everywhere. The talks and discussions with Dr. Billings made me realize how close this technology is to being commonly used. The hydrogen used in these cars can be produced by RE sources like photovoltaics, wind turbines, and microhydros.

The EV and Solar Car races were nonstop. You could have spent all your time at the starting line. We were lucky enough to get a ride in an Electric Rabbit made by Electro Automotive. We took our milliGauss meters along because we'd been wondering about the magnetic fields that may be in EVs. We were pleased to find that the average field within the operating EV was a very low 0.47 milliGauss. This is a less intense ac magnetic field than the one in front of a TV set.

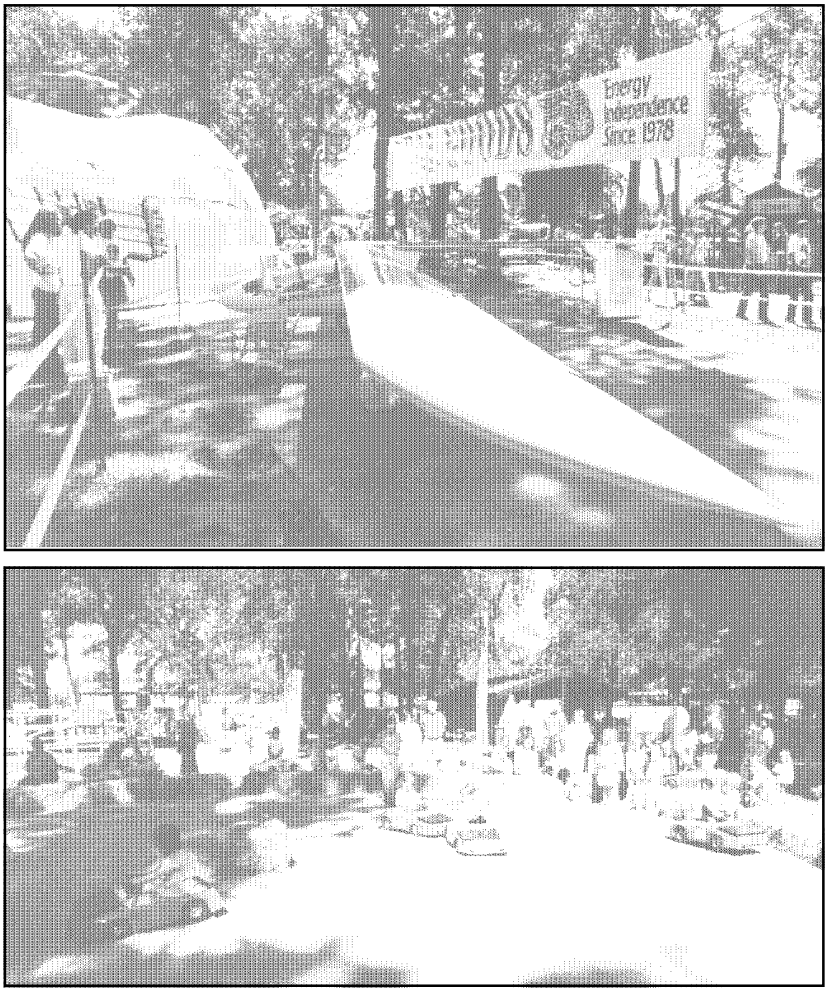
Power Gizmos

David Booth and the Alternative Engineering Crew set up a wonderful PV to hydrogen system. This system uses power from five PV modules to make hydrogen in four of Hydrogen Wind's electrolyzers. The hydrogen was stored at low pressure in common containers (like 55 gallon drums) and used for cooking and water or space heating.

Many of us are now approaching energy independence with large PV, wind or hydro systems. There are inevitably days when we are producing more energy than we can use or store in our batteries. This is where the electrolyzers come in. We can store our surplus energy as hydrogen and retrieve for high-level heat uses later.

David Booth's setup is simple and can be done by anyone familiar with hand tools. Home power people have successfully put sunshine to work for electric power, hot water and space heating. The only appliance we have yet to put on sunshine is the cook stove. Hydrogen produced with our surplus energy offers us food cooked with sunshine on regular cook stoves.

The folks from Ananda Power Technologies were displaying their power centers. These units take the pain out of wiring and interconnection. The load centers contain all the NEC-required fusing and disconnects. Also included are a variety of charge controllers, cables, and instrumentation.



Top: the Real Goods booth was a huge geodesic dome covered in reflective insulation. Above: the Diaper Derby where kids could safely drive small PV-powered cars.

Batteries

Two battery technologies captured my attention. One is lead-acid and the other nickel-cadmium. Rob Wills of Skyline Engineering was displaying the Hoppecke fiber-plate nicads. These cells claim greater energy density and longevity than conventional pocket-plate nicads. We're testing them and will report on the results in a future issue.

The big news in inexpensive storage are the Lineage 2000 lead-acid cells from Northwest Energy Storage. These individually-cased pure lead cells weigh 330 lbs. and have a capacity of 1680 Ampere-hours. These cells were designed by Bell Laboratories and made by C&D Batteries. Rob and Jean Shappell of Northwest Energy Storage are testing and selling these used cells at very reasonable prices. These cells are round (14 inches in diameter and 29 inches tall). They are made from pure lead instead of lead alloyed with antimony and have a

Above: David Leverett of Earthlab worked for months on SEER '91. The Monday after the fair he was on the job at

reputation for great longevity (up to 40 years). The used cells are about ten years old.

Solar Heat

Both space heating and water heating technologies were on display. The most interesting solar thermal technology I saw was the Thermomax collectors from Ireland. These collectors use an alcohol filled heat pipe inside an evacuated (10^{-6} torr) glass tube about four inches in diameter and six feet long. A system using thirty of these evacuated collectors will provide hot water for a family of four. The Thermomax will produce hot water even in very cold climates and on relatively cloudy days. These collectors have been providing hot water in Europe for the last ten years. The Thermomax system is so cost-effective that it is employed in active space heating systems. We used the demo Thermomax that Bob-O from Electron Connection set up for eight to ten hot showers nightly.

Having fun

The best part of Energy Fairs is the people. Sunshine Superhumans with sparks flying from their ears. For example, George Hagerman of SeaSun Power Systems flew in all the way from Virginia to run his PV for Kids workshop. There was a constant crowd of children (and more than few big kids) surrounding George's setup. Here everyone got to play with instrumented PV demonstration systems. It was highly educational and entirely too much fun. George set up shop right next to the "Diaper Derby" with midget solar cars for the kids to drive.

Everyone was tired and dirty on Thursday night before SEER officially opened. We'd worked hard all day setting up the displays. Jon Hill from Integral Energy Systems set up a Chofu wood-fired hot tub and we soaked out the kinks. The Chofu uses a small wood stove with a thermosyphoning heat exchanger. Jon had it set up heating a six foot diameter stainless steel stock tank. It was hot, wonderful and portable.

The munchies at SEER '91 rated five stars. The folks chowing down on the fresh seafood from Tsunami were delirious. If you pass through Willits, CA and don't eat at Tsunami, then you might have well have stayed home. All manner of sol food was served on the SEER grounds. Our favorite was the Solar Aide, a combo of fruit juice and sun tea. When we pulled out of town after the fair we stopped at the local supermarket for a case of Red Tail Ale to take home. They were sold out.

I've been to many Energy Fairs. None were more amazing, informative or fun than SEER '91. It's no wonder that Willits California is called "The Solar Capital of the World".

Access

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Photos by: Jeff Damm, Andy Colonna, and Richard Perez

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Earthlab Energy Systems, 358 S. Main St., Willits, CA 95490 • 707-459-6272

Electro Automotive, Box 113, Felton, CA 95018 • 408-429-1989

Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3401

Integral Energy Systems, 105 Argall Way, Nevada City, CA 95959 • 916-265-8441

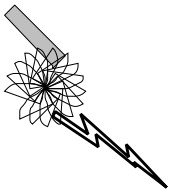
Northwest Energy Storage, POB 137, Colburn, ID 83865 • 208-263-6142

SeaSun Power Systems, 124 East Rosemont Ave., Alexandria, VA 222301 • 703-549-8067

Skyline Engineering, POB 134, Applewood Lane, Temple, NH 03084 • 603-878-1600

Backwoods Solar Electric Systems

Chorizzo Solar Corp.



Editorial

A Buck for PV

Tom Lane

Gainesville Florida Regional Utilities Citizen Advisory Board recently presented a recommendation to the city council allowing each utility customer to voluntarily add one dollar a month to their utility bill. The money goes for the purchase of PV modules whose power will be placed on the grid.

The Plan

Once a year, when the utility bill is mailed to the customer, there will be a place on the bill to select a voluntarily addition of $1 per month. This money will be used only for the direct purchase and use of solar electric modules by the utility.

The Reasons

This will allow the citizens of Gainesville to choose their energy future and help lead the utilities away from burning dead dinosaurs and start them burning sunshine directly. Mankind is crucifying both the planet and humanity on a black cross of burning carbon. The problem is not one of too little fossil fuels, but an overabundance of coal and oil. From the Valdez oil spill to the fires in Kuwait, we have learned that the cost of burning dead dinosaurs is far more than the bill from the gas station or the utility.

We live in an era when the politicians are frozen into nonaction by huge deficits and accounting practices that do not factor in the health or environmental cost of burning carbon. The community needs to lead the utilities into an acceptable energy future. Get on your utilities' advisory board, and help spread this "spark" across the country. How can any utility refuse free funds to add solar electric power to the grid? Even a small contribution will require the utility to begin the learning process.

The Spark

Make no mistake, if we the people that support solar energy do not choose our energy future, then others will choose it for us. If you are connected to the grid, then get organized. Find out how you can create a vehicle to guide your utility into a viable, pollution-free, energy future. The technology is here, the time to start is now while we still have time. We have a historic opportunity to spread the "solar spark" by leading our public utilities in a revolutionary energy transformation.

Access

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Blackout Protection with an Emergency Power System™

Rick Proctor

An Emergency Power System™ (EPS) automatically supplies 120 vac power to critical loads such as lighting, furnace fan, outlets, and well pumps during a power outage. The system is designed to automatically supply the critical loads for 12 to 24 hours (with energy conservation). A standby generator can be easily added if long term blackouts must be endured. The system can also be expanded to incorporate renewable energy sources, reducing dependence on utility-supplied power.

Who Needs an EPS?

Every home is a candidate for an EPS. Each year the number of homes that experience power failure increases and the duration of the outage gets longer and longer. In Washington state the brutal wind storms and freezing weather during the winter of 1990 left 250,000 people without power. For some the outage lasted over a week. The New York area was hit with an ice storm that left tens of thousands without power. According to reports, 11,000 homes were still without power a week after the storm. Living huddled in a down parka with candles for light loses its romance after the first few hours. The San Francisco earthquake left the entire city without power. Natural disasters can strike anywhere. Floods, high winds, tornados, hurricanes, earthquakes, and lightning can all cause major power outages. During the coming years, as the utility system ages, demand increases, and new power plant construction is delayed, the possibility of blackouts or brownouts will increase.

Rural homes are more likely to have an extended power outage because the utility first concentrates on getting the power back to the largest population clusters. However, as many of the recent power outages have proven, no household is immune. Rural homeowners should consider an EPS with two times more capacity than the city home. They may also want to incorporate an engine/generator or RE power sources.

EPS Theory of Operation

Critical loads needed during a power outage are supplied from the EPS sub-panel. Critical loads are such things as lighting, furnace fan, well pump, and refrigeration. Large loads, such as electric heaters, water heaters, electric stoves and ovens are not appropriate to be supplied from the EPS. The power for the EPS sub-panel normally comes from the main 120 vac panel through the inverter's internal transfer switch. When the utility power goes off, the inverter automatically begins producing 120 vac power, from the DC power stored in the battery. The inverter supplies power to the EPS sub-panel through its internal transfer switch. The inverter also incorporates a battery charger that keeps the battery fully charged whenever utility or engine/generator power is available. The monitoring system lets the user know how the battery is being charged and discharged, what the state of discharge of the battery is, and the control regulates charging from optional energy sources.

The EPS has four major components

1) An EPS sub-panel containing critical load circuit breakers.
2) A battery which stores DC power to be used during a power outage.
3) An inverter/charger to convert battery power to emergency 120 vac power and to recharge the battery.
4) The monitoring and control systems necessary to run the system.

An EPS may also have these optional components

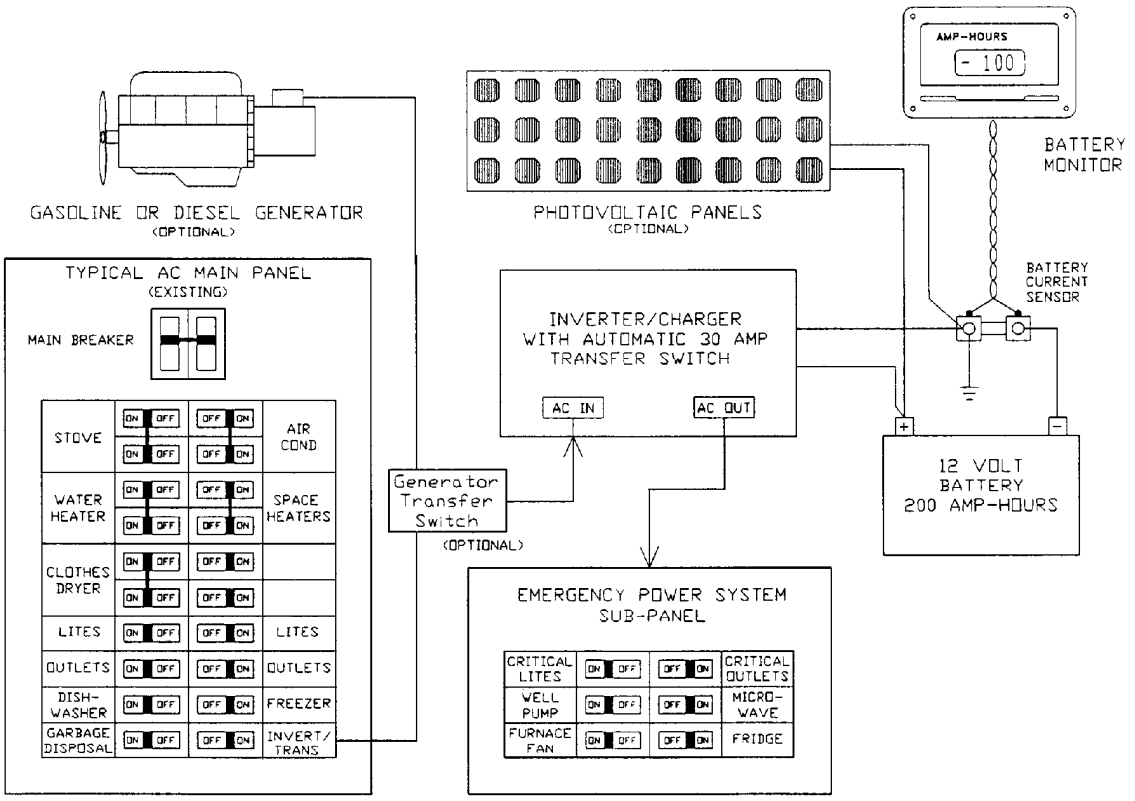
1) PV Panels to recharge the battery.
2) An engine/generator for battery charging during prolonged power outages.
3) A generator transfer switch to supply generator power directly to the EPS sub-panel.

EPS Sub-Panel

The EPS subpanel should include at least six circuit circuit breakers, three 15 amp, and three 20 amp. This 120 vac distribution panel must supply all the critical circuits. Typical circuits might include the following:

1) a lighting circuit for each room of the house.
2) a circuit for the furnace fan.
3) a circuit for the well pump
4) a circuit in the kitchen for microwave use
5) a circuit for the refrigerator
6) critical circuits for alarm and communication systems

The EPS sub-panel is selected by making a list of the



circuits, and the current used by each, to be supplied from the EPS. Once the number and size of the circuits is determined then the sub-panel and the appropriate breakers may be chosen. During normal operation from the utility the total load supplied by the EPS sub-panel may not exceed the 30 amp current capacity of the inverter's internal transfer switch unless an external transfer switch is used.

If the normal load on the EPS exceeds 30 amps when utility power is available an optional 50 amp external transfer switch may be used. With this option the EPS Sub-Panel may supply 50 Amps during normal utility service.

Inverter/Battery Charger

The Inverter/Charger actually does three jobs. Its most important job is to convert energy stored in the battery into 120 vac power for the EPS Sub-Panel during a power outage. Its second job is to charge the battery and maintain it in a fully-charged state, whenever 120 vac power is available from the utility or an auxiliary generator. Its third job is to automatically supply utility power through its internal transfer switch to the EPS Sub-Panel. The power is supplied from the utility, if it is available, or from the inverter if it is not. The EPS should use an 1800 Watt inverter that is capable of supplying 15 Amps of 120 vac power when utility power is not available. This inverter should also have a built in automatic 65 to 110 Ampere battery charger with electronic regulation.

A system that requires more capacity would utilize more powerful inverter that is capable of supplying a maximum of 25 Amps of power when utility is not available.

Battery

The EPS may use any typical 200 Amp-hour deep cycle battery purchased locally. The battery is the energy storage reservoir that supplies the inverter with power during a blackout. The larger the battery the longer it can supply energy without recharging. Watt-Hours of use is how the utility determines your bill. If you use a 60 Watt light bulb for 1 hour you have used 60 Watt-Hours.

Unfortunately batteries are typically specified by the voltage and the number of Ampere-hours (Ahr) that it can supply. To convert your Watt-Hour requirement to Amp-Hours use the following formula: Amp-Hour Battery Capacity Required = Watt-Hours Required /Battery Voltage

If you want to know the Watt-Hour capacity of a battery use the following formula: Watt-Hour Battery Capacity = Amp-Hour Capacity x Battery Voltage

If a battery is routinely fully discharged, it shortens its life.

If the EPS is to be used only during power outages, this is not a critical design factor. However, if the system is to be expanded for use with renewable energy then the battery size should be increased by a factor of two or more to avoid damaging discharges.

A 200 Ahr, 12 Volt battery will supply about 2,400 Watt-Hours. If discharge were limited to 80% there would only be about 1,900 usable Watt-Hours. Battery systems can be designed with capacities of thousands of Ahrs. To do so requires careful engineering judgment to make sure the system components are properly matched. The Standard EPS is intended to provide a limited amount of power for a limited time. If you need a larger system, consult an experienced renewable energy system designer, or learn the design process yourself.

How to Make a Load List

List the actual or estimated power consumption (watts) of each load. Sometimes the number of Amps a load uses is given instead of its Wattage. To find the number of Watts a load uses, multiply the number of Amps it uses by its Voltage. If a load uses 1 Amp when supplied from 120 Volts then it is a 120 Watt load.

To determine your daily Watt-Hour requirement use the following formula: Daily Watt-hours = Number of Watts the load uses X Hours of use per day

Making a load list is the only way to determine exactly how much battery capacity is required for your EPS. An EPS with a 200 Ahr, 12 Volt battery (2,400 Watt-hours) will last four to twenty-four hours, depending on the loads. In the two examples that follow, the significant impact of using energy saving lighting, appliances, and energy conserving tactics, is clear. Use these examples to make a load list for your particular requirements.

Load List for 24 hour blackout without conservation

Load	Watts	Hrs.	W-hrs.
Living Room incandescent light	60	5	300
Kitchen incandescent light	60	4	240
Bedroom Room incandescent light	60	2	120
Bathroom incandescent light	60	1	60
Refrigerator/Freezer (frost-free)	330	10	3300
Furnace Fan (temp @ normal setting)	240	10	2400
TV (full sized color)	300	5	1500
Microwave Oven	1200	1	1200
Total Daily Watt-hour Power Consumption via EPS			9120

From the above load list we can see that the 2,400 Watt-hour (200 Ahr 12 Volt) battery, supplied with the standard system, will last for 4 to 6 hours. If the outage lasts longer it will be necessary to use a generator to recharge the battery. The generator will need to be run for 3 to 4 hours to recharge the battery. It can then be shut off for another 4 hours. This generator cycle of 4 hours on and 4 hours off will have to be repeated until the power is restored. If longer periods are desired between battery charging, the battery capacity will have to be increased or the load will have to be reduced. Reducing load is often the best choice.

Load List for 24 hour blackout with conservation

Load	Watts	Hrs.	W-hrs.
Living Room fluorescent light	18	5	90
Kitchen fluorescent light	18	4	72
Bedroom Room fluorescent light	18	2	36
Bathroom fluorescent light	18	1	18
Refrigerator/Freezer (no frost-free)	240	6	1440
Furnace Fan (temp @ low setting)	240	6	1440
TV (small color)	48	2	96
Radio	12	8	96
Microwave Oven	1200	0.5	600
Total Daily Watt-hour Power Consumption via EPS			3888

This example shows the impact of energy conservation. There has been minimal impact on the quality of life. The energy consumption is less than half of the home without conservation. The major differences are few. Using energy efficient fluorescent lighting reduces the lighting load to less than 1/3 of the previous example. An additional benefit of energy efficient lighting is reduced power consumption during normal operation on the utility. The refrigerator is not a frost-free unit or the "energy save" mode has been selected to reduce power consumption. The thermostat for the refrigerator has also been set up as high as possible and the door is opened only when absolutely necessary. The furnace fan power consumption has been reduced by setting the thermostat down to 55 or 60 degrees, closing off all unused rooms, and supplementing the furnace with a wood stove, fireplace, or kerosene heater if possible. Extended use of a low power consumption radio, to keep posted on the news, instead of a full sized TV saves power. TV time has been reduced to 2 hours and the power consumption has been reduced with a small color TV. The microwave time has also been reduced to one half hour.

In this example the 2,400 Watt-hour (200 A-hr, 12 Volt) battery will last for 10 to 12 hours. If the outage lasts longer it will be necessary to use a generator to recharge the battery. The generator will need to be run for 3 to 4 hours to recharge the battery. It can then be shut off for another 10 to 12 hours. This generator cycle of 4 hours on and 10 to 12 hours off will have to be repeated until the power is restored. Using the microwave mostly while the generator was running could extend this period.

Monitoring and Control
Instrumentation is essential to determine the state of charge of the battery. An EPS must use an Ampere-hour meter. It displays how discharged the battery is. A fully charged battery has zero Ahrs removed from it. The Ampere-hour meter counts Ahrs removed from a fully charged battery and displays them with a minus sign. When the Ampere-hour meter displays -160 Ahrs on a 200 Ahr battery, then it is about 80% discharged. During recharging the Ampere-hour meter counts back up toward zero. When the Ampere-hour meter once again displays zero the battery is fully charged. Monitoring the rate at which Ahrs are consumed allows you to know about how long it will be before the battery needs to be recharged. If, for example, ten Ahrs are consumed in one hour then the standard system's battery will be 80% discharged in about 16 hours (160 A-hr / 10 A = 16 hr).

Control in the simplest systems is strictly manual. If the Ampere-hour meter tells you the battery is discharged it must be recharged so you start the generator and do it. If photovoltaic panels are incorporated into the system a regulator will probably be necessary. Some systems may also incorporate automatic generator starting. The basic EPS has no control functions beyond those found in the inverter/charger. If other sources are to be incorporated into the system more control functions may be necessary.

Optional Power Sources
During a blackout the EPS can supply energy until the battery is discharged. Once the battery's energy is used, some method of replacing it is needed. Often the grid will be restored before the battery is discharged, but what if it is not? Energy could be supplied from a variety of sources. Wind power, photovoltaic panels, an engine driven 120 vac generator or alternator, micro-hydro, human-powered generators, and micro-nuclear (just kidding) could all be candidates. Some of these sources are not practical, some not cost-effective, and some not readily available. The two sources that seem most appropriate for an EPS are photovoltaic panels and a gasoline or diesel-powered generator.

Installation
An EPS that does not include a subpanel does not require any installation skill. The loads that need to be run during a power outage are simply plugged into the inverter outlet provided and the inverter's charger is plugged into a wall outlet. A better EPS includes a subpanel that must be connected to the main 120 vac panel. This typically requires a qualified electrician or a knowledgeable homeowner. Installation time should be less than five hours for an electrician.

EPS Cost
Cost for the EPS is low— about what you would spend for a high-quality 120 vac engine/generator. See the cost breakdown below.

Emergency Power System Cost

EPS Component	Cost
Inverter/Charger	$1,500
200 Amp DC Circuit Breaker	$250
200 Ahr 12 VDC Battery	$250
Ampere-hour Meter	$200
Wiring Labor	$150
EPS Subpanel with breakers	$140
Shelf Support Unit (Housing for EPS)	$100
Shunt for Amp-hour Meter	$40
Misc. Hardware	$40
10"x10"x6" NEMA 1 Box & Cover	$34
Battery Cables (2/0 Copper)	$20
Total EPS Cost	$2,724

In Conclusion
Storms are weathered best by the prepared. Learning is a part of preparedness. Installing and using an EPS in your home not only gives you the security of being prepared, it also serves as a learning tool. You can learn how to save energy and use it more efficiently. With the installation of a couple of solar panels you can learn how easy it is to generate your own power. Energy independence comes from knowing that you can be independent.

Access
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Solar Hot Water

Tom Lane

An interesting aspect of the solar industry has always been that there is little crossover between solar thermal (hot water and pool contractors) and solar electric contractors. Most solar thermal contractors have hardly any experience in photovoltaics. Conversely, solar electric contractors who are on top of "what works" in photovoltaics do not seem to have a clue about what is a value in a solar hot water system.

Why Me?

