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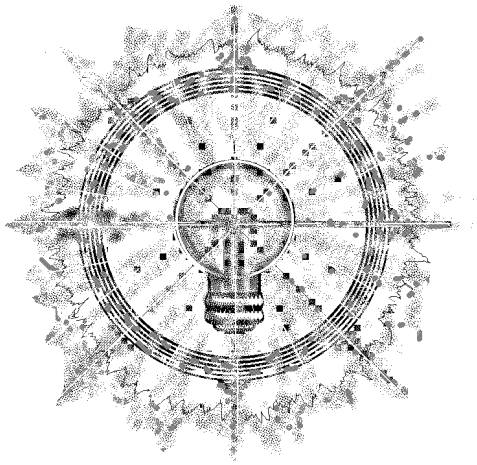

# HOME POWER

## 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

"You don't need a weatherman to know which way the wind blows."

Robert Zimmerman

### Cover

A Northern Power Systems HR3 wind generator powers the Cook's Farm in Pennsylvania. Story on page 6.

Photo by Arthur K. Cook.

Above: the REEF '92 Fair Crew at Arcata, CA. Photo by Bart Orlando

### *Earth Speaks During Earth Day Energy Fair*

*The 1992 Renewable Energy & Efficiency Fair, April 25th, in Arcata, California was the first fair this year. Saturday morning we went to Redwood Park and set up our booths. The park is a large meadow perched on a hillside above Arcata and is ringed with tall redwood trees. The sun blessed the fair by shining for the first time in days. Fairgoers arrived by shuttle bus and began cruising the booths, asking questions and gathering information. Workshops began on renewable subjects. The Earth Games for the kids started. The solar powered stage hosted music, skits, and speakers. At 11:06, an unsheduled event happened.*

*A 6.9 earthquake, centered 40 miles south of Arcata, hit the fair. The ground jerked and rolled like a small boat in large ocean swells. The tall redwood trees now looked threatening as they swayed and lurched. In a few moments it was over. No trees fell, no one was hurt, and the band played on, powered by the sun.*

*Throughout the day we had quake damage reports from Arcata and beyond. Grid power was temporarily out for 23,000 homes. Witnesses closer to the epicenter reported power lines colliding and sparking. Gas lines sprung leaks from Petrolia to Eureka and caused fires. Luckily, no damage was reported at Humboldt Bay Nuclear Power Plant in Eureka. This plant was shut down in 1988 because it sits on a major earthquake fault. There is still radioactive waste stored there.*

*We got Nature's message. So did the 2,000 people who attended REEF '92. Decentralized renewable energy allowed us to rock and roll while those around us were powerless. When it comes to power, Mother Nature wins.*

*Kathleen and the whole HP Crew*

## People

Barry Brown
Joel Chinkes
Arthur K. Cook
Maxine Cook
Sam Coleman
Christopher Freitas
Chris Greacen
Lucien Holy
Loren C. Impson
Kathleen Jarschke-Schultze
Kid's Corner Kids
Stan Krute
Don Loweburg
Bradley E. O'Mara
Bart Orlando
Therese Peffer
Karen Perez
Richard Perez
Jack Pouchet
William Raynes
Mick Sagrillo
Bob–O Schultze
Larisa Welk

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Electron Connection
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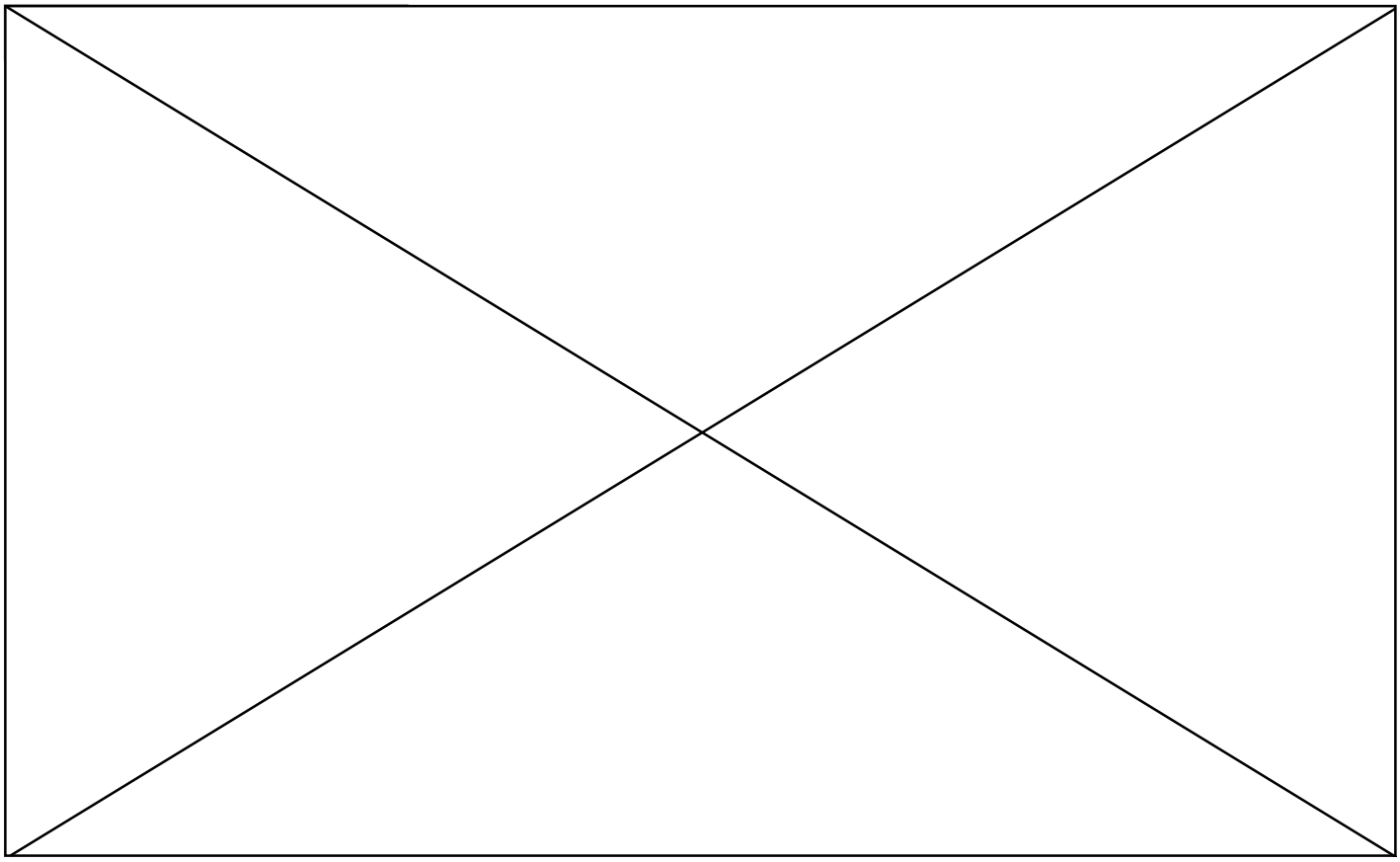


Above: Arthur and Maxine Cook's wind and photovoltaic-powered farm.

# 120 VDC Wind and PV Hybrid

Arthur K. and Maxine Cook



We have been experimenting with wind and solar power since 1978 when we installed our first RE systems. We became "Earth Conscious" in the 1960's and early 1970's as did many people worldwide. We realized that Mother Earth and her resources were being rapidly depleted. We felt powerless to do anything about the world's environmental problems, but decided we could and would take our own measures to live environmentally friendly lives in harmony with the Earth and our fellow man.

**Awakenings**

On December 29, 1974 an electrical snow storm hit with devastating effects. Over forty inches of wet snow fell overnight. The storm was windless, so the snow lay where it fell. Our utility lines were stretched to the ground. Most of the large transmission towers feeding our county were crushed. No more electricity. We slept in a 29° F house with no heat or light. We had no water for our cattle which were trapped in the barn. There were no backup generators to be had – they had all been bought. Five days later we got our power restored and I pledged that this would never happen to us again.

**Beginnings**

Maxine and I, our two Tennessee Walking horses (Go-Boy and Prince), two German Shepherd dogs (Tuffy and Velvet), and three macaw parrots (Ruby, Scarlet, and Sparky) live on a 70 acre solar-powered farm in Somerset County, Pennsylvania. Somerset, Pennsylvania is located about 60 miles southwest of Pittsburgh in the beautiful

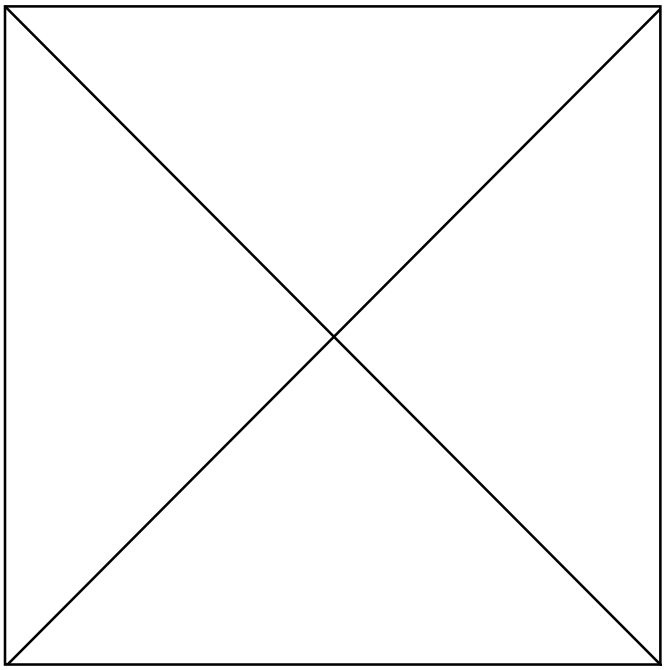
Laurel Highland Mountains. After 14 years we are now comfortable with a fine working system that uses the utility grid as a backup if we don't use our backup generator.

Maxine and I were married in 1969; she was 22 and I was 25. Like most young couples we were anxious to start our life together. I was working in a family business which I was to take over. While it was quite lucrative, it was simply not for me. We were both drawn to the land, country living, and a simpler lifestyle. On May 5, 1973 we made the move to our cattle farm in the country. In 1987 we sold our cattle and became vegetarians. Raising beef cattle will do that to you!

We have been building our system since 1978. In those years we were all pioneers. Nobody was an expert. Electronic controls, inverters, and so on were "iffie" and some were outright junk. People have always thrived on challenges. My wife, Maxine and I were no exception. We have learned through failures, ours as well as others.

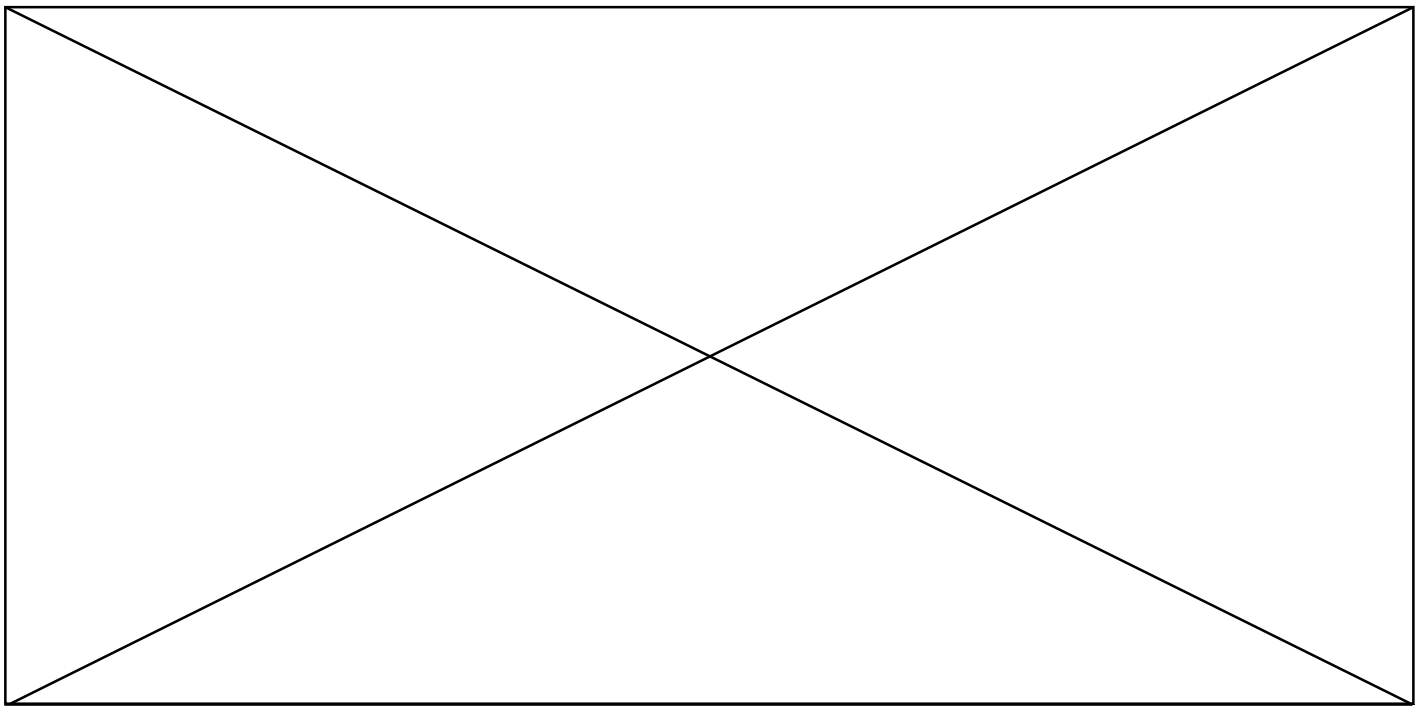
**Wind System**

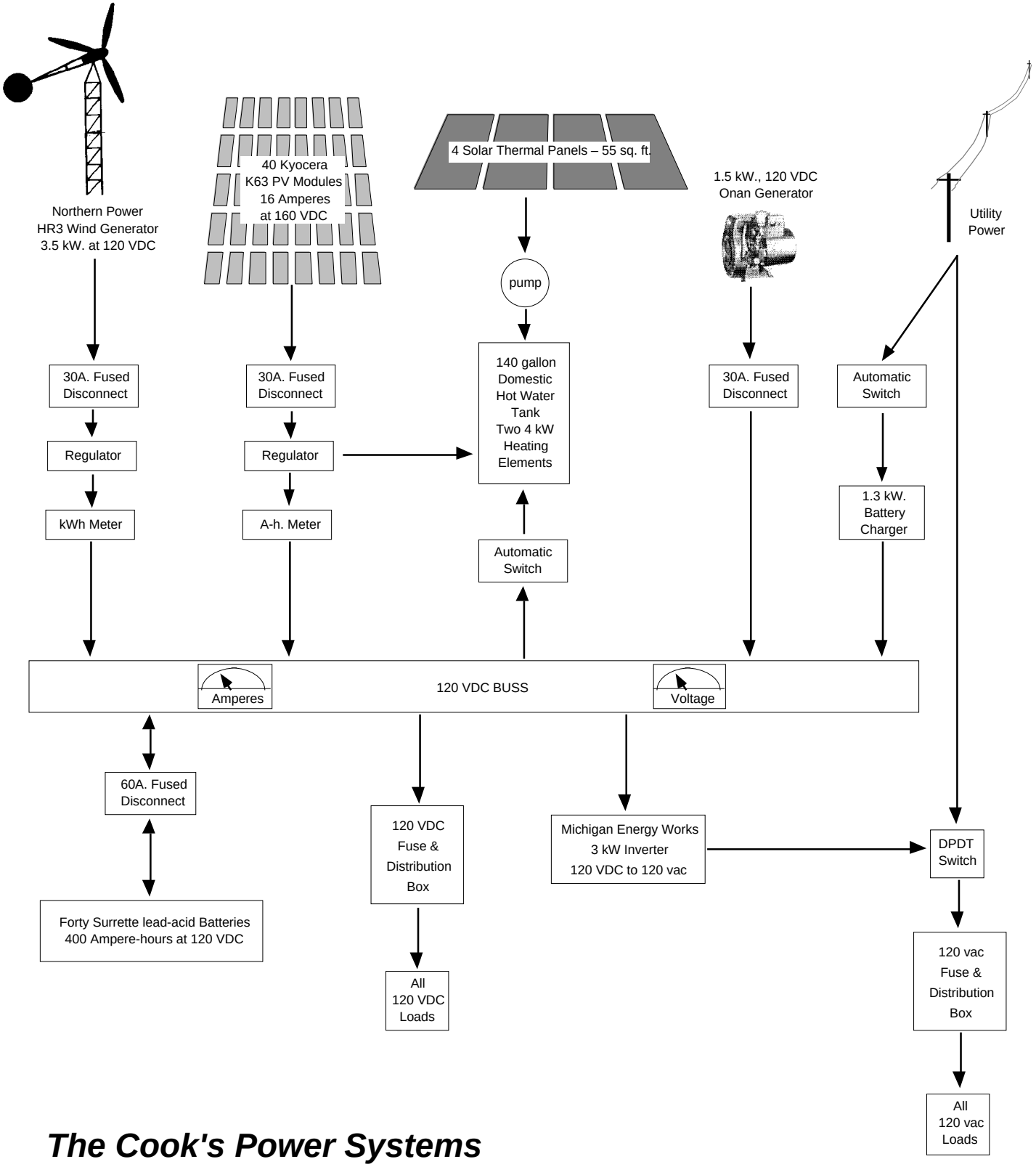
Our first wind generator was a 115 VDC rebuilt Jacobs. It was destroyed in a terrible blizzard in January 1980. The wind that day gusted to 82 mph and the temperature was -27° F. The Jacob's governor failed due to the cold; the springs lost their tensile strength, the rotor overspun, and the machine flew apart. We replaced our "Jake" with our present Northern Power Systems' HR3, an 825 pound, direct drive 120 VDC alternator with a five meter (16.4 foot) diameter three-bladed rotor. We mounted her atop a 60 foot Rohn self supporting tower. This magnificent machine will produce 3,500 watts at 25 mph and requires only one hour of maintenance per year. It hasn't missed a beat in 11 years.