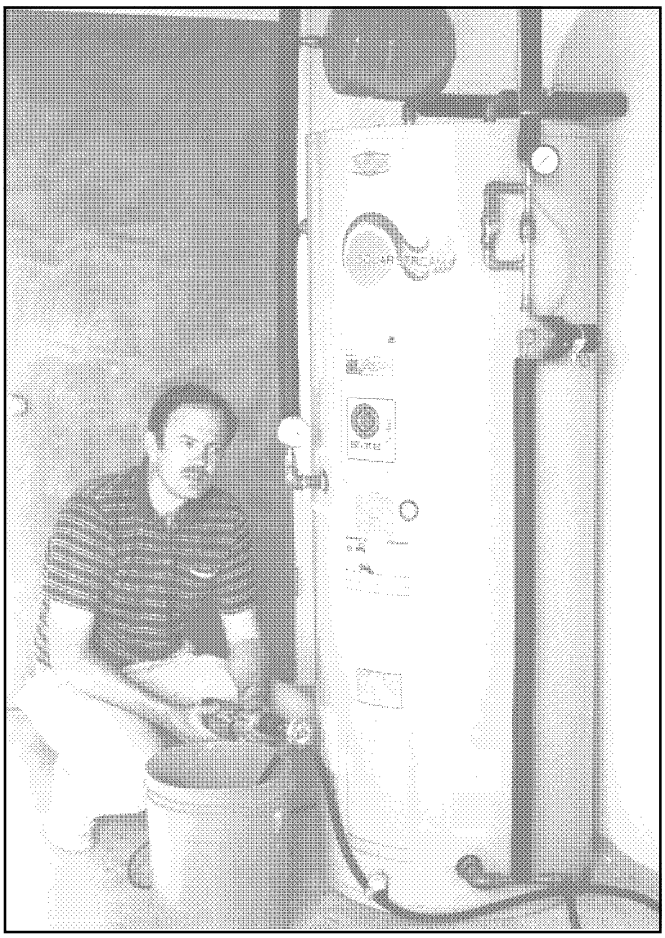
Presently I am heating water for my family of six using a 120 gallon closed loop solar tank with two 4 x 10 black chrome U.S. Solar collectors. Using a Solarex SX-20 PV module as the controller and power to run a 12 Volt March 809 DC pump for circulating the solar loop is my personal preference for this system. I like its inherent simplicity and immunity from scaling and freeze damage and low cost per square foot of collector area.

Our company, a local contracting company in Gainesville, Florida since 1977, has installed and is maintaining over 2,000 solar hot water systems in Northern Florida. I have worked in the '70s and '80s training people throughout the U.S. in installing solar hot water systems for several manufacturers.

Why You?

Solar hot water systems can be an excellent investment. However, you owe it to yourself to make sure you are getting a good investment. Your system shoud be more than just a gimmick "token" solar system that heats a little water, makes you feel "environmentally correct" but really gives no real return on your investment.

Solar hot water heating for showers, dishwashing, and laundry will cost about $110 per person if LP gas costs $1.15 a gallon, or if electricity costs $.07 a kilowatt hour. At $.10 a KWH, it costs $646 a year to heat water for four "average" people. A solar hot water system with a 120 gallon tank and 64 to 96 square feet of collector area will typically save about $500 to $600 out of the $646. Don't forget that all savings are in nontaxable income which would be equivalent to $600 to $750 that you earned and pay taxes on to the IRS to support John Sununu's and Dan Quayle's golf and ski trips. If you are heating hot water for two people or more and you are not hooked to natural gas pipelines, then you need to examine solar hot water as an investment AND LOOK FOR VALUE — total BTUs delivered into storage.



Above: Tom Lane at work on one of the 2,000 solar DHW systems he has installed in Florida.

Design Choice

There are basically two types of solar hot water systems. Open loop systems, in which the same water for your showers, etc., goes through the thermal collectors and a

closed loop system. These typically uses a glycol antifreeze or a drain back reservoir and an external heat exchanger or a heat exchanger built into the tank. The main criterion for these systems is how hard the freezing weather is where you live.

Open loop systems should be used where you get no freezes. If your local area can grow mangoes, avocados, or citrus groves without danger of being damaged by a mild freeze, then you are in an area that can directly circulate water through the collectors. If not, use a closed loop system or one day you will have a visit from Mr. Murphy. Since 95% of the U.S.'s population, including Central Florida and most of Southern California and Arizona are in areas where freezing conditions occur, I will discuss my experience with closed loop systems and solar hot water as an investment.

System Sizing

The home owner must make sure he is getting enough storage (gallons) in tank size and enough collector area to give him a real return on his investment. Plan on at least 20 gallons per person for the first four people and 15 gallons for each additional person per day. Solar hot water tanks typically come in 80, 100, and 120 gallon sizes. The 120 gallon size tank typically costs only $150 to $200 more than an 80 gallon tank and the money is well spent considering you are adding 50% more storage capacity for a small increase in dollars. Experience in photovoltaics has obviously taught solar electrical contractors the value of amp hour capacity in battery storage whose counter is gallons in storage.

You should have at least 40 square feet of collector area for the first two family members, then add 12 square feet of collector area for each additional family member, if you live in the sunbelt. In northern climates, add 14 square feet of collector area for each additional family member. Never add more than 64 square feet to an 80 gallon tank or 96 square feet to a 120 gallon tank. Keeping tank size at a ratio of 1.25 gallons or more to a 1 square foot of collector area will keep the solar system from grossly overheating in times of little demand. This assures that the collector to storage ratio is efficiently matched. Overheating a hot water tank dramatically decreases its life span. In Arizona and Southern Florida keep the ratio at least 1.5 gallons to 1 square foot of collector area.

Collectors

The typical sizes available for flat plate collectors are 4' by 8' (32 sq. ft.) and 4' by 10' (40 sq. ft.). The minimum collector area size worth investing in is one 4' by 10' in a closed loop system. I strongly suggest two 4' by 8's with at least an 80 gallon tank for more than three people. Use two 4' by 8's, two 4' by 10's, or three 4' by 8's with a 120 gallon tank for larger families. Always use thermal collectors that have ALL copper tubes AND absorber plates for collecting the solar energy, that has a tempered glass cover in front of the absorber plate. NEVER use plastics or fiberglass covers instead of tempered glass or any other material than all copper collector plates for absorbing the heat. Avoid using evacuated tube collectors for heating hot water. It is like hunting rabbits with a howitzer and can grossly overheat your tank. A 120 gallon tank with two 4' by 8' or 4' by 10' collectors is the best investment in dollar per BTU delivered into storage. Avoid solar systems with less than 40 square feet of collection. They are simply not worth the investment. All solar hot water heaters capture sunlight to heat water. No matter how exotic the bottom end of a solar water heater might be it cannot create more solar energy than falls on the collector area. Less than 40 square feet just is not enough square footage in an active open or closed loop system.

Thermosyphons

Avoid external heat exchangers that rely on thermosyphoning of heat. Thermosyphon heat exchangers that work off natural convection will typically only heat the top half of the tank NO MATTER HOW YOU PLUMB THE TANK. External heat exchangers only work well if you double pump in counter flow, also pumping the water side of the heat exchanger through the tank and back through the heat exchanger. Another serious problem for external heat exchangers is scaling due to hard water. If you have hard water, especially calcium and magnesium, DO NOT use an external heat exchanger unless you have a water conditioner or anti-scale equipment.

Closed Loop

Fortunately the two largest manufacturers of hot water tanks in the country, Rheem/Rudd, and State Industries, manufacture 82, 100 and 120 gallon solar tanks. These have closed loop heat exchangers that are bonded to the lower half of the solar tank's wall. This enables you to use a closed loop system that avoids the two biggest problems for solar hot water systems: 1) freezing and 2) scaling due to hard water. It also keeps the system incredibly simple since you need only one pump to pump the heat exchanger side of the system. The Rheem or Rudd tanks use copper tubing bonded to the exterior wall of the tank. This enables you to use Prestone II car antifreeze in a 2 gallons of antifreeze to 3 gallons distilled water mix to run through the heat exchanger. If your coldest freeze on record is above 0° F use 1 gallon of

antifreeze to 2 gallons distilled water. State Industries uses an integral single wall heat exchanger that is bonded to the lower half of the outer tank wall. The State heat exchange tank works extremely well, however, you cannot use ethylene glycol (Prestone II) but must use its cousin, propylene glycol, a non-toxic antifreeze used in all soft drinks and many other foods. The mixture ratio is the same and the excellent heat transfer properties are identical for ethylene and propylene glycol. Never use hydrocarbon oils, silicone oil or alcohol as heat transfer fluid because they have low specific heat characteristics and are poor choices for heat transfer fluids. One of your local plumbing distributors can order you a State, Rheem, or Rudd closed loop solar tank. The cost is about $480 for an 80 gallon tank, and $580 for a 120 gallon tank.

Caution on Materials

The entire collector loop, all fittings and pipe, must be copper or red brass. All copper couplings must be soldered with 95/5 tin/alimony, or brazed. Never use 50/50 lead solder. The antifreeze/distilled water solution will not need to be changed for over ten years if you do not mix metals in the collector loop. NEVER use galvanized pipe, yellow brass, or any plastic pipe or parts.

Pumps & Panels

The most efficient trouble-free control and pumping system is to use the 12 Volt DC March 809 pump. Then connect it to a small solar electric module rated, at a minimum of 1.2 Amps to a maximum of 2 Amps under full sun conditions (typically a 14 to 20 Watt PV module). The solar electric module pop-riveted to the side of the frame wall of the solar thermal collector will slowly start pumping at the correct solar intensity at a variable speed.

Solar thermal and solar electric energies are completely different forms of energy from the sun. However, they are always in the same proportion based on the intensity of the sunlight. The choice of a solar electric or PV module rated 1.2 to 2 Amps matched to the March 809 12 Volt DC pump enables it to provide power to run the pump. It also acts as a variable speed controller to start and stop the pump and vary the speed at the correct solar intensity. A smaller PV module (less than 1.2 Amps) will start too late and a module bigger than 2 Amps would start too early and run too long. Use only a single crystal or polycrystalline PV module - do NOT use an amorphous PV module. Just connect the positive and negative leads on the March 12 Volt 809 pump with 18 or 16 gauge stranded PVC jacketed wire. This means no sensors to fail, no differential thermostats, (which means it cannot malfunction and run at the wrong time), no AC power outages from the utilities. After the hurricane that hit Tallahassee, Florida, in 1985, the city lost utility power for several days. The solar systems with solar electric pumps were still providing hot water to their homeowners. Do not let anyone try to sell you on the obsolete differential controls with sensors and an AC pump. Tell them to send their dinosaurs back to the city dump.

Pipe

All lines in the solar loop from the tank to the collectors and back should be in type L soft and/or hard 3/4" copper pipe. Use hard type L copper around the tank and collectors and use soft type L coils on the long attic pipe runs. Insulate the lines with 3/4" thick elastomeric insulation (trade name Rubatex or Armaflex) available at air conditioning and heating distributors. Do NOT use polyethylene rigid pipe insulation! All exterior insulation exposed to sunlight must be protected from UV light. One way to do this is by encasing the insulation in PVC or ABS plastic pipe, or you can spray it with auto motive undercoating spray and touch up as needed in the future.

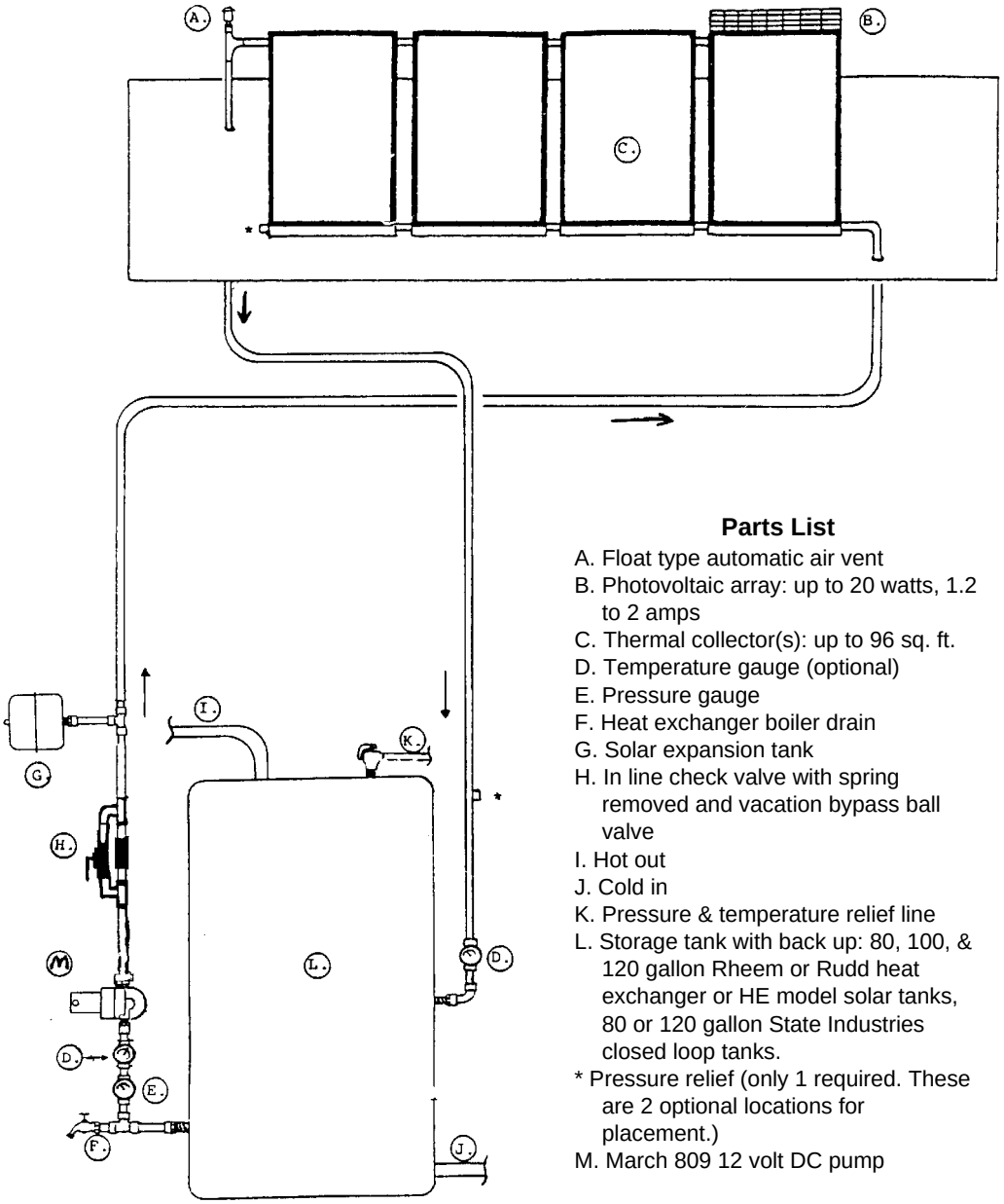
Safe Six

Besides the pump, there are only six simple parts in the system. 1) A pressure gauge (0-60 PSI) will let you know your system has not lost its charge of antifreeze and water. 2) A solar expansion tank (about the size of a basketball) that allows the solar solution to expand into it as a fluid heats up. 3) A check valve above the pump to prevent reverse flow thermosyphoning at night. 4) A pressure relief valve rated at 75 PSI to 125 PSI (not a pressure & temperature relief valve). 5) One boiler drain (hose bib) valve at the lowest point in the system for filling and draining. 6) A two way ball valve, to create a bypass around the check valve. This last item, #6, enables you to fill and drain from a single drain hose bib. If you go on vacation you can let the system dump all the heat back to the roof each night by reverse thermosyphoning if the ball valve bypass is open. If you vacation for a week or more and do not have a means to keep your tank from overheating , you will definitely shorten the tank's life.

Charging

Once the system is completely installed it will be time for charging. All you will need for system charging is two washing machine hoses, a drill pump for the end of a 3/8" power drill, and a bucket.

Simply add your antifreeze/distilled water mixture, to the bucket as your drill pumps the water into the washing machine hose connected to the lower boiler drain. If the collectors are extremely high, cover the collectors, remove the air vent, and slowly fill from the top with a



Parts List

A. Float type automatic air vent
B. Photovoltaic array: up to 20 watts, 1.2 to 2 amps
C. Thermal collector(s): up to 96 sq. ft.
D. Temperature gauge (optional)
E. Pressure gauge
F. Heat exchanger boiler drain
G. Solar expansion tank
H. In line check valve with spring removed and vacation bypass ball valve
I. Hot out
J. Cold in
K. Pressure & temperature relief line
L. Storage tank with back up: 80, 100, & 120 gallon Rheem or Rudd heat exchanger or HE model solar tanks, 80 or 120 gallon State Industries closed loop tanks.
* Pressure relief (only 1 required. These are 2 optional locations for placement.)
M. March 809 12 volt DC pump

funnel. Keep charging until your pressure gauge reads 20 PSI plus 1 pound of pressure for every 2 feet the solar collector is higher than your tank. One way to crank the pressure up is to connect the washing machine hose to a 100 foot garden hose that you fill with your mixture through a funnel. Connect that garden hose to a hose bib on the tank drain or an outside spigot and let your city or well water pressure crank your pressure up by forcing the extra mixture in by water pressure.

Cost & Value

An 80 gallon closed loop system with two 4' by 8' collectors and components will cost about $1688 for the equipment and save about $556 a year at $.10 KWH. A 120 gallon tank with two 4' by 10' collectors and components will cost about $1950 and save about $720 a year at $.10 KWH. A good rule is that if you are paying less than $27 a sq. ft. in collector area for the system, you are getting a good buy. Piping and insulation will cost about $1.25 a foot. The tank and heat exchanger should last 20 years with no maintenance other than to change the antifreeze mixture every 10 years. The absorber plate in the thermal collectors may need to be replaced every 50 years, about twice in the 150 year life of a good flat plate collector.

Conclusion

It is ironic, a family of four that has LP gas or high electric rates will pay for a solar hot water system in utility bills over the next 4 to 8 years, whether they get one or not. You can invest, wisely, in a solar hot water system and have something to show for your money or send the money you would have saved on solar each month to the utility company. Then you have nothing to show for your money but more NO_2, SO_2, and other airborne pollution and/or nuclear waste.

Access

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American Energy Technologies, POB 1865, Green Cove Springs, FL 32043 • 904-284-0552
Solar Development Inc., 3630 Reese Ave., Riviera Beach, FL 33404 • 407-842-8935 Rheem heat exchanger tanks, closed loop components, PV panels and DC pumps.
Radco, 2877 Industrial Parkway, Santa Maria, CA 93455 805-928-1881 Thermal collectors
Heliodyne, Inc., Richmond, CA 94804 • 510-237-9614

BERGEY

PHOTRON

…On Grounding

Mick Sagrillo with Richard Perez

Much has been written about the need to ground DC home power systems, how to do it, and the requirements of the National Electric Code (NEC). We are told that the negative line of a DC system must be connected to ground. I don't think anyone knows why, other than that it's "the law". I challenge this concept. I contend that grounding the negative leg of a DC system is useless and may even cause problems like increased shock danger, electrolysis, and interference with radio/electronic devices.

Background

This article grew out of a very lively conversation between Ken Olsen and Johnny Weiss of Solar Technology Institute, Jim Sievers of Iowa Alternative Energy, Richard Perez and myself over a pitcher of brews at the Midwest Renewable Energy Fair (MREF).

My (Mick's) experience comes primarily from wind systems. I also have dabbled with transportation systems (i.e., cars, trucks, trains, and planes), high voltage battery systems, large DC systems, hydroelectric, and PV systems. I have no experience with regulations or electrical code rationalizations. This information may have little to do with truth and justice of my statements, but needs to be stated for credibility.

My (Richard's) primary experience comes from PV systems. I have also been professionally involved in commercial television, and hold an FCC radio techie license. My background is in physics and electronics.

The Dilemma

Again, I maintain that grounding the negative leg of a DC system serves no useful purpose. It can actually cause problems that might not otherwise happen if the leg had not been grounded.

This does not mean that equipment should not be grounded. Towers, conduit, PV frameworks, and electrical equipment chassis should all be grounded. The reason for grounding is to protect equipment from direct lightning strikes and lightning's transient voltage surges. Grounding also dissipates the static charges present on electrical equipment, making the equipment less attractive to lightning. (For a thorough discussion of lightning protection see Home Power #24.)

Here are some of the reasons for not grounding the negative leg of a DC system.

Floating Systems vs. Grounded Systems

A DC wind generator (or three phase ac wind generator) is a 'floating system,' meaning that the current carrying conductors are only "hot," or have electric potential, in relation to each other. None of these current carrying legs are grounded. Grab the positive or negative leads, touch the ground and nothing will happen. The electric potential is only between the positive and negative of the system, It does not involve the ground, or another DC generator, a disconnected battery bank, nor any ac system. This constitutes a completely floating system. A floating system is isolated from everything but itself. Examples of floating systems are wind machines, PVs, microhydros, airplanes, automobiles, and boats. If you make connection between any current carrying conductor and ground, then nothing happens. If you get between the positive and negative, however, nasty shocks and/or burns can occur because you have become part of the current conducting path.

In 120/240 vac systems, we are taught not to come between any "hot" wire and ground. Ac is not only hot in relation to itself, but also relative to the ground. I think that this is where most of the confusion originates. In the United States, ac system codes ground the "neutral" conductor. This is not true for most of the rest of the world (all of Europe, South America, and Australia), which does not ground any of the current carrying conductors. That's right, virtually the entire world, except the USA, does not ground current carrying conductors. If you don't ground current carrying conductors, then items like ground fault interrupter circuits are not necessary.

Ground Loops and Ground Faults

Electricity flowing from one leg of a DC system through the ground creates a ground loop. The current then flows to the other leg of the DC system. How? Well, maybe

through you if you are standing on that ground and happen to touch the other DC leg. Let's develop a scenario. I have a 120 VDC battery bank in my cellar, rated at 1440 Amp-hours. Fully charged, this battery bank contains 200 + kilowatt-hours worth of electricity! Assume that the negative side of this battery is connected to ground. Let's say that it has been raining, and the cellar floor is damp. If I went down to the cellar to fiddle with the batteries and touched a positive pole, guess what would happen? Fried Mick! I became part of a ground loop between the two hot battery terminals. This scenario is not far-fetched. In my cellar on humid spring days when the air was condensing on the cold battery cases, I have touched the negative or positive bus, had my bare arm brush against a case, and received quite a tingle.

A ground fault occurs when current leaks from a current carrying conductor to the ground. If the ground fault path has low resistance, then appreciable current will flow, creating a current loop to ground.

The danger for the generator or the electronics comes not from a single ground fault, but when a second ground fault happens, particularly if that second ground fault is of the opposite polarity from the first. In that event, the generator case, electronic equipment chassis, tower, or ground becomes a short circuit conduit between the positive and negative poles. This situation will also result if the negative line is grounded at the battery bank and a ground fault occurs in the positive circuit of the generator or electronics. The outcome is a current loop. Electricity does not flow to your batteries or inverter, but instead dissipates as heat in the short circuit. If this happens long enough, you will burn out the generator.

The situation is a different with inverters. Synchronous inverters with silicon controlled rectifiers (SCRs), bipolar transistors, or field effect transistors (FETs) will not tolerate ground faults or current loops. Typically, a synchronous inverter that is grounded on the ac side will short circuit and blow the power semiconductors. Synchronous inverters consider the negative leg of the DC system connected to ground as a ground fault.

Electrolysis

One final argument against grounding the negative leg of a wind system is the problem of electrolysis. A common practice of wind generator manufacturers in the 1920s and '30s was to ground the negative leg of the wind generator to the tower. This saved some materials in a highly competitive fledgling industry--only two slip rings and two slip ring brushes were needed, one for the positive and one for the field. The negative line of the machine was connected directly to the tower. The negative was then picked up at the tower's base and three wires, negative, positive and field, were brought into the house to the control panel.

After a decade or so, many of these towers began falling over. Close inspection of the tower at ground level revealed that the metal there was soft and spongy. The voltage in the tower leg set up a weak battery with the earth. Slowly, metal ions would disassociate from the tower and migrate from the tower legs into the earth. The tower became weakened at the soil line and eventually fell over.

Interestingly enough, at least one manufacturer capitalized on this idea. The Jacobs Wind Electric Company manufactured a wind plant that reversed this phenomenon for a special application— gas pipe lines. Cathodic plants, as they were called, had one leg of the generator connected to the gas line and the other leg buried in the ground. By pumping current from the ground to the pipeline, gas companies eliminated the maintenance caused by electrolysis in buried metal pipes.

Getting Grounded

To summarize, ac circuits brought to you by your friendly utility are grounded because the code says so. The current carrying wire is hot compared to the ground because the neutral is grounded at your mains panel. However, in DC circuits, the positive and negative leads are hot only in relation to each other, but not to the ground unless you ground one of them.

In both cases, an earth ground is used for lightning protection and static charge dissipation. However, ac and DC should never be grounded using the same grounding rod. The NEC prohibits using ac and DC in the same fuse box or junction box for safety reasons, but this should also apply to grounding rods to eliminate stray ac voltages on a DC line. A system should minimize the number of grounds to prevent electric pathways or stray voltages between multiple grounding rods.

This advice comes to you from an electronics person. The NEC was written for electricians, who want as many grounds as possible for safety reasons, but electronics people know that stray voltages develop between multiple grounds. These electrical pathways result in radio frequency interference (RFI), the familiar hum on communications equipment, radio and television. Somehow, the NEC will have to be changed to adapt to the needs of both electricians and electronics home power folks.