Above: The Northern Power Systems HR3 wind generator atop her sixty foot tower.

Below: Forty Kyocera K63 photovoltaic modules make 2,348 kWh. of electric power annually.






***The Cook's Power Systems***

The HR3 is 270 feet from our house and is fed with two runs of #00 gauge copper cable and one run of #6 copper cable. We experience virtually no voltage loss at 120 Volts. I always overdo everything – it's my nature. Maxine calls me, "Mr. All or Nothing At All."

**The Photovoltaic System**

Photovoltaic (PV) systems complement wind systems because there is often wind without sun and sun without wind. We installed forty, 63 Watt, 20 Volt, Kyocera K63 panels. These Kyocera PV modules contain 44 series PV cells instead of the usual 36 cells found in most 12 Volt modules. Eight panels are wired in a series string producing 160 VDC at 3+ Amperes. With five of these strings in parallel, our PV array produces 16+ Amperes at 160 VDC, or 2,500 Watts. On very bright days we have gone over 3,000 Watts. Energy production from this array amounts to about 10 kiloWatt-hours daily. One clear and cold day this spring, our PV array produced 3,600 Watts (22.5 Amperes at 160 VDC). We routinely get 20 Amperes from this Kyocera array even on hot summer days. This power production is about 25% greater than Kyocera's ratings for these K63 modules. One reason for this is that our array operates at 145 VDC or less, which is below its maximum power point. See page 34 of this issue for more info on maximum power point.

We built our own PV racks out of 1 1/2 inch by 5/16 inch angle aluminum stock. All hardware used on the racks is stainless steel. Each rack holds four panels and is adjustable from 30 to 50 degrees. At $50 per rack, we saved some money over commercially available racks. Number 10 gauge wire was used to series connect the PV modules. Number 8 gauge wire was used to connect the array to our batteries, a 70 foot run with no measurable voltage loss.

**Power Production**

During the year from March 1991 to February 1992, the wind generator produced an average of 239 kWh per month and the PV array produced 196 kWh per month. Our total power production from both RE sources was 5,220 kWh for that year.

**PV Regulation**

Bobier Electronics designed and built a 6 kiloWatt voltage regulator for us. I had them make a load diversion circuit (shunt regulator) so when the battery reachs a voltage of 143 VDC, PV power is diverted into heating our hot water.

**Battery Storage**

Battery storage is via two 120 Volt lead-acid batteries each consisting of twenty Surrette 6 Volt, 200 Ampere-hour batteries wired in series. Both banks are then wired in parallel giving us a total of 400 Ampere-hours of storage (48 kiloWatt-hours). One bank is 12 years old with 85% capacity. We added EDTA to the older battery last year and EDTA does work well. (Editor's Note: See page 44 in this issue for info on EDTA treatment of sulfated lead-acid batteries.)

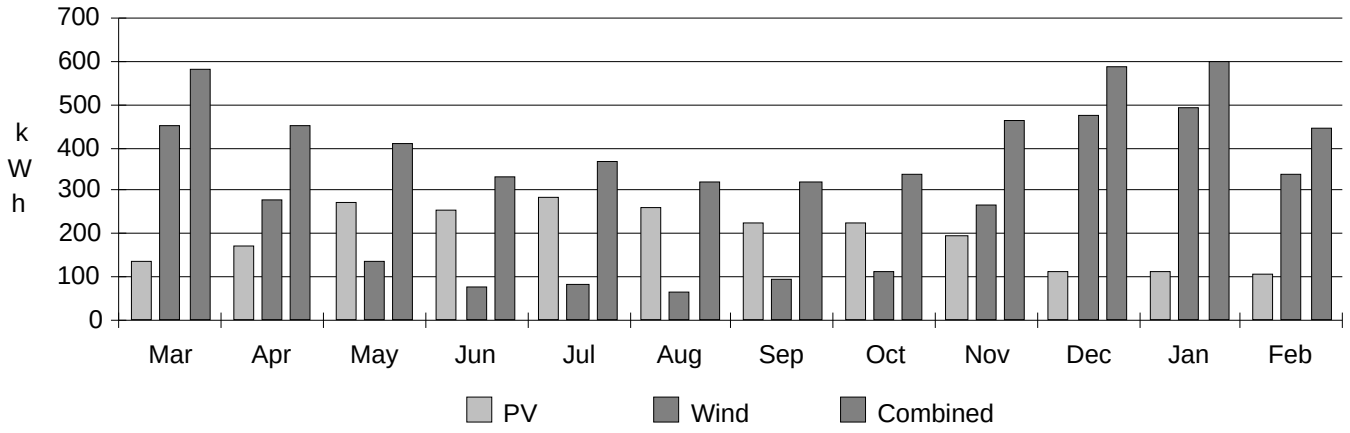
**Inverter**

Chad Lampkin of Michigan Energy Works built a 3,000 Watt, 120 VDC to 120 vac inverter for us. I can't say enough about Chad. His custom-made inverters are of the highest quality. Our inverter runs at room temperature – no heat means high efficiency. Chad hand delivered the inverter and helped us install it.

**120 Volt DC**

I feel the high voltage systems are superior in performance and efficiency. There are many reasons for choosing 120 VDC over 12 or 24 Volts DC. Some of the advantages are: small wire size, low power transmission

**Cook's Power Production from 1991-1992**



losses, higher efficiency in DC motors, cooler running inverters, very low battery off-gassing and longer battery life due to gentler charging and discharging currents, inexpensive switches and fuses, and greater compatibility with appliances such as vacuum cleaners, and electric tools. We operate several loads directly on 120 VDC. These loads are a 20 cubic foot refrigerator, 20 cubic foot freezer, and the resistance water heating elements.

**Backups**

Backup power is supplied by two sources. I don't believe in keeping all my eggs in one basket. One backup power source is a 1,500 Watt, 120 VDC Onan gasoline-powered, engine/generator with blocking diode in the circuit. We installed this generator before we had any photovoltaics.

In addition, we maintained utility power to run a 1,300 Watt automatic battery charger. This battery charger automatically starts working when the battery voltage falls to 105 VDC. It then regulates the battery voltage at 125 VDC when they are full. Utility and generator transfer controls were built by Natural Power Company. Utility power only runs our electric range, electric clothes dryer, and arc welder. The range and dryer can be fueled by LP gas if we so choose, but at only $0.08 per kWh for grid-supplied electricity, it's not practical at this time. We use about 200 to 300 kWh of utility power monthly and our power bill averages about $22 per month.

**120 vac Inverter-supplied loads**

We power the following appliances with inverter processed electricity: 30 compact fluorescent light bulbs, two 40 watt fluorescent light fixtures, one 80 watt fluorescent light fixture, my amateur radio station (NB3E), three televisions, stereo, three ceiling fans, several outside spotlights, microwave, blender, vacuum cleaner, dishwasher, washing machine, sump pump, timers, ultraviolet water sterilizer bulb, forced air furnace, humidifier, and a juice extractor.

**Refrigeration**

We built our own freezer and refrigerator in 1980. Each unit is 20 cubic feet and runs on 120 VDC. We used Baldor motors (1/3 hp for the frig and 1/2 hp for the freezer), Fricke model 16436 compressors, and homemade controls. We started out with stainless steel boxes made by the Howard Co. For the freezer's evaporator, we zig-zagged 200 feet of 1/4 inch copper tubing under the freezer's shelves. In the refrigerator we used an old fashioned evaporator setup and added a 120 VDC fan motor (10 Watts) inside the box. Both boxes only have 2.5 inches of insulation, so efficiency is limited. Each unit consumes 3 Amperes at 120 VDC. Our refrigeration load is about 2.5 to 3 kiloWatt-hours a day. If we had the amount of insulation that the Sun Frost units have, we could equal their spectacular performance.

**The Water Pumper**

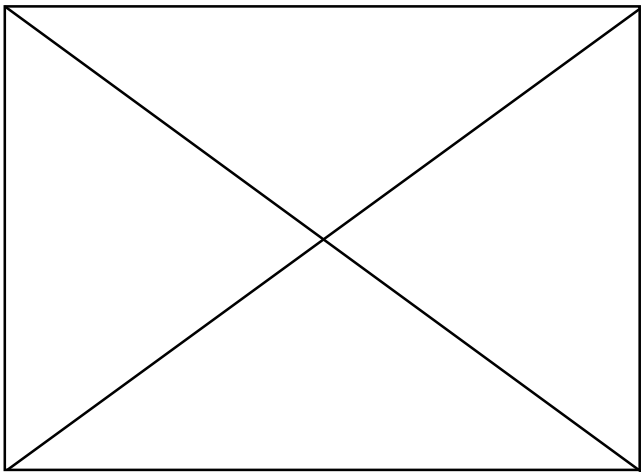
All of our water is pumped from a 170 foot well by an 8 foot Aeromotor windmill installed in 1978. She is perched atop a 40 foot tower. A 2,000 gallon concrete storage tank sits beside the mill just below ground level. The mill is on a hill about 60 feet above our buildings. Water flows by gravity to home, barn, and shop. We have enough pressure (38 psi) without having to add

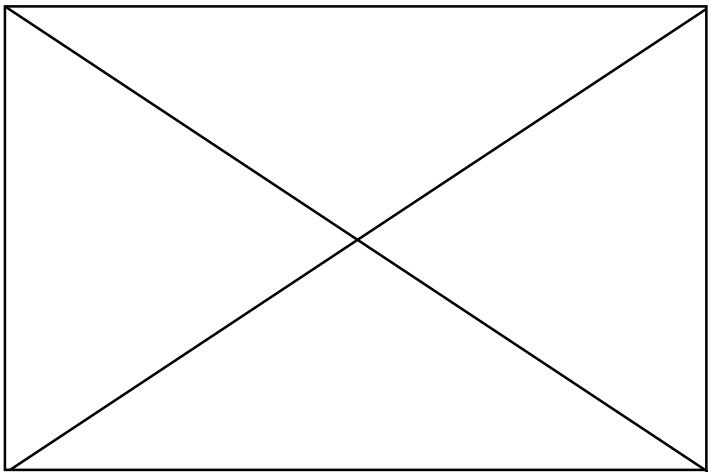
***The Cook's System Cost***

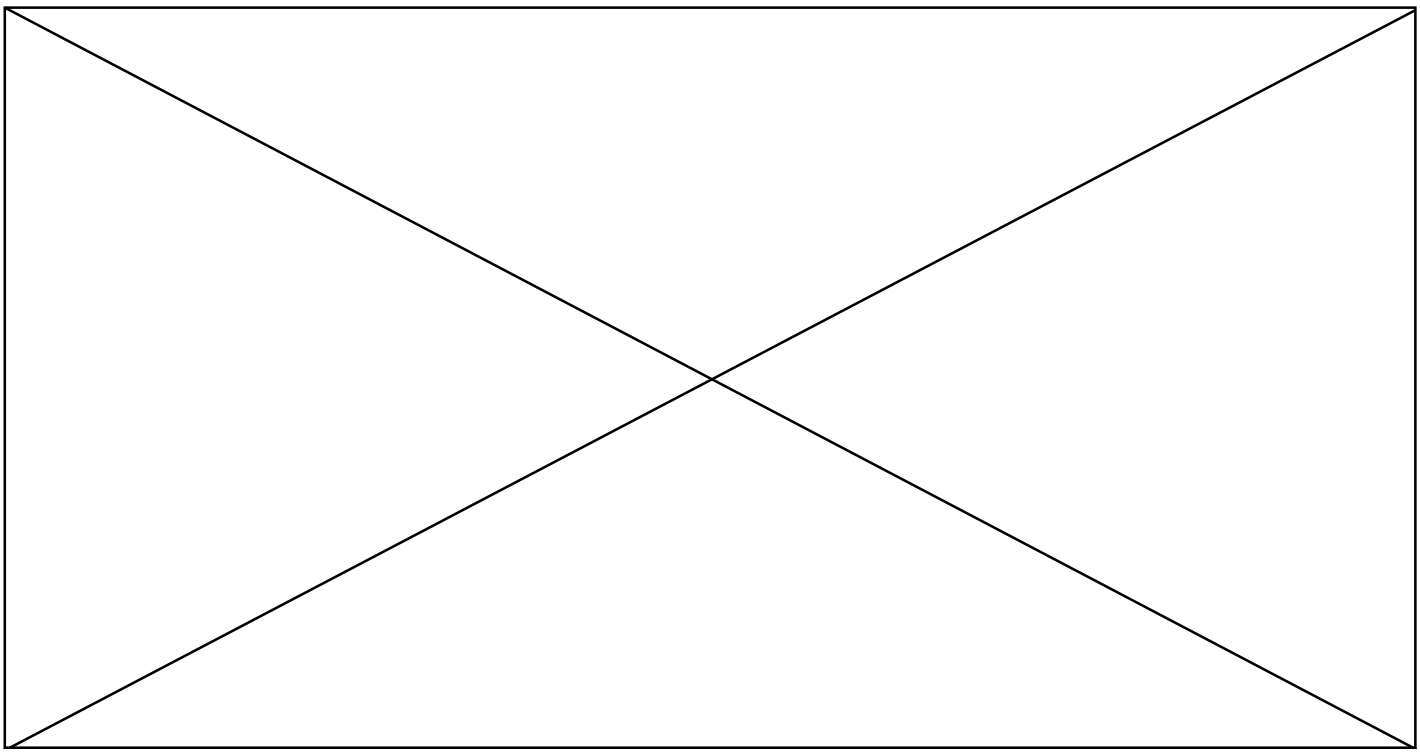
| *Equipment* | *Cost* | *%* |
|---|---|---|
| HR3 Wind Generator and Controls | $9,000 | 18.6% |
| 60 foot Rohn SSV Tower | $3,000 | 6.2% |
| Wind Generator Installation | $3,000 | 6.2% |
| Kilowatt-hour Meter | $400 | 0.8% |
| *Wind Generator System Total* | *$15,400* | *31.9%* |
| Forty Kyocera K63 PV Panels | $13,500 | 28.0% |
| Bobier PV Regulator | $600 | 1.2% |
| Photovoltaic Racks | $500 | 1.0% |
| Misc. Wiring, Disconnect Box, etc. | $300 | 0.6% |
| Ampere-hour Meter | $280 | 0.6% |
| *Photovoltaic System Total* | *$15,180* | *31.4%* |
| Forty Surrette 200 Amp-hr Batteries | $4,000 | 8.3% |
| 3 kW. Michigan Energy Works Inverter | $3,500 | 7.2% |
| 1300 Watt Battery Charger | $1,300 | 2.7% |
| Misc. Wire, Boxes, Fuses, etc. | $800 | 1.7% |
| 1.5 kW., 120 VDC Onan Gas Generator | $600 | 1.2% |
| *Other Electric System Equipment Total* | *$10,200* | *21.1%* |
| Aeromotor Pumping Windmill & Tower | $3,500 | 7.2% |
| Storage Tanks, Pipe, and Installation | $3,000 | 6.2% |
| DHW Hydronic Collectors, Tank, Controls | $1,000 | 2.1% |
| *Water System Total* | *$7,500* | *15.5%* |
| *Total System Cost* | $48,280 | |

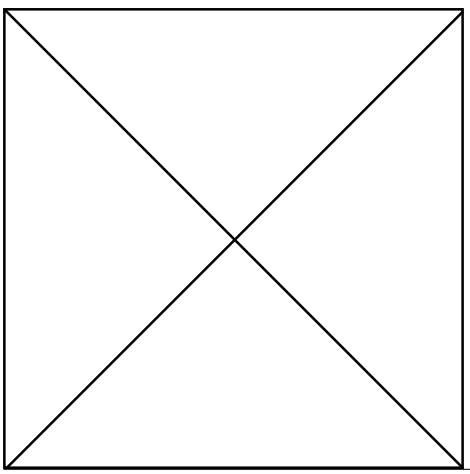
Photos on page 11.

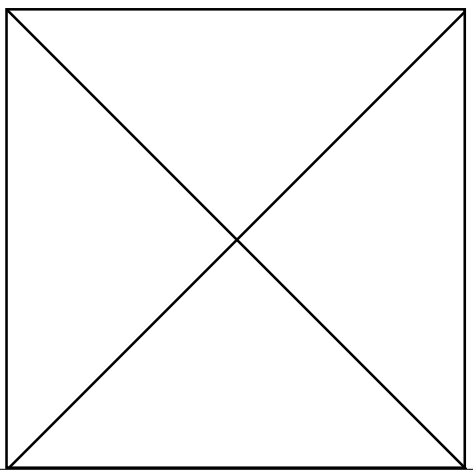
Above Left: Jo-Li-Co Farm's sign. Above Right: the parrots. Center: Maxine and Arthur on their 20th wedding anniversary celebration in 1989. Below Left: Tuffy. Below Center: Prince. Below Right: Go-Boy.

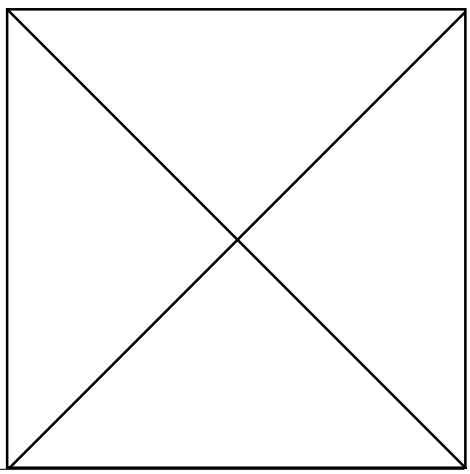












an additional pump. Isn't gravity wonderful?!