Guidelines

Some good rules to live by (pun intended) that have worked well for me and my customers:

1. Ground all wind tower legs, PV module frameworks, conduit, generator frames, and electrical equipment chassis.
2. Connect all indoor DC equipment cases to only one ground. The ground should be dedicated to DC equipment only. The DC ground should not include any current carrying conductors.
3. Connect all ac equipment to its own dedicated, NEC approved, ac ground. Use only one grounding rod to avoid stray voltages.
4. When working around batteries, temporarily ground the negative leg of the battery bank!
5. Never permanently ground either the positive or negative leg of a battery bank.
6. Never get between the positive leg and negative leg of a DC system.

One Final Story

I was recently contacted by an individual working on a wind system that was struck by lightning. Apparently lightning hit the incoming wires on the tower. The destruction was almost total: the tops were blown of all the batteries, and the battery shed burned to the ground. The control panels, inverters, and distribution panels inside the house were destroyed. Every outlet in the house had a three foot hole blown around it. The system used multiple grounds and had the negative leg of the battery bank grounded.

Had the system been floating, as it should have been, and had the system been grounded in only one place, less damage would have occurred. Banks that are floating usually have only one or two batteries destroyed.

Upon Further Review

I do not claim to be an expert on the NEC. I do, however, have a certain amount of expertise with wind electric systems. Maybe it is time that the home power people who produce their own electricity (photovoltaic, wind, hydro) sit down with the people responsible for the NEC and update them on what's happening on our individual scenes. It can only help!

Access

Mick Sagrillo has never been penalized for intentional grounding at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

ANANDA POWER TECHNOLOGIES, INC.

SCI

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Lead-Acid Gel Cells

Pete Chiboucas

Every year brings new announcements about technological advances. In some areas progress seems to come by the inch, with each part of the inch won through incredible effort. Occasionally a miraculous discovery thrusts us light years down the road of progress in months. Frequently, new products find their way into the marketplace surrounded by controversy about the validity of the the technological claims. The debate can last for years, while manufacturers gather a following of believers, just as readily as critics gather evidence to support their claims.

Gel Cells

The new Gel Battery is such a product. Touted as the State of the Art in Lead Acid style batteries, these batteries are presented as being practically indestructible, while offering charge and discharge characteristics previously undreamt of.

The Gel Batteries differ from conventional deep cycle lead acid batteries in a number of ways. The electrolyte is not liquid but semi-solid or gel. Gel Batteries contain a large number of thin plates to facilitate plate/electrolyte interaction. The chemical composition of the plates, as well as the electrolyte, is different in the Gel Battery. The result is a battery that has a lower self-discharge rate, lower internal resistance (it will charge faster), and several other advantageous characteristics.

It was approximately four years ago that a Prevailer Distributor exposed me to my first Gel Battery. He came confidently into the shop with a DF 230 and a capacity meter in tow. "This battery can be installed upside down, discharged dead flat and left for months," he said. "It will charge twice as fast as a conventional battery and never needs maintenance!"

At the time I was involved with a group that designed electrical systems and electronic equipment for offshore cruising yachts. As in any Off Grid Electrical System batteries are a (if not the) critical part of the system. This fellow must have been monitoring our dreams, because he knew exactly what to say.

We took the battery in, along with his technical data and started testing. As we tested the battery we began asking for more information. Our search for the whole truth and nothing but the truth led to calls all over the country, even Germany. Here we are four years later and some aspects of this technology are still a topic for debate.

Capacity

The first thing we tested was the rated capacity of the DF 230. The information provided to us indicated that it was a 110 Amp Hour battery (at the 20 Hour Rate). The capacity meter he provided (one of the kind that bases its measurement on internal resistance) indicated that to be accurate. Calculated and measured (with an Amp Hour Meter) load tests confirmed this to be the case.

Recharge Rates

The claim that the battery will charge twice as fast as a wet battery is a little more difficult to prove. Information from the manufacturer in Germany demonstrated that the batteries did have a higher charge acceptance rate than wet batteries. C2 (50% of capacity) as a charge acceptance rate is twice that of a wet lead acid battery when you are less than 50% discharged. This information and information garnered from practical experience indicates that the Gel Batteries can be charged from a 50% state of discharge to a nominal full charge in half the time of a wet battery, if you have a large enough charge source. Most serious Deep Cycle systems are a little large to accommodate a 50% source for charging. In a constant current environment, there is little difference in the recharging time required. A 20% charge rate is as high as you want to use in a constant current system. I did work with a group on a fancy Offshore Racing boat that charged Prevailers at a 30% rate (constant current) to 15 Volts. The batteries were to be discharged at least 50% each day and charged in about 2 hours. Life expectancy was approximately 8 months. I have heard of similar systems having the same result. You can expect these batteries to charge more quickly than conventional batteries, and live their normal life, if you have an adequate charge source and stay within the recommended charging tolerances.

Cycle Life

Among the most debated characteristics is that of cycle life. Cycle life is the measure of how many times a battery can be discharged and charged before loosing a significant portion of it's capacity. As with rated capacity, there are many factors affecting cycle life and the parameters of any test must be specific to have meaning.

When dealing with systems such as Marine and Off-Grid, the 20 hour rate is the most common choice. To determine cycle life expectancy a battery is discharged at 5% of its 20 hour rate until it reaches 10.5 Volts (in a 12 Volt system), at a specified temperature. Then the battery is recharged and the discharge repeated. How many times this cycle can be repeated before the battery loses 20% of its original capacity is a frequently used measure of cycle life.

All of the data provided to us indicated the gel battery would cycle 200 times according to these parameters. When questioned, the local distributor said that these numbers were far too conservative. In the interest of truth I personally contacted Prevailer America (this was in 1989). An individual who was introduced to me as a staff engineer stated the 200 cycle information was accurate.

In the following couple of years evidence from the field seemed to confirm the 200 cycle number. The most dramatic being a customer whose gel battery failed after 8 months (approx 240 days). A little investigation showed that he was discharging 100% daily.

Just a couple of months ago I put the question: " How many times can you cycle a Prevailer to 10.5 Volts, at the 20 hour rate, at 80°F, before it will lose 20% of its capacity?" to an engineer at East Penn (the current license holder for American Prevailer). The answer: 200. I put the same question to an engineer at Johnson Controls, makers of the Dynasty Gel Battery, concerning their product. The answer: 200 times.

Still common are advertising claims of 1000 full cycles for Gel Batteries. The distributors who make these claims maintain that the information supporting 200 cycles is not accurate for all of the batteries. They say that to use the same parameters used on wet batteries does not take into consideration the special qualities these new Super Batteries offer us.

At the time of this writing the distributor in my area is reasserting his claim of 1000 full cycles. He even provides a copy of a memo addressed to him from Prevailer America (dated in 1989) supporting this claim. I attempted to contact someone at East Penn to confirm this information (since it was in direct conflict with some of the information I had previously received) and my phone calls were not returned.

In Conclusion

It cannot be denied that there are intrinsic benefits to the gel technology. They do charge faster in constant voltage systems than wet lead acid batteries. No acid will spill if they are turned over. They require no maintenance. It is true that you can restore a gel battery to near full capacity after a total discharge, although they will develop a high internal resistance which must be overcome, making charging difficult in many systems.

In marine systems if the battery is difficult to get to for service, or if the owner is notorious for poor maintenance habits, I will frequently recommend the gel technology. Offshore racing boats reap benefit from this technology. If, however, an average quality lead acid battery is properly maintained it should last at least as long as the gel in a cycling situation. A good quality wet battery, like the Trojan L16W or Surrette, should live much longer. If the claims of 1000 cycles (per the above parameters) are ever supported irrefutably, then this is truly a fantastic technology. Some more time is needed before experiences in the field are conclusive, and cycle life testing doesn't seem eminent.

Only you can be the judge of what is important to you in your system. If you do not care for your batteries, then the gel may be right for you. If the small amount of care required to maintain a wet lead acid, or Ni-Cad, is within your capabilities, then careful consideration should be given to the rival, more traditional technologies. In the "Bang for Buck" department, good quality traditional batteries are steadfast, predictable, and true.

Access

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First Year PV Basics

Richard Perez

The transition from grid power, generator power, or no power at all to solar power can be confusing. The user becomes his own power company and in the process inherits the responsibilities along with the Watt-hours. Fortunately, PV systems are ultrareliable, simple to size, install, and operate. The user only needs to know a few basics to get started on PV power. So, country folks and city dwellers, here's a guide to the basic concepts involved in a simple starter PV system.

The Need is for Electric Power

The size and success of your new PV system rests on you. What do you want to power with the system? What kinds of appliances will you power? How long will you power them? All of these considerations affect the design and size of the system. If you are considering putting your entire home on PV power, then you have two choices. One, learn to do the job right yourself. Two, hire a pro with the knowledge to do the job for you. The cost and complexity of a PV system increases with the amount of energy required from it.

If, however, you wish to replace the kerosene lights, or take a circuit in your home off of the grid, then this article, about simple and inexpensive systems, is for you.

Four Major Components

Every PV system has the same major components. The only difference is the quantity of hardware. This means you can get started with a small system, learn first-hand from that system, and expand it later.

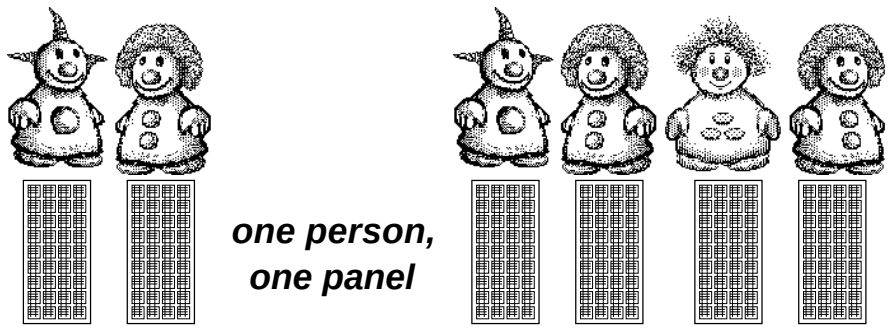
The four major components in a PV system are: energy source (the PV modules), energy storage (battery), energy processing (inverters, controls, instruments, and such), and loads (appliances).

Every system has these components; the only differences are in size and quantity. For our purposes here, consider a small system as one that uses between one and four PV modules. Such a system will use between two and four small lead-acid batteries like the Trojan T-105 (220 Ampere-hours at 6 VDC). Energy processing may or may not include an inverter (like the small Trace 612 or PowerStar models), a simple charge controller (like the Trace C30A), and a voltmeter. Typical loads appropriate to the small starter system are: lights (high-efficiency fluorescents), electronics (TV, stereo, VCR, computer, etc.), kitchen appliances (blenders, juicers, & mixers), and smaller workshop tools (like drills & saws).

A Starter System

I have written many articles detailing the mathematical approach to system sizing and design. This article is different. Here we are going to size and design the system with a nontechnical approach. We are going to design the system by the person. Sort of a "one person, one panel" approach to solar energy. This will work. It is based on my experiences in over one hundred small PV systems.

The starter system will use a 12 Volt battery. This keeps the system affordable to those now using kerosene lights. It also makes the system inexpensive enough that folks downtown can use it to gain experience in RE use. The system is designed to be expandable. It can grow about three times in capacity without requiring major component replacement.



one person, one panel

PVs

Allow one 50 Watt PV module for each person in the household. This means that each person can use, each day, the

energy produced by a single module— about 250 Watt-hours. While 250 Watt-hours may not sound like much electricity, it is more than enough for lighting, electronics, and conservative use of kitchen appliances and shop tools. Cost is about $370 per installed module.

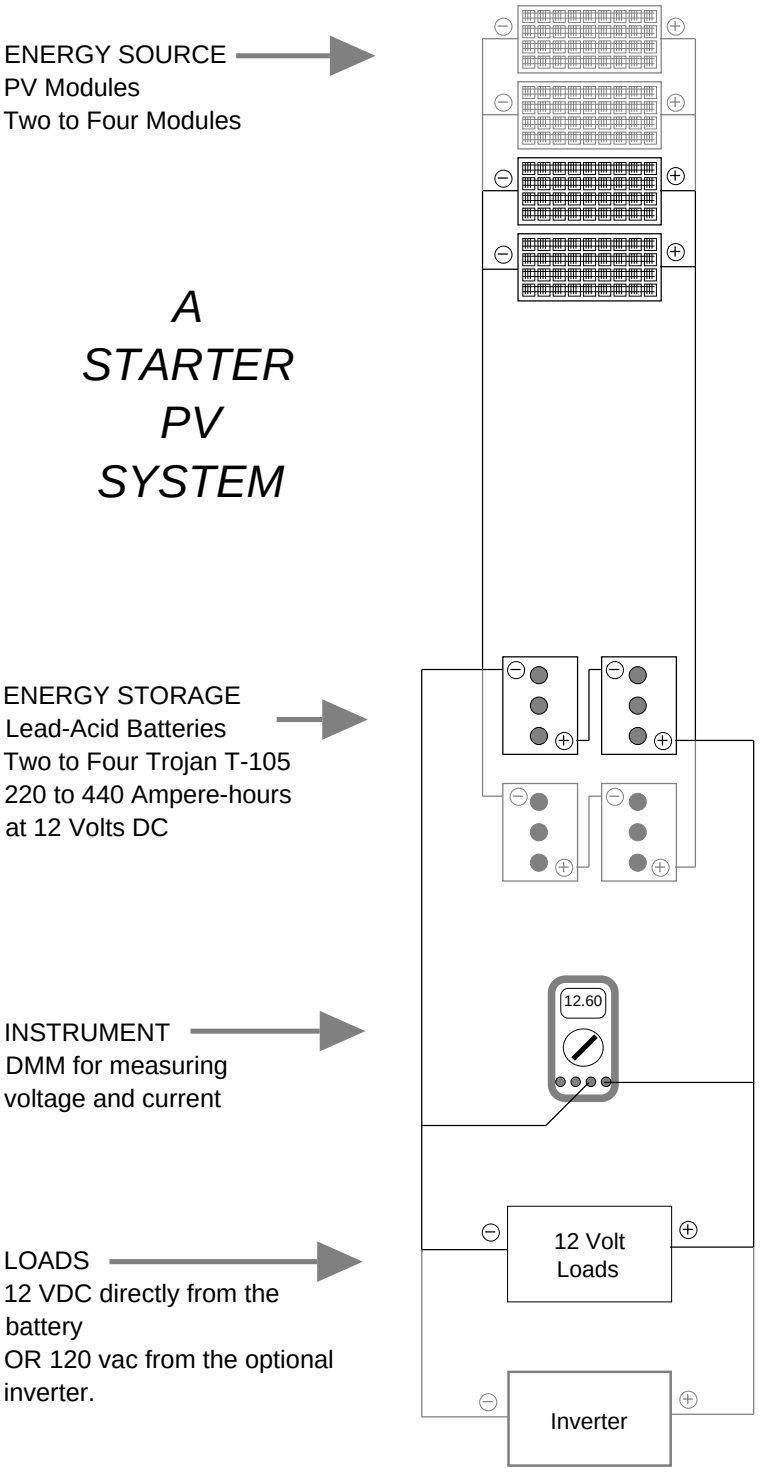
Battery
Provide about 220 Ampere-hours of battery storage for each two people in the household. For example, this means two Trojan T105s (or equivalent) for a family of two and four T105s for a household of four. The resulting system is properly proportioned and will supply power for about four sunless days in a row. Battery cost will be about $170 for two batteries to $340 for four batteries. These "golf cart" batteries will last about five years and can then be replaced with higher quality storage.

Inverter
The use of an inverter is optional. In small systems, it is often much less expensive and less difficult to use the power exclusively as 12 VDC. Efficient low voltage DC lighting is readily available as are many varieties of low voltage electronics (stereos, TVs, and radios). The starter system is capable of supporting a small inverter. The Trace 612 and PowerStar UPG400 and 700 will function well and supply 120 vac for appliances like VCR, TV, and even compact fluorescent lighting. Using an inverter will add about $600 to the system's overall cost.

Controls
A control is not necessary if the system is continually occupied. If you go on vacation simply disconnect half of all of the PV modules. If you do wish to add a control, then keep it simple and inexpensive, like the Trace C30A for about $85.

Instruments
For economy and flexibility, buy a digital multimeter (DMM). The DMM can make most essential voltage and current measurements. An instrument provides you with the information required to operate and learn from your system. If bucks are tight, go to Radio Shack and spend about $60. If you can afford it, either a Fluke 77 ($130) or a Fluke 87 ($280) will accurately serve you for a lifetime.

A STARTER PV SYSTEM



Installing the Starter System
Mount the PV modules on metal racks or even wooden ones. The racking is not as important as the location. Make sure that the PVs are mounted where they will receive the most sunshine. Mount the PVs at about a 45° angle to horizontal and facing due south. Wire

the modules with 10 gauge wire. Wire the modules in parallel, which means all the modules have their positive terminal wired together, and all their negative terminals wired together.

Bring the PV power to the battery with 10 gauge wire for less than 25 feet (one way between the modules and the battery), 8 gauge for about 50 feet, 6 gauge for 75 feet, and 4 gauge for 100 feet. All distances are one way, i.e. the physical distance between the battery & modules. Use UF type insulation for wire exposed to sunlight and USE type insulation for wire that is buried.

Locate the batteries where they are warm, dry, and not in human living spaces. Build a battery box (or buy and modify a plastic/foam ice chest), either inside or outside the house. A box keeps the battery clean and protects humans from the acid and fumes involved. I have lived within five feet of a working lead-acid battery for the last twenty years with no incidents. We are now building a power house so that the batteries are out of our living space. 'Nuff said.

The rest of the wiring is straightforward. Keep track of positive and negative wires by color coding. Twelve volt convention is red is positive and black is negative. 120 vac convention is black is hot, white is neutral and green (or bare) is the redundant, vestigial ground.

Operating the Starter System

Keep an eye on your battery's voltage. If the voltage dips below 12.2 Volts, then it is time to ease up on power consumption. If the battery voltage is below 11.9 Volts, then it is time to STOP consuming power until the PVs refill the battery. A full battery will show a voltage around 14.5 to 15 VDC while under charge by the PVs. That's about all there is to it.

This regime is not designed to give maximum life from what is a short-term battery. This first battery is a learning experience for you. It is inexpensive and suitable for making mistakes. Through this first battery you will learn the advanced lessons of PV life.

Getting Started

The important thing is to get started. Don't wait until you can afford a megasystem or to take your whole home off of the grid. Do it now. Replace those kerosene lamps. Take your house off the grid a circuit at a time. Only through actually living with solar energy can you learn the lessons you need to know.

Access

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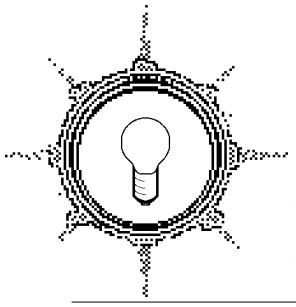

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☐ **As my only power source** ☐ **As my primary power source**

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My site has the following alternative energy potentials (check all that apply).

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NOW	FUTURE		NOW	FUTURE	
☐	☐	Photovoltaic cells	☐	☐	Gas/Diesel generator
☐	☐	Wind generator	☐	☐	Batteries
☐	☐	Water power generator	☐	☐	Inverter
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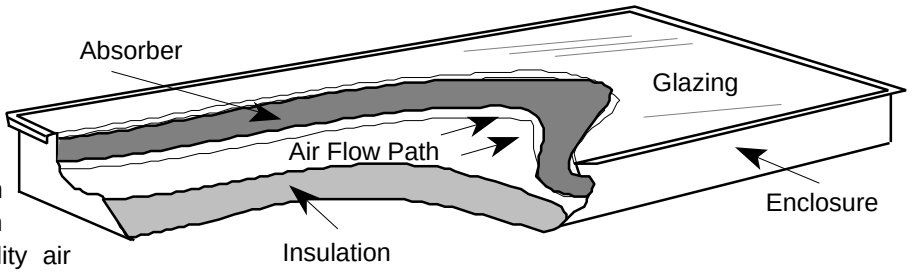
Solar Hot Air Collectors

Chuck Marken, Debby Jennings, and Jeff "Smitty" Schmitt

Solar air collectors are the best kept secret in the solar industry. Throughout the 1970s and 80s, air collectors were virtually ignored by government-supported R&D projects. Air collectors hold their small position in the marketplace as a result of private enterprise and 'word of mouth' advertising. Air collectors are being used successfully today for such diverse applications as composting toilets, heating water, and benzene removal from the earth. Their main function is for solar space heating of homes and buildings.

The Collectors

When we started installing solar air systems in the late 1970s, most collectors were of questionable construction, with efficiencies of 40 to 50%. By 1985, efficiencies had risen to 60 to 70% and collectors were built with life spans up to fifty years. All high quality air collectors today have three things in common: an enclosure made of aluminum or steel, insulation on the back and sides and low iron, tempered glass glazing on the front. Differences in design are in the absorber plate that collects the solar energy and in the way that the air is passed over the plate. Air collector designs are called front pass, back pass and dual pass with reference to whether the air is passed on the front of the absorber, the back, or both sides. Due to significant heat loss from the heated air touching the glass that is exposed to the outside elements, front pass and dual pass collectors normally have two pieces of glass with an insulating dead air space between them. Back pass collectors normally have a single glazing with a dead air space between the glass and the absorber plate. Because of the added cost of an extra glazing, most of our installations in the last five years have used back pass collectors.



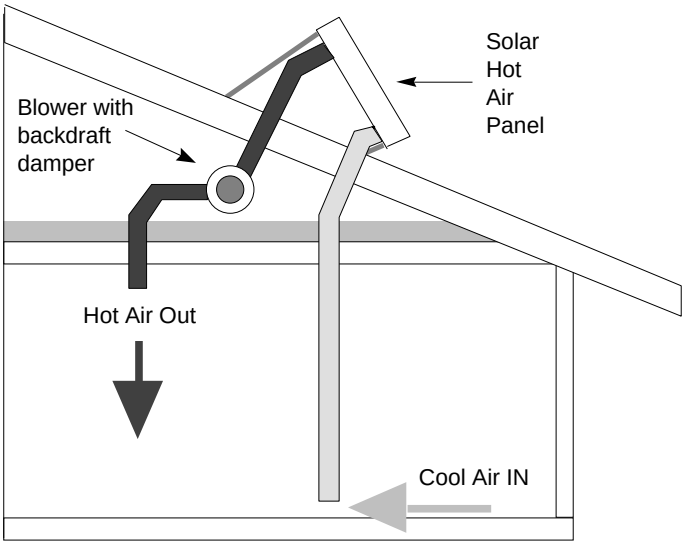
Absorber plates are made of aluminum, steel or copper. The plate is coated on the side facing the sun with black paint or a selective surface process. Selective surfaces (black chrome) increase efficiency 5 to 10% by limiting reradiated energy back through the glazing. Air collector absorber plates should be dimpled or corrugated to create air turbulence that helps 'wash' the heat from the plate. The best collector today in terms of 'bang for your buck' is a 4 foot x 8 foot or 4 foot x 10 foot, single glazed, low iron, tempered glass, back pass design with a selective service absorber and insulated aluminum enclosure.

Blowers and Controls

When installed properly a 4 foot X 8 foot air collector can provide 25 to 50% of the energy needed to heat a 400 to 800 square foot space depending on climate and building construction. This makes air collectors systems ideal for zone type heating systems. We normally use a separate blower, control and ducting system for every 32 to 64 sq. ft. (one or two 4 foot X 8 foot) of collector area. The blower pulls air from the cold air inlet of the space through the collector and blows the heated air back to the hot air outlet. Optimum performance is achieved with a squirrel cage blower of approximately 200 to 400 cubic feet per minute air flow. Smaller blowers can be used and performance is slightly affected, but they must be of a squirrel cage configuration.

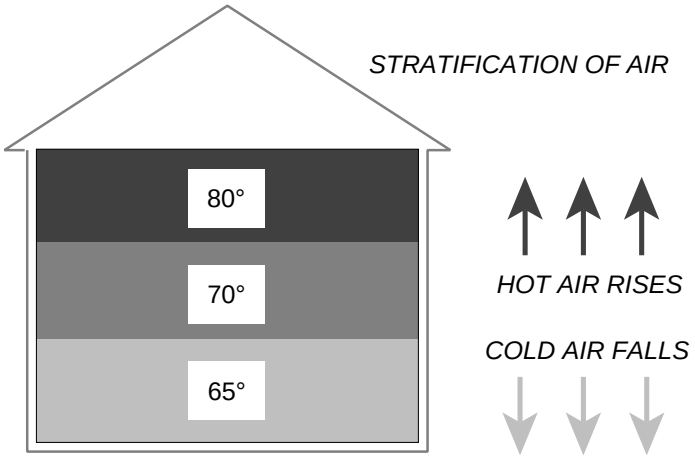
The system is controlled by a simple, reliable bi-metal switch in the collector which turns the blower on at 110° and off at 90°. This gives automatic operation with each sun cycle. An interior thermostat or manual switch wired in series with the with the bi-metal switch allows the occupant to "call for heat" or shut the system off when heat is not required.

The system is completed with the addition of a backdraft damper in the duct system to prevent nighttime cooling from thermosyphoning.



Air Movement

Hot air rises and cold air falls. This concept of air movement, called natural convection, is important in any space heating project no matter what fuel is used. Wood stoves are superior to fireplaces in heating mainly because the stove causes a convection current of air throughout the room or building. Most fireplaces only radiate heat into the immediate area. Although this concept is ignored in designing many modern fossil fueled heating systems, it is an integral part of all successful solar heating installations. If a solar heating system works with natural convection, hot air rising and cold air falling, then the results in comfort level can exceed expectations.