**Controls and Hot Water**
Both wind and PV controls are designed to divert excess power to heating domestic hot water. Two 4,000 watt resistance heating elements immersed in a 140 gallon insulated tank absorb this excess energy. When the battery voltage reaches 140 VDC, the dynamic load switch diverts power into heating water until the voltage drops to 130 VDC. The PV diversion regulator works in the same fashion on the second water heating element. PV diversion starts when the battery voltage reaches 143 Volts and stops when the voltage falls to 133 VDC.

Fifty-five square feet of solar thermal collectors also add to heating our domestic hot water tank. We installed these Israeli collectors in 1978 at a total cost of $800. This closed loop system circulates a non-toxic, silicon-based oil instead of water. This offers protection from freezing and rust. These collectors have been working since 1978 without failure; we are delighted.

**Heating**
We heat our 3,000 square foot farmhouse with a wood-fired furnace with oil backup. Heat delivery is via twin blowers which can be driven by 120 vac from the inverter or 120 VDC directly from the battery.

**Concluding thoughts**
We were not forced to use alternative energy; we already had utility power. A backup generator would have been sufficient for emergency power. We chose the alternative energy lifestyle because God has already given us all we need to live comfortably and once we started building we just couldn't stop, it was so much fun!

**Access**
Author: Arthur K. and Maxine Cook, R.D. #3, Box 295, Somerset, PA 15501 • 814-445-4520

Wind Generator: Northern Power Systems, One North Wind Rd, Moretown, VT 05660 • 802-496-2955

Inverter and PVs: Michigan Energy Works, Chad Lampkin, 9605 Potters Rd, Saranac, MI 48881 • 616-897-5161

Custom PV Control: Bobier Electronics, 512 37th St., POB 1545, Parkersburg, WV 26101 • 800-222-3988

Load Switches: Natural Power Inc., Francestown Tpk, New Boston, NH 03070 • 603-487-5512

Refrigeration Parts: Fricke Co., 345 W. Main St., Waynesboro, PA 17268 • 717-762-2121. Johnstone Supply, Exton, PA 19341 • 800-262-8400

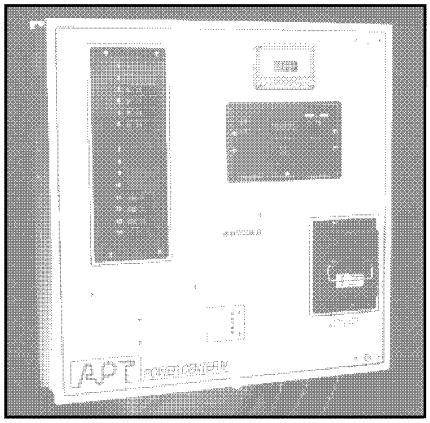
# IS YOUR SYSTEM SAFE?

*Are all your system components protected against dangerous short circuits and equipment malfunctions?*

*How do you choose the right protection device from the hundreds of different types available?*

*How do you connect components so that when problems occur it's a minor inconvenience instead if a major disaster?*

**ANANDA POWER TECHNOLOGIES IS DEDICATED TO PROVIDING ANSWERS. We strive to supply proper equipment and service to make sure your alternative energy system is safe and protected. Our user friendly, high quality products are designed to meet National Electrical Code standards and also be very easy to understand and install.**

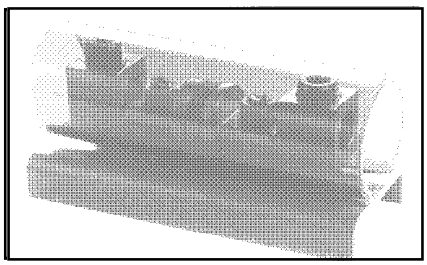


The **Power Center IV™** is the heart of an AE home system and saves time, money and space by combining all of the NEC required DC safety devices, metering, controllers and terminal blocks into one compact easy to install unit. The Power Center IV comes prewired and fully tested in a 24" X 24" X 6" UPS shipable enclosure.

***"The PV industry has been waiting for this product for a long time...These good people are on the frontline , introducing safe, quality products. We highly recommend the products built by Ananda Power Technologies."*** Dan Brandborg, Sunelco.


The **SF400-T** is our **"Big Switch"** in a little package. It packs a full 400 amps of continuous power handling ability in a compact 8" X 9" X 5" unit (includes Class T fuse).

***"The performance of the Ananda Big Switch is Outstanding!...When it comes to over current protection and switching high current, the Ananda SF400-T is the best device I have ever seen, tested, or even heard about. I sleep easier knowing it's on the wall of our power room."*** Richard Perez, Home Power magazine #27.



Our new **Class T Fuseblock** includes a protective red cover with warning label and is less expensive than other comercially available units without covers! Available in 110 to 400 amp sizes to provide short circuit protection for a wide range of applications.

***"A current limiting fuse should be used in the positive conductor of the battery bank in all stand alone systems."*** John Wiles, Southwest Technologies Development Institute, HP#17.

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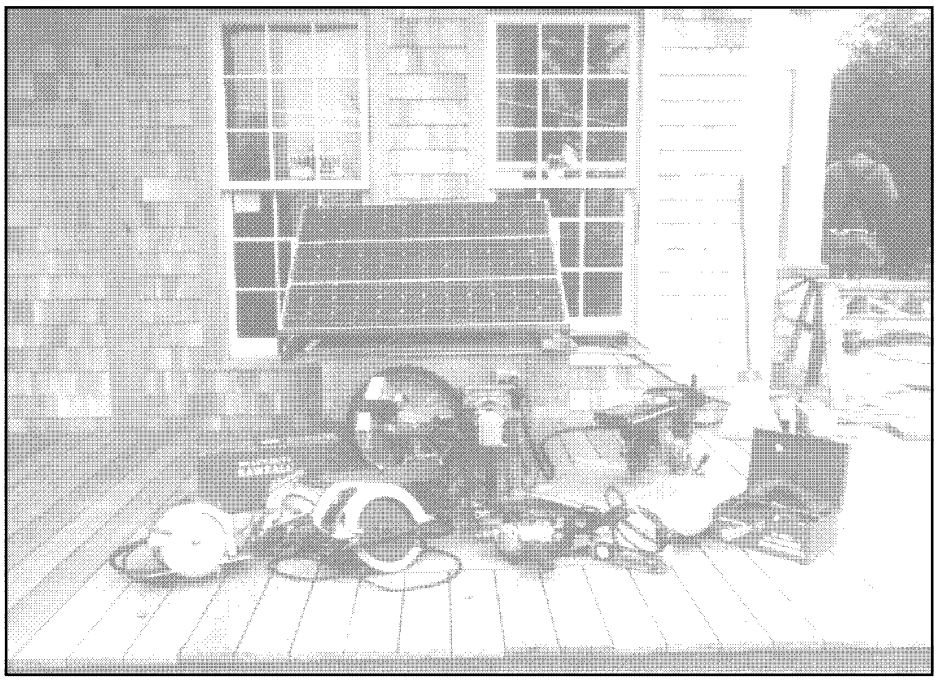
***Manufacturing Quality Products for Safe Solar Systems***

# Cartable Power

William Raynes





Above: The PowerCart and the tools used to build the house in the background. Photo by William Raynes

For the past three years, I have been living on an island off the coast of Maine. This area has a number of neighboring islands on which I work as a carpenter. Most of my work involves the use of a small portable gas generator. Many of us with alternative power have them as backup units to our homes, and use them (infrequently) to charge batteries, or take up the larger loads, like laundry. Although most of the homes on these islands have some degree of photovoltaic power, they don't always have an inverter or a battery bank large enough to support the demands of our power tools. So for me and the crew I work with, one of these "rattle-traps" was used on an almost daily basis. As you can imagine, the dream of a peaceful day without the constant noise of a generator scrambling our brains was something to be cherished. So, after much consulting with alternative energy people, I decided to give my cart idea a try.

**The System**

Portability was the key design factor in this project. A small garden-type cart, capable of carrying a substantial load was necessary because the deep-cycle marine batteries I use are close to 75 pounds each. Handles were added to the end of the cart making it possible for two people to lift the cart in and out of boats, as my work requires.

Power to recharge the batteries is provided by three Arco photovoltaic modules. These are the older variety, and only put out 2.3 Amperes each for a total of about 7-8 Amperes on a good day. The panels are attached to the cart by wing nuts allowing the array to be removed. Thus the PVs can be placed out of harm's way and in the best possible location for sun, while the cart and its more sensitive components can be kept inside or under cover.

The charge controller is an old one from a system that has since been upgraded, but any simple controller would be adequate. With large amounts of power consumed, the batteries need to be replenished rapidly. Because of this, I would recommend the SCI ASC-12, a simple and reliable unit which can withstand harsh environments.

The Trace 2012 inverter was chosen because it has proven itself to me. A similar unit has been providing power to a 110 volt deep well pump on this island for the past three years without fail. The Trace also has a built-in

battery charger; this feature comes in very handy when exceptionally heavy demands are made on the system. By simply plugging the inverter into a portable generator (via a separate cord to its input side), full power can be restored to the batteries in under two hours. There's no need to take the cart apart or attach jumper cables.

**Safety**

Safety in the system is controlled by a 200 Ampere DC-rated circuit breaker between the batteries and the inverter. These two are connected by a pair of 2/0 cables with color coded ends. Don't skimp on any of these components because the Trace inverter is capable of drawing 160 Amperes in normal use; some may say even this amount of protection is inadequate. Consult your favorite electrician and get his opinion before you decide to build a similar unit. It's important that we keep alternative power as free from accidents as possible.

Inside the cart, the batteries are seperated by a wall. Batteries give off hydrogen and oxygen when charging, and should be partitioned from anything that could ignite this gas. For that same reason, the end of the cart that contains the batteries is not closed. This allows the gas to dissipate into the air. The batteries are secured inside the cart and cannot fall out the open end. The cable between the controller and the panels is connected with a twist lock plug. This allows me to use these panels in other projects and also ensures that anyone unfamiliar with the system keeps the polarity right if the panels are disconnected.

**Loads**

Although this is meant to be a portable unit, the power cart serves double duty. During the winter this system powers the tools in my shop. There is a separate system for the lights, which are 12 Volt.

The largest load I have is a 1 $^1/_2$ h.p. table saw, which the inverter has no problem running. Other tools it runs include a miter saw,13 amperes ac; shop vac, 7.5 amps; a small 1 1/2 h.p. compressor, and a 12 amp router. These are the large loads. Numerous hand tools, jig saws, sanders, grinders, plate joiners, and so on are used as well. The only problem load is a small chainsaw sharpener. For some reason, this small tool won't run to full speed on an inverter. In all fairness to Trace, the sharpener won't run right on our Heart inverter either.

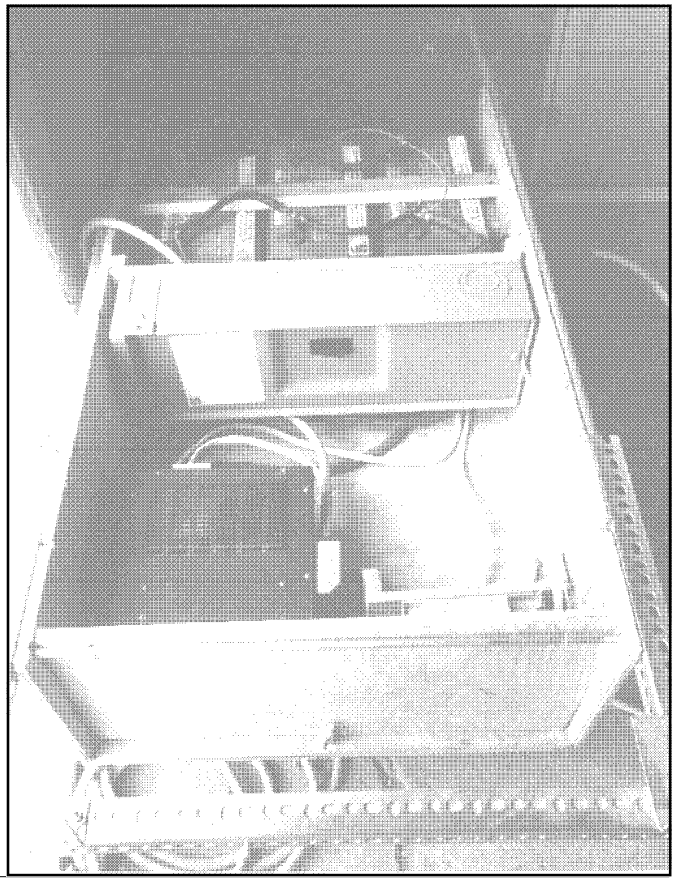
**Drawbacks**

Now, I should give you the down side of this system. Although the inverter is capable of handling large loads such as a saw, two people cannot use power at the same time – at least not the larger loads. Most inverters will not be hurt by this type of overload. As part of their protection, they will shut down until the overload is corrected, but this can create a dangerous situation. If someone is using a tool and does not switch it off after an overload, the tool will have full power when the power comes back on, possibly catching the user unaware. The habit of one person at a time using power soon becomes routine.

The Trace people recommend that their inverter be placed in an environment suitable to the finest stereo equipment. This inverter has been in places I wouldn't even leave a Walkman, but it has held up admirably. Other inverters on the market, some of which are more sealed to the elements, and some with less features, should be considered by those with different needs.

My design is by no means perfect. I had doubts, especially about the batteries. The lack of battery capacity is a drawback, but the ability of this type of battery to be quickly discharged without damage allows it to work. If I were to start fresh, nickel-cadmium batteries would be my first choice. The ability of the new fiber-plate nicads to stand up to more abuse really makes them more desirable. However, on a low budget, this power cart has certainly proved adequate for my needs.

Below: The PowerCart's innards. Photo by William Raynes.



So far we've had ample power for our usual crew of three, but found when the crew grew larger, we had to use the generator more often. With a larger crew and shorter days of winter, the three panels could not keep up with the demand for power. Still, even having to run the generator to recharge the batteries once or twice a day, we're keeping the noise and air pollution down to a new low for us – a welcome relief.

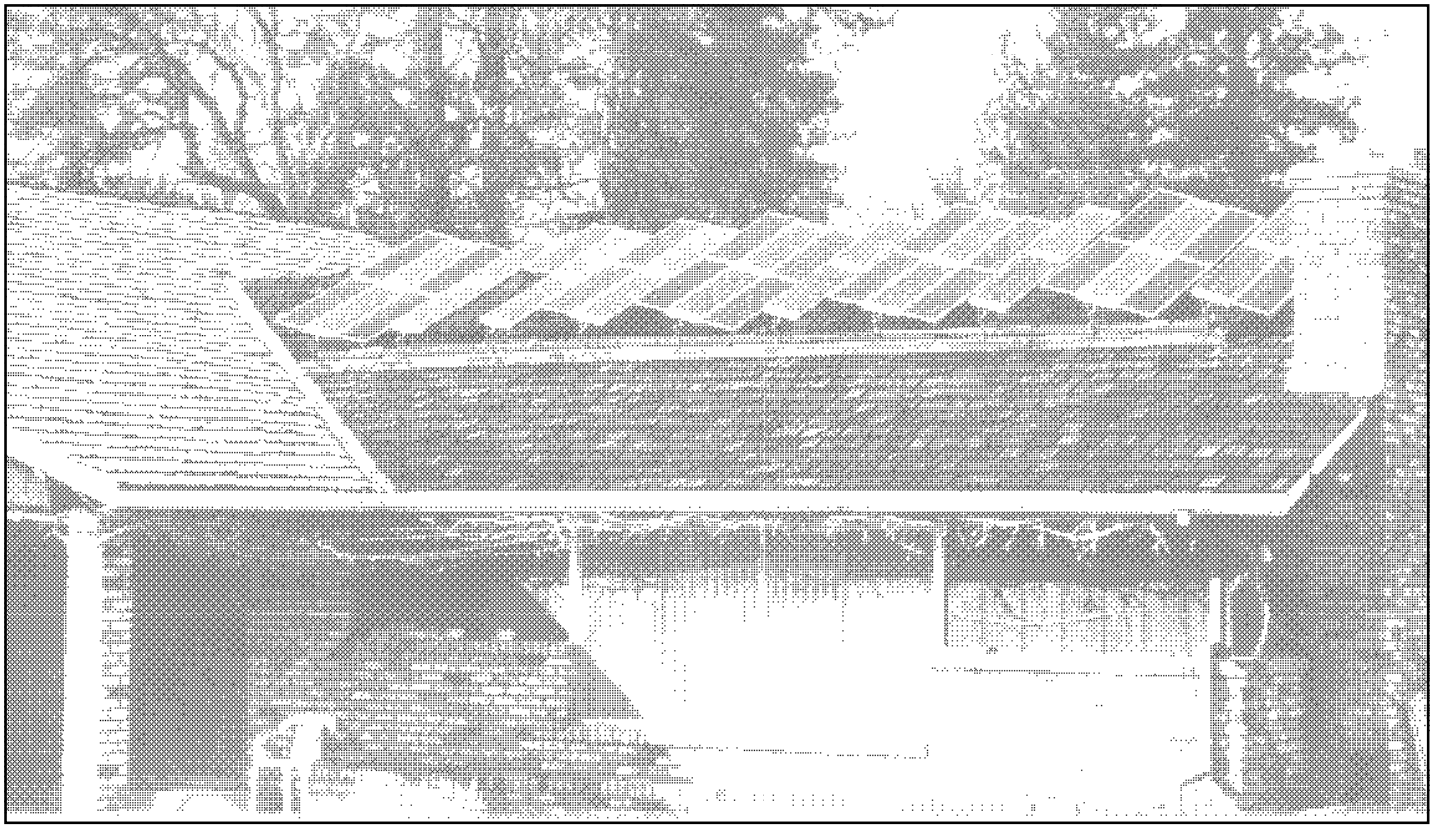
**Conclusion**

I wanted to write this article to show another way to use alternative power. We all know how well it works in our homes, but it should not be confined to that job alone. The more we can expand the ways we use alternative energy, the more people will be exposed to the viability of photovoltaics and aspects of renewable energy. When I first designed the portable power cart, the people I asked for advice in making it work told me it wouldn't. Notwithstanding that type of stumbling block, I hope people continue to find new ways to apply alternative energies to their everyday lives.

The future holds more refinements for my system. As money allows, I will improve it. If you depend on a brain-scrambling, noisy generator for remote projects, I hope this gives you a "quiet" alternative.

**Access**

Author: William Raynes, Great Spruce Head Island, Sunset, ME 04683



Above: Ed and Marty Burckhard's home after they disconnected from the utility and connected with the sun.
Photo by Don Loweburg

# Utility Disconnect!

Don Loweburg



Ed and Marty Burckhard's adventure with renewable energy began over 10 years ago. At that time they owned a comfortable home and ran a successful business in a small community in central California. The winter of 1981 was cold and, like people all over the country, they saw the monthly electric bill go up dramatically. When they had purchased their "Gold Medallion" all electric home 10 years earlier, they had never dreamed that they would be paying the high electric bills that were now routine.

Ed went "critical" the day he opened the $324 electricity bill for February. After being told there was nothing the power company could do, Ed told the manager to remove the power from his home. Thinking that Ed would cool off, the manager told Marty that maybe they should think about it for a few days. Later that day, while Marty was washing some dishes, the lights and power went out. A few moments later Ed came into the kitchen with the power meter (the thing that goes 'round&'round and eats money) in his hand, saying something to the effect that "this'll show the SOBs." To make sure they got the message, Ed took the meter to the power company's office, tossed it on the service desk, and demanded that the utility wires be removed from his house. In less than two hours, a crew arrived and the wires were down.

Ed's bold, perhaps irrational, act set off an immediate shock wave of opinion and comment in his local community. The story appeared in the newspaper the next day, hit the AP wire service, and went national. Two days later NBC had a crew at Ed

and Marty's house taping a story for national prime time TV news. During the month following the disconnect, their phone rang constantly. Sometimes they would do two radio talk show interviews in the same day. The Burckhard's action had struck a resonant chord in the psyches of people all over America: "You can take your power and shove it."

**Connecting to Renewable Energy**

During the following months, Ed and Marty made do. They used propane lights and refrigeration. Sometimes they ran the generator in their motor home to do the wash. They were also doing lots of reading, especially Mother Earth News. Ed was particularly interested in the articles on photovoltaic power. When Ed read about a seminar on PV being offered locally, he decided to attend. Thus began the relationship between the Burckhards and the Folks at Offline Independent Energy Systems.

Designing an adequate PV system was straightforward because the Burckhards had already made important changes in their energy usage. They had already installed a propane range and oven, propane refrigerator, and a solar water heater. The PV system was initially sized to handle lighting and small household appliances. The fixed-mount array consisted of ten Arco M-73 modules connected to a SCI charge control. Since future upgrading was anticipated, a high quality Helionetics 2.5 kiloWatt (kW) inverter and a heavy duty 500 Ampere, 24 Volt IBE forklift battery was used. Backup consisted of a 100 Ampere, 24 Volt IBE battery charger and the Burckhard's existing 5 kW Honda generator. A custom transfer switch handled ac power switching between the inverter and the generator. Ac power was connected to the standard ac service panel located in the garage. The equipment, except for the generator, was located in a well-ventilated corner of the garage.

The Burckhards were thrilled with their new power system. After almost a year of roughing it, the return of convenient lighting and the normal comforts of everyday living was much appreciated. They quickly discovered a bonus. While the local utility power went down many times that first year, Ed and Marty never had a power outage. Ed reports, with some joy, the phone calls he made during these stormy outages to the local utility manager. Ed always let him know that his power was not interrupted.

Over the next two years the system worked flawlessly. During this period a propane-fired tankless water heater was installed to augment the solar batch type water heater. However, the Burckhards required extensive winter backup and their generator needed repair. It was time to upgrade.

**Expanding the System**

The array on the roof was increased by ten more ARCO M-73s, bringing the total number of modules up to twenty. A custom rooftop tracker designed by Robbins Engineering was also installed. Another 500 Ampere hour, 24 Volt IBE industrial battery was added and the DC

***"During these last ten years I would have paid $24,000 to the power company. Instead, I bought a PV power system for about the same amount. From now on I get free power."***

Right: Marty and Ed Burckhard relax at their home. In the background is a Zomeworks tracker with 12 Hoxan photovoltaic modules.
Photo by Don Loweburg

***Cost of the Burckhard's System***

| Equipment | cost | % |
|---|---|---|
| 20 ARCO M-73, 21 Lams, & 12 Hoxan PM-50 Panels | $13,260 | 50.2% |
| Two 500 Amp-hour, 24 VDC IBE Batteries | $3,900 | 14.8% |
| 2500 Watt Helionetics Inverter | $2,200 | 8.3% |
| 4 kW Winco Propane Generator | $1,800 | 6.8% |
| Custom-made Robbins Engineering PV Tracker | $1,500 | 5.7% |
| 100 Amp, 24 VDC IBE Battery Charger | $1,200 | 4.5% |
| Instrumentation, Cable, Fuses, Disconnects, and Misc | $1,102 | 4.2% |
| Zomeworks PV Tracker for 12 Hoxan PM-50 Panels | $1,040 | 3.9% |
| Heliotrope CC120 Charge Controller | $398 | 1.5% |
| **Total cost** | $26,400 | |

disconnect and fuse box were upgraded. Other enhancements included input-output digital Ampere-hour meters and quick disconnects on the inverter, batteries, and the backup charger. The ailing generator was replaced with a 4 kW, 1800 rpm Winco fueled with propane. The residence was also extensively remodeled which required a code inspection. Everything passed without a hitch.

Some changes were made inside the house. The propane refrigerator was replaced with a Sun Frost RF16. They also bought a satellite receiver and large screen television monitor. With the increased power, Ed and Marty could relax a bit and enjoy life without worrying about running out of power. During the summer months, the Burkhards were 100% energy self sufficient. The winter months still required backup during stormy periods, though the amount was far less.

A year after the upgrade, during 1986, the first of two system breakdowns occurred. The inverter became erratic. The problem was traced to a poorly crimped interconnect cable inside the inverter. Another breakdown was a repeated fuse failure in the charge controller. Even though the array current was less than the rated capacity of the fuse, enough heat was generated in the fuse holder to cause fuse failure. The inadequate, glass-type AGC fuse was replaced with a larger fuse of the same rating. Four years passed without any major problems. Occasional drop by service to check battery condition and routine system check was about the extent of attention from Offline.

**And More Energy!**

The last upgrade was begun in the spring of 1990. Total power independence during the summer months had been attained by the previous upgrade. It was now time to eliminate all winter generator backup. This upgrade began with a disappointing experience with a Tri-Lam product. It was later determined that the original rating system was inaccurate and additional Lams were provided by the distributor, who was responsible under the terms of the warranty. The final Lam array consisted of 21 modules, three parallel sets of seven in series. This configuration was barely adequate. These modules were added to the existing twenty Arco M-73s on the Robbins tracker. Though significantly more than the original tracker design allowed for, the array tracked satisfactorily.

There was no more room on the roof, so when Ed decided to add even more modules, a ground-mounted Zomeworks tracker was used with twelve Hoxan PM-50 modules. These 53 tracked modules deliver 50+ Amperes at 25 VDC. The PVs produce 350 Amp-hours per day – 8.7 kiloWatt-hours per day. The increased array current required a new Heliotrope CC120 charge controller and an upgraded 100 Amp array disconnect and fuse box. A SCI DM3-24 system monitor was added, providing a digital display of system voltage and array current.

**Free Power**

Ed's goal was achieved. During this last winter, the backup generator was run only once for a few hours. The Burkhards are very satisfied and feel they can pretty much run anything they want and not worry about running out of power. I asked Ed how much the system had cost altogether. He paused, then said, "About $25,000." Though I should have known, I was a little shocked. Spent over the course of ten years, the investment had not seemed that large. I asked Ed if it had been worth it. Without hesitation he replied, "Absolutely. I would have been paying over $200 per month for electricity. During these last ten years I would have paid $24,000 to the power company. Instead, I bought a PV power system for about the same amount. From now on I get free power."

**Access**

Author: Don Loweburg, Offline Systems, POB 231, North Fork, CA 93643 • 209-877-7080

System Owners: Ed and Marty Burckhard, Box 364, Oakhurst, CA 93644

*Editor's Disclaimer: Say, Kids, if you're going to rip the electric meter off the wall, then be sure to ask your Mommy first.*

ZOMEWORKS
camera-ready

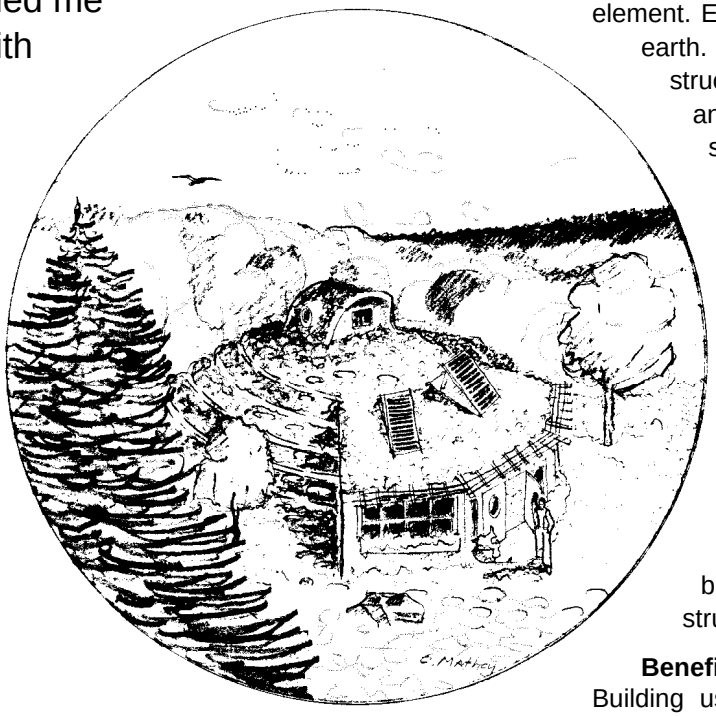
UTILITYFREE
camera-ready

# The Earth as the Perfect Blanket

Loren C. Impson



For the past several years, I have observed structures as they slowly deteriorate through the actions of the wind, sun, moisture, and other natural enemies of wood-framed houses. This observation has led me to these rules: heat with the sun, cool with the wind, and protect the home with a blanket of earth. Nature's actions become my friend instead of my enemy, and I am left to enjoy the beauty of the landscape. In all earth sheltered structures, the soil moderates the inside temperature from the outside blazing sun or icy wind, acts as an air infiltration barrier, dampens sound, and protects against fire.



How revolutionary is this idea of earth sheltered housing? How long has this technology been tested? In Tunisia, the Romans built their courtyards on the ground surface and their homes below for protection from the severe heat. In central Turkey, archeologists have unearthed 41 earth sheltered cities. Kansas City, Missouri has a growing industrial park where over 100 companies have rented and bought space in solid limestone, 50 – 200 feet into the earth. St. Pierre de Feric, France is the site of 47 homes built into a 45 degree slope. Sacramento, California has an 180,000 square foot earth-sheltered state office building. Our two communities of earth sheltered homes north of Denton, Texas are merely another affirmation that earth sheltering is becoming popular again.

**What is Earth Sheltered Housing?**

The term Earth Sheltered Housing (ESH) defines all types of homes built with the earth as a key design element. ESHs vary in relationship to the earth. Below grade describes a structure built in a hole in the earth and then covered to return the site to its original state. Recessed means cut into the side of a hill. Bermed involves pushing earth against the sides, but leaving one or more sides exposed. An atrium is built with the primary view areas of the home turned inward to create a central courtyard; this form of structure can be either below grade or bermed. Earth-covered means putting a blanket of earth on the roof of a structure built on grade.

**Benefits of Earth**

Building using earth offers a long-lived, affordable, and low-tech shelter. Most people in our society want to own their home, yet many cannot afford the expense. By reducing the cost, we can make this dream more viable. The expense of owning a home includes the initial construction cost, interest on the loan, and insurance for disasters. Then we have the monthly utility bills and increased maintenance as age and the mortgage near their terms.

Building an earth-sheltered home can be an inexpensive solution for those who don't have a lot of money but have some time. The cost depends on the materials and the amount of excavation of the site. Scrounging materials and borrowing a few friends' time can reduce the cost. A 1500 square foot home in Arkansas took three months, four primary people (including myself, extra friends

needed for the heavy stuff), and $25,000 for material and some labor. The structure consisted of three reinforced-concrete domes – one dome 32 feet in diameter, a 20 foot dome, and another 20 foot dome with an 8 foot extension. By reducing the initial construction costs, interest and mortgage costs are then reduced. Maintenance is reduced since painting and roofing are not necessary.

Protection from natural disasters is another benefit of an Earth Sheltered House; danger from windstorms, fire, hail, and earthquakes is virtually eliminated if the structure is properly built. Insuring just the contents of the structure will reduce insurance costs.

The blanket of earth covering a home can reduce the amount of heating and cooling necessary in most climates, thus reducing utility bills. Utility bills can be eliminated with the use of photovoltaic cells, a wind generator, hydroelectric power, and/or solar heating.

An ESH can occupy sites normally unacceptable to other types of construction. Malcolm Wells, a noted ESH architect, built his office near a freeway to demonstrate the sound deadening qualities (and because the price was right!)

**Choosing a Site**

Selecting a site for the earth sheltered home involves deciding where and how the house will be built, for example, into the side of a hill or on a flat plain (not in a flood plain!) The next question is how to excavate the site. You may cut into a south facing slope, build the house, then recover it and integrate it back into the natural landscape. That's not always possible; you can work with what you have. How much of the house will be earth-covered should be determined. Think of how any exposed areas will be finished – with windows or decorative stone, or back-filled with earth and then held on the house with retaining walls.

A lot of people think underground homes are like bomb shelters. Back in the early 80's, we decided to call them Earth Sheltered Homes because the earth is used to protect you from the elements. You don't have to bury yourself in a deep hole, a couple of feet will do just fine.

**Materials**

What types of materials are appropriate for a home that is to be covered to some extent with earth? Judging from the materials I've seen in use, just about any material. Fiberglass-coated plywood, treated wood, and stone are examples, but concrete is my favorite. Concrete is the most durable and the most formable material. It will not rot; it won't burn. Concrete can be poured in forms or shot onto a form. The concrete dome provides a strong form for earth shelterd homes. Curved homes – domes or free-form shapes – are most easily built using cement (concrete shell on a rebar framework). The material list includes concrete, reinforcing bar, chainlink fencing, extended metal lathing, wood for scaffolding, and tools for putting it all together.

**Soil**

The home needs to be designed to rest comfortably on its footings. The expansivity, percolation rate, and load bearing capacity of the soil all need to be determined. When you have this information in hand then you are ready to design the foundation and the drains.

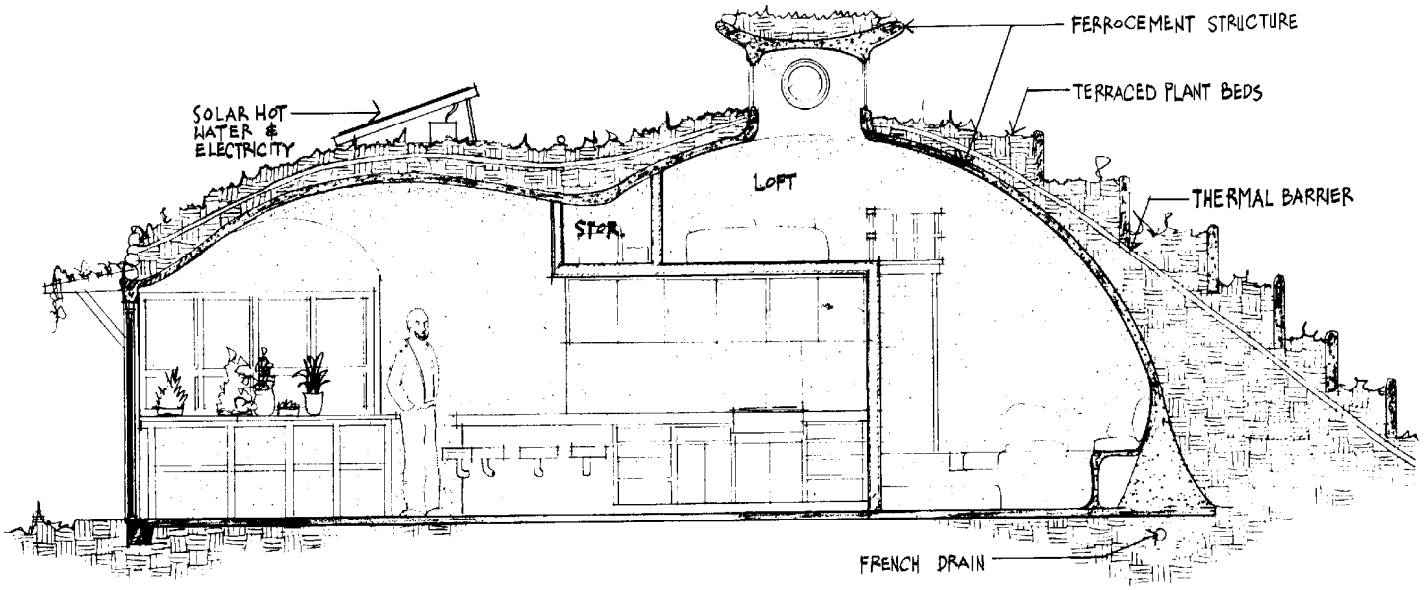
**Waterproofing**

Waterproofing seems to be most people's greatest concern, but moisture can be completely controlled. I believe in redundancy and use several systems. One system, a French drain, ensures that water cannot enter via the floor. A French drain consists of a perforated pipe – like that used for a septic drain field – surrounded with gravel. This drain is placed around the structure's perimeter at a level below the footings to quickly divert a rising water table away from the structure. Another method prevents water entering from the roof of the structure. The exterior of the concrete shell is painted with a pargetting (water resistant plaster) coat to fill any surface cracks and damp-proof the structure. The walls should then have a sheet of plastic laid against them.