The Installation

Almost everyone today only lives in half their house– the bottom half. We need heat the most when the weather is cold and we are sedentary (sitting or lying down). In any building with little air movement the air tends to stagnate or stratify. Air temperature rises approximately 1°F. per foot. (The ceiling of an A-frame house can be 20° to 25° hotter than the floor.) Any good space heating system is designed around the fact that we live near the floor and the heat is at the ceiling.

The cold air inlet to the heating system is the key to efficiency and comfort. To heat any given space, the cold air must be removed and circulated through the heater; therefore, the inlet must be ducted so it is on or near the floor. If the inlet is placed on the ceiling, the heater will tend to recirculate the hot air and leave the floor cold. The hot air supply may be placed at the ceiling or on the floor with little difference in performance. If placed on the floor, the hot air rises to the ceiling within a short distance. Since collectors are normally installed on the roof of the building being heated, it is best to place the hot air outlet in the ceiling to shorten the duct run. A system installed in this manner destratifies, or mixes, the air in a building like a ceiling fan, in addition to supplying solar heat.

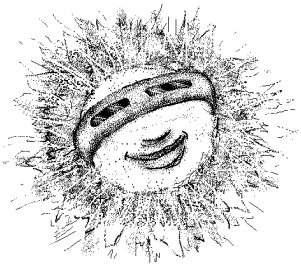
Orientation

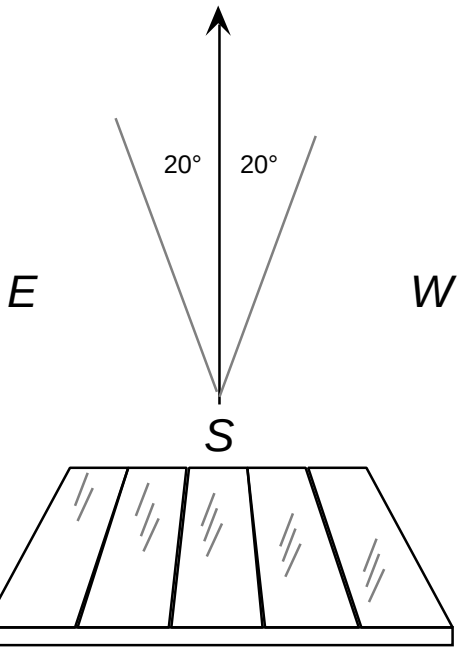
The orientation of solar collectors (which way they face and how they are tilted) optimizes their collection ability. The earth's atmosphere absorbs and reflects a significant portion of solar radiation. Thus, the most energy that can be gathered on any given sunny day is at solar noon, when the direct beam radiation is least affected by the atmosphere. Solar noon is true south in the northern hemisphere. Although orienting the collectors to true south will normally maximize performance, a variation within 20° east or west is acceptable without additional collector surface area. Local weather patterns (i.e., morning haze or prevailing afternoon cloudiness) should also be considered in collector orientation. If local weather is not a factor and collectors cannot be faced true south, orienting them to the west is generally preferable due to higher afternoon temperatures (collectors have less heat loss with higher outside temperatures).

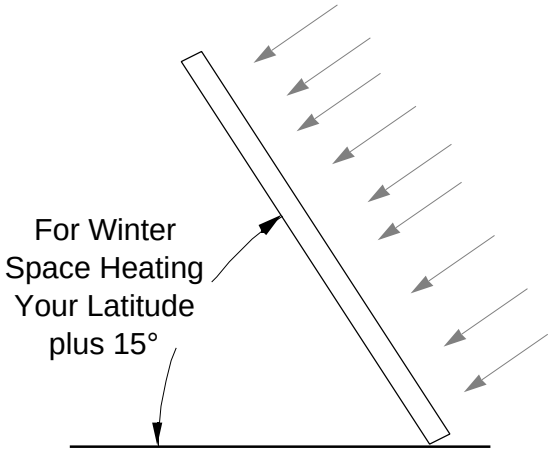
Since elevation of the sun varies throughout the year depending on local latitude, collectors should be tilted towards the sun depending upon application. The angle of tilt is determined by local latitude and type of system. Space heating systems are tilted more to the position of the winter sun.

Energy Storage

The main niche for air collectors in the solar industry is supplying 25 to 50% of required energy for space heating. Additional storage is not required in most cases. A normal, well insulated house has enough interior mass alone to store enough heat for three to four hours after sundown, if the temperature is raised 10°F. (i.e., 68° starting, 78° ending). More massive construction, such as







Access

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adobe or block, can store even more thermal energy. Due to their complexity, large rock and water storage systems are rarely cost-effective. They often require extraordinary maintenance.

The best features of air collector systems are simplicity and reliability. The collectors are relatively simple devices. A well-made blower can be expected to have a 10 to 20 year life span if properly maintained, and the controls are extremely reliable. Since air will not freeze, no heat exchanger is required. By using packaged insulated flex duct, the installation can be accomplished by anyone with a little mechanical ability. All this adds up to a quick pay back on the cost of the equipment, perhaps saving a few trees and helps give the environment a needed boost.

Things that Work!
The Wattsun Two-Axis PV Tracker

Richard Perez

Things that Work!
tested by Home Power

Using a tracker to follow the sun is far from a new idea. Trackers have been used for years to maximize PV power production. The Wattsun tracker is different from others because it tracks both the east to west axis and the north to south axis. It is electrically operated making it very reliable and ultraprecise.

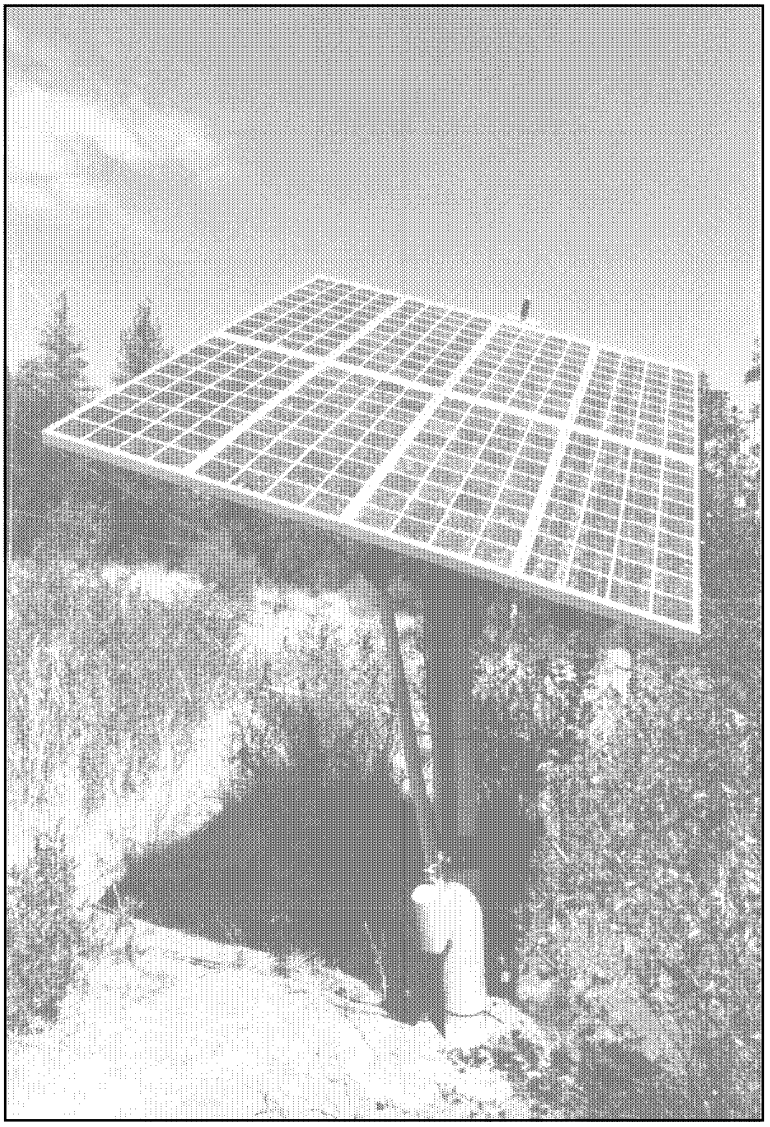
The Concept

The power output of a PV panel depends on the amount of light falling on the panel. By moving the PV modules so they are alway facing the sun, we can maximize their production. A device that keeps the modules perpendicular to the incoming sunlight is called a tracker.

Before the Wattsun, trackers used the sun's heat to move the modules around a single east/west axis. These types have had problems in cold windy climates where the tracker cannot build up enough thermal energy to operate.

The Wattsun uses two electrically powered linear actuators to move the modules. These linear actuators are the same kind of motorized, long screw actuators used on satellite TV dishes. The Wattsun uses one actuator to move the modules from east to west and a second actuator to move the modules north to south. Both electric actuators are controlled by a brain box that constantly keeps the tracker perpendicular to the sun within 0.5° on both axes. The power for the tracker comes from one of the modules mounted on the tracker. Wattsun uses a small on-board battery to return the array to the east about one hour after sunset. This means that the tracker is facing east and ready to work at dawn.

The use of any tracker assumes two things. One, that you have a tracker site with unobstructed sunshine from dawn to dusk. And two, that you are placing at least eight modules on the tracker. Using fewer modules is simply not cost-effective unless the system is highly specialized, like array-direct water pumping.



Above: A Wattsun two-axis PV tracker with eight Kyocera K51 modules aboard. The tracker is supported by a five inch steel pipe set four feet into the ground with cement.

Shipping & Documentation

The Wattsun tracker arrived via UPS in four cartons. This is radically different from shipping

other types of trackers. Most trackers are assembled at the factory and shipped via truck. The Wattsun is shipped dissembled and that saves money in shipping costs and transportation costs to the site.

The documentation is extensive and complete. Bob-O Schultze and I had very little trouble assembling the tracker from the provided documentation. Our only complaint is that the docs could have used a greater number of more detailed diagrams.

Installation

We installed the Wattsun tracker on Agate Flat on 15 May 1991. This particular Wattsun holds eight Kyocera K51 modules and costs $1,135. Other Wattsun models will track from four to twenty modules. We mounted the tracker about twenty feet east of an identical static array. Both the eight tracked panels and the eight static panels supply the same battery in Home Power's main system.

The Wattsun is mounted on a ten foot length of five inch diameter schedule 40 steel pipe. We dug a hole and sunk about four feet of the pipe into the ground. We used eight bags of redimix concrete to cement the pipe in place. Two days later we assembled the tracker on top of the pole.

I've installed eight module trackers before. The last one took four people all day with two step ladders to get the tracker mounted on top of the pole. The Wattsun went up with two of us in four hours and we never used a ladder. This tracker could easily be installed by a single individual with no ladder at all. All the parts are very well-made and finished. Everything fit with no drilling and nothing even required persuasion with a hammer.

Performance

It works. The Wattsun relentlessly follows the sun. It adjusts one or the other axis about every six seconds. The modules are always perpendicular to the sun. The Wattsun's brain is smart enough to even find bright areas of sky during cloudy and overcast conditions. The tracker has survived high winds (≈60 mph), two heavy rains (over an inch in thirty minutes) and walnut-sized hail.

I inserted a shunt in line between the eight modules on the Wattsun and the main power wiring. I did the same with the identical array of untracked modules. Then I measured the daily Ampere-hour production of the Wattsun tracked array and the static array. The eight modules on the Wattsun produced 187.2 Ampere-hours that day. The identical untracked array produced 141.7 Ampere-hours on the same day. This is a 32.1% increase in power production due to tracking the array. This test was done on 10 September 1991 and the temperature was a warm 85°F. This test measures tracker gain in a good (but not perfect) tracker site during the fall. Increases in the summer will be more (≈50%), and less in the winter (≈20%). An excellent tracker site, with dawn to dusk sunshine, will see the average yearly gain of 40% claimed by Wattsun.

This Wattsun tracker uses less than 20 Watt-hours of energy per day to operate. The tracker gets this power from one of the modules mounted on board. The tracker uses about 5% of just one module's energy output to operate; it is very efficient.

In all my years of watching single-axis trackers, I have never met a user that regularly adjusted the second, manually controlled, axis. The Wattsun is the first to completely automate the tracking process in both axes. This alone puts the Wattsun far ahead of other trackers. The Wattsun is never more than 0.5° from perpendicular to the sun in both axes. Thermal trackers are usually within 10° of perpendicular on their single east/west axis, and wherever the user set them on the north/south axis. If the average single axis tracker stays within 15° on its user adjusted second axis, I'll eat my hat. In my experience, users don't regularly adjust the second axis.

The Wattsun also eliminates the vagaries of heat-powered trackers. Heat-powered trackers wait until they warm up in the morning and then swing to the east. The Wattsun goes back to the east just after dark and is ready to face the dawn sun. Heat-powered trackers also have problems in cold and windy climates. The tracker simply cannot build up enough heat to operate. All of these vagaries are eliminated by using electricity to power the tracker.

Conclusions

The Wattsun is the most effective PV tracker I have ever seen. Its performance is reliable and precise. I have never been excited enough by a PV tracker to install one in our system. The mechanical vagaries seemed to decrease the inherent reliability of the PV system. Wattsun has changed my mind. They have made a PV tracker we can rely on.

Access

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Things that Work!

The New Trace 2012 Inverter with Battery Charger

Testing by Bob-O Schultze and Richard Perez

Things that Work!
tested by Home Power

More than anything else the advent of reliable and efficient DC to AC inverters has brought the use of renewable energy into the mainstream. There are more Trace inverters in home-powered households than any other brand. For many years, Trace Engineering has set the standards by which all other inverters are measured. Now, the best just got better again!

Packaging and Documentation

Trace has always packaged their inverters as if they were headed for the African bush. No doubt some are. A custom fit framework of tight cell foam surrounds the inverter on all sides. The whole shebang is then wrapped in plastic and slid snugly into a heavy, unbleached cardboard box.

The owner's manual is meant to have a place in the reference section of your bookshelf. The manual is FORTY FOUR pages of very well-thought out and readable instructions, tables, charts, and graphics. This is no small thing. An inverter/battery charger as full of features as the Trace 2000 Series requires a good operation and installation manual. Writing such a manual that is understandable by the average user is a large order indeed. Nobody does this better than Trace.

The Inverter

The inverter section of the Trace 2000 series is essentially unchanged as far as operation is concerned: very well regulated 120 vac RMS output (±2 vac) between 10.8 and 15.2 VDC input, well over 90% efficiency in the output range where the inverter will likely spend most of its on-time, and the best self-protection circuitry in the biz—bar none. What all this adds up to is HIGH reliability.

The big change in the inverter section is the new placement of the Search Mode control. Gone forever is the little dammit dip switch stuffed sideways halfway under the charger control board. In its place is a cute little blue adjustable resistor (potentiometer) on the front plexiglass panel that's adjustable from 5 to 80 watts. The search mode feature puts the inverter to sleep when there is no load, or a small load below the adjustment threshold. This allows the inverter to go to sleep when you do, resulting in many Amp-hours saved from your battery.

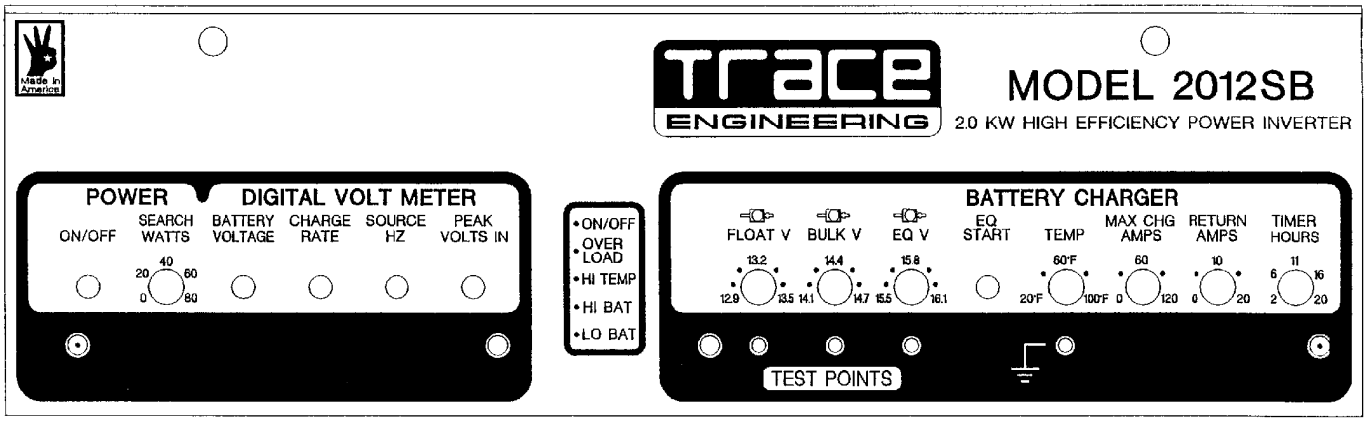
If there's a wart to be found anywhere on this inverter, it is that it shuts itself off at battery voltages about 15.5 Volts This makes it difficult to use this inverter with alkaline batteries. There are good engineering reasons for the 15.5 V cutoff. With a transformer-based inverter, there is a finite input voltage "window". Feeding the inverter voltage which is higher or lower than that window makes precision output voltage regulation iffy. Rather than chance feeding your expensive appliances something nasty, Trace wisely chose to shut down the machine entirely. Trace is aware of the growing use of alkaline batteries and is working on either a modification of the existing unit or a new model entirely.

The Standby Charger

Merely saying that the charger section of the Trace 2000 series has been updated would be an understatement. One look at the controls (now mounted on the front panel) is enough to convince you that this is an entirely different inverter. This sophisticated new circuitry utilizes a three step design to maximize battery life and generator efficiency. The adjustable controls not only allow the user to fine tune the charge rate during the three charging steps, but also incorporate a timer to insure that the charger doesn't hold the batteries at high voltages during prolonged periods of generator operation or ac grid connection. Want more? OK, there's also a timed, voltage-adjustable, equalization cycle to allow you to give your batteries an occasional controlled overcharging to combat the effects of plate sulfation and stratification of electrolyte. More? How about a temperature control which allows the user to program in the ambient temperature of the battery environment to further optimize the charge rate settings. Whew!

The Controls

Max Chg Amps- This control sets the maximum charge rate in amps. Trace recommends finding this setting by dividing your battery capacity by a factor of 5 (for



lead-acid and 3 for gel-cells) when using a generator for recharging. Alternatively, if your generator is not up to maximizing the charge rate while also running any concurrent loads, you can use this control to optimize your generator's output efficiency.

Bulk V- This controls the maximum charge voltage during a normal (not equalizing) charging cycle. For most lead-acid batteries, this is 14.4 V for non-sealed and 14.2 V for sealed batteries.

Return Amps- An interesting adjustment. As the battery voltage rises and the current into the batteries tapers off, this setting controls when the charger switches from bulk charge to the float cycle. So? Well, if your system has any constant DC loads, like radios, pumps, a refrigerator, etc., the current requirements of the loads could keep the charge rate from falling low enough to switch to the float cycle. Increasing the setting will compensate for DC loads.

Float V- Once the batteries are fully charged, this control sets the voltage at which the charger will hold the batteries during periods of extended generator usage or connection to an ac grid. The default setting is a safe 13.2 VDC.

Timer Hours- This control limits the amount of time that the charger holds the batteries at the maximum (Bulk) charge voltage. It also controls the maximum duration of an equalization charge cycle.

EQ V- This controls the maximum voltage for an equalization cycle. It is adjustable from 15.5 to 16.1 VDC.

EQ Start- This switch which initiates the equalization cycle. During equalization, charging will continue at the Max Chg Amps rate until the batteries reach the EQ V setting or the Timer Hours times out the cycle.

Temp- Using battery voltage to determine the state of charge is temperature dependent. A cold battery will need to attain a higher voltage to be full than a warm battery. Setting this control to the ambient air temperature of your battery compartment allows the Trace to adjust the Bulk, Float, and EQ maximum voltage points accordingly. For the technerds in the crowd, the compensation slope is -3.9 mV. per degree C. based on cell voltage.

Three different colored mini LEDs mounted on the front panel indicate at a glance which cycle the charger is working on.

Potentiometer settings not accurate enough for you? Four access holes in the front panel allow insertion of test probes from your DMM to tweak the three cycle voltage settings to within 0.1 VDC.

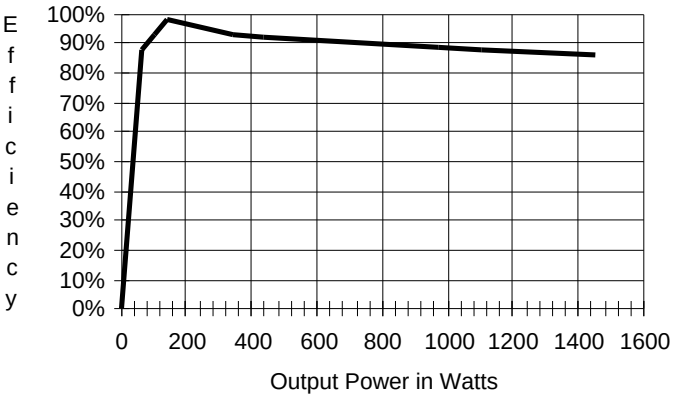
Inverter Testing

We tested the inverter output using a variety of different loads. Four Fluke 87s were used to measure DC input voltage, DC input amperage, RMS ac output voltage, and ac amperage out to the loads. Most of the readings were taken on resistive loads, i.e. light bulbs, heaters, etc. The Trace would start and run all the inductive and inductive plus resistive loads that we could lay our hands on just fine, but inductive loads caused errors in our measurements, so we discarded the measurements. The table and graph tell the story.

Trace 2012SB

INPUT			OUTPUT			
VDC	Amps	Watts	Vrms	Amps	Watts	Eff %
13.90	5.1	71	121	0.52	62	88%
13.80	8.0	110	121	0.85	102	92%
13.64	10.4	142	121	1.15	139	98%
13.42	27.2	365	121	2.82	340	93%
13.24	36.0	477	120	3.66	440	92%
13.08	84.0	1099	120	8.12	973	89%
13.00	96.8	1258	120	9.25	1106	88%
12.85	132.0	1696	119	12.21	1454	86%

Efficiency vs. Output Power for Trace 2012 Inverter



Charger Testing

The Trace was sourced by a 3.5 Kw. Miller alternator. It didn't have the suds to push the maximum 110 Amps DC out of the Trace, but it managed 85-90 Amps just fine. The problem with most fossil-fueled generators is low peak-to-peak voltage output. If you're looking for full output from the Trace charger, get a generator in the 6.0-6.5 Kw. range. The Turbofan (Trace option ACTC) is a good idea if you need or want to push the charger to its maximum potential. After a couple of hours of 85 Amps DC output, the heatsinks got pretty warm. I suspect that 3 or 4 hours of max output would cause the charger's thermal protection circuitry to be activated.

Conclusions

The Trace 2000 series has the most full-featured and intelligent battery charger on the home power market today. Frankly, most users won't use all of those features, but for those that can, wow! The greatest benefit will be realized by those folks who occasionally plug into the grid or shore power. For those folks, it's an amazing set-it-and-forget-it system. The weekend sailor, for example, can plug into shore power on Sunday night and come back the following Friday after work to find his batteries fully charged and ready to boogie. The rest of us will just have to be satisfied with the most reliable inverter available today. The price is the same as always.

Access

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ECS
camera-ready

Things that Work!
tested by Home Power

Things that Work!
Offgrid Systems' Power Meter 15

Testing conducted by Sam Coleman and Richard Perez

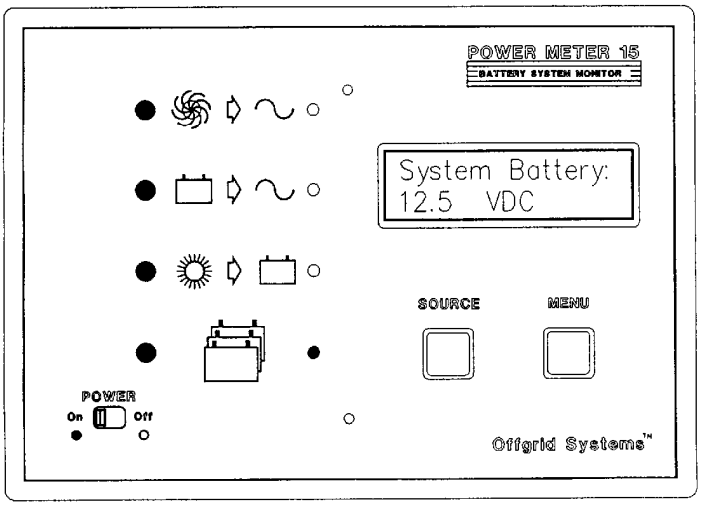
It was just a matter of time before someone applied a full blown microprocessor as a system instrument. Offgrid System's monitor uses a dedicated computer to measure and record a wide variety of system data. The Power Meter 15 gathers vital information from the battery, the DC power source (PV, Wind, Hydro, or whatever), the inverter, and the 120 vac engine/generator.

What is a mystem Monitor?
Every user of renewable energy needs information about the system's performance and status. Without accurate data it is difficult to effectively operate the system. Without accurate data it is far more difficult to learn from the system as it operates. A system monitor provides information about major component performance.

Offgrid Systems' Power Meter 15
This meter used a miniature computer called a microprocessor to measure and record system functions. The data is displayed on a two line, sixteen character per line, alphanumeric LCD display. The display uses plain English prompts to tell the user that he is viewing, for example, system battery voltage. Several measurement functions also have recording and/or alarm capabilities. This instrument measures so many components in so many ways that we need to look at each in turn to avoid being swamped by the data.