Earth-covered houses have another layer of protection. A layer of earth covers the concrete shell, then a layer of insulation and plastic is added, followed by more earth. This plastic layer runs into another French drain perimeter further from the structure. Thus, any surface water that should penetrate this deep is allowed to percolate down to the French drains.

Two feet of the best soil available is placed over the final layer of plastic for growing ground cover or a garden. Plants are chosen which have a root structure that does not penetrate more than eighteen inches. Plants with a good root structure will slow the percolation of the rain water. Rainwater seldom penetrates below six inches into the normal lawn. The foliage will help cool the structure in the summer and if mulched will insulate in the winter.

The house must include a provision to remove water in the event of a spill inside. If a water heater leaks, or a bathtub or kitchen sink runs over, you should be able to direct the water out the door to the lawn or garden. Here's another reason for not putting your home down into a hole!




Above: A ferrocement home blanketed with earth. The terraced gardens integrate the house into the landscape and absorb rainwater. The thermal barrier insulates the home; the barrier and the French drain divert water away from structure.

**Thermal Mass**

Energy cost reduction is often the most appealing feature of an ESH. Placing the home in the earth reduces air infiltration. The mass of the structure and the earth surrounding it provide thermal lag to moderate the temperature year round.

Thermal mass measures how well a material holds energy as heat. When the sun shines on a stone, the stone holds or absorbs heat. In the evening, the stone lets off this heat. Weight is a good indicator of thermal mass. Heavy objects usually hold more heat than lighter ones. Earth sheltered homes use lots of material (earth) which absorb heat during the day and release it at night. Different materials have different heat storing capacity. When a curtain interrupts the sun, the curtain picks up some heat, but doesn't have the capacity to store this heat. Thus heat is convected into the room.

Thermal lag refers to the amount of time it takes for a material to absorb and release heat. When the sun shines on the earth in the summer, heat builds up and eventually works its way down into the soil. By fall that warmth has penetrated deep into the soil. The warmest time for soil ten feet down in the earth is October. The same effect is reversed in winter, so that the loss of heat makes the soil ten feet down the coldest temperature in May.

In the same way, the house creates a micro-thermal lag effect from within. If heat is picked up during a sunny December day, that heat is stored in the structure and surrounding soil for the night. During summer months, any interior heat generated or collected is eliminated at night by ventilation and by evaporative cooling from watering the rooftop gardens.

**Insulation**

High thermal mass ensures the capacity to store a lot of heat, but insulation can prevent the stored heat from escaping. The insulation system we use is directly from John Hiat's *Passive Annual Heat Storage*. When the desired shape of the structure has been achieved with gravel and dirt, place layers of polyethylene plastic and styrofoam over the earth in the shape of a sloped hill. This insulation is placed at a two foot depth (or deeper depending on frost line) then covered with plastic. He suggests going 20 feet beyond the foundation to encapsulate a large quantity of earth. The thermal mass of the earth under the insulation holds the desired heat in the house; the plastic sheeting protects from unwanted moisture.

**Let there be light**

Light and ventilation are two important elements of a living environment and are normally achieved with windows. Windows need to be oriented to allow for sunlight and breezes at the appropriate time of year. At the planning stage, note where the sun rises and sets at the extremes (the 21st of June and December) and note seasonal wind patterns at the site. Design windows so that summer sun does not enter but winter sun is available for solar heating. We are fortunate in this part of the country to have prevailing summer winds from the south. Cross

ventilation is provided as needed by vents – either skylights or doors – placed high in the structure. Plan the location of trees. Look at some of the books on this topic – Ed Mazria's *Passive Solar Energy Design* is one of the best.

**Conclusion**

Overall, the advantages of Earth Sheltered Housing are exciting and persuasive – low construction cost, reduced energy costs, elimination of costly and time consuming maintenance chores, and the safety and security of underground protection. The residents in such dwellings enjoy the rewards of the state of the art technology that is in harmony with – not in conflict with – the natural environment. Let the sun shine, the wind blow, and the water flow clean!

**Access**

Author: Loren C. Impson, Sun Life Homes, Rainbow Valley, Rt. 2 Box 28-8, Sanger, TX 76266 • 214-704-0922

Illustrator: Courtenay Mathey

Insulation: John Hait's *Passive Annual Heat Storage* from the Rocky Mountain Research Center, POB 4694, Missoula, MT 59806. ("How to store summer's sunshine to keep your wigwam warm all winter." I paid $15 for the book, shipping was extra.)

Permaculture: Bill Mollison's *Permaculture: A Designers' Manual* from local bookstore or Tagari Publications, POB 1, Tyalgum, NSW, Australia 2484. (How your home fits into your environment – as Architectural Graphics and Standards is to architecture, so is Permaculture to self-sufficient homesteading.)


*116 Cross Street, Amherst, WI 54406*
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# COME

- *Alternative Fuel Vehicles*
- *Model Home*
- *Giant Sun Oven*
- *Workshops for everyone*
- *Solar, Wind, and Hydro electric displays & exhibits*
- *Music & Food*
- *Entertainment*

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*How-to's from Beginning to Advanced*

Solar Electricity: from site analysis to fine tuning PV systems, new technologies

Battery Storage and Controls

Efficient, Electric, and Hydrogen Vehicles

Housing: Greenhouses, Passive Solar Design, Insulation, and Heat Exchangers

Conservation: water, refrigerators, lighting

Fuels: Wood gassifier, Methane, Ethanol, Hydrogen Fuel Cell

Ten Energy & Environment Workshops for Kids 3 on up

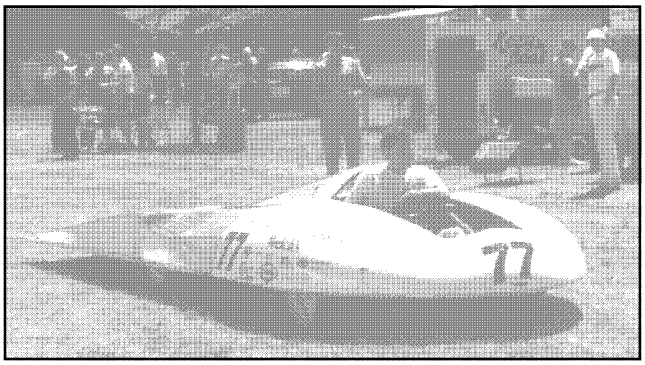
Teacher Curriculum Workshops

Discussions on utility and community involvement, education, policy, and other issues

***DISPLAY BOOTHS***

Demonstrating, displaying and selling innovative energy products for use in home, business and transportation.

Below: The Sunseeker Race Car



Wind Electricity: from microwind to 10kW

Low Head MicroHydro Electricity

Solar Food Cooking and Drying

Solar Water Pumping

Solar Domestic Hot Water

Sustainable Living and Gardening

Below: Crowds check out the display booths at the solar and wind powered fairgrounds

***Times***

| | *Exhibits open* | *Workshops/activities* |
|---|---|---|
| *Friday, June 19* | *9 am – 7pm* | *9:30 am – 5:30 pm* |
| *Saturday, June 20* | *9 am – 7pm* | *9:30 am – 7:30 pm* |
| *Sunday, June 21* | *9 am – 6pm* | *9:30 am – 5:30 pm* |

# FOOD, MUSIC, & FUN,

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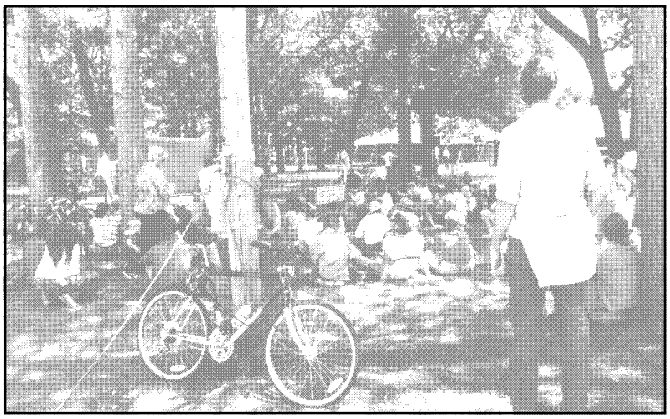
## at the Midwest Renewable Energy Fair!
## June 19 - 21, 1992



Above: Kids and parents enjoy Energy Theater

*Amherst is 12 miles southeast of Stevens Point at the intersection of Hwy 10 & County Rd B*

*For camping, motel and hotel accomodations in the Amherst area, contact Stevens Point Area, Convention, and Visitor's Center 1-800-236-4636 or 715-344-2556. Call for camping, Portage County Parks 715-346-1433.*

***KEYNOTE SPEAKERS***

Spencer Black, Wisconsin State Representative

Jan Hamrin, Founder, Independent Energy Producers Assn

Above: Model Home conserves energy and uses PV and wind electricity and solar heat

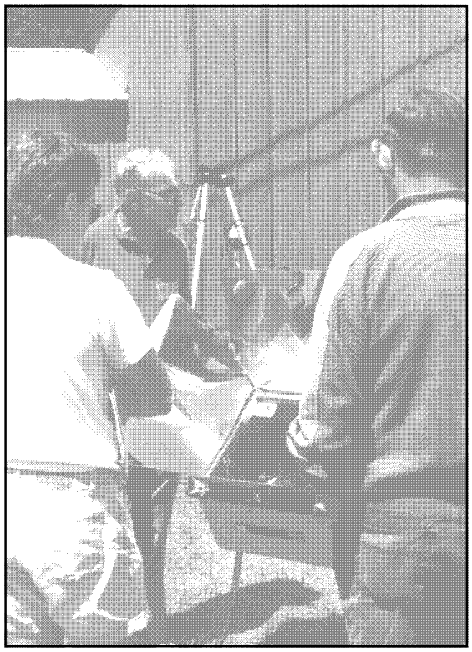
***ENTERTAINMENT***

Friday, June 19
- Evening: Stoney Lonesome- Bluegrass

Saturday, June 20
- Afternoon: The "Billys"
- Evening: Greg Brown- Modern Folk

Sunday, June 21
- Afternoon: The "Billys"-Environmental Music

Right: Solar Cooking with the Sun Oven



***ADMISSION***

| | Daily | Weekend | Evening Concerts |
|---|---|---|---|
| Adult | $5.00* | $10.00* | $6.00 |
| Juniors (13-17) | $2.50* | $5.00* | $6.00 |
| Children (12 & under) | Free | Free | Free |

*Does not include evening concert

*For more information, contact:*

*Midwest Renewable Energy Fair*

*116 Cross Street, Amherst, WI 54406 • 715-824-5166*

*Event Sponsors: Wisconsin Energy Bureau, Aaron Enterprises, Gimme Shelter, Home Power Magazine, Lake Michigan Wind & Sun, Snowbelt Energy Center, Solar Spectrum, Wisconsin Power & Light, Wisconsin Public Service Corporation*

# ELECTRICITY FROM THE SUN

Editorial

# A Look Ahead

Richard Perez

Have you ever wondered what America's electric power structure could be like in ten years? I am constantly gazing into my crystal ball and wondering where our power will come from in the year 2002.

**Speculation**?
We do our best to publish real and useful information in Home Power. We try to keep speculation, untried ideas, and technical fantasies out of our publication. We are technical crew and interested in things that work. We much prefer pie on the plate to pie in the sky. But…

During the last year our nation's attitude to renewable energy has changed. We didn't see this on the nightly news, or read about it in the newspapers. The change become apparent slowly in our conversations with RE users, equipment manufacturers, and public utilities. America is finally ready to accept renewable energy sources as a working realities. This acceptance not only gives us great joy and hope, but also the courage and certainty to share our view of the future with you. So join me for a ride on my time machine.

**A Trip to 2002**
The first thing we notice in the year 2002 is that all the buildings have photovoltaics (PVs) on their roofs. These PV arrays are everywhere, on each home, business, and even standing by themselves. Wind generators dot the countryside in windy locations. A quick peek inside these structures reveals that there are no batteries. Instead, each renewable energy site is equipped with a synchronous inverter feeding the PV-produced electric power to the nationwide grid. Everywhere we look, electric vehicles are charging up at parking meters, parking lots, and in garages. The national electric grid functions as our battery and distribution network. Here's how it all happened.

**Public Utilities- America's Powerful Servants**
During the mid-1990s America's public utilities were struggling to keep up with the demand for electric power. Afternoon brownouts had become a common occurrence. To the utilities' credit, they were doing all they could to provide reliable and continuous power, but they were being hamstrung by their rate-payers. Americans were just not interested in having a new coal-fired, or oil-fired, or nuclear power plant in their neighborhood. We weren't interested in having any more new powerlines strung across our already littered landscape. We wanted the juice, and we wanted it to be produced by clean and sustainable power sources.

**What's a Power Company to Do?**
America's public utilities turned to the only major energy sources left to them: solar, wind, and hydro. They discovered what home power users had known for decades, that renewables work better and cheaper than burning fossil fuels or nuclear fission.

In the early days of this primarily solar-powered transition, the utilities wrestled with a tough question. Who would own these renewable power sources? Would the utilities themselves own the PV arrays, the wind generators, and the hydroelectric plants, and then rent the power to their customers as usual? Or would these energy sources be owned by individuals and these individuals would become, in effect, micro power companies. Well oddly enough, the utilities decided to let go of their monopoly on power production and concentrate on what was to become their major business – power storage and distribution.

In many ways having the individuals own their particular PV array, or wind turbine, or microhydro plant made perfect technical and economic sense to the utilities. The major problem with solar and wind from a utility's point of view is that the source is not constant. The wind doesn't blow at a steady speed all the time, and the sun sets every evening. Having many independent and widely distributed power sources contributing ensured a constant and reliable power supply for the grid.

Suddenly, America's power companies didn't need to build any new power plants. The utilities decided to electrolyze water and store the incredible power surplus generated by the millions of RE sources nationwide as hydrogen. This hydrogen was then used nightly to fire their already-in-place turbines.

Local production and consumption of the electric power took the distribution burden off the utilities. They didn't need to build new power lines. The distribution network already in place was much larger than required because most of the power wasn't being shipped great distances. The power was being used in exactly the same place it was being produced. This was a relief to the utilities as they had never figured out how to counteract the health

hazards inherent in large scale, high voltage, power transmission.

**Every Home is a Power Producer**
The RE sources we see everywhere are owned by individuals. Each homeowner has purchased a PV array and/or other RE power source. These RE sources are coupled to the grid through a synchronous inverter. RE-produced power is either consumed directly on site, or fed to grid through a bi-directional power meter. This power meter measures the amount of electricity that the individual system either supplied to or received from the grid. Folks with PV arrays and/or wind generators producing more than their home consumes receive a monthly check from the utility. Folks who consume more power than they produce pay the utility at the end of the month. The grid has become a power broker instead of the sole power producer.

**Storage was the Problem**
The utilities took a monumental step in cleaning up our environment and in ensuring their own existence by storing power as hydrogen. Each local utility set up banks of electrolyzers which produced billions of cubic feet of hydrogen gas daily. In 2002, the stored hydrogen is burned in turbines that were once fired by coal, oil, natural gas or nuclear fission. By converting their turbines to hydrogen fuel, the utilities stopped emitting carbon dioxide and sulfur dioxide. They ceased contributing to the Greenhouse Effect. The turbines' combustion byproduct is pure water, a far cry from the pollutants of the last century. The more forward thinking utilities have already switched from turbines to the higher efficiency and reliability of the new fuel cells.

*"I believe that water will one day be employed as fuel, that hydrogen and oxygen will constitute, used singly or together, will furnish an inexhaustible source of heat and light…" — Jules Verne, Mysterious Island 1874*

**Energy Life in 2002**
Most buildings are energy autonomous. Each home, office, and industrial plant makes most of the power that it uses, and many export energy, for profit, to the grid. Brownouts and blackouts have become a thing of the past. Water and even some space heating is accomplished by evacuated tube, solar thermal collectors. These evacuated tubes, first developed in Ireland during the '80s, revolutionized the way things got hot. Buildings now use solar architecture principles – direct solar gain, superinsulation, and thermal mass. All the oil, coal, and natural gas that were once burned as fuel are now left in the ground where Mother Nature put them, or used sparingly as input to the recycled plastics industry.

**Transportation in 2002**
The renewable electric revolution complemented the ongoing revolution in transportation. Combustion of any type of carbon-based fuel is now limited to specialized vehicles such as some long distance aircraft. Electric automobiles have been in common use since the late '90s. The RE sources located everywhere are used to recharge these early, battery based, electric vehicles. These vehicles are now being replaced by electric cars using hydrogen storage and fuel cells to supply their electric motors. Many residences and car parks, are now equipped with smaller versions of the utility electrolyzers. These smaller electrolyzers are used to recharge hydrogen/electric vehicles. The society of 2002 is inherently less dependent on transportation. Many people now work primarily at home and the daily commute has become a rarity. With the decentralization of electric power production came the decentralization of manufacturing. Goods that were once produced in a single location and shipped nationwide are now made and consumed locally.

**The Environment of 2002**
The overwhelming energy and environmental worries of the '90s have been replaced with the certainty that things are indeed getting better. While the Earth still shows the scars of a society bent on fossil fuel consumption, the environmental effects of our oil binge are lessening. The atmosphere's carbon dioxide content has dropped and global warming was halted before it destroyed the planet.

**Stand-alone RE Systems in 2002**
When the utility grid converted to RE sources in the late '90s, it also stopped extending its powerlines. Most areas not already serviced by the grid became entirely energy self-sufficient and were never connected to the grid. These systems use their own hydrogen storage and fuel cells to store locally produced power. In many ways, these modern stand-alone systems are identical to early home power systems except they don't use batteries anymore.