Battery Channel
The unit measures system battery voltage, lowest recorded battery voltage, highest recorded battery voltage and average battery voltage. There are also user programmable alarms for high and low battery voltage. There is also a channel that measures the voltage of the 9 VDC battery which provides memory backup power.

DC Power Input
This channel of the meter is used to measure the power output of any low voltage DC power source. It can be used to measure the output of PV modules, a wind machine, or a microhydro turbine. The DC input channel is user selectable to handle either 32 or 250 Amperes using the appropriate shunt. The DC input channel measures these parameters: Amperes, Watts, Ampere-hours, and Watt-hours. The system monitor measures and records DC production in both Ampere-hours or Watt-hours. This means that the unit is also a totalizing Ampere-hour meter and a totalizing Watt-hour meter in addition to an instantaneous Ampere and Watt meter. This amount of data on the DC input channel is unique, and allows the system user to very accurately measure and record renewable energy potentials at his specific location.



Engine/Generator Channel
This channel measures the critical output parameters of engine driven 120 vac generators. It measures peak voltage, frequency in Hertz, current operating time in hours, and accumulated operating time in hours. These functions give the data necessary to keep the engine/generator happy and well adjusted. Both peak volts and frequency are used to set the generator at the proper operating RPM. The timer function help to keep track of fuel consumption and periodic oil changes.

Inverter Channel
The Power Meter 15 measures the ac RMS voltage and frequency of the inverter.

Documentation and Installation
The Offgrid Systems' Power Meter comes with one of the best instruction and operations manual we have ever seen. Even though there are a snake's nest of wires crawling out of the unit's back, we had no trouble figuring out what went where. The documentation is extensive (22 pages). It answered all our questions about installation, programming, and resetting the many memories.

We installed the Power Meter in a standard single-wide plastic box just like the ones that hold ac wall outlets. We wired it into a PV system with nicad storage.

Operating the Power Meter
The unit uses two momentary switches to accomplish all display and programming chores. The user simply pushes a button to scroll through all the information provided by the monitor. Reprogramming the memories is as simple as setting a two button digital watch. There are simple to understand, plain English prompts on the display to assure that you and the meter are always communicating.

Performance
We ran all the instrument's functions and checked them against a battery of Fluke 87 digital multimeters. We did this for three months. All voltage measurements met the maker's specification of 1% accuracy. All current measurements met spec at 2%. Wattage measurements met spec at 5%. The derived statistics of Ampere-hours and Watt-hours met spec at 2% and 5% respectively. The inverter RMS voltage measured by the Power Meter was, while powering inductive loads, a few percent higher than its rated accuracy of 10%. The inverter frequency measurement was within the spec of 1 Hz. The 120 vac peak voltage measurement on the generator channel met spec at 10%. The other generator functions also worked as per spec.

Conclusions
The Power Meter 15 is a well-made, accurate system instrument. At a retail price of $345, it offers an incredible number of measuring functions, alarms, and memories in a single box. It is as accurate as its maker, Offgrid Systems, says it is. It has a very good "user interface" and is simple to use and understand.

Access
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Things that Work!
tested by Home Power

Things that Work!
Wattevr Works' Guzzle-Busters Kits

Installation and Testing by Kathleen Jarschke-Schultze

It was an older, clean, stock Maytag washing machine when it arrived. It had small pieces of black electrician's tape marking the start and stop on the control dial, as if someone who couldn't see very well had owned it. I figured it was a kindly old lady who only did delicates on Sunday. It looked like a one owner model.

Pre-kit Blues

I needed to run the washer before installing the kit to make sure it really did work to begin with. We have a Trace 2012 with 480 ampere hours of nickel-cadmium pack run off eight Kyocera K-51 PV modules. The Maytag would not run. It would not run on the Trace 2012 or the PowerStar UPG 1300. It was an older Maytag so Bob-O installed a capacitor between the motor and control panel. This allowed running the washer with the Trace, but not the UPG 1300. It ran very well, without any hitchs.

Our house usually runs on a PowerStar UPG 1300. Whenever I wanted to use the washer, Bob-O had to switch over to the Trace so I could do a couple loads, then he would switch back. Sometimes it was hard coordinating our time so that both of us could deal with the laundry in a timely manner.

Guzzle-Busters

When I received the kit for the washer (a Maytag 115 volt) is was well packaged for shipment. Everything was snug in its place and easy to find. Right on top were the instructions with the cover page shouting, "STOP & READ FIRST." That is exactly what I did. It was the evening before I was going to do the conversion so I did not feel rushed. I completely read through the booklet. It didn't seem all that difficult. The instructions are laid out so that as you complete each short step there is a place for you to check it off. This came in very handy later.

There are many warnings about safety. I can appreciate that. When working with electricity you cannot be too careful. Although I do not fear them, I have a healthy respect for deep water, sharp knives, fast machinery, and electricity. This has always stood me in good stead. These instructions may be followed fearlessly by a complete rookie.

Installation

The next morning Bob-O left for the day. I sent Allen to play in his fort after breakfast. With my only companion, Amelia Airedale, I ventured to the basement with instructions and a pencil. Everything went swimmingly until instruction #20. I couldn't find a 3/16 inch Allen wrench. I might suggest here that you assemble all the tools needed at the onset. I called my neighbor, Stan, and went and got the Allen wrench from him. He claimed you could do anything with the right tool. I demurred. There have been several times that I have wished for the upper body strength of the male to loosen or tighten various things. "Ah," said Stan, "there is always the lever, or cheater bar."

Once back to the basement the very first thing I encountered was a stuck allen bolt. The instructions suggested WD-40, which did not loosen it. The next suggestion was using a blow torch to heat it. I instinctively knew this was not an option for me. "Ah, the lever." It worked like a charm. I plunged onward.

The instructions were very easy to follow. The diagrams illustrated all that they should. I was having fun. I knew Bob-O would be proud of me, I was proud of myself. I was *doing* it! Also in doing the conversion I was learning how my washing machine worked and giving it a cleaning and tune-up at the same time.

In one place, you need to drill holes in the back of the washer. A template and a drill bit are provided for this. I saw the brilliance of this when I had to modify my first holes because they were a little off. I didn't have to worry about dulling one of Bob-O's tools, I had my own.

It was very exciting for me to watch the washer do its first load after the conversion. Everything went smoothly. I was triumphant. It took me four and a half hours working steadily (except for the trip to Stan's) but not hurrying. The machine now ran on the Trace, the UPG 1300, and even a PowerStar 400W inverter. This means it will run on the Trace 612 or any other inverter of that size.

Wattevr Works! Maytag Washer Conversion

Cycle Time in Minutes	Max. Peak Amps	Average RMS Amps	Average RMS Voltage	Watt-hours per Cycle	Power Source
41	6.00	1.59	120.50	130.92	Trace 2012
25	5.28	2.68	116.40	129.98	UPG 1300
31	5.44	2.60	115.70	155.42	UPG 1300
33	6.08	2.14	118.40	139.36	UPG400

When Bob-O saw the washer running he noticed that the agitation seemed a little slower than usual. I called Jim and he told us how to exchange the capacitor that was in the control panel for the one we had used to allow the Trace to run the unconverted motor. This solved the problem.

Conclusion

I now have the freedom to do the wash whenever I can get to it. This is really great. I find I can do a couple of loads (my clothes line holds three) every couple of days instead of one marathon day where I get nothing but laundry done.

All brands of washers and even different models within a brand use different amounts of power. There are no hard and fast figures for different brands; the range is from 350 watts-hours to 750 watts-hours for a load of wash. Guzzle-Buster Kits™ claim to lower a washing machine's power consumption by about three times. Our findings bear this out.

The main advantage of the kit is reduction of washer power consumption to about one-third of an unmodified washer. Other advantages of these conversion kits are: less stress/heat on the inverter, less PV/batteries needed in a new system, and large inverter not required. In an off-grid home adding a washer, the Wattevr Works' Guzzle-Buster Kit saves increasing PV/battery capacity.

Availability

Kits available for washing machines are:

1. Kenmore/Whirlpool (pre-1985) a very common washer-12 VDC–$448 115 vac–$398

2. Maytag 115 vac–$458

3. Newest models made by Admiral, Magic Chef, Norge, and Signature by Norge (M. Ward) 115 vac–$468

Call for information and prices on 24 VDC kits. Jim also makes a variation on these kits for shop machinery, wringer washers, large pumps, and fans. These kits are less expensive than the washer kits and are called 'Genuine Generic Kits.™' If the machine is used over 2 hours per week, and/or if no large inverter is owned, these kits become advantageous and cost-effective to install. They are available in 12 VDC, 24 VDC, or 115 vac. Twenty-four VDC operation is available for these kits because they use standard efficient motors in them, not custom motors like the washer kits.

To avoid any confusion, Jim recommends that you first get his Guidebook/Catalog ($5) so you will know which voltage kit is best in your situation, what needs to be done, and which washer to get (washer shopper's guide).

Access

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The Code and Balance of Systems Equipment

John Wiles

As PV systems become more widely distributed, the requirements established by various local codes and the National Electric Code may be imposed upon many of them. Balance of Systems (BOS) manufacturers need to become more aware of the requirements of the National Electric Code (NEC) and the implications of Underwriters Laboratory (UL) Standards concerning power handling equipment. In many cases, charge controllers, inverters, and other PV components may be required to meet the NEC or other codes. Early implementation of these requirements will result in products that are safer, have lower production costs through standardization, have greater performance, and possibly a greater market share. It is also necessary— at least until equipment is standardized— for installers, dealers, and end users to be aware of the internal configuration of these products so that proper system connections can be made.

Equipment and the Equipment Grounding Connection

One of the first things that many electrical inspectors examine is the grounding system. Each metal case (on switch gear, module frames, charge controllers, inverters, etc.) of an alternate energy system of any voltage (including 12 Volt systems) must have some provisions for connecting a grounding wire between the case and a ground rod. This is the equivalent of the green, equipment-grounding wire found on many ac appliances. Since PV equipment is not standardized to the point where plug-in connectors are used, a separate wire must be used. There are specific requirements for how the attachment is to be made (e.g. bare metal, no painted or anodized surfaces, certain sizes of screws and number of threads through the metal). These requirements are spelled out in the appropriate UL Standards and they tell the equipment manufacturer how to provide the grounding point.

Isolation Between Case and Conductors

In addition to this equipment grounding requirement, the metal chassis of any PV equipment must be isolated from the current-carrying conductors. This means that the case may not be internally tied to either the positive or negative current carrying conductor. If such a connection were made internally (as is done in some inverters) and one or more pieces of equipment were grounded, then current could flow through the possibly uninsulated equipment grounding conductors which is not safe and is not allowed by the NEC. UL standards also require this isolation so that one and only one definite connection can be made between the current-carrying conductors and the grounding system. This single connection in grounded systems is usually made at the PV disconnect switch, the battery disconnect switch, or possibly the negative battery terminal. The NEC requirement is that systems over 50 Volts open-circuit voltage must have one current-carrying conductor grounded. Performance requirements (less radio frequency noise, better lamp starting, etc) may also dictate that 12 and 24 Volt systems also be grounded.

Positive Processing Only Please

In a system where one of the conductors is intentionally grounded (usually the negative conductor), this conductor must have either white insulation or be marked with a white marker. In a grounded system, all points on the grounded conductor should be at essentially the same voltage (very near zero) with respect to ground— that is at ground potential. This generally means that no switches or relay contacts or transistors should be placed in the negative conductor inside any piece of equipment. Unfortunately many charge controllers and some inverters on the market use negative conductor processing. They modify or process currents flowing in the negative or grounded conductor. If an alternate energy system unintentionally had more than one connection to ground, then this device would not function properly since some portion of the internal circuitry would be bypassed by the external grounding connections. Even the use of shunts in the grounded or negative conductor may pose problems. BOS manufacturers should restrict all internal processing to the positive, ungrounded conductor. Installers and

users should place meter shunts in the positive legs using equipment designed for that purpose.

Exposed Terminals
All current-carrying terminals and connections in alternate energy systems must be enclosed or otherwise protected from inadvertent contact with people, tools, or other conductors that might cause shock, short circuits or equipment malfunctions. Exposed terminals on charge controllers, load panels, fuse blocks, inverters, batteries, and switches will generally not be allowed by electrical inspectors. This behooves the BOS manufacturer to package PV and other alternate energy systems equipment in enclosures and boxes much like those used by other power equipment manufacturers. These enclosures come in numerous styles and have a NEMA (National Electrical Manufacturers Association) designation as well as UL listing.

Panelboards and Other Control Boxes
The National Electric Code provides information on the construction and mounting of panelboards, switchboards, and other non-standardized control boxes. This information governs the internal layout, working clearances, accessibility, and many other details. It is found in NEC Articles 110, 240, 373, 384, and others. The UL standards also give specific information on construction details for these devices.

Safety, Standardization, and Performance
Adhering to accepted and existing standards such as those in the National Electric Code and those in the UL Standards will result in safer alternate energy systems. Even though component complexity may be increased, the only way that standardization can be achieved in the PV industry is to implement the existing standards and good engineering practices that have withstood the test of time.

Added benefits will accrue for both the user and the industry as these standards are adopted. Performance and durability will increase, costs will come down and PV and other renewable energy systems will become even more widely used.

Access
John Wiles, Southwest Technology Development Institute, P.O. Box 30001 Dept 3 SOLAR, Las Cruces, NM 88005 505-646-6105

National Electric Code, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096

Zomeworks
camera-ready

I'm an electron and this is how I work

Current is the number of electrons moving past a point per unit time. Current is measured as *A*mperes or *A*mps.

12 Volts

24 Volts

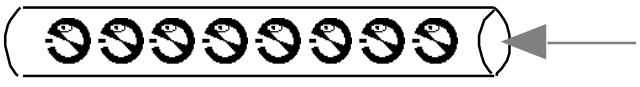
$$Current = \frac{Voltage}{Resistance}$$

$$Wattage = Voltage \times Current$$

Voltage is like pressure produced by height in a gravity water system. Voltage is electron pressure, the force that makes electrons move. The unit is *V*olts.

Resistance is the property of a material that limits electron flow.
Just like a big pipe passes more water, a material with low resistance easily passes electrons.

Materials with higher resistance act like a smaller pipe and electron pressure (voltage) decreases through the material.



Resistance is measured in Ohms (Ω).

120 Volts

Therese Peffer

Editorial

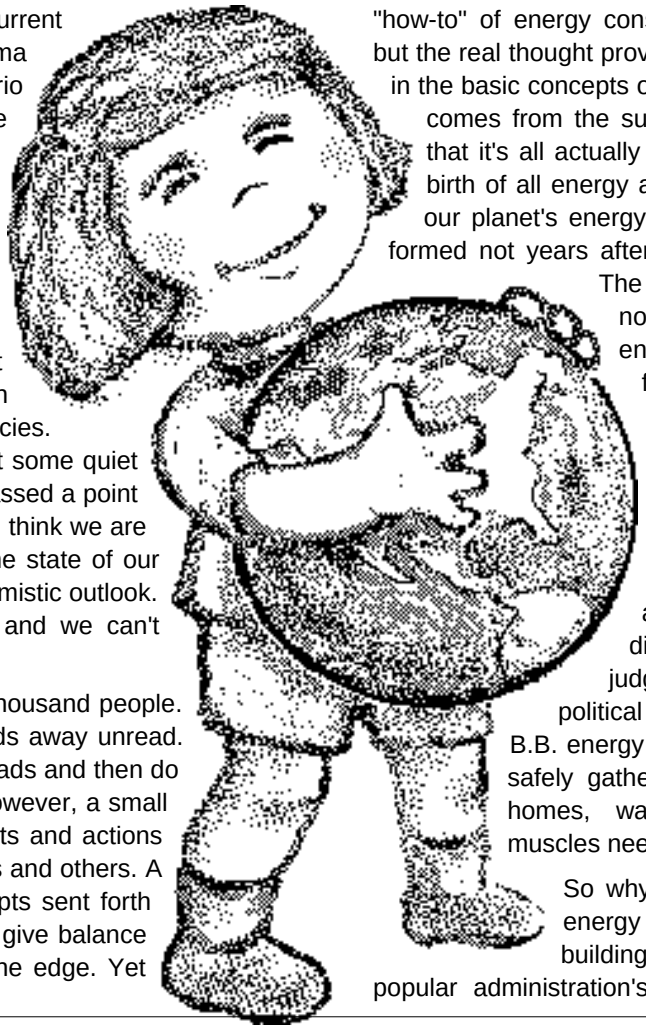
Energy 101

Kurt Nelson

I sit here imagining myself as an incoming photon, seven minutes into the trip from the sun to planet earth. I prepare to deposit my energy into the world below and smile at the thought of my welcome reception. Suddenly I slam into a dense atmosphere and in a twinkle of light, transform my nuclear magic into a tiny bit of heat. I dissipate into a collective energy consciousness, hovering above a hot barren world prickling with long dead smokestacks and the rusted empty shells of something that once was and now doesn't matter. At least the planet survived.

I awaken, a good start, but realize that a much larger percentage of the world's population is going to have to do likewise if we are going to avert the coming environmental disaster. I should confess that I don't think we're going to make it, but the optimistic portion of me will direct the remainder of this article.

Maybe we should look at our current energy and environmental dilemma from the depressing scenario detailed above, and then figure out what could have been done to prevent our future demise. Hindsight is 20/20 and in looking back it is easy to put the pieces together.



People didn't deliberately plan their own annihilation; it didn't happen suddenly. It wasn't an overnight extinction of all species. The process took a long time. At some quiet and undocumented moment it passed a point of no return. Looking back on it, I think we are approaching that moment. It's the state of our planet that lends bite to my pessimistic outlook. People don't change overnight and we can't wait for the sunset.

This article will go out to a few thousand people. Most of them will throw the words away unread. Many of the rest will nod their heads and then do nothing about it. There exists, however, a small handful of people whose thoughts and actions will be influenced by these words and others. A small group of ideas and concepts sent forth into the world with a mission, to give balance to a world that is teetering on the edge. Yet with education as the fulcrum, enlightenment the lever, and personal commitment the driving force, the impact of a single thought may echo through all time. Perhaps that is what gives purpose to our individual lives. The real issues come down to such a close call.

Education on the mechanics of solar home building or the "how-to" of energy conservation is extremely important, but the real thought provoking, earth moving stuff is found in the basic concepts of energy. Basically, all our energy comes from the sun, period. Some would point out that it's all actually "Big Bang" energy, the universal birth of all energy and matter. Regardless, 99.9% of our planet's energy comes to us via the sun, which formed not years after the aforementioned loud noise. The amount of energy we get from non-solar, direct from Big Bang energy is small. Part of it is nuclear fission energy, which is obviously too closely related to the "actual explosion." I personally prefer my nuclear reaction to simmer in space for awhile, gather together at about 93 million miles, do a little atomic fusion, and then radiate out in every direction, every day, and without judgments, expectations, or a political agenda. This second generation B.B. energy is the kind of energy that can be safely gathered and stored in trees, plants, homes, water, batteries, lives, and the muscles needed to birth small earthlings.

So why don't we see solar energy and energy conservation as the basic building blocks of our current and popular administration's energy policy? It must be a

simple misunderstanding, or perhaps more accurately, a lack of understanding. Most people don't even understand the fact that the energy released by the burning of firewood is the exact same energy that was radiated from the sun, gathered by the tree's leaves, photosynthesized, and stored in the plant's trunk and branches. We learned in school that energy can't be created or destroyed, just transformed. Step outside on a hot day and feel the movement of the energy-charged air, "blown" by the sun. Notice its cooling effect. It "takes" energy to transform the moisture on your skin's surface into vapor, hence a net "loss" of energy perceived as coolness (loss of heat). The same moisture will later condense, resulting in a release of energy (violent thunderstorm), and will then illuminate someone's home as it falls back to earth and helps turn the blade of a hydroelectric turbine. Is your light bulb lit yet? The more steps in the process the less efficient and the more damaging to the environment. Gather the sun directly into your home, don't just store it in a tree and burn it. Worse yet is to gather and store it in a tree, bury it in the ground, wait a million years, get a permit to dig a hole, mine it as coal with machinery burning petro-fuels, use more big machinery to haul it to a giant building, burn it to generate heat and release countless years of stored hydrocarbons in a single moment, use the heat to turn water into vapor, use the steam to turn a turbine, generate electricity with the mechanical energy, send it down millions of miles of electrical wires (line loss and EMF), run it through a meter on the site of the Jones's house and use electrical resistance heat to warm up some water to do the dishes. What's wrong with this picture?

Perhaps we need to take a long, deep look, not just at our energy needs and how they relate to the sun, but at our technologies, life-styles, and our very relationship to our sun. That colossal ball of burning hydrogen around which we rotate on a gravitational lifeline is our earth's mother! It powers our very existence! Maybe we just can't focus on something that's staring us right in the face. Step outside on a clear cool night and take a long, "sol" searching look at someone else's sun. Comprehend it, and feel the breeze of the cosmos blow through your mind. Viva La Sun!

Access

Author: Kurt Nelson, 2861 Sandy Creek RD, Mosinee, WI 54455.

This article was originally printed in the Midwest Renewable Energy Assoc. newsletter. Kurt Nelson was the sparkplug of the wonderful demo house displayed at this year's Midwest Renewable Energy Fair.

NorthWest Energy Storage
camera-ready

Tech Notes:

PV Module Test

David W. Doty

This test was carried out on eight different Hoxan PV modules. Four of them were Hoxan H-4810 modules, while the other four were Hoxan/Photron Label H-4810/PM50 modules. Two sets of data were taken for each module (eight sets in all for each type of module).

Data

The eight data runs for each module type are presented graphically in their corresponding charts. The critical parameters for each module type were averaged over the eight sets of data. The averages are shown in their corresponding tables, and compared there with the rated values.

Instrumentation and Procedures

Solar insolation was measured with a Li-Cor Model LI-200SB Pyranometer and a Fluke #87 DMM. The Fluke 87 was used in the 4 1/2 digit and recording mode. The insolation level was taken during each data run and the average reading was recorded for each data run. In all cases relevant to this article the average recorded for each run was greater than 100 mW/sq. cm

Panel voltage was measured with a Fluke #23 DMM. Current was measured with another Fluke #23 DMM. The test load was a 15 Ω 150 Watt rheostat. Two consecutive tests were done on each panel.

Temperature was measured with a mercury type lab thermometer. The ambient temperature for the H-4810 module tests ran from 29 °C (84 °F) to 32 °C (90 °F). The ambient temperature for the H4810/PM50 module tests was from 26 °C (79 °F) to 27 °C (81 °F).

Access

David W. Doty, 14702 33rd. Ave. N.W. Gig Harbor, WA. 98332 • 206-851-2208

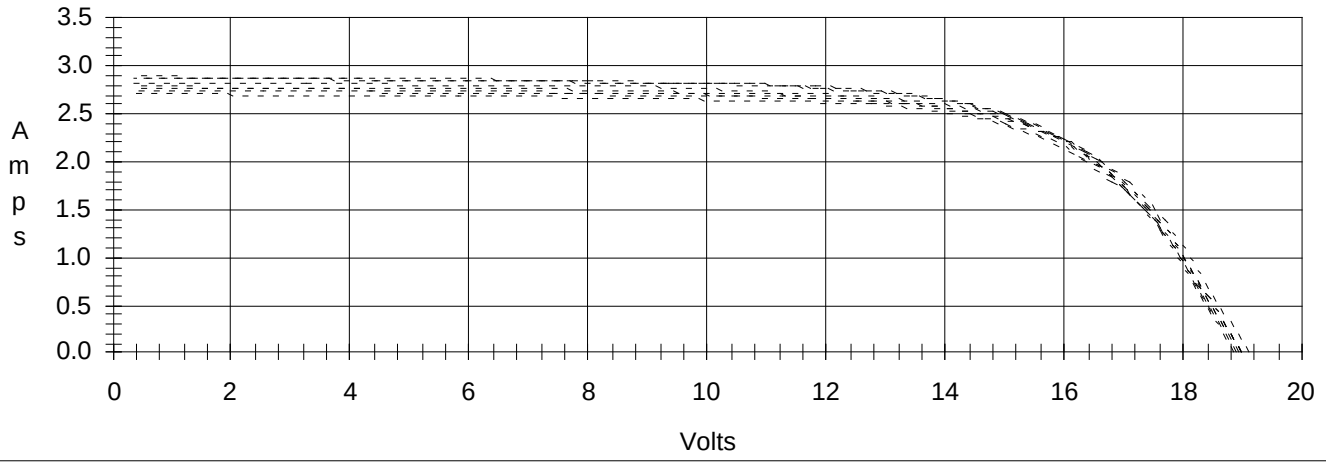
Hoxan H - 4810

	Rated Value	Average Measured Value	Percent of Rated	
Isc	3.30	2.81	85.2%	Amperes
Voc	21.30	18.95	89.0%	Volts
Pmax	48.60	36.84	75.8%	Watts
Vpmax	16.20	14.77	91.2%	Volts
Ipmax	3.00	2.48	82.5%	Amperes
PV Temp	25.00	44.00	176.0%	°C.
Insolation	100.00	103.13	103.1%	mW/sq. cm.

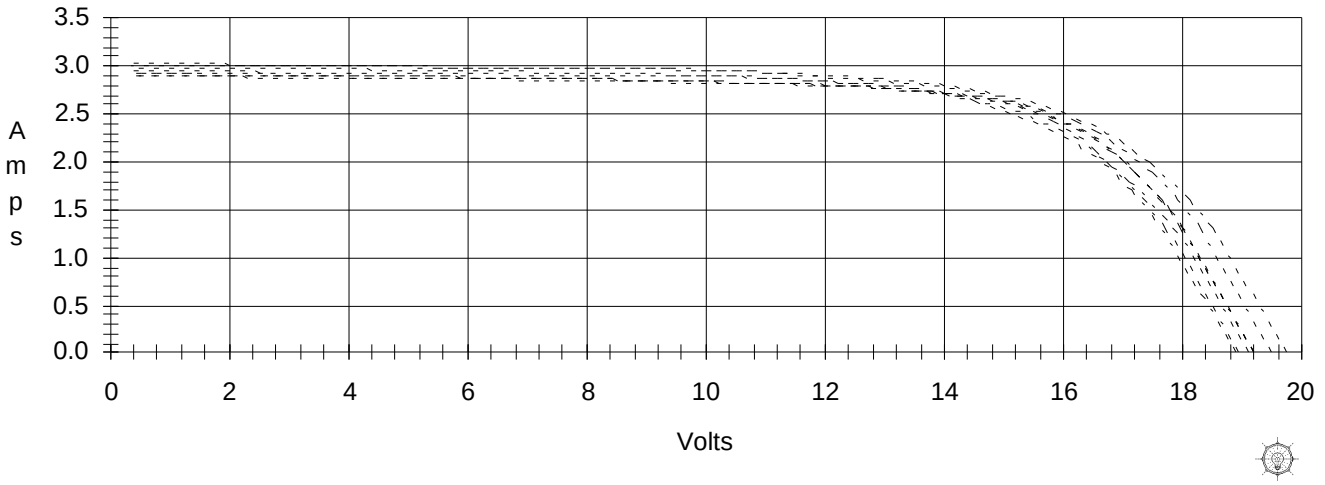
Hoxan/Photron Label H - 4810/PM 50

	Rated Value	Average Measured Value	Percent of Rated	
Isc	3.30	2.95	89.5%	Amperes
Voc	24.50	19.20	78.4%	Volts
Pmax	49.50	39.44	79.7%	Watts
Vpmax	16.50	15.06	91.3%	Volts
Ipmax	3.00	2.71	90.5%	Amperes
PV Temp	25.00	40.38	161.5%	°C.
Insolation	100.00	103.14	103.1%	mW/sq. cm.

Hoxan H - 4810



Hoxan/Photron Label H - 4810/PM50



BackHome Magazine
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Tech Notes:

A Brief Evaluation Guide for Used Pocket-Plate Ni-Cad Cells

Dan Lepinski

Although pocket-plate ni-cad cells offer numerous advantages over their lead-acid cousins, buying new ones can be hard on the budget. If you are fortunate enough to come across a used set, but don't know how to determine their condition, here are some simple guidelines.

Precautions

Be very careful when handling the cells. The dry crystals that may exist on the cell exterior as well as the liquid inside are caustic. Caustic means corrosive— like lye. Ni-Cad cases tend to be made of very smooth plastic. They are slippery, especially when wet. Connecting posts and hardware can develop very sharp edges. The potassium hydroxide (KOH) solution will search out every little scratch or cut on your hands or arms. It will get into your skin by contact alone and is uniquely painful. It burns like mad and goes on hurting for a long time, even when rinsed with large amounts of water. Wear two pair of elbow length kitchen gloves, goggles, and if possible, some type of rubber raincoat or something similar. Use great care when handling potassium hydroxide.

Preliminary Evaluation

Carefully examine each cell case for cracks. Ni-cad cases are nearly impossible to repair. Cells that are cracked in the electrolyte area cannot be fixed reliably and should not be considered. Small cracks or leaky seams above the maximum fluid level may be patched. I've had some success with special epoxies for hard plastics. Hot-melt glue also seems to work. Standard epoxies will not adhere to ni-cad cells. The old reliable silicone seal won't do the job either.

Poorly maintained cells may be heavily encrusted with potassium hydroxide crystal. Unless the cell connecting posts are severely corroded, this may be ignored for now.

Look at the electrolyte level. It can be seen even through translucent cases. Compare the level to the "minimum" level marked on the case. Is it above this mark? If the electrolyte falls below the minimum line on the case, thus exposing the plates, the cell can be permanently damaged. Cells with electrolyte much below the minimum should not be considered for purchase.

Look into the bottom of the cell, even if it means backlighting the translucent case. You are looking for "junk" (for lack of a better term). If you see much junk in the bottom of the cell, it may indicate that the cell is heavily contaminated with potassium carbonate. This is formed when potassium hydroxide in the cell comes into contact with airborne carbon (carbon dioxide, carbon monoxide, etc.). If a heavy layer is present on the bottom of the cell, it will almost certainly indicate the need to recondition the cell. Part of the reconditioning procedure involves the complete replacement of the electrolyte— a labor intensive and potentially nasty job.

Don't use the open circuit (no load) cell voltage as a test of the cell's condition. Pocket-plate ni-cads can sit for very long periods of time at almost any state of charge without damage. In fact, neither open circuit voltage nor electrolyte specific gravity tests are reliable for determining how a cell will perform. Also, just because a cell shows a good open circuit voltage (1.27 to 1.30 Volts or more) does not mean it will work well under load. Load testing is the only accurate means of determining the overall health of any cell.

If a cell's polarity is "reversed" (positive polarity present on the negative terminal and negative where the positive should be) don't worry. A normal charge will return the cell to normal. This does not appear to harm the cell. However, it may indicate that this cell is weaker than others in the same string; it went dead first. The other cells continued to provide current to the load thus reversing the polarity on that cell.

Cleaning

If the cells are clean and dry, consider yourself fortunate and go on to the charging step. If they are dirty, you'll need warm water, dish soap, and a bristle brush. Do NOT use a metal wire brush. Wear protective clothing and goggles. Use a large plastic bucket as a wash tub. Clean each cell gently and thoroughly. Do not let any of the wash water get into the cell. Allow the cell to air dry. Dispose of the wash water in a responsible manner as it may contain potassium hydroxide, potassium carbonate, cadmium, oils, plus an assortment of other chemicals.

The connecting hardware can be cleaned just like the cells. There may be a layer of grease or other material coating the connectors. This is normal. This coating prevents the electrolyte from attacking the metal. Wash the connecting hardware removing all corrosion, grease, and other material. If the cells are put into use, you will need to coat the hardware with Vaseline or other light grease after all connections are tightened.

Charging
From the ampere-hour rating of the cells (designated by the letter 'C'), charge the cells as a battery at a C/8 rate for 24 hours. For instance, cells rated at 160 A-H will be charged at a 20 Amp rate. After charging, allow the cells to rest for 24 to 48 hours.

Load Testing
A rough indication of cell capacity can be determined through load testing. Cells may be load tested individually or connected together as a battery. If you test each cell separately, a better record can be made of its condition. Cell groups may be tested as a series battery to save time. If you test a group of cells as a battery, please be sure to allow for the heat that will be generated by your load resistor. In plain language, it will get HOT! To keep things simple, I elected to test the cells one at a time.

Before performing the load test, measure the voltage of each cell. The values should be very close to each other. If a cell voltage is much below 1.30 Volts, the internal discharge rate is excessive and may indicate a shorted cell. A cell that loses voltage much faster than the others should be considered suspect.

Attach a resistor or resistors to give a C/5 discharge rate. For a 100 A-H cell, this would mean a discharge rate of 20 Amps. Since this is only an approximation of cell condition, use a battery voltage of 1.28 Volts to determine the resistance value. Using Ohm's Law (R = E/I), this would mean a resistance of 0.064 Ohms (R=1.28/20). Using a wire table, this works out to 24 feet, 10 1/4 inches of number 14 gauge wire.

Other load resistor sizes can be easily constructed from various lengths of number 14 copper wire. Attach this "resistor" and monitor the cell voltage with a digital voltmeter (even the inexpensive Radio Shack models are suitable for this task). At the C/5 discharge rate, perfect cells will stay above 1.000 Volts for 5 hours or longer. Reaching the one volt level in less than five hours means the cell does not have its specified A-H capacity. For instance, if the cell drops to one volt in 2.5 hours, you can estimate that the cell has 50% of its rated ampere-hour rating. A one volt reading in 3 hours means 60% of its rating, and so forth. According to Lon Gillas of Pacific West Supply (a terrific source of ni-cad info!), cells at or above the 50% level can frequently be reconditioned back up to their original capacity.

If the cells test below the 50% level, don't despair. Even low capacity cells may be strung together in a battery and connected in parallel with healthier cells to increase overall A-H rating. The only thing this costs is space. Batteries of this nature can also be used in areas where neither use nor total reserve is critical and where distance might otherwise prohibit easy access to your main power system. Just remember to use cells that are as close to the same A-H capacity as possible. Your battery will be only as good as the worst cell in the string.

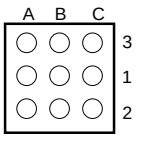
What Next?
Public access to used ni-cads may become a thing of the past. EPA regulations now require that ni-cads be disposed of only through firms licensed to handle such material. As a further note, the effort required to recondition cells is considerable. Unless you obtain the cells for next to nothing, I'd recommend purchasing them through Pacific West or other HP advertisers handling new or reconditioned ni-cads.

On the other hand, if you are considering reconditioning a set of ni-cad cells, feel free to contact me. I am not a battery expert, but I have learned a great deal from my daily vigils with the cells I purchased. If you have questions, send me a SASE with your questions and I'll be glad to share what I've learned.

Additional Credit
I have successfully evaluated and reconditioned a group of over 50 pocket-plate ni-cad cells. I could not have done it without the generous help from several people. Many thanks to:
Lon Gillas of Pacific West Supply (an HP Advertiser) for his generous advice and guidance.
Richard Perez - The Battery Nerd of Home Power Magazine.
George Patterson, (whose article in HP #15 proved to be an excellent reference guide) for sharing with me some of the details of his countless hours of work with ni-cads.

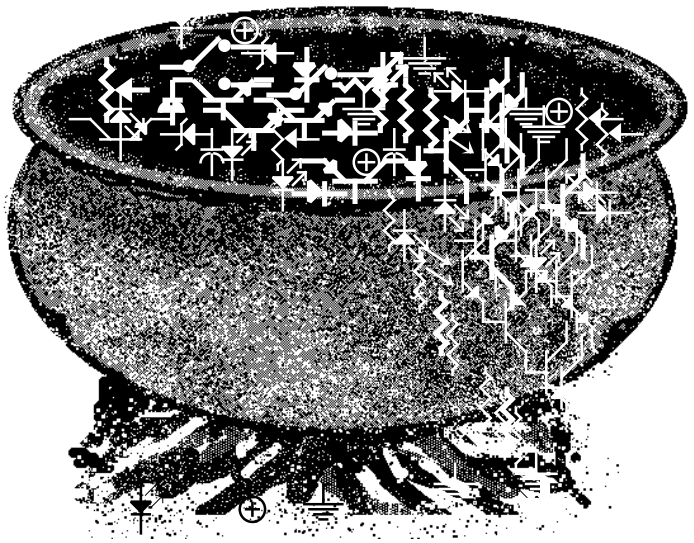
Access
Author: Dan Lepinski, 4631 W. Marlette Ave., Glendale, AZ 85301

Editor's Note: Last issue I screwed up the switch diagram in Dan's Tech Notes (HP#24, pg. 70). The correct diagram appears below. My apologies. Richard



PIN CONNECTIONS
FOR THE 3-POLE
DOUBLE-THROW
SWITCH (REAR VIEW)

Homebrew



"Latch-Up" Shunt Voltage Regulator

Donald F. Scott

I use this regulator to "dump" all our excess power to our super insulated hot water tank. This regulator design is a variation on a basic bistable multivibrator. The turn on voltage is higher than the turn off voltage. This prevents cycling or outright oscillation as the shunt load "kicks in" and the battery voltage drops. The 339 QUAD COMPARATOR requires only a single power supply— the regulated battery itself. Only one section is used.

R3, R4 and 9V Zener diode Z2 cause a positive feedback voltage (LATCH-UP VOLTAGE) to be applied to the non-inverting input (+) when the battery voltage rises above the point set by R2. This drops nearly instantly the battery voltage at which the shunt load will be turned off again, eliminating the need for fancy combinations of resistors and timing capacitors to prevent cycling. The base currents for both transistors were chosen to insure that both are driven to saturation when the shunt load is on (339 output off). This prevents overheating of the output transistor. At 4 amperes and 0.2 Vce saturation Q2 is dissipating only 0.8 watts. HEAT SINK THE OUTPUT DEVICE. Higher rated output devices are available.

R3, R4 control the voltage gap between turn-on and turn-off. The fixed 33K resistor, R4, insures that the feedback resistance is never so low as to affect the bias of Q1 and so cause Q2 to overheat.

R2 controls the voltage setting of the regulator. R3, initially set around 50K, will affect this set point. You will to play a little with R2 and R3 to find your desired set points, both on and off.

If you are starting loads that cause transients, a 0.15 µfd. capacitor connected between the + 339 input and ground will prevent false cycling.

I sized the shunt load a little low to prevent unnecessary cycling and provide a little equalizing on each cycle. For output resistors to adjust the load, Nichrome coil elements from stoves, hot plates, etc., cut to length are cheap and easy; some come with their own stand-off ceramic insulators which a dedicated homesteader can re-use.

If you have several loads, build several regulators and set according to priority or as a "fail safe".

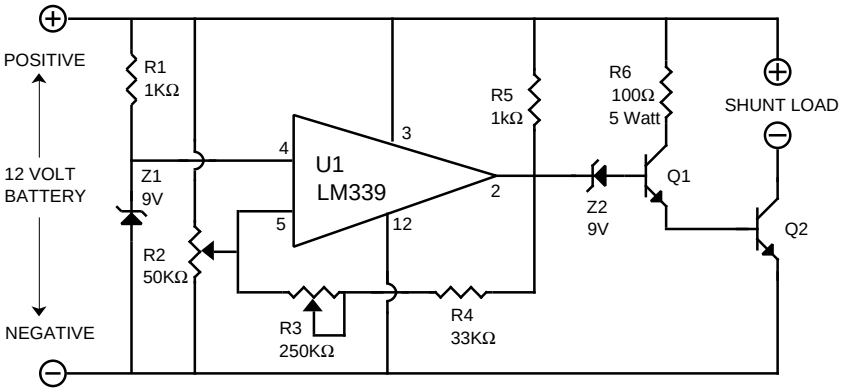
I have a 14 Volt bank controlled around a 15 Volt set point. A 12 Volt bank will require 6V Zener diodes in place of both 9V Zener diodes. That is the only change that I see required. Make certain that Q2 goes to saturation on turn-on with any changes. Vce Q2 < 0.3 Volt. Layout does not appear to be critical.

Critical comments are not necessarily welcomed, but probably necessary. Homebrew is fine but commercial rights and copyrights are reserved to the author. See what we learn by reading Home Power? Oh yes, offers for rights cheerfully considered. I am happy with this toy. I hope you will be also.

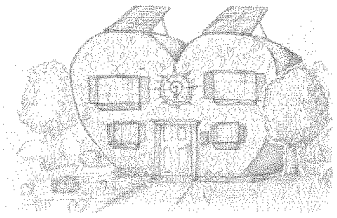
Access

Donald F. Scott, 219 N. Euclid, Tucson, AZ 85719

1.) Q1- NPN switching - Radio Shack #276-1617
2.) Q2- NPN power-2N3055 (shunt load** 5 amp.)
3.) Heat sink Q2 - be sure Vce is on - state < 0.3VDC.
4.) R2 sets reg. voltage, R3 voltage diff, on-off. R2-R3 interact.
5.) R4 prevents bias problems if R3 set too low



Home & Heart



Kathleen Jarschke-Schultze

I believe the biggest political statement you can make in America today is to produce your own power and grow your own food. Of course it is very nearly impossible to grow all your own food but growing even part of it is still taking a stand.

Guerilla Gardening

Many of the large seed companies are owned by large corporations now. It is becoming more difficult to buy open pollinated seeds. These are seeds that you can save from year to year. In fact, some companies have made it illegal to save seeds from their plants. If you do so, you are breaking the law.

Hybrid plants may yield more fruit that looks better and lasts longer during shipping, but you can lose your whole crop to one pest or disease. History is full of tragic examples. The Irish potato famine, the French grapevine blight, the coffee fungus of Ceylon to illustrate a few. In 1984, a bacterial disease in Florida forced 135 nurseries to destroy 18 million citrus trees and seedlings.

There are groups and centers throughout the world trying to save and protect the world's land races. Land races are wild plants and those traditionally grown by farmers throughout history. These are needed to keep the germ plasm available to plant breeders to combat virus and disease that could cause another famine in hybrid monocrop cultures.

Heirloom Seeds

There are also a few groups in America that preserve heirloom variety seeds. The biggest is Seed Saver's Exchange. Started by Diane and Kent Whealy when Diane's grandfather gave them seeds that had been brought from Bavaria by his family generations before, SSE now has over 5,000 backyard gardeners who maintain more than 12,000 heirloom fruit and vegetable varieties.

Power & Potatoes

The sun gives us power in in several ways. Electrical power to run our homes. Life-giving warmth to grow the food we need. Heat to cook that food or dry it for later use. We supply the power to make these choices to the best of our ability.

I have found that most people who live a RE lifestyle are also gardeners. Maybe it is because they are more aware of what it really takes to maintain their life. There is no monthly bill to the power company to have that part of your life covered for you by a faceless impersonal monopoly. Maybe it is the fact that most RE people are doing it out in the country. It is hard to see the rural plants and animals on your own land and not take an active interest in them.

I have begun growing different types of garlic and potatoes to see what will grow well in my microclimate. I already have one heirloom open pollinated corn, Aunt Mary's Sweet Corn, and a tomato, Oxheart, that I have grown for the past four years. I really enjoy this facet of gardening.

Box Gardening

There are several gardening methods that will enable you to grow crops in almost any climate and location. The Bio-dynamic French Intensive Method is used extensively throughout the world. John Jeavons, his sister Betsy Bruneau and her husband Bill, continue to maintain a selection of open pollinated seeds and work on a solution to world hunger at their farm, Bountiful Gardens in Willits, California.

Box gardening has proved successful for several HP readers living in Northern remote areas. This method allows you to easily control soil composition, temperature, moisture, weeds and some pests. Once set up, this method is the easiest to maintain.

Jorrie Ciotti of the Holistic Institute of Montana has developed a garden of 4' x 4' boxes that have interchangeable depths and coverings according to what her Montana weather dictates. She has found that she can start her garden a month earlier than usual.

Marilyn Dinger of The Sunshine Garden uses a different approach to box gardening. At the experimental gardening center located at 9,000 ft. altitude above Woodland Park, Colorado, she has been growing a variety of herbs and vegetables. All this in a virtually 'impossible' area without the use of pesticides, chemical fertilizers or plastics. The center also offers workshops for individuals, groups, small farms, and communities.

Although you can start raised bed gardening at any time of year, Autumn is the best time. If you prepare your beds now they will be settled in and ready to plant in the Spring. It is hard to resist sowing a nice bit of dirt in the Spring when the cold of Winter recedes and the green of young plants become visible. Go ahead, do it.

Sun Cooks

We get many requests for recipes for solar cookers. I am working on a recipe book for future publication, but in the meantime, just about any recipe can be adapted. If you usually cook a dish 30 minutes or longer at 300° F to 350° F then you would only change the timing. A rule of thumb is to cook your sun oven dish about twice as long as you would in a conventional oven. This is a loose rule. Cook it till it's done. Don't worry, it won't burn. Vegetables that are usually steamed or cooked lightly, such as cauliflower and broccoli don't take very long, so keep an eye on them. Any recipe developed for a crockpot or slow cooker needs no adjustment. People ask about rice. My Mom taught me to put in rice up to the first knuckle and water up to the second. This works fine for me. Pasta is difficult. With lasagne you don't cook the noodles first, so that's okay. I have heard that if you heat the pasta in one pot (dry) and boil the water in another pot, then combine and return to the solar cooker it will be done in 10 - 20 minutes. I have not tried that yet. Meats and root vegetables are moist and tender, casseroles are the best.

Experience is the best teacher. Get used to your oven in your location. Then try your favorite recipes. It's not hard and the results taste good.

Gas Irons

For those of you who have had difficulty in finding butane cartridges for your gas iron, Katcha Sanderson has turned up a source that is closing out their inventory. Martin Bros. in Jacksonville, FL are still carrying cases of 96, 9 oz. canisters for $69. They are closing out this item, so when they are gone that's it.

Access

Kathleen Jarschke-Schultze lives, gardens and cooks in northernmost California. POB 130, Hornbrook, CA 96044 916-475-3401

Seed Savers Exchange, Diane & Kent Whealy, Decorah, IA 52101

Bountiful Gardens, Ecology Action, 5798 Ridgewood Rd., Willits, CA 95490

Holistic Institute of Montana, Inc., POB 14, Niarada, MT 59852-0014

Marilyn Dinger, The Sunshine Garden, POB 5161, Woodland Park, CO 80866

Jules Abbosh II, c/o Martin Bros., POB 2230, Jacksonville, FL 32203-2230 • 800-322-2317

The Fuel Savers

Edited by Bruce N. Anderson

Reviewed by Kathleen Jarschke-Schultze

The sub title on this 83 page, softcover book is 'A Kit of Solar Ideas for Your Home, Apartment, or Business.' Editor Bruce Anderson takes each method of using solar heating in your home and discusses each one. He explains the individual concept and design. The concept is then explored as to how to incorporate it into your home. He rates the cost-effectiveness of each method by showing an oil barrel with the amount of fuel saved each year. Each method gets a numerical rating from 1 to 20.

The illustrations are useful in helping to understand the different solar heating designs. Some chapters are Window Treatments, Sunrooms, Wall Applications, Solar Water Heating and more. While the book covers and explains the different methods, there are no specific instructions on installing any of them. Bruce gives you the information and then gives you a detailed list of access sources to home in on the methods you decide on. There is a helpful section that shows six different houses before and after solar retro fitting. What I liked best was that I found myself saying, "I could do that! or that, and that."

There is one short paragraph on photovoltaics. It mentions that they are not cost-effective for grid powered homes, yet. This book really excels in explaining the choices urban and suburban home owners have in using solar heating on their house to cut their utility bills. Even though I live off the grid I was inspired by Fuel Savers to plan on incorporating some options in our home.

The Fuel Savers is published by Morning Sun Press, Lafayette, CA, and printed on recycled paper. All the royalties from The Fuel Savers are being donated. Half goes to the Dr. John and Barbara Yellott Scholarship Fund of the ASES, Boulder, CO. Dr. Yellott was one of the world's foremost solar pioneers and friend of the earth. The other half of the royalties goes to the National Foundation on Poverty and the Environment, Peterborough, NH, addressing the relationship between problems of the environment and poverty.

Access

The Fuel Savers: A Kit of Solar Ideas for Your Home, Apartment or Business by Bruce Anderson is available in bookstores or by sending $4.95 plus $1.50 for shipping and handling to: Morning Sun Press, POB 413, Lafayette, CA 94549

HAPPENINGS

Hands-On Solar Workshops
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. Micro-Hydro Power Systems, Oct. 7-10; Solar Home Design & 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.

The Big Island Renewable Energy Fair
Some of you will remember an announcement early this year for a renewable energy fair on the Big Island of Hawaii. Soon after announcing their plans, the fair's organizers realized that they were unprepared for the task at hand and had to abandon the project, much to the dismay of those who had made an effort to contact them.

The good news is that a local business association has agreed to sponsor the event, and plans for the fair are again proceeding. On February 8th and 9th, 1992 the town of Pahoa will be turned over to alternate energy specialists and their devotees. The Pahoa Business Association plans to make use of a recently completed by-pass road for access while closing off the single street that traverses the town, creating a well-serviced haven for pedestrians. Booths will be available along the street and within clusters set up in some of the town's vacant parking lots.

Hawaii's mild climate, abundant sunshine, overburdened utility, and vast number of home lots not serviced by the grid have created a large market for alternate energy products. In preparation for the event, local entrepreneurs are participating in the State's energy audit program. The town plans to use the expertise of fair participants by inviting specialists to tour the town and make suggestions as to how the town can become more efficient and self-reliant.

Those interested in the fair should contact the Pahoa Business Assoc. at POB 1189, Pahoa, HI 96778.

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 homes, 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
Florida's energy research institute is soliciting innovative concepts to make solar water heaters more affordable to Florida homeowners. Supported by the state energy office, the Florida Solar Energy Center (FSEC) is holding a competition to generate solar system design ideas from inventors, engineers, students -- anyone, in fact, who has a good idea for a low-cost solar water heater. Entries are due by Nov. 1, 1991. All submissions will be reviewed by a technical evaluation committee, which will select up to five concepts that best meet criteria for low cost, durability, reliability and marketability. The inventors will then be contacted to design and construct prototype systems, and FSEC will test the system's performance. The ultimate winner of the competition will receive the Governor's Solar Product Award, recently established by Gov. Lawton Chilies to encourage energy savings and economic development in Florida through advances in

solar technologies. The winner will also receive state assistance in commercializing the solar system.

For more info contact Ingrid Melody, 300 State Rd 401, Cape Canaveral, FL 32920-4099 • 407-783-0300 ext 139

NE Sustainable Energy Assoc.
October 26 & 26, 1991 - SOLAR AND ELECTRIC VEHICLE SYMPOSIUM will feature an extensive exhibit of prototype, pre-production EVs and components plus ongoing 30 minute workshops on the basics of EVs and presentations by specific car companies. The workshops will cover choosing the right components, photovoltaics, motors, batteries racing strategy, fund raising, team, electronics, conversions, composites, wheels, design, and more. The Symposium will be at the Sheraton Hotel, Boxborough, MA just off RT 495. Contact NESEA for more information at 413-774-6051

4th Annual American Tour de Sol, May 1992, solar and electric car championship. Contact NESEA at 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

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 last workshop in the 1991 schedule is Saturday, October 19, from 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

SunAmp Seminar
SunAmp Power Co. will hold a 2 day PV seminar on November 8 & 9, 1991. The seminar is designed for everyone from professionals to do-it-yourselfers. Topics will include introduction to PV hardware, demonstrations of systems, instrumentation, information access, system design and marketing. Cost of the seminar is $175 ($125 for each additional person in the same party) and includes two lunches, refreshments, syllabus & classroom materials. A $50.00 deposit is required. For more information contact Steve at SunAmp Power Co., POB 6346, Scottsdale, AZ 85261-6346 • 602-833-1550 or TOLL FREE 1-800-677-6527.