**What Next?**
New energy systems are being concocted daily within a large and growing industry. One of the latest, a combination concentrating PV array (500 suns!) and solar heater, promises to unify the production of electric power

and at efficiencies greater than 95%. New lights using light emitting diodes (LEDs) are yielding ultrabright, white lamps with lifetimes in hundreds of years. Ultrasonic clothes washers have replaced the clumsy mechanical types. And I hear rumors that the gravity sled may be up and working…

**Meanwhile back in 1992…**
Thanks for taking an imaginary trip into the future with me. I wrote this to describe what I see as our most possible and maybe even most desirable energy future. There are, in fact, many possible futures, most less rosy that the one I described here. The real future is up to you and me. I'm ready for a change. How about you?

**Access**
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# A Call to Action

Jack Pouchet



NOW is the best possible time to change our energy habits. This is the year to begin a serious drive to put renewable energy (RE), our environment, electric vehicles (EVs), and social awareness on our political agenda. If we work intelligently and tap the proper resources, we can make a significant impact on our society's energy problems.

**Why Now?**

Why is it time to act? Well, there have been a host of seemingly unrelated recent events and developments which are yielding startling results. Some of these items are:

1. New air quality legislation in California mandates the sale and use of non-polluting vehicles. By 2003, at least 10% of the vehicles sold in California must be zero emission vehicles (ZEVs).

2. Over 11 states, including New York, Massachusetts, and Florida, are considering adoption of the California air quality standards.

3. Fuel taxes and toll road costs have increased. New toll roads charge higher tolls during peak travel times and reduced rates for high occupancy vehicles (HOV).

4. Continuing photovoltaic research by Siemens and breakthrough technology from Texas Instruments (TI) and Southern California Edison (SCE) will make lower cost photovoltaic panels (PV). Expect a two fold reduction in the price of each panel by mid 1994 and PVs in the realm of $1 per watt by 1995.

5. California exempts buyers from sales tax on electric vehicles and EV conversion kits through 1995. In addition, a state tax credit up to $1,000 is available for purchasing a certified "low emission vehicle."

6. Southern California Edison is proposing legislation requiring all new residences built in their service area from 1995 onward to have 2 kW. of PVs and to feed the excess power into the utility grid.

What ties these news items together? They signal the economic and social reality of solar power. This realization is due to economics, not a world oil crisis.

Now for my "Call to Action." We need to target government and industry to make changes accommodating Electric Vehicles (EV). Legislation promoting EVs is a waste of paper if there is no incentive for people to buy and use EVs. California's offer of tax credits is a great start.

**I recommend the following:**

1. Dedicate 2% of all public parking spaces to EVs by 1995 with an increase to 15% by 2005.

• All EV spaces will have free RE-produced electricity available. What energy is not used by EVs will be sold to the utility grid.

• Non-EVs will be towed away if found parking in an EV space, with a fine of $250 plus cost of towing and storage.

• EV spaces would be funded from state and federal highway taxes, public bond offerings, developer/builder fees for all new construction, and fees from toll roads/bridges. Revenue generated from selling excess power back to the utilities would be used to pay off the bonds and fund further construction.

2. Utilities will buy back excess RE produced power at a price that includes the utility's environmental impact costs. The minimum rate is $0.06 per kilowatt-hour.

3. EVs with 2 or more passengers will pay no tolls through 1997. From then on they will pay tolls equal to or less than 50% of the HOV rate. Single passenger EVs will get at least a 25% rate reduction through 1997.

Private organizations may take advantage of EV spaces and utility buy-back, but at least 3% of their parking places must be for EVs.

We need such a program to encourage people to buy and use EVs. Such a program will promote the development of new technologies, increase PV production, lower PV costs, improve our environment, reduce traffic, and improve our quality of life. And this will create positive, Earth friendly jobs and bolster our economy.

With EV parking spaces available, the EV user, you and I, can now venture 80 to 90 miles in almost any direction from our homes. This is the type of freedom of movement and ease of use that will be needed to make EVs acceptable to America.

This can be a win-win situation for everyone. The manufacturers have an open market. The government and politicians can point to their environmental efforts. The utilities sell more electricity, but can do it with no increase in capacity. The RE industry gets an opportunity for growth and recognition. And our planet gets a much needed break.

Your help is needed to make this a reality. Get involved now with whatever political party you favor. Insist on RE and EVs being included in their platform. Seek support in your local community and take your message all the way to the President. Write letters, write articles for newspapers, send copies of pertinent articles to local and national leaders, and then telephone everyone you have written to. Don't forget local planning commissions, regional air quality districts, zoning groups, or agencies dealing with land and highway use.

A well-written letter combined with a thoughtful phone call is worth more than a thousand votes at the national level! The same letter and phone call to General Motors, Ford, Chrysler could be worth many thousands of U.S. JOBS!

***It is up to US to GET INVOLVED. ACT NOW!***
***MAKE IT HAPPEN!***

**Access**
Author: Jack Pouchet, 19085 Consul Ave., Corona, CA 91719 • 714-734-0714

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# “What’s All This Maximum Power Tracking Stuff, Anyhow?”

Bradley E. O'Mara



Maximum Power Point Tracking (MPPT) will revolutionize the way renewable energy systems are designed. Similar changes due to high-frequency electronic power conversion (EPC) and MPPT technology happened 30 years ago in spacecraft PV systems. Twenty years ago this revolution took place in renewable energy grid intertie systems, and 10 years ago with DC to AC inverters. In the next five years, we will see MPPT technology revolutionizing battery-based, stand-alone PV systems.

In fact, these changes have already begun. EPC technology is now being used to couple high voltage PV arrays to low voltage batteries. This reduces voltage losses and frees designers to install arrays hundreds of feet from the batteries. (See Things That Work!, p. 47 in this issue, also "Long Distance Power Transmission" articles in HP28, HP25, HP12, and HP6). Charge controllers based on relays, and simple on/off solid-state units are being replaced by EPC controllers. Voltage converter products today use EPC circuitry to efficiently operate 12 Volt appliances from 24 and 48 Volt batteries.

**What Are EPCs and MPPTs?**

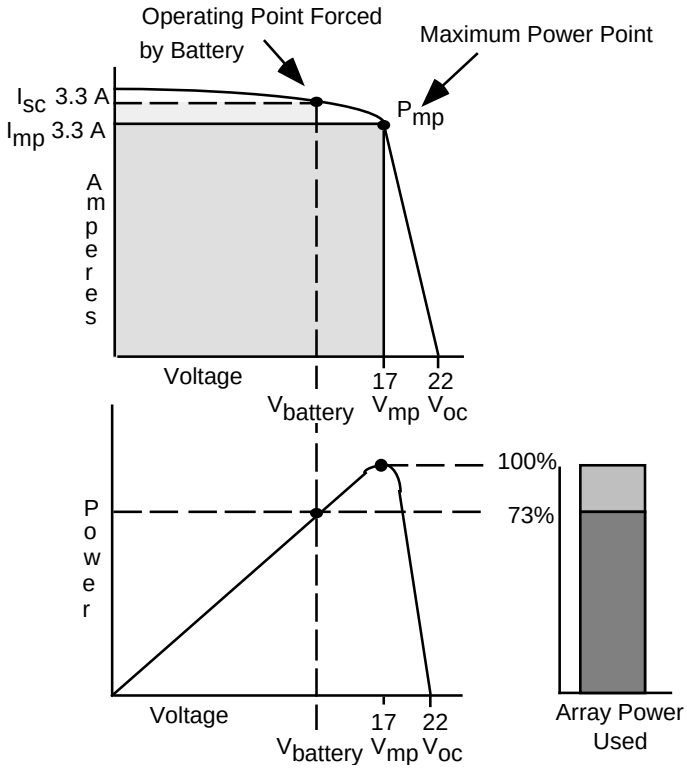
EPC devices use high frequency switching to efficiently convert power from one DC voltage to another. You can think of EPCs as "DC to DC transformers". On some EPCs you can set the "number of turns" in these "transformers" with the turn of a knob. MPPTs are EPC devices which are "smart" and constantly adjust the "number of turns" to maximize power production from your power source (PVs, wind generator, etc.). Think of MPPTs as computers with only one mission: to maximize power out of your renewable energy sources. Or here's another analogy: an EPC is like a manual transmission in your car. It changes the form of the power from the engine (your PV panels) to the wheels (your batteries). If an EPC is like a manual transmission, a MPPT is like an automatic transmission, but with an infinite number of gears.

**Same Panels, but More Power**

Are your PV panels putting out as much power as they could? Probably not. The current a solar panel delivers depends on the voltage across its terminals (see graph 1a). If the positive and negative wires from the panel are touched together (short circuited) the voltage is very close to zero and the panel will put out its maximum current, ($I_{sc}$ standing for short circuit current). If the leads are attached to a battery, the panel's voltage becomes the battery's voltage ($V_{battery}$ on graph 1a), and current (less than $I_{sc}$) will flow into the battery. If the PV panel's wires are not hooked to anything (open circuited), the voltage of the panel rises to its open circuit voltage ($V_{oc}$ = 22 Volts in graph 1a) and no current flows. The panel will produce current at a continuous range of voltages between zero and Voc, shown by the current vs voltage (or "IV") curve in graph 1a.

PV module power is equal to the current times the voltage – or graphically, the area of a rectangle under the IV curve. (See the shaded rectangles on graph 1a.) At one specific combination of voltage and current, the area of the rectangle reaches a maximum (the darkest rectangle on graph 1a). This is called the maximum power point, shown as $P_{mp}$ on the graph.

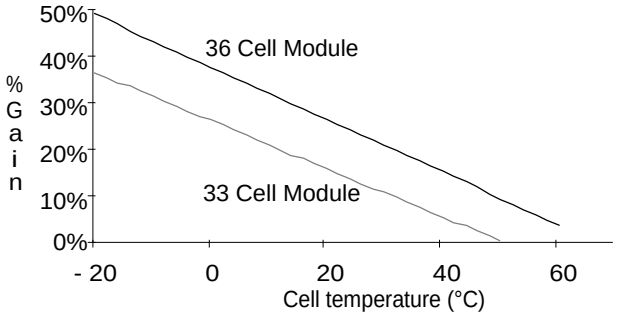
Graph 1b plots power as a function of voltage for the same panel. In this example, holding the voltage of the panel to the battery's voltage ($V_{battery)}$ means the panel produces only 73% of the power it could produce. Moving the voltage up to $V_{mp}$ allows the panel to produce all the power it can. This example is pretty optimized for MPPTs. You probably wouldn't see this much power gain unless your panels were cold.




Graph 1a (top): PV Module current vs. voltage (IV) curve and 1b (bottom): Power vs. voltage curve

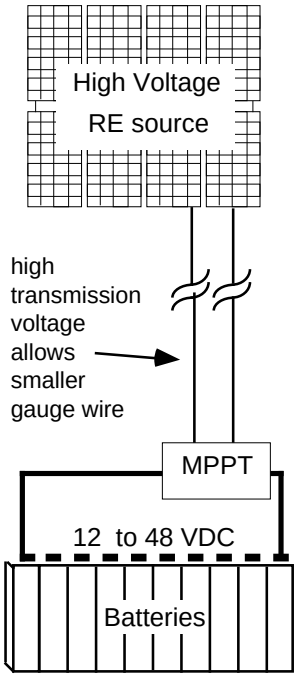
**How Much More Power Could I Get with a MPPT?**

A panel's IV curve depends on temperature and sunlight intensity. Graph 2 below shows the theoretical percent power gain as a function of temperature for 36 and 33 cell modules using a MPPT. Of course some of this gained power will be lost in the MPPT itself, since the units are not 100% efficient. The more series cells per module, and the lower the temperature, the more power will be gained by operating at the maximum power point, compared to using a traditional charge controller.




Graph 2: Theoretical power gain using a MPPT, assuming battery charging at 14 VDC.

**High Voltage PV Arrays**




MPPTs can further optimize PV systems by allowing panels to be wired in series strings. Transmitting power at high voltages decreases power lost in the wiring. This means you can shrink array power cables to an affordable size or take advantage of that 'perfect' sunny spot, even if it is hundreds of feet away. Back near the batteries, the MPPT's electronic power conversion circuitry converts the power to low voltage for your batteries to digest.

All of this applies similarly to wind and hydroelectric generators. Alternators in these machines will produce more power operating at their maximum power points. Higher voltage alternators can be used, reducing losses in power transmission.

**How MPPTs work**

Regardless of battery voltage or any other system variable, a MPPT continuously "hunts" for the maximum power voltage. By using sample-and-hold IC's to "remember" how much power was happening before the MPPT re-adjusted itself, the MPPT compares two power levels. This allows the MPPT to "know" which direction on the solar panel's IV curve it must move in order to get closer to the maximum power point. This logic circuit then tells the EPC part of the MPPT where to set the input voltage.

**You Cannot Buy a MPPT Today...**

Converting power from a high voltage RE source to lower voltage batteries is beginning to be done today by EPCs. But this equipment is incapable of automatically extracting maximum power. These EPC devices can't compensate for changing solar cell voltages without being manually re-adjusted. There are many reasons why you can't buy a true Maximum Power Tracker today. They are difficult to design and manufacture on the budget required for the home power market. Until recently few have realized the need for true MPPTs.

**A Little MPPT History**

Surprisingly, PV maximum power point tracking has a long history. In 1958 the U.S. Vanguard I satellite launched PV technology into space and into government funded labs around the world. In satellites, weight and room for solar cells and batteries was at a premium. Cost was of little concern. In the 1960's, necessity forced engineers to invent EPCs and MPPTs. They replaced inefficient and failure-prone relay-based charge controllers used aboard the early PV-powered satellites. These power processors reduced the size and cost of their space arrays by up to 30%. Batteries lived longer because charge/discharge processes were controlled with precision. Individual system loads were freed to receive power at the voltage best suited to their operation. The system was no longer tied to a fixed battery voltage.

Here on earth in renewable energy systems MPPTs have been applied to motors, and to grid intertie synchronous inverters, but rarely to batteries, the component most in need of MPPT benefits. Today, 25 years later, MPPT technology is about to be reborn in PV, wind, and hydro controllers. Recent advances in switchmode electronic power control will make MPPTs affordable for us on earth.

**MPPTs: a Future RE System Element**

As MPPTs become available, renewable energy systems will become much more flexible. Power will be generated at its maximum power point, in many cases at a voltage considerably higher than the battery voltage. We'll be able to mix and match renewable energy sources producing power at different voltages. Wind and hydro machines will be able to use a wider range of higher voltage generators. These higher voltage power sources will be sited farther from batteries, to take advantage of particularly sunny, windy, or good hydro locations. Day in and day out, every second, MPPTs will help our renewable energy systems to most effectively accept the energy nature gives us.

**Access**

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This article was adapted from Brad O'Mara's new book *Get More Power: How To Instantly Become an Expert On Maximum Power Point Tracking in Photovoltaic Power Systems.*

***CHRONOLOGY OF PV MPPT CONTROLS***

| *YEAR* | *COMPANY* | *REGULATOR* | *MPPT* |
|---|---|---|---|
| 1973 | Philips | First commercial product | No |
| 1975 | Solarex | SRO series & SHM shunt linears | No |
| 1978 | Solar Power | BVR linear shunt | No |
| 1979 | Ecotronics | 2 part solid-state switching shunt | No |
| 1980 | Photocomm | SR-12 solid-state switching shunt | No |
| 1980 | ARCO | BP,VCC,UCC, relay based | No |
| 1981 | SCI | Relay-based series | No |
| 1982 | Solarex | ACR relay-based 'Charge Pump' | No |
| 1982 | BOSS | SS, Centrix solid-state switching | No |
| 1982 | TriSolar | MPC Motor Drive | Yes |
| 1983 | Rho Sigma | Solid-state series linear | No |
| 1983 | Tideland | Model 600 solid-state linear shunt | No |
| 1983 | Heliotrope | Hi Eta | No |
| 1983 | Photowatt | PCU relay-based series | No |
| 1983 | BOSS | PCC motor drive | Yes |
| 1983 | BOSS | AC/DC PV power mixer | Yes |
| 1983 | Solapak | Solamax | Yes |
| 1984 | SunAmp | PBR solid-state switching shunt | No |
| 1985 | Photron | Solar Brain | No |
| 1986 | Bobier | Linear Current Booster | No |
| 1987 | Australian | Energy Research Lab, Maximizer | Yes |
| 1988 | Outside Pwr | 1.2 V NiCd battery voltage booster | No |
| 1989 | Outside Pwr | Turbo-Cooler auto ventilator | Yes |
| 1991 | Outside Pwr | Micro power motor tracker | Yes |
| 1992 | Outside Pwr | High voltage MPPT | Yes |

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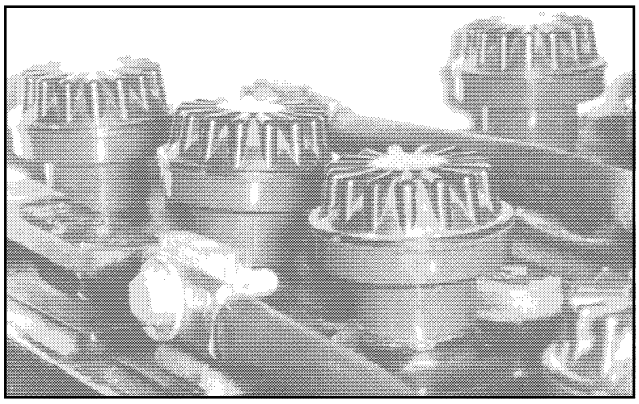

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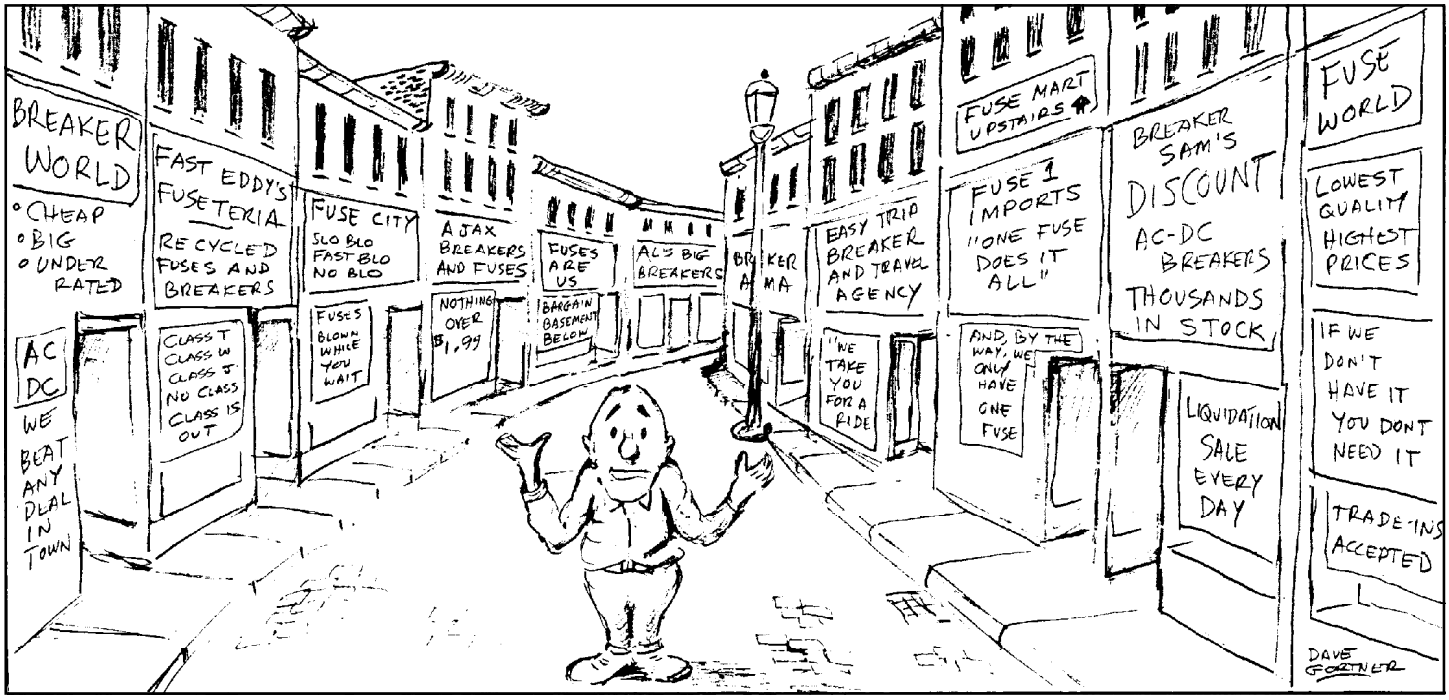


# Understanding System Protection

Christopher Freitas



Protecting your investment in renewable energy equipment from damage is a necessity. A short circuit can cause a battery to explode, threatening severe bodily harm or even death. An overloaded circuit can melt and ignite the insulation on wires, possibly destroying the photovoltaic (PV) system and even your home.

**Protecting Your System**

Designing an effective protection system is not easy. Most manufacturers of fuses and breakers are not familiar with the special problems of high current, low voltage systems. Although some protective devices do have DC ratings, they are rated at voltages higher than the 12 or 24 Volts common in our renewable energy (RE) systems. Most are not designed to minimize voltage drop, and require additional wire, enclosures, and wall space. Comparing the protection ratings of different devices can be difficult, because rating methods vary.

So how do you protect your system without spending a king's ransom? How can you tell if a fuse or breaker will be able to protect your expensive inverter, battery or solar array? How do you add protection without making your system like the cockpit of a Boeing 747?

**Understanding the Hazards**

In order to design an effective protection system one must first understand the hazards present and their relative magnitude.

The greatest hazard in a stand-alone RE system is short circuiting the battery. A single deep-cycle battery can melt cables and connections when a misplaced wrench or screwdriver causes a short circuit. Most systems use several batteries, increasing the damage potential. The short circuit hazard is the greatest for components connected directly to the battery. A significant short circuit hazard exists even on distant load circuits, particularly if the main system is not properly protected.

Another hazard present in all RE systems is overloading a circuit's wiring. This is a significant risk for the parts of a

system which use small gauge wires (#4 to #14). The potential for overheating heavy gauge cables is usually low. Most systems do not have enough battery capacity to provide high current flow long enough to overheat these large conductors.

Although the DC section of an RE system usually has little chance of shock, under certain fault conditions a very serious hazard may be present. I know of an installer who was knocked unconscious while replacing a charge controller connected to a solar array that the homeowner had mistakenly wired in series (160 Volts) instead of parallel (16 Volts). A properly designed protection system isolates the controller from all power sources, thus eliminating the chance of shock. A well-designed protection system guards against the unexpected as well.

**System Protection Basics**

Short circuit protection must be provided to all components connected to the battery. The maximum ability of a fuse or breaker to interrupt a short circuit without being destroyed is called the AIC rating, or Amperes of Interrupting Capacity. A single deep cycle battery can deliver over 6000 Amperes when short circuited. Most RE systems have several batteries in parallel, greatly increasing the ability to produce extremely high currents.

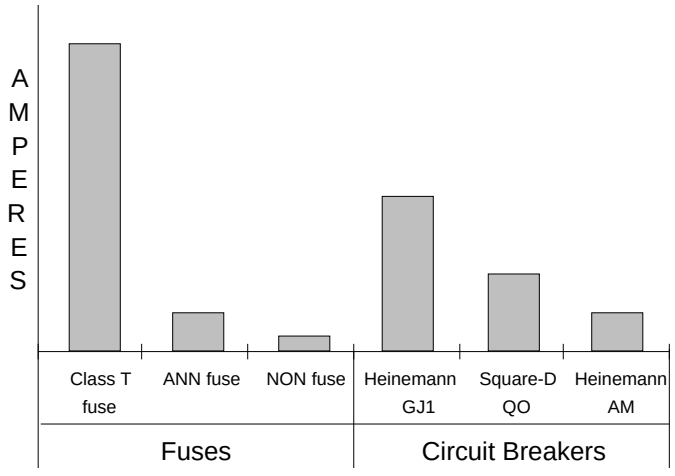


Figure 1: Relative Amperes of Interrupting Capacity (AIC) Comparison, Based on AIC Ratings at 125 VDC

**AIC Rating Dementia**

Comparing direct current AIC ratings for fuses and breakers is a headache. It would be nice if these devices had ratings at 12 or 24 Volts DC. They don't. The main market for these devices is in high voltage ac applications. Some devices have ratings at 65 VDC. The Heinemann GJ1, for example, has a manufacturer's AIC rating of 25,000 Amperes at 65 VDC. The only industry-wide AIC rating for these fuses and breakers in DC applications is an Underwriters Laboratories (UL) rating at 125 VDC. At 125 VDC, the Class T fuse is rated 20,000 Amperes, the ANN fuse 2500 Amps, and the NON fuse 1000 Amps. At 125 VDC, the Heinemann GJ1 is rated 10,000 Amperes, the Square-D QO 5000 Amps, and the Heinemann AM 2500 Amps. An engineer at Littelfuse told me the interrupting capacity of these fuses is better than inversely proportional to voltage at DC voltages below 125 VDC. In other words, at 12.5 VDC we could expect the Class T fuse to have an AIC of more than 200,000 Amperes. The current interrupting capability of breakers also increases with decreasing voltage, but less so than for fuses. This is because the contacts in breakers must pull apart to break the arc established by the short circuit, whereas in a fuse, the arc simply melts the conductor. Figure 1 provides a relative comparison of AIC ability for various fuses and breakers commonly used in RE systems. The plotted values are actually the UL generated AIC ratings at 125 Volts, but they also give an indication of the relative AIC performance of these protection devices at lower DC voltages.

**Current Limiting Fuses**

Further protection is available from fuses which are rated as “current limiting”. These special fuses are able to interrupt a short circuit condition very quickly. These fuses allow only a small amount of energy to flow in the circuit, limiting the damage. Current limiting fuses can also protect small inexpensive breakers used in load distribution centers. Components that are not as sensitive to short circuits can be protected by large, high AIC breakers. This includes inverters, battery chargers and large DC motors.

All wiring must be protected from being overloaded by a properly sized fuse or breaker. Wire type, temperature, and application (whether in free air or conduit) must be considered when estimating the maximum allowable current. Table 310-16 of the National Electrical Code Handbook provides a listing of wire types and ampacities. Ratings can also be obtained from the wire and cable manufacturers for unlisted types such as welding cable.

**Disconnects**

Every component in an RE system should be able to be disconnected from the source of power. This can be done by a switch, breaker, or fused disconnect. When disconnected, no voltage should be present on the fuse or component. Solar array charge controllers must be disconnected from both the battery and the solar array.

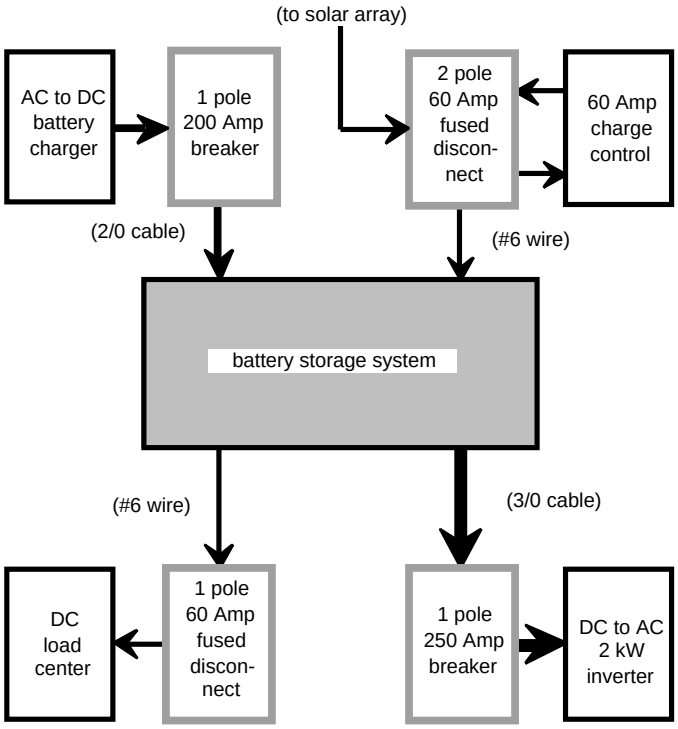


Figure 2: Individual Component Protection

**Individual Component Protection**

Figure 2 shows a typical system layout as implemented by many installers. Individual disconnects and breakers protecting major components are shown with dashed lines. The controller is isolated from both the array and battery by using a two pole disconnect. The inverter and battery charger use large breakers as disconnects, but the load center and charge controller require disconnects with current limiting fuses to protect them from short circuits.

Providing individual protection for each component separately has several problems:

1. DC rated, high amperage, single pole fused disconnects and breakers are not readily available and are expensive.

2. Several battery connections are required with unprotected wiring between the battery and overcurrent protection device. Keeping the disconnects close to the battery would be difficult when installed, increasing the length and hazard of this wiring.

3. The protection system might be difficult to understand. Shutting down the system would require operating several disconnects.

4. Additional wiring is required, lowering overall system efficiency and adding cost and installation time.

**Combined Component Protection**

An alternative layout is shown in Figure 3. This configuration takes advantage of exceptions, known as the "Tap Rule", to the National Electrical Code's normal protection requirements (NEC 240-21). A tap is a smaller ampacity circuit which serves a single energy-utilizing device (load center, motor, etc.), and is connected directly to a protected circuit of larger ampacity. This "Tap Rule" allows smaller wires to be protected by a large fuse if the following restrictions are met:

For taps under 10 feet in length, the tap conductor must be rated for the ampacity of the device it supplies and must be rated at least 1/10 the ampacity of the overcurrent device from which it is tapped.

For taps under 25 feet, the tap conductor must be rated for at least 1/3 the ampacity of the overcurrent device from which it is tapped and must terminate in a single circuit breaker or fuse which will limit the load to the ampacity of the tap conductor.

Other National Electric Code restrictions also apply such as protecting the conductors from damage, etc.

In the combined protection system example, fewer overcurrent protection devices are required. The main protection is provided by a 400 Ampere fused disconnect which is connected to the battery with heavy duty, fine strand 4/0 welding cable. The fused disconnect must use

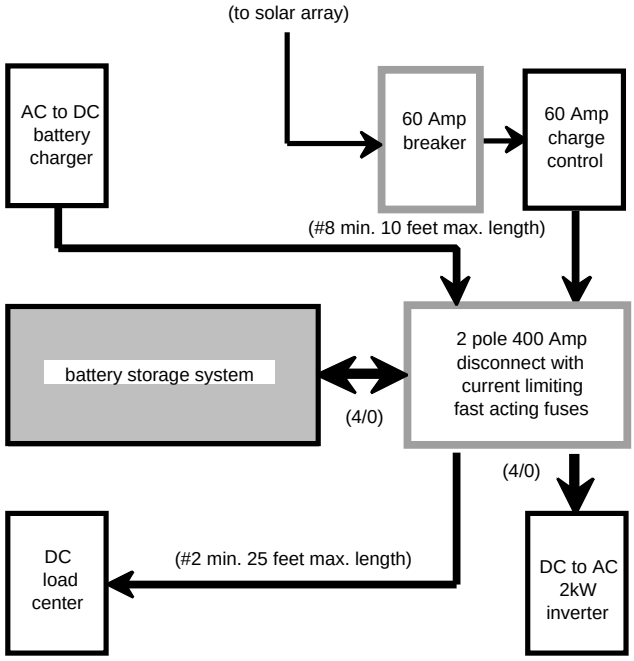


Figure 3: Combined protection

current limiting fuses to protect the low AIC components in the DC load center and the charge controller from damage by short circuits. Isolation of the charge controller is allowed by a breaker on the array side.

**Advantages of Combined Protection**
The combined protection design has several advantages:

1. The entire system may be shut down by simply operating a single disconnect.

2. All components are extremely well protected from short circuit damage by the current limiting fuses in the main disconnect.

3. The only battery connection is one pair of heavy 4/0 cables, reducing the amount of unprotected wiring.

4. Fewer battery connections reduce corrosion problems and simplify periodic servicing.

5. All major components in the system attach at the main disconnect, reducing voltage drop and increasing efficiency.

6. Fewer overcurrent protection devices are necessary, reducing installation time and expense.

7. Inexpensive low AIC breakers may be used to protect and disconnect smaller input and output wiring.

**Parts Specifications**
An important requirement of the combined protection design is the use of a two pole main disconnect. If a single pole disconnect was used, the solar array could be connected directly to the DC loads and inverter, causing possible equipment damage and shock hazard. A two pole breaker should not be used as a main disconnect because it will not protect low AIC components from short circuits.

Because the load fuse must handle both the inverter and the DC loads, a higher amperage device must be used. In the examples, a 400 Ampere fuse replaced the 250 Ampere breaker. Figure 4 compares the time delay characteristics of each unit to the maximum current draw of a commonly used inverter. Notice how the fuse's time delay is better matched to the inverter and how nuisance tripping of the breaker may occur when operating large loads.

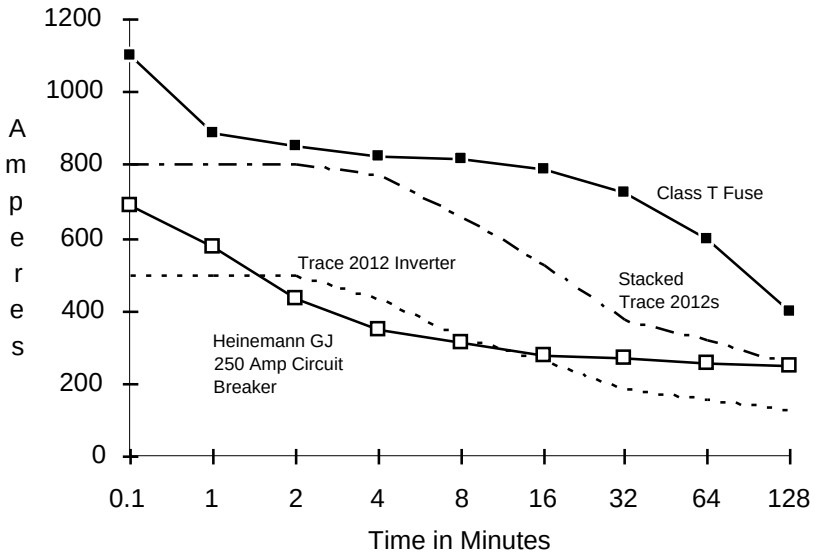


Figure 4: Fuse and breaker time delay

The 400 Ampere fuse will still provide overload protection to the battery and inverter cables as most 4/0 welding cable is rated for over 500 Amperes continuously.

**Overcurrent Device Comparison**
Figure 5 compares the overcurrent protection provided by commonly used devices. Although fast acting Class T and R fuses provide similar protection, the Class T fuses have much lower let-through of current during severe short circuits, providing greater protection. Class T fuses are also less expensive and more compact, reducing enclosure size and cost.

Figure 5: Fuse and Breaker Comparison

| | FUSES | | | CIRCUIT BREAKERS | | |
|---|---|---|---|---|---|---|
| | | | | Heinemann | | Square-D |
| | Class T | ANN | NON | GJ | AM | QO |
| Protects low AIC components from high short circuit currents | ✔ | | | | | |
| Arcing is suppressed to reduce explosion hazard with batteries | ✔ | | | | | |
| Underwriters Laboratories (UL) rated for DC applications | ✔ | | | ✔ | ✔ | ✔ |
| Provides the maximum AIC rating available for its type | ✔ | | | ✔ | | |
| Can protect DC load centers from high short circuit conditions | ✔ | | | | | |

High amperage (200 and 400 Ampere) Class R time delay fuses should not be used in main disconnects for short circuit protection of battery systems as the let-through current is too high for protection of low AIC components.

**Summary**

Combined protection design can simplify the installation of renewable energy systems. It can increase the level of safety, performance, and efficiency while reducing cost, installation time, and space requirements for safety components. The system user will be able to operate and service the system much more easily, as fewer components and less wiring is required.