Solar Electric Classes in Nevada
Solar Electric Classes for a max. of 4 students. Taught at remote Solar homesite. 2 days on the 4th weekend of Oct. & Nov. Will build a small system. $75. For info SASE to Solar Advantage, 4410 N. Rancho Dr. #148, Las Vegas, NV 89130, 702-645-6571

Permaculture Design Course in Florida
Dan Hemenway, editor and publisher of The International Permaculture Solutions Journal, will lead a full three week permaculture design course Oct. 19-Nov.9, 1991 in Orange Park, FL. The course will include sections on ecological design principles, design application of appropriate technologies and economic, social and legal considerations in permaculture design. Themes include energy, nutrient cycles, cultivated areas, potential catastrophes, water, buildings, urban design, alternative economics and bioregionalism. Students form teams and design the course site. For more information send SASE to Elfin Permaculture Institute, 7781 Lenox Ave., Jacksonville, FL 32221.

World Conference on Solar Cooking
On June 19-20, 1992, two days of paper presentations, roundtable discussions and displays on all aspects of solar cooking, open to presenters and participants from all relevant disciplines, including environmental studies, appropriate technology, health, humanities, social studies, scientific, engineering, governmental and other fields. This conference is a forum for individuals who recognize that Solar Cooking can play a major role in the quality of life on Earth in the coming decades.

Papers, posters, audio visual materials, and displays of solar cooking devices are being solicited on all aspects of Solar Cooking (including water purification): Solar cooker designs and/or analysis, cultural or sociological issues of using solar cooking, health and nutrition issues, promotion of solar cooking, updates on projects using solar cooking, and solar cooker devices, both commercial & experimental. Submit two copies of a one or two page abstract or a letter describing your display, poster, or

audio-visual material by Nov. 1, 1991. For more info contact; University of the Pacific, 102 Khoury Hall, Stockton, CA 95211, 209-946-2377, FAX 209-946-3086

N. San Francisco Bay Chapter- Electric Auto Assoc. All interested persons are invited to the meetings of the North San Francisco Bay Chapter of the Electric Auto Assoc. The meetings are held on third Saturday of each month at the Citibank in Novato, CA. Contact Andy Clary, 1710 Greeneitch Ave., Santa Rosa, CA 95401, 707-526-7692 from noon to 5 pm.

Active Tech
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Thermo-electric Junctions

Thermo-electric junctions, called Peltier junctions, are in limited use today. They are used to cool small ice chests and to produce small amounts of electric power from heat. When one side of a Peltier junction is heated, direct current is produced which can be used to charge batteries or run small lights or appliances directly. A fairly large temperature differential is needed to produce this effect. Conversely, if current is passed through a Peltier junction, heat is transferred from one side of the junction to the other. Thus, one side becomes cooler (or hotter) than the other. This cooling is in the neighborhood of 10°F to 40°F.

Although present uses of Peltier junctions are limited, they do hold some promise for the future. Research is necessary to produce higher efficiency, more rugged, and longer lasting junctions. In the future it may be possible to produce arrays of Peltier junctions which will take care of all our refrigeration and air conditioning problems. This might be done by series-stacking the Peltier junctions to produce greater temperature differentials. It would also totally eliminate the need for any environmentally threatening chemicals in these applications.

Other possible future uses are the production of electricity from waste heat, and even efficient electric heating. Research and development in this field may yield even more potential uses for Peltier junctions, and should be pursued vigorously by the scientific community.

muddy roads

Is The Tank Half Empty Or Half Full?

Jim Forgette

I was getting ready to go to SEER '91 in Willits, California. For my fledgling bootstrap RE business, I bartered for a booth to show my wares. I was very excited, as it would be the very first time I've attended such an event, let alone been an exhibitor at one. I knew that all the 'bigwigs' would be there and I'd meet them. Richard Perez & the Home Power Crew, Dave Katz from AEE, Elliot from PowerStar, John Wiles (Code Corner), the "Real Goods" gang, just about everybody in the RE field would be there! Heck, I was even sharing my booth with the guy that designed and sells the "code-approved DC load center" (John Mottl).

With all these knowledgeable VIPs pokin' around, my stuff had best be done right, right? So you can bet I was putting extra effort into making my exhibit as 'up to snuff' as possible. The Fair date was fast approaching, and I was falling behind schedule...so many loose ends to attend to. Then, as if I wasn't behind enough, in stepped good ol' Murphy's Law.

First, the appliance I was bringing for demonstrations began to make an awful noise, taking me a whole extra day to repair (it was, after all, old and retrieved as scrap in the first place). Now I was really behind schedule, with only two days left before "D-Day". On my way to town to get the new appliance part, the tread on my truck's right-front tire came partly unpeeled, flapping along the road like a worn out shoe. My bald spare got me home, but now I'd need to go get a new tire (and a better spare) for the trip. I was so behind, and hadn't yet even thought out the details of what to bring to the fair. A main exhibit item hadn't yet arrived in the mail, and the booth signs still had to be picked up in town.

The truck I was taking, an old '61 Chevy farm truck, began making a disturbing, grinding noise when it hit certain bumps on the road. What about food, bedding, music while I was there?? Surrendering and relaxing a bit (partly in desperation), I decided that I was going to ENJOY this whole trip in spite of it all..."just do my best." It all seemed worth it, though, because I was 'going to the Fair!' for the very first time.

When all the packing was done, the truck was stuffed: appliance, 3 sets of 160 nicads (my hard-earned house batteries— be careful!), lumber for booth, tables, barrels, clothes, wares, tools, map, etc., etc., etc. Well, old "Nelle Belle" (my truck) was going to carry me on an adventure one more time. She's 30 years old and gettin' pretty worn out. She'd been a good ol' farm truck for the past eight years, enduring a river crossing, and miles of hilly, bumpy winding dirt roads, four or five times a week, to get me to town and back. These roads have tortuous "washboard" bumps, which proceed to hammer and ruin a vehicle's suspension. She's hauled over her limit many times for me, like full cords of wet oak, and palates of bricks, to mention a few. This load though was much lighter and would be a piece of cake for Nelle Belle.

She's geared low, so can pull like a tug boat. Out on the highway, her motor screams too fast when only doing 50. I just pull to the side every few minutes, and let the line of cars whiz by. My truck is also quite UGLY to look at, having various dents and patches of bondo/primer/rust/partly faded 4-tone paint job. A semi-rotted wood flatbed (the bed even has a hole in one place, and your foot will fall into it if you are not careful). Truth be told my family is embarrassed to be seen in it. I love old Nelle Belle, for helping me to carry my loads through the years. She was trusty, and I knew her well. Now 60 miles away from home was all I had ever ventured in her, so this trip was going to be a real test: 500 miles round trip. I really didn't want to put her through this, and she was making that funny noise in the front suspension somewhere. She was all I had, and she'd have to do.

It was already the first day of the fair, Friday, the day when only booth people would be there, to share with each other before the crowds came. We hadn't even left home yet, but were ready to hit the road about noon. My neighbor, Gary, was coming along to help me. Driving out to the main road, we decided to swing by his house and get a big jug of drinking water for the trip.

On the way back out to the main road, I accidentally ran the truck through a gentle, but deep, chuck hole on the

right side of the road. Nelle had hit much worse, and more times than I can count. As we drove out of the driveway, about 40 feet further, the truck's right-front corner suddenly lurched and fell, while I felt the steering wheel pull heavily to the right. We were jerked to a stop by the problem, which seemed like a flat tire only different (Gary and I looked at each other with dread).

Well, I found out what the funny noise had been all last week. The right-front wheel's lower ball joint came completely apart, the top one was shattered, and the wheel was smashed up into the wheel well at a crazy angle. As we made our inspection underneath, Gary said, "I KNEW I shouldn't have changed into my good clothes yet".

My heart sank as I realized there would be no quick way to fix the truck. I'd tried to find suspension parts for it before, and ball joints were a discontinued item for this particular chassis. The damn things were riveted on, besides, and we'd start a wildfire for sure if we tried to torch or grind them off here. As I looked over the cargo I'd worked so hard to prepare, I thought, "Nelle Belle, how could you do this to me, right now when it's the most important thing I've ever asked you to do? You've ALWAYS been faithful before...how could you?"

Collecting ourselves, we formulated a plan. The truck was blocking an access road and needed to be moved pronto. Gary went off to fetch his backhoe (just happens to have one!)...We'd chain up the scoop to the truck's front and pull her out of the way. I was in an 'altered state' to be sure, and my mind raced over the possibilities. Maybe Frank and Trisha would LOAN me THEIR truck. I walked a few blocks to their house. Well, thank God they were even home, and that they said YES! They are really great neighbors, to help in a pinch.

Gary and I worked quickly to undo all the ropes, transfer the whole load to the new truck, go back home, take showers and change clothes again, and get back on the road in only two hours' time. I was exhausted, but felt thrilled that we might get to the Fair after all (knock on wood).

As we drove off, I looked back at Nelle Belle. She looked pretty sunk and sad, especially with her wheel all cockeyed like that. I thought of all the tune up and maintenance work I had done to get her ready, and the two new tires I bought for the trip, and here she wasn't even going with me now. It was as if she was saying, "I'm just a farm truck, and I don't belong far away at Fairs!" She let me down, right when I needed her most. Thirty years of driving on those loose ball joints, over hill and dale, over bad roads...thirty long years. How could it be that they would fall apart right THERE, right THEN???

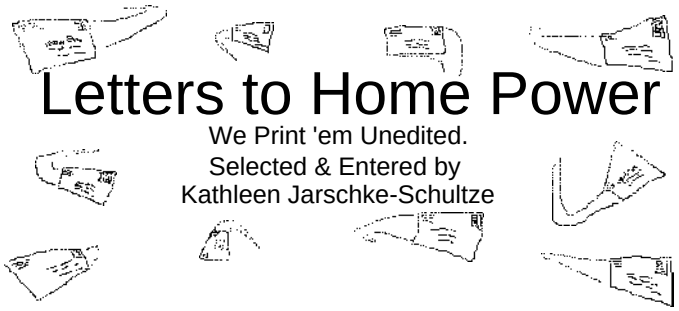
We'd now arrive at the Fair late in the day, and have to put the booth together in the dark, but hey, at least we'd BE THERE! As we drove along, I kept thinking about the broken ball joint. Suppose it had broken a few more miles down the road, and we'd have had to walk far, and waste more time, to get back home, drive the backhoe there, etc. For that matter, what if it had broken when we were, say, 100 miles from home? We'd have been very late for the Fair, to say the least. What if it had come apart while we were going around a mountain curve at 50 MPH?

There are plenty of mountain curves between here and the Fair, and the ones out here are single lane with no guard rail. Likely, it would have been a total loss of control. With horror I imagined batteries, appliance, wares, lumber, and OUR BODIES strewn down some deep canyon wall. The more I thought about it, the more I became awed and mystified. I mean, after 30 years of use, those thousands of loads and bumps, that old truck finally broke down at the PERFECT, SAFEST spot possible, if she HAD to break down. Not flying down the road at 50, not 100 miles from here, but driving slowly, only two blocks away from my home, near my supportive neighbors.

I wonder if Nelle Belle broke down at just the right time so I'd have the best excuse to borrow a more presentable, sea-worthy truck for this special trip. Maybe SHE was embarrassed to be seen at the Fair, and just bowed out ever so gracefully. I really don't know. The timing of it was just so strangely perfect. You can call it coincidence. I call it a miracle.

The SEER '91' Fair was more than I hoped it would be. My booth was a hit, and the weeks of preparation and trial WERE well worth it in the end. I made good connections with many folks, saw the latest in RE equipment, and had a great time overall, especially at the booth with the blackberry pie and ice cream. This year, the Fair was held in a grassy park with many big trees around, a bit of a challenge for the solar powered stuff. It was very pleasant, especially sleeping there each night under the stars. "What a trip," is all I can say. Hope to see y'all there next year!

Access
Jim Forgette, POB 207, San Andreas, CA 95249 • 209-754-3627



Letters to Home Power

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

Mobile PV Power

Dear Home Power, I am a member of a few grass roots organizations here in Maine such as the Maine Solar Energy Association, the Maine Nuclear Referendum Committee, and the Maine Greens. My town is on the state's list of potential low-level radioactive waste dump sites, so I am trying to help educate my community on the issues involved. I power my home with the sun, and am learning to do solar workshops to teach folks how to do it themselves. I have built two mobile solar-electric generating units-- the larger on a utility trailer which I haul with a pick-up truck, the smaller on a bicycle trailer. I go around to fairs, demonstrations, and public lectures to power the PA system, slide projector, rock bands, etc. In the past, I have traveled with the larger one as far as the Pilgrim Reactor on Cape Cod to help out the Clamshell Alliance. When I'm home, I plug my house into them and run my construction projects.

My larger PV system consists of eight 51W Kyocera panels, 6 Trojan L-16s, a Trace 2012 inverter and a C-30A controller, and an SCI monitor on an old GMC pick-up turned into a trailer with a gambrel-roofed hippie style camper top. My smaller system consists of a set of recycled Tri-Lam panels from Photocomm, a pair of exide golf cart batteries, and a small SCI controller on a Cannondale bicycle trailer (I will add a Powerstar inverter when finances allow).

Folks up here in the Northeast don't see much of this technology, so I have become a sort of solar extension worker. If any of you Home Power folks come to New England and would like to do a speaking engagement powered by the sun, I'd be happy to help set it up. I'd appreciate it if you could keep me in the back of your mind if you talk to any other energy and/or environmental experts, designers, philosophers, etc. who might be passing through or living in our area. (This is an open invitation to the readership as well.)

Thanks for all the good work you're doing. Keep it coming! Love ya! And I have a question: Can you share with me any insight and information (scientific literature, research reports) into the extent of industrial pollution generated in the manufacture of photovoltaic modules? The State Nuclear Safety Advisor here in Maine is going around telling people that the PV industry causes serious environmental contamination with heavy metals such as cadmium, and he equates it with the production of semiconductors in Silicon Valley. I've also been asked questions about such pollution by people I meet at fairs, so it seems to be out there in the public consciousness. I know there's no panacea out there as regards energy production, but I'd like to help put things in perspective for people so that we can make responsible choices. Jared Crawford, Box 1210, RR 2, Brooks, ME 04921 207-722-3006

Hi, Jared. The making of a PV cell involves the same processes and chemicals as the making of most silicon based semiconductors. While cadmium is not usually one of the metals used, other toxic materials are used in making PVs. The main danger is from the CFC solvents used to clean the cells. Consumer silicon PVs do not employ toxic dopants (like arsenic), but instead uses phosphorus and boron, both fairly benign. The danger involved depends entirely on the manufacturer. If the maker is careful, then manufacturing PVs does not present any danger to the environment. If the maker is a slob, then every living thing around him is in danger. If we ever hear of a PV maker being responsible for toxic spills, or violating the EPA guidelines for semiconductor manufacture, then HP readers will hear about it in print. We are determined to make solar energy part of the solution, not part of the problem. Richard

Light Adaption

Gentlemen: The local power company made fluorescent lamps available at a special rate so I bought one for my home office. I had to change the light fixture because the old one would not accept the bulb due to presence of a 'harp' that supported the glass diffuser. I installed the new fluorescent bulb and it lit up the room fairly well, with a lot of light on the ceiling, where I seldom read or write. What I needed was a reflector, but the fixture had no provision to support one. A trip to the local building supply/household supply store was in order. I found a white plastic type of bowl that appeared to be suitable. It was shaped like a truncated cone, 11 3/4 inches in diameter at the wide part, 4 3/4 inches in diameter at the truncated (flat) part. I located the center and cut a 1 1/4 inch diameter hole in it. The neck of the bulb is about 1 1/8 inches in diameter so the shade hangs nicely on the bulb. Not enough heat is generated to be a problem, the ceiling is dark and there is a lot more light in the room where I need it. The price was under $2.00, which was in

the right range for me. Hope some of your readers can benefit from this. Fred J Mocking, 5248 Arcadia St., Skokie, IL 60077

Good work, Fred! That's the idea—Yankee ingenuity. It doesn't have to cost an arm and a leg to do the right thing. If something isn't perfect (what is?), why just adapt it to your needs. Adaption and survival go hand in hand. Kathleen

Missionary Man

Dear HP Staff, I am a missionary to the West African country of Sierra Leone. I have just completed installing and living with solar power, and it's wonderful. I use 9 Arco M-75 panels, a Trace 1512 inverter, B.O.S.S. control systems and 9-110 AH marine batteries. For our refrigeration needs, we use a Sunfrost unit, that is fantastic in our tropical heat. I was given a subscription as a gift, and have gleaned a lot of useful information from it. The information is easy to understand, and I especially like the 'Hands On' testing you do, the reader input is very valuable, as well as the ads for various products. I hope to gain more valuable input this year, while on leave in the U.S.A. You have done a great job, the best I have read. Keep up the good work! Sincerely, Dan Harrigan, Sierra Leone, West Africa

It is always exciting for us to get mail from other countries, Dan. If you get the chance at all while you are stateside you should go to any one of the energy fairs that spring up in good weather. A guarantee that you will 'gain more valuable input'. Kathleen

Solar Blimps

Dear HP Folks, Somehow I let my subscription elapse with #22 and WOW! how I have been missing your wonderful connection. I guess I took too much for granted when #1 etc., etc. began arriving out of the blue. The link up you've provided with/for a lot of similar energy minded folks out there has been a source of inspiration & hope beyond the scope of mere words.

The stunning color image of Sunseeker soaring cross country gracing the cover of #19, for example, was not only fresh hot news to me, as I'd heard not a word of it though other media, but what a milestone of genius as well! Years prior I'd given up the prospect of ever seeing another crystal clear sky over my native soil on the east coast because of the unrelenting high altitude haze fuelled in no small way by the emissions of thousands of daily jet flights. After Sun Seeker's trailblazing crossing one can't but hope that blimps decked out in flexible PV arrays might some day (soon!) be ferrying those passengers who will slow down enough to enjoy the trip. If it is really a serious proposal to begin punishing polluters (sky-dumpers) with fines, then shouldn't pollution-free air fare eventually edge out the competition? Visions to work toward!

I love your publication for the contagious attitude of sharing and fellowship that underlies so many articles. We ARE in this together. Life goes on but I've been feeling a little too detached without you. Please find check enclosed. Send me a #23 and resume my subscription ASAP. Gratefully! Hal Strickland, RR1 Box 817, Johnson City, TX 78636

Wow, Hal– we're blushing. We went round & round about sending out renewal notices. We decided not to do it because be don't want to raise HP's price to cover dunning you for bucks. We're already guilty about all the paper we use (2.5 tons per issue). So if your mailing label says "THIS IS YOUR LAST ISSUE" it's time to reup your subscription. Karen

Snake Eyes

Dear Karen, It was a pleasant surprise to open issue #22 and find a picture of our electric car. We have had numerous calls from other subscribers wanting to see the car and our other solar things in person. Thanks for the surprise.

Please renew our subscription of Home Power starting with #24. Your magazine has saved us thousands of dollars in mistakes not made. Our system consists of 8 Arco M-55s, 26 Exide EMF 500 Gel batteries configured as 12 volts and a Trace 2012 with most of the options including a D.V.M.. When the inverter is powering a load pressing the charge rate button gives a reading in direct proportion to the load. The bigger the load the larger the number. Is this telling us how many amps the inverter is drawing on the 12 volt side? We find these readings most useful when powering new loads and use it often. Our book does not mention this valuable feature.

Another question we have is just how tightly can we turn the wire clamp screw in the junction box of the panels and is there an optimum torque? I am always afraid someday I'll break something.

The bus bars were made from 1/4 x 3/4 wide copper. The batteries are configured as 2 separate 12 volt banks joined as one by using 2 negative and 2 positive cables. This was done to save space and keep cells closer to the wall. Both negative ends are fused with bolt on fuses. Each side contains one extra cell parallel connected to allow for removal of any bad ones in the future and still be able to change to a 24 volt system. The solar panels were frequently coated with bird droppings. Two plastic toy

snakes wrapped around the mount near the top of each side seems to have solved this problem.
Access - 2 pieces 1/4 x 3/4 x 6' copper UPS shipped for $39.04 total from; Mc Master-Carr Supply Co., Monmouth Junction Rd., Dayton, N.J. 08810. Part #8964K83 Phone # (201) 329-3200
2 toy snakes at $.98 each from Sunken Gift Shop at Cape May Point, Cape May, N.J. Sincerely, Debby Henne, R.D. #1 box 104, Robesonia, PA 19551

Hi, Debby. The DMM in your Trace only reads recharging current into the batteries from an ac power source. This current meter only functions when the inverter's charger is operating. The Amps section of the Trace will not read the amount of DC current passing through the inverter when it is operating as an inverter. This meter only functions when the inverter is operating as a battery charger. What you are seeing on the display is random noise, generated by the inversion process, picked up by the DMM.

Don't get real physical with any of the electrical connections on the PV modules. Good and tight with a screw driver does the job. It is virtually impossible to overtighten these connections with a screw driver. Richard

Light Side
Dear Richard, Please find inclosed our check for $20.50 for back issues # 22, 23, 24, and please renew our subscription for another year.

As mentioned in our conversation, we have been inspired by your very important magazine to do what we can to cut ourselves loose from the oil nipple in the Middle East. We know our effort is but a drop in the bucket, but if everyone would do something like this it would sure make a difference.

We bought circular and tube fluorescent bulbs for about 98% of the light fixtures in our home, it took a while to get used to them but we did and in a very few weeks we hardly knew the difference. We bought these lights over a two month period, a few each week as we had the money each time I would go to Builder's Emporium here in Lake Elsinore. The first one we bought was $7.99 plus tax or about 'ten times' the price of an incandescent bulb!! The next week I go to buy another one and they are on sale for $4.99!! So, I bought four or five, then So. Cal. Edison puts rebate forms in the light department at Builder's Emporium and my wife Sally, the coupon queen, of course finds them and we get an in-store $5.00 rebate per the three light per family limit Edison has going. Some people are selling these lights for 2-4 times these prices so I figure how much quicker will the payback be!! Now, speaking of payback. Everybody has been talking about how much money you can save with these things but, I got to see it to believe. So, I am going to give this thing the benefit of the doubt and see what happens. Well you can't argue with the facts, the first eight months of last year our average bill was $69.18 and the first eight months of this year our monthly average bill is $44.96, and a $24.22 or a full 35% savings per month!!!!!!! And I tell you we did NOTHING different this year than last other than to convert to fluorescents!!!!!!!!

Now as far as the payback, we spent about $160.00 and since our average savings has been $24.22 per month, we had our money back in just 6.6 months, such a deal! Now it's for sure going to vary from household to household, but the bottom line is that if we are ever going to get Americans to convert to fluorescents or almost any other energy saving device for that matter, it will have to be something that has a very short payback time and the shorter it is the quicker Americans will be to convert over to it. Its sad but true, we do vote with our wallets and not with our minds. You guys keep up the good work, you have made a convert out of me. Yours truly, Jacob D. Junker, POB 455, Lake Elsinore, CA 92531

We also have 90% of our household lights in compact fluorescents, Jake. We do not pay a power company bill but every bit of electricity saved is used in some other way. For on-grid people this is a great way to save money. Then put that savings into some renewable energy options. - Kathleen

Compact fluorescents are truly amazing. Never before have we had such high quality light for so little electric power. We're converts too, Jacob. We've ripped out all the DC lighting from our home/business and replaced them with 120 vac compact fluorescents. Richard

Solar Education
Dear Kathleen Jarschke-Schultze; Your June/July issue was my introduction to your magazine. Unfortunately after reading it from cover to cover I was more confused than ever. With the price of electricity predicted to escalate by as much as 40% over the next 3 years and other sources following suit, solar power seems to be a reasonable alternative.

Beginners like myself need extremely basic information. How about an introductory column for the absolute and complete beginner. I know that with my present level of knowledge, I'm easy prey for a fast talking salesman. Only fools purchase items they know nothing about, especially when your talking about hearth and home. I have sent away for 'The Solar Electric Independent

Home Book' and written various solar organizations who are within 1 day driving distance from Toronto for information pertaining to their workshops. I desperately need basic kindergarten level information regarding solar and hope you will consider us slow learners in future issues.

Information such as: What type of cost is one looking at to convert the average home? What is a reasonable payback time? What type of questions should one ask when considering a solar purchase. What type of maintenance is involved and how much money is reasonable to put aside for repair and replacement parts. With all other forms of energy becoming more costly is solar a good idea for those considering retirement within the next 10- 20 years or will solar costs make them have to retire at the mercy of the grid?

My friends and I do not want to be slaves to non-stop energy increases... is solar our answer? I presently own a few solar books, the most understandable being about solar projects for under $500.00. I intend to make some of these items, but this is really scraping the surface of solar energy's potential. Help! Yours, Sharon Cruise, 7 Roanoke Rd. # 206, Don Mills, Ontario, M3A 1E3, Canada

Well, Sharon, we have published articles on the basics. Richard started laying out the basics in issue #21 and has continued adding more information for beginners in every issue. There is no average renewable energy home. Every family, every site, every power source potential is different. This means there is also no average price of a system. Just too many variables. Issue #21 has an article on the Basic Site Survey. Keep reading every thing you can get on the subject. If there are any renewable energy fairs around you, go to them. When calling RE businesses for information it is very helpful if you have a good idea of your regular consumption habits. Look at all your appliances and see how they are rated. Add up all the watts of your light bulbs. Figure out how often you use each thing. Cheer up! You're unique. Keep asking questions, it's the only way to get answers. Kathleen

Step by Step

Dear HP: I've got an idea I was hoping we could run up the flagpole via your 'Letters' column. To do this, I'd like to go through my assumptions step by step; perhaps you could point out where I'm off.

It seems to me that for every hardy soul living off-grid, there are a dozen people who would like to. However, the leap from utility to independent power is an expensive one, with many unknowns and few definite guidelines.

Unless a person has money to burn and/or is forced to it by the inaccessibility of power lines, I'm thinking that we need ways to make a gradual transition, as we accumulate experience and generating capacity. One of the major roadblocks to this concept is energy storage/management. For instance: I'd really like to buy a few panels, but I'm not about to buy hundreds of dollars worth of batteries and controllers.

However, if someone made an inverter that could tie into the grid AND function independently... now that might be a worthwhile investment.

World Power Technologies makes the 'Whisper 1000', a 1 KW windspinner, as well as a 5 KW bigger brother. They also market utility interface inverters for both windmills. When I called, a gentleman explained that both inverters automatically shut down in case of a power outage. In other words, these inverters are specifically designed NOT to function independently, as the utility linemen would not appreciate your 5KW windgenerator happily pumping maximum output back into their downed lines on a stormy night while they're trying to re-establish service.

Next, I called 'Real Goods' and chatted with one of their techies, who gave me Trace's number. The fellow at Trace said he'd asked about their making something like this, with an internal switch of some kind so one could dedicate the inverter to 'ON' or 'OFF' grid operation. Evidently the feeling is that it's not worth the money to develop. World Power's little inverter goes for about $1200, the bigger one for $2800. I have no idea as to their efficiencies and such, and I'm a dunce with electronics. However, I just don't see where it would cost all that much more to design and make a dual function inverter. If Trace or PowerStar could build an interface inverter which matched the efficiencies of their current products and included proper safeguards so no linemen get bit repairing power lines, I think they could sell lots of them.

Maybe I'm way off on this. I'd like to hear what you and your readers think. Thanx, Bill Barmettler, POB 1462, Chehalis, WA 98532

Bill, utility intertie has great promise as the wave of the future for those already grid connected. Unfortunately, it isn't encouraged by the utilities in America as it is in other places. When they become more "enlightened" I'll bet we'll start to see the kind of dual function inverters that you envision, but you're still going to need batteries or some form of energy storage to power the inverter when the grid goes down, it's nighttime and the wind isn't blowing. No? Bob-O

EV Info

Dear Friends, I intend to build an EV and have rejected "conversion" of old, heavy, in efficient cars in favor of a light, streamlined, high performance 3-wheel EV. The only disadvantage of this approach has been the engineering, design, and development required. Now professionally designed and well-tested EVs can be built that are so superior to "conversions" that it is no contest.

Consider this: The Doran EV is similar in size and shape to the Honda CRX, but is much lighter (!) at 1,490 lb., has about the same performance a $23,000 Alfa Romeo Spyder sports car at legal speeds (0-30 in 3.3 sec., 0-60 in 10.9 sec.), has 10.2 cu. ft. of luggage space, an 85 MPH top speed for easy 2,650 RPM cruising at 55, goes 61 mi. city and 42 mi. freeway at 80% discharge, and does it all with NINE mundane golf cart batteries! Ain't efficiency wonderful? Besides being heavy, batteries are the main operating expense for EVs. These high-performance EVs should cost about one-third as much run as a "conversion". More fun, too!

Plans and construction manuals are available from:
Doran Motor Co., 3425 Ridgecrest Dr., Reno, NV 89512-1443 Info- $5, Plans- $39.95 + $4 postage
Dolphin Vehicles, POB 110215, Campbell, CA 95011-0215 Info- $12, Plans- $40
Both also include plans for gasoline (YEECH!) versions.

If you are really serious about EVs, obtain all information available, decide what finished product you really want, and do it right, whether conversion or scratch built. No electro-clunkers! Also, forget techno-nerd gimmicks like hybrids (for EV drivers who are nostalgic for noise, vibration, and poison gas). Finally Conrad Heins' ("Hydrogen As A Potential Fuel", HP#21) information is hopelessly out-dated. PV is potentially by far the cheapest source of electricity! After all, they are made out of sand, and require no maintenance or fuel. Texas Instruments has a PV panel made out of cheap (buck-a-pound) metallurgical silicon, and an Australian group expects PV electricity to cost half as much as from coal.

Solar hydrogen could be a very cheap fuel within 10-years! Now we have the "laser cell" H2 fuel cell by Dr. Roger Billings that acts as its own electrolyzer, in reverse, when hooked up to electricity and water, producing its own fuel! Fossil fuel isn't the problem... it's fossil politicians! Lucian Holy, Deer Park, TX

Thanks, Lucian. After seeing all the wonderous possibilities at SEER '91 in Willits this summer I want an EV so bad I can taste it. Unfortunately we live so far out of town the range is a problem for us. Plus, we live in the Siskiyou Mountains. EVs are the transportation of the present in urban and suburban areas and future transportation everywhere. With a few more battery breakthroughs they will see their day. Necessity is the mother of invention.- Kathleen

Contact Roger Billings at the American Academy of Science, 26900 East Pink Hill Road, Independence, MO 64057 • 816-229-3800. He's got the straight scoop on hydrogen-fueled vehicles. Richard.

Consumer Alert!

If you own a generator be sure it is in a fire-proof location! Don't run your generator near dry grass, trees, or flammable building walls.

This is especially important with some models of Honda generators, but it could apply to others as well. I know of two that have had problems when the gasoline float in the carburetor got stuck. One of these was not running at the time so all the gas in the tank just drained out on the ground. The other one was running and caught fire, destroying the generator and almost burning a nearby house.

If you own a Honda generator it would be a good idea to occasionally replace the plastic carburetor float and its associated needle valve/seat assembly.

Whatever type of generator you own, be sure to clear the area around it of all flammable materials, or house it inside a building with masonry or sheetrock covered walls. Ross Burkhardt, POB 2800, Ukiah, CA 95482

Thanks, Ross. After the fire danger of summer there is a tendency to think you are fire safe in winter. The preferred option is to not have to run your generator at all. For many of us, though, that is still a goal to be reached. Get ready before something tragic happens. Don't forget to clean your flues and keep the leaves off your roof. Kathleen

I can verify this info. The plastic carb float in my Honda gave up and sank. While I didn't have a fire, it did flood the engine. Bottom line is be very careful with fuels. Richard

Water & Wind

Dear Folks, As usual, I've been enjoying the magazine, and this time I have some questions.

Cameron MacLeod's article on ultra-low-head hydro fascinated me, since I am continually ambushed by broken dams and abandoned millsites here in New England. Many small millsites still have their turbines and generating or other power equipment seemingly intact. I

am tempted to get involved with rehabilitating these sites, but: what are the barriers? ($/kW of installed capacity yield too long of a pay off, even if you're not selling the excess capacity at the grid's below-retail cost? Can't fix the dam without installing fish ladders?) What might be the first stop for legal and environmental information, FERC, State Department of Environment Management?

By checking the numbers in Mr. MacLeod's article, I noticed that the water-to-electricity efficiency of systems 1 through 6 varied from 77.5% to 29.3% (systems 1 and 2, respectively), with 4, 5, and 6 all 57%. Why the variation?

Not that it necessarily matters, it's what you get in electricity, and what you pay. Reliability is probably great, what are ballpark figures for $/Watt, considering also the amount of sweat equity?

What did Mr. MacLeod mean by "...the diversion had better not be long"? The weir must go the length of the stream, right? Why is this a consideration: strength, regulations, or some other factors?

Onto wind! Mr. Bergey's article gave us a new perspective. I've been poring over the map of US annual average wind speeds. Where can I get one? I can't really differentiate the classes, especially where they're close together. Looks like there's some excellent wind potential here in the east, which various companies are acting on. (Renewable energy companies, especially in Vermont, US Windpower on Mt. Equinox in Vermont and on the St. Lawrence River in NY State, Endless Energy in New Gloucester, ME). I'll echo Mr. Bergey that the post-1985 wind-energy shakeout left only the best companies, and that the best way to find out who they are and keep up with windpower is to join the AWEA, American Wind Energy Association. Their directory has been a well-thumbed resource for me as I look for an engineering or technical job in the renewable energy field, it gives a great idea of what's out there for equipment, and who's doing it, & who specializes in what, including consultants.

Finally, I've gobbled up Mr. Sagrillo's articles and reviews. It made me think that maybe he and Home Power get together a reprint of collected topics: towers, measuring the wind resource, utility interconnection. Home Power could use it to flesh out answers to routine inquiries, (free with a new subscription?), and so could Mr. Sagrillo. Perhaps you could throw in your article on 'The Basics', like deciding on wind potential by noticing how often things get forcibly blown around your yard, and whether you notice any flagged vegetation in the vicinity. Two questions for Mr. Sagrillo on towers: is rotor size or the weight of the package on top of the tower negligible compared to other factors, i.e. the height? Finally, what percent of $/(kW installed) do towers run?

And here's a renewed subscription for my favorite rag in the world. Keep up the good work, and don't burn out without letting us know first. I want to see you around in the next millennium, too. With respect and regard, Alex DePillis, 27 Gaylord St., Amherst, MA 01002

Hydro: Efficiency is low in System 2 because the water flow is reduced to summertime level throughout the year. Efficiency varies from 50 to 60% in a well designed system. The cost per installed kW. is shown on the table below.

System #	Cost	kW.	$/kW.
1	$5,000	0.39	$12,821
2	$4,000	0.39	$10,256
3	$3,000	4.55	$659
4	$12,000	1.56	$7,692
5	$20,000	7.00	$2,857
6	$10,000	1.95	$5,128

System cost varies with site. Items like owner sweat equity, purchasing used or rebuilt equipment will lower cost as in System 3. Plan on spending at least as much money on civil works as you do on turbines and electric equipment. If you are working with in-stream hydro, then get in touch with FERC, Fed, and State agencies. Sooner or later you will have to deal with them. The length of the diversion is kept short for ecological and environmental reasons. A good book for hydro is "The Microhydro Power Sourcebook" by Alan Inerson. Available from: NRECA International Foundation, 1800 Massachusetts Ave. N.W. IPD#2-16 Attn: Lincarley, Washington, DC 20036 • 202-857-9615. Cost is $26 postpaid. Cameron MacLeod

*Wind: Rotor diameter is **the** major consideration in sizing towers, while the weight of the machine is at most a small factor. The swept area of the rotor acts as a force on a lever arm, i.e. the tower, and tries to push the tower over. The bigger the rotor the bigger the force. As far as towers themselves go, the tower will cost about 25% to 50% of the system's cost. This does not include installation which varies widely because of soil type, distance of machine to house, and other factors. Both of these questions would make excellent subjects for future articles, Thanks. Mick Sagrillo*

Lost Mail
Dear Home Power, Some time ago I placed an ad in HP MicroAds, and it appeared in Issue #23, the last ad on page 97, 'ENGINEER'.

For some reason, the Post Office did not forward my mail from the old Box # to my new box #, so I didn't get one reply. I filled out a change of address card, old box # to new box #, and my box was payed up.

The chances are that they forward by name only, so my mail was probably returned to sender. By the time I realized what must have happened, it was too late to do anything about it.

Even though I have found a place to work and live, I would like to hear from those that answered my ad. Perhaps you could let the readers know what happened in 'Letters to Home Power'. Thank you. Raymond Patton, POB 102, Cainsville, MO 64623

Consider it done, Ray. - Kathleen

The Plunge
I have a thousand questions and don't know where to start! As a reader of your magazine, and reader-dreamer of alternate energy and more harmonious lifestyles, I've come to the point where I would like to take the plunge (though on a somewhat limited scale).

We live in a metropolitan area of the Central Valley and are contemplating the addition of a couple rooms onto our existing house. What I would like to do is add solar panels to the house and need to know what I can expect as far as costs, so I can figure it into our equity loan.

I'm thinking in terms of just a series of panels and a synchronous inverter to feed into Southern California Edison's grid rather than completely unplugging due to limitations of funds, space available, battery hassles, etc.

-Who in this area can you recommend to me for panels, installation, parts, moral support, etc.?
-About what amount of cost am I looking at?
-What is the approximate life expectancy of such a setup?
-Do power companies make life difficult and treat people with such systems as outcasts?
-Have they (the Govt.) taken away all tax advantages?

I have always been a supporter of alternate technologies, but am not a techie myself. I wish to do more than just offer lip service, and feel that each of us doing small things will help the whole.

Before I forget, we are a family of five, in an approximately 2,000 square foot, leading a fairly typical American lifestyle (suburban). Our electrical consumption runs around a high in July of '89 of 766 KwH, and a low of Nov. '90 of 379 KwH.

Finally in closing, the last issue I've received was #22 (April/May 1991). Has #23 not yet been issued or is it my mail has been misplaced or mis-routed by the postal service? If you have issued it already and have an extra copy I would appreciate it if you could forward it to me, I've kept all of my issues!

Thank you so much for all you've done and are doing. It is important and uplifting to see people actually practice what they preach! Enclosed please find a SASE for your quick response. Peace, Craig Kiefer, 1823 E.Westcott Ct., Visalia, CA 93277

PS What a dope! I just looked at my address label & realized #22 was my last issue! Enclosed please find my check for $10.00 to renew my subscription.

Sorry you missed some issues there, Craig. HP doesn't send renewal notices in order to save a few trees and to keep the cost of the mag down.

At this point in time, it would not be cost-effective for you to try and power your house with PVs. Understanding this if you still wish to go solar, then contact the dealers in your area advertising in HP. If you do an efficiency job on your home, the system will cost between $10K and $40K, depending on your appliances and usage. Lifetime will be between twenty and fifty years. Richard

In Germany, nearly all new construction incorporates PV modules on the roof with a synchronous inverter intertie to the local grid. This makes blinding-clear sense, as the peak demand time for power is during the hottest, sunniest time of the year when the PVs are producing best. As logical and practical as that seems, it isn't available from SCE as far as I know. At least, it sure as hell isn't encouraged! I suggest that you RAGE with righteous anger at the next open Public Utilities Commission meeting about it. There are no tax credits, either state or federal, for using renewable energy. Frankly, the HP crew thinks that this is just fine. Let the renewables flourish because their time has come and it's the thing to do. Governmental intervention is almost guaranteed to muck it up. What you can do is look into solar collectors for your domestic hot water. There is new and exciting technology in this area and most of the fly-by-night dealer/installers who showed up with the tax credits have moved on. Those left in that industry are, by and large, experienced and reliable. A good solar DHW system will experience a payback in about 3 years in your area. Bob-O

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Q&A

Exploding Battery
Dear Friends: I have a problem that I've never seen discussed in your excellent magazine. My house has been powered by an off-grid system for many years. My 12-volt battery bank is charged by a Jacobs wind generator, with back-up by a diesel generator.

After trying golf-cart batteries and recycled telephone company batteries, I have switched to using 3 pairs of locally available 6-volt lead acid batteries made for electric floor scrubbers. They have black rubber cases and are very heavy duty, yet light enough to carry by hand to my remote location. About 3 years ago I installed Hydrocaps on all cells to reduce the corrosive fumes in my battery house.

In the last two years, 3 of these cells have exploded, showering acid all around and destroying the heavy rubber cases. Has this happened to other people? What can I do to prevent it? Are the Hydrocaps responsible? Or am I causing the trouble myself by overdoing the equalizing charge? Any suggestions would be welcome. Very truly yours, Bill Spikowski, Calusa Is., POB 216, Bokeelia, FL, 33922-0216

Dear Bill- You didn't give us enough info about your batteries, i.e. manufacturer, size, capacity, etc., to be completely sure, but I suspect that the problem is caused by overcharging. We've seen and written about Hydrocaps going blooey before (see HP#19, pg. 50) What happens is this: when the batteries are gassing very heavily, the platinum catalyst screen in the Hydrocap saturates with liquid and forms a very effective hydraulic seal. As the gassing continues, the pressure builds up in the battery cases until… Blooey! Hydrocap Corp. recommends that you remove the caps prior to doing an equalizing charge to avoid just such an occurrence. Being careful not to overfill the batteries with distilled water before recharging will help also. Bob-O

Condensed Version
Hi Home Power Team, I just bought a set of recycled Nickel-Cadmium batteries so I need more info on them. Please send me copies of these mags 4, 12, 15, 13. Enclosed is enough money.

Also, is there a way to cut the diodes out of my m-65 (ARCO) self-regulating panel? I wonder if that would void the warranty? I'm in no hurry, maybe an article someday. Thanks for a really, really good magazine.

Also I want to respond to the letter in HP 24 from Jonathon Sutton; water cooled condensers.
(1) Water cooled condensers must be designed to be cleaned. Mineral deposits from the water collect on the condensers. The result is inefficiency.
(2) Running too "cold" a condenser can result in too Low Head Pressure and cause trouble too.

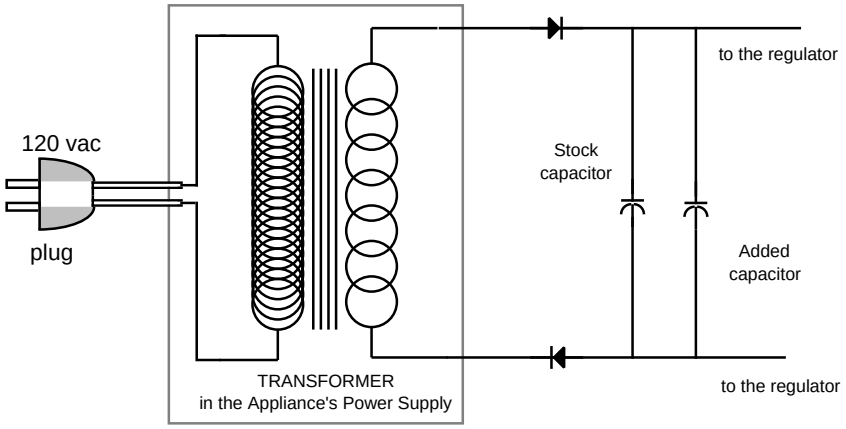
A really good book on refrigeration is "Modern Refrigeration and Air Conditioning" by Althouse, Turnquist and Bracciano-Goodheart-Wilcox Co. Publishers. Nearly 1,000 pages of tech. literature from using water as a refrigerant to ammonia systems and everything else. HP should find a good refer man for your staff. Steve Nagel, POB 343, Babbitt, MN 55706

Thanks for the tips on those condensers, Steve. Each of us sharing our experiences is what makes Home Power work. As to your M-65s, removing the diode won't buy you anything. It is wired in reverse-biased to protect the module when the array is wired for high voltage. The diode is not connected in series with the charging current path, so eliminating it will not change your module's operation. If your problem is low output voltage during less than ideal light conditions, I'm afraid that it's intrinsic to the 30 cell module itself. Consider using modules with at least 36 cells in series. Bob-O

Microfarads
Dear Home Power, I'm a missionary in Togo and would like to get your magazine. Please tell me how much you need to send it to me.

I also have a small question. In HP 12 there was a letter asking about how to cure inverter hum. You suggested putting "several thousand microfarads of capacitance to the low voltage side of the ac/dc supply". How much is several thousand microfarads? Do I just stick it in the hot side of the transformer output before the rectifier? I also have this problem. Thanks for your response. Sincerely, David W. Maffett, 5621 Signet Dr., Dayton, OH 45424

A 1,000 µfd. capacitor is about the size of a roll or quarters. Use at least 5,000 µfd. and watch the polarity. These capacitors are electrolytics and are polarized. In some cases, I have had to add as much as 10,000 µfd. to shut up the device. In other cases, no amount of capacitance would make the device totally quiet, and a line filter was required. Richard



P.S. Please be sure to include my e-mail address ('tan@.....) if you publish this letter.

Tan Bronson (tan@Microvation.COM), 20 Sperry Rd., Madison, CT 06443

Thanks to the efforts Don Kulha of Sonoma Online, Santa Rosa, CA, Home Power can be downloaded via modem. Currently Don is carrying the first ten issues of HP as text and art files. We are supplying him with more info regularly. You can call the following nodes of Fido Network Echo Conferencing System and access Home Power info. In things go well, who knows maybe online conferences & roundtables.

FIDONET designator is ***HOMEPOWR***

Sonoma Online, Santa Rosa, CA 707-545-0746
Humanity Net, Chico, CA 916-891-1920
Wildfire, Chico, CA 916-345-4253
Aerospace Tech., Fairfield, CA 707-437-5389
The End of the World, Fortuna, CA 707-725-5785
The Outland, Santa Rosa, CA 707-575-0636
SF Bay Interconnect, San Francisco, CA 415-863-8718
The Reservation, Coventry, CT 203-742-7205
Energy BBS, Rockledge, FL 407-690-0032
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EchoMaster, Temperance, MI 419-475-2241
Pro Photographer, Minneapolis, MN 612-341-8172
Earth-Net, Chapel Hill, NC 919-929-0677
REDCON, Raleigh, NC 919-859-3353
Intervision, Francestown, NH 603-547-6485
Helix, Seattle, WA 206-782-3365

This is a partial list of the FidoNet Nodes that carry Home Power. More are coming on line daily, so call Don Kulha at 707-526-9473 to find a node near you. Richard

Generating Interest

Dear Sirs, I'm moving a 150 year old barn to a site in Windham, Vermont where the power company wants $16K to install power (2000' road + 500' driveway), so we're going to install a generator/battery bank next year and later on we'll explore using hydro and/or PV. For the short term I've purchased a 12 V marine battery and charger to power car stereo, light, B&W TV and a 400W inverter for my portable PC. This will be charged by whatever generator I can borrow until I get a larger system. (That) will run on propane.

I plan on using a 24v battery bank, but I will also be using the house for 24 VDC and converting to 12 V as needed, or wiring for 12 VDC outlets and only bringing 24 VDC to those places where it will clearly be used (inverter, lights, and refrigerator).

I'm a software engineer who's home computer is on Usenet. Usenet is a system which connects universities, business, and homes around the country with a series of discussion groups and e-mail. There is a hierarchy of groups which I don't have room to discuss here, but I was wondering if there was any interest among your readers for a 'misc. rural homepower' group and/or mailing list. I like the idea of creating a home power magazine in Apple Hypercard stack format, it would be an interesting way to present the information available in Home Power and would be a wonderful way to present all the information in all the issues. If space is a problem it could be shipped as a CDROM once a year or so...

I'd also like to see some generator evaluations. Most people need something for backup and there must be some major differences between designs. Keep up the good work!

Ozonal Notes

I gave away our generator. She was an old friend that helped us construct Home Power's home. The truth is we hadn't run her for over two years and she was dying from disuse. I think she knew she'd had it when our first inverter showed up years ago…

So we gave her away. A friend hauled her away in his car. I just watched and waved goodbye. I not sure if I'm happy or hesitant. I've never been without a generator before. I could always fall back on her for a quick energy hit. Eventually she would always start. Now I'm without a backup— flying without a parachute.

What I'll miss most about our generator are the countless hours we spent together. Both of us covered with oil, I whispered encouragement down her carburetor. We spent many afternoons discussing life over a case of motor oil. She could really hold her oil.

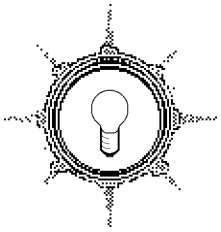
I'll miss her when I don't have to hump several five gallon jerry cans into the pickup. I'll miss her at her old watering hole, the pumps. I'll miss her at the parts counters. I'll miss her voice, and the smell of her.

I'm really looking forward to missing our generator. For a good servant, she sure turned out to be a hard mistress.

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 through #8 are available. Back Issues of #21thru #25 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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FOR SALE HEART H12-1200X, 1200 watt ultra high efficiency inverter. 12 VDC input, 120 vac output, regulated RNS voltage. Reactive load compatible. Has 50 amp battery charger, standby mode for use as an emergency system. Excellent condition. $700. 916-475-3428

THE COLUMBIA, 52", 4-bladed, brass 12 volt D.C. ceiling fan: Draws 0.4 amp, reversible motor and oak blades. For information on this and other models plus names of dealers, send S.A.S.E. to R.C.H., 2173 Rocky Creek Rd, Colville, WA 99114

1991 GUIDE TO UNUSUAL HOW-TO SOURCES. Describes 50 periodicals & handbooks on backyard tech, camping, crafts, finding new friends, gardening, home education, low-cost shelters, travel, woodslore, etc. All addresses are included. Free for SASE. Light Living Library POB 190-HP, Philomath, OR 97370

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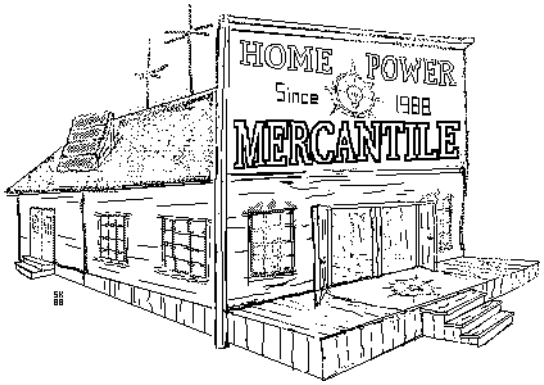

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