**Access**

Author: Christopher Freitas, Ananda Power Tech, Inc., 14618 Tyler Foote Road, Nevada City, CA 95959 • 916-292-3834 • FAX 916-292-3330

National Electrical Code - 1990, National Fire Protection Assoc., Batterymarch Park, Quincy, MA 02269

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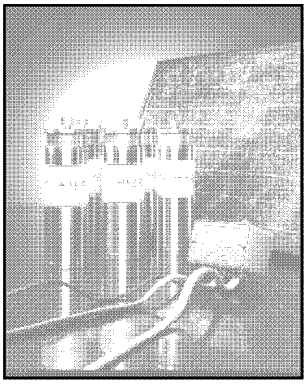

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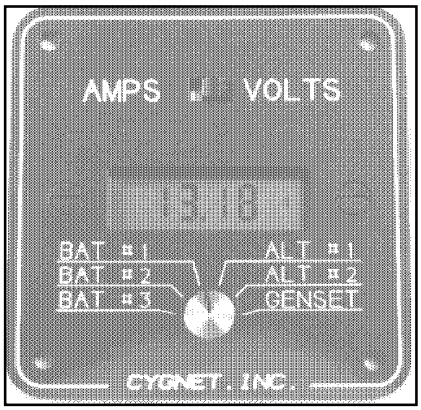


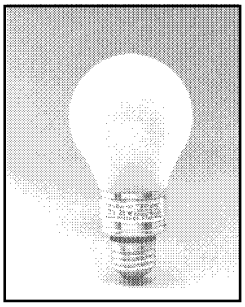

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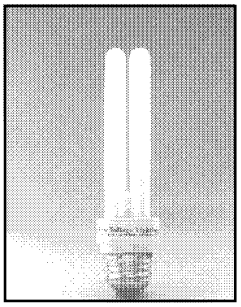

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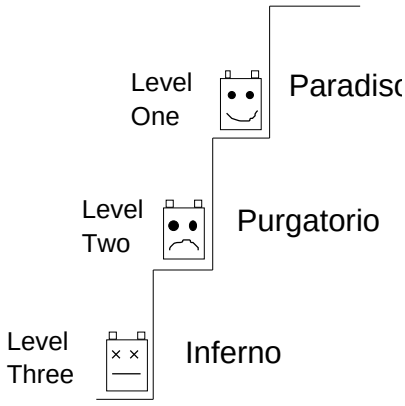
# Healing Troubled Cells

Richard Perez

Here is what to do when the ole' battery is not storing what she used to. Many troubled batteries can have their capacity restored through healing procedures. These procedures vary from a series of overcharges to radical chemical surgery.

**First make sure that the patient is really sick**
In HP #28, page 36 I wrote an article about diagnosing battery problems. If you haven't read this article, then please do so before attempting to heal your battery. Chances are that your battery only needs to be fully recharged. The healing procedures in this article are only for sick cells. Performing these procedures on heathy cells will not improve their ability to store electric power. If your battery is already in good shape, then these procedures will only waste time, money, and materials. The procedures here are for sick cells, not dead cells. These procedures will not cure cells with internal short circuits, internal open circuits, or foreign material contamination.

**Lead-Acid Cells**
The biggest problem in lead-acid cells is sulfation due to chronic undercharging. Here the sulfate ions have entered into deep bonds with the lead on the cell's plates. The sulfate ions can bond with the lead at three successively deeper energy levels. Level One is the bond we use when we normally charge and discharge the cell. After a month or so at Level One, some of the bonds form Level Two bonds which require more electric power to break. After several months of being Level Two bond, the sulfate ions really cozy up to the lead and form Level Three bonds. Level Three bonds are not accessible electrically. No amount of recharging will break Level Three bonds. The longer the lead sulfate bond stays at a level the more likely it is to form a closer acquaintance and enter the next deeper level. This is why it is so important to fully, regularly, and completely, recharge lead-acid cells.




Dante's Guide to Lead-Acids

**Equalization Charges**
If the loss in capacity is due to Level Two bonding, then a repeated series of equalizing charges will break the Level Two bonds. Under equalization the Level Two bonds will first be transformed into Level One bonds, and then the sulfate ion can be kicked loose of the lead entirely and reenter the electrolyte solution.

If your lead-acid cells have lost capacity, then a regime of equalizing charges is the first procedure to try. An equalization charge is a controlled overcharge of an already fully recharged cell. First recharge the cell and then continue to charge the cell at a C/20 rate for five to seven hours. During equalization charges, the cell voltage will become very high, about 2.7 VDC per cell. This overcharge contains the necessary power to break the Level Two bonds and force them to Level One. Once they reach Level One, the bond is easily broken and the sulfate ions reenter into solution in the electrolyte.

**EDTA Treatment**
If a bond spends several months at Level Two, it eventually enters the depths of Level Three. The Level Three bonds must be chemically stripped from the plates. This is a job for an organic acid called EDTA, a close chemical cousin of vinegar. EDTA stands for the compound "ETHYLENEDIAMINE TETRAACETIC" Acid. In chemical techie terms, EDTA is a "chelating agent." EDTA comes in several forms. Use the tetraacetic variety.

The EDTA procedure is simple. Use one tablespoon of the EDTA powder for each quart of electrolyte in the cell. Mix the EDTA with a small amount (an ounce or two) of distilled water and add it to the cell. Recharge the cell and give it an equalizing charge. Recharging the cell speeds up the reaction and allows the EDTA to strip the Level Three bonds from the surface of the cell's plates. After

this reaction takes place, the dead Level Three materials fall to the bottom of the cell as a precipitate. The reaction can take from several days to several weeks depending on temperature, recharge rate, and depth of Level Three bonding. Once the Level Three bonds are stripped from the plates, new lead is exposed and can enter into Level One bonding with the sulfuric acid electrolyte.

The amount of EDTA used here is a ballpark guess. If your cells are badly riddled with Level Three bonds, then you may wish to repeat the EDTA treatment in a month or so. Feedback from hundreds of HP readers who have tried EDTA indicates that it will not harm the cell. For a complete discussion of EDTA treatment see HP #20, pg. 36, and HP #21, pg. 36.

**Alkaline Cells**

Most alkaline cells with diminished capacity suffer from electrolyte carbonation. This phenomenon usually occurs after 15 to 20 years in nicad and nickel-iron cells. The potassium hydroxide (KOH) electrolyte enters into chemical combination with atmospheric carbon dioxide ($CO_2$) and forms potassium carbonate ($K_2CO_3$). This removes the KOH ions from the electrolyte and makes the cell less able to conduct electricity. The decrease in electrolyte conductivity makes the cell reach a lower voltage much more quickly under discharge. As such, electrolyte carbonation appears to the cell's user as diminished capacity.

In pocket-plate nicads, electrolyte carbonation is usually caused by not maintaining a sufficiently deep layer of mineral oil floating on top of the electrolyte. The mineral oil layer protects the electrolyte's surface from contact with the atmospheric $CO_2$. One-eighth of an inch of mineral oil is all it takes. If alkaline cells are charged hard (>C/20) when they are full, the cells will gas violently. This gassing agitates the oil layer and works air (which contains about 0.03% $CO_2$) into the electrolyte.

Testing for electrolyte carbonate level is possible via titration. For the specific procedure see HP #15, page 23. It is more expensive to test a cell's carbonate concentration than it is to replace the electrolyte in a cell. So the test procedure is usually skipped if the cell is over ten years old.

**Electrolyte Replacement**

To cure carbonation just replace the electrolyte. The best procedure is to buy an electrolyte replacement kit from a nicad dealer. This kit comes with return privileges for the old carbonated electrolyte. It is very important to dispose of the old electrolyte safely because it contains a small amount of cadmium – a toxic material.

The procedure is simple enough, but use caution. KOH can burn exposed skin and eyes. So look sharp! Wear rubber gloves, long sleeves, and tight fitting goggles. Gently shake the cell to stir up any sediment. Slowly empty the cell by inverting it over a plastic bucket or washtub. Refill the cell with new electrolyte, and add an 1/8th inch layer of pure mineral oil. Refill the now empty container with the old electrolyte and proceed to the next cell. After all cells are done, ship the old electrolyte back to the nicad dealer for proper disposal.

If you are daring and want to mix your own electrolyte, see HP#15, page 23 for technical details. I don't recommend doing this because this method offers no easy avenue for the old electrolyte's disposal. Also the small amount of lithium hydroxide used in the electrolyte is difficult to obtain and potentially dangerous in its pure state. Buy your replenishment kit from a dealer who will give you the standard mix. The replacement electrolyte usually has a specific gravity of 1.25 and contains 10 grams of lithium hydroxide per liter (40 grams per liter if the cells are nickel-iron).

**No Sure Cure**

If you run the appropriate procedures on your cells, then you should notice an increase in capacity. If you don't, then something else is wrong. The procedures here are specific cures for specific problems. Your cells may have other, possibly terminal, problems such as contamination. I recall hundreds of beautiful, virtually new, Edison nicads that were terminally contaminated with diesel fuel. I've seen lead-acids ruined with dirty hydrometers. Your cells are a chemical machine. Keep their insides pure and they will return your efforts with long life.

**Access**

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

**EDTA**

Bryant Labs, Peter Barnett, 1101 5th St., Berkeley, CA 94710 • 510-526-3141. Cost: $22.50/500 grams.

Trailhead Supply, 325 East 1165 North, Orem, UT 84057 • 801-225-3931. Cost: EDTA, $10/LB. ppd.

**Alkaline Replacement Electrolyte**

UtilityFree, POB 228, Basalt, CO 81621 • 800-766-5550. A four gallon electrolyte refill kit costs $79, plus shipping. It includes gloves, funnel, return labels, instructions, and disposal. Ship the spent electrolyte back to UtilityFree (prepay shipping) and they will properly dispose of it. UtilityFree also has KOH and LiOH.

# Things that Work!

*Things that Work!*
tested by Home Power

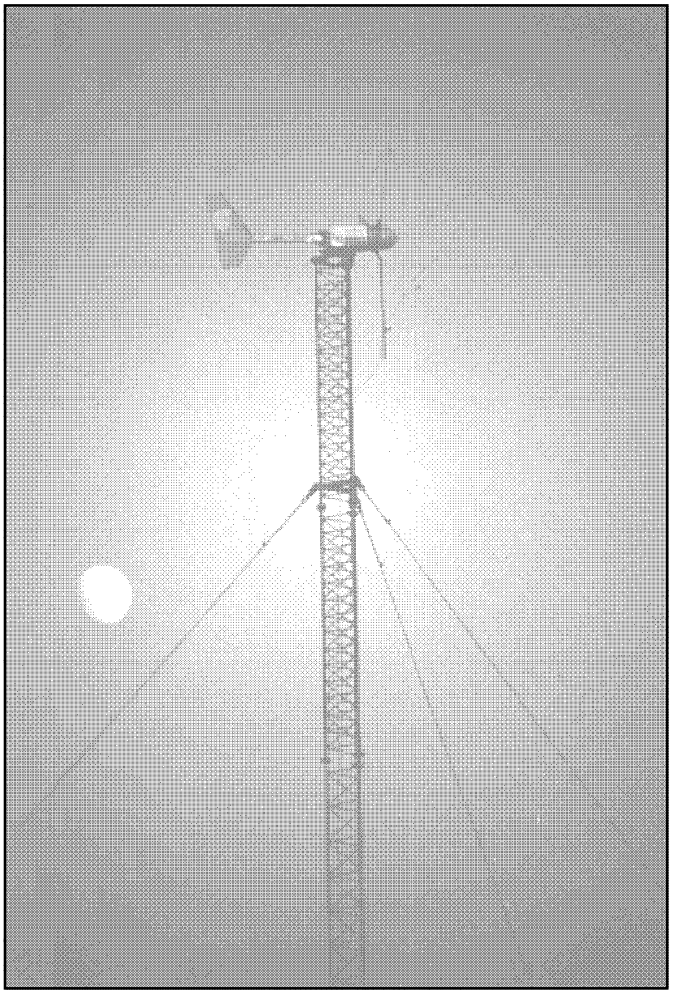
# Bergey's BWC 1500 Windpower Generator

Tested by Mick Sagrillo



For about 13 years, the name Bergey has been synonymous with "state of the art" in wind generators. Needless to say, when I heard that they had replaced their 1000 Watt remote battery charger (BWC 1000) with a new and improved BWC 1500, I was enticed. Bergey Windpower has been building wind generators for a long time, with over 1000 turbines scattered across the U.S. and more countries around the world than I care to remember

My new 32 VDC Bergey arrived in Amherst just in time for the 1991 Midwest Renewable Energy Fair. In the crate, everything was laid out in one neat bundle: the generator, tail and fin, blades, control box, and the ever important Installation Manual. I assembled the genny and solicited a few "volunteers" to help hoist the Bergey up onto the stub tower that I had built. Later in the afternoon I had a chance to take a good look at Bergey's latest design.



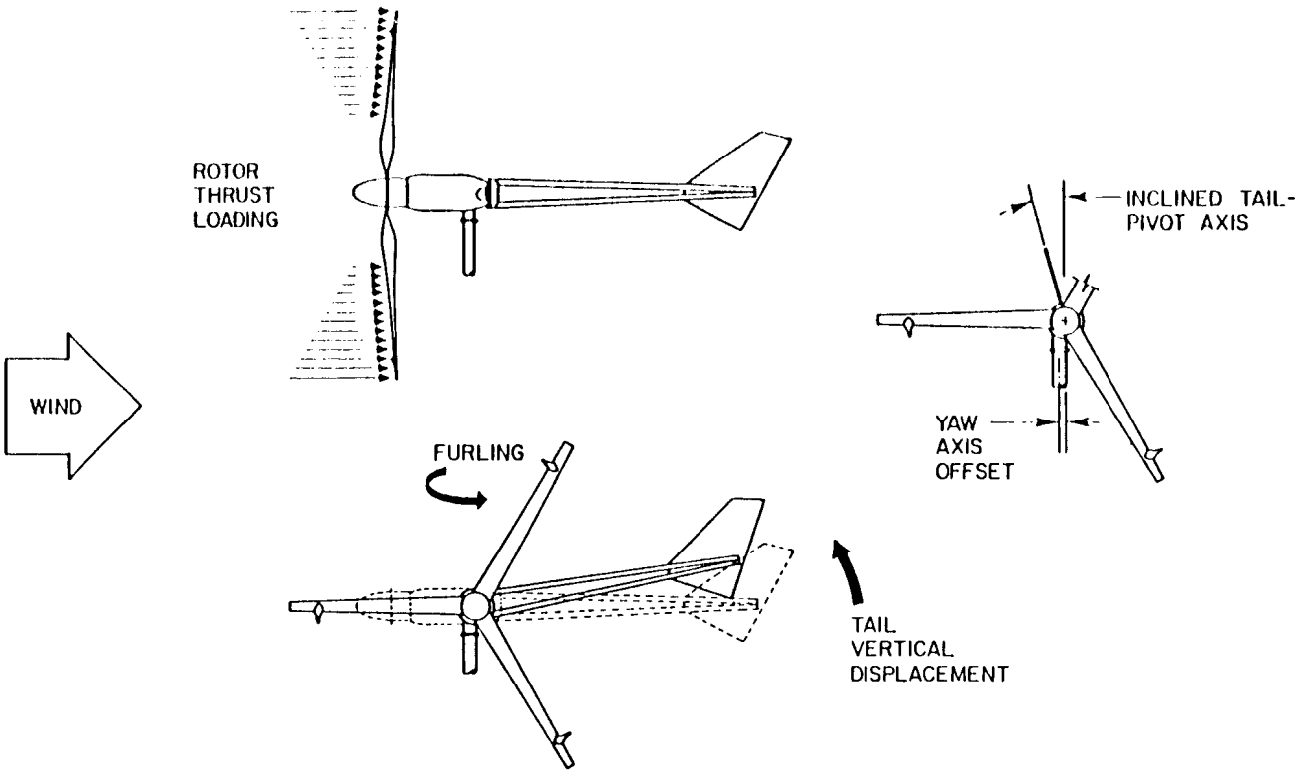
Above: Bergey Windpower's BWC 1500 with the moon rising to the left of the tower.
Photo by Mick Sagrillo

**Three Moving Parts**

This wind generator is the height of simplicity. Mike Bergey explains his design philosophy by quoting Antoine de St. Exupery: "Perfection is achieved not when there is nothing more to add, but when there is nothing more to take away." The BWC 1500 reaches this goal by having just three moving parts: the rotor, the yaw, and the tail.

Most alternators have the current-producing windings attached to the outer frame. This is known as the stator. The field rotates within the stator, and is known as the rotor. Slip rings are used to carry current to the spinning rotor, to excite the field, and thereby generate power.

The BWC 1500 generator is permanent magnet in design. This unit produces 3 phase wild (i.e. variable frequency) ac. The stator is attached directly to the mainframe of the wind generator and doesn't move. The permanent




magnets, which produce the field, are mounted in the outer housing, called the magnet can. This magnet can rotates around the fixed stator. Since permanent magnets are employed, there are no brushes to wear out. Attached to the front of the magnet can are the three blades. So far, we're generating electricity with only one moving part: the magnet can..

The second moving part is the yaw bearing which allows the mainframe/alternator, with the help of the tail, to follow the shifting wind. The entire mainframe assembly is offset slightly to the side of the yaw bearing. Strong winds try to push the rotor around the tower. Since the machine is offset, not directly in line with the center of the tower, it can do this. This "self-furling" protects the genny from excessive winds.

Bergey controls the furling with the free floating tail, the third moving part. The tail is hinged at the rear of the mainframe, but the hinge is canted several degrees from true vertical. As the wind blows harder on the rotor and furls it around the tower, the tail continues to track the wind. Because the tail is mounted onto what is in effect a cocked hinge, it moves slightly upward as it furls, just a few inches. In the fully furled position, which is achieved when the wind is blowing its hardest, the blades are nearly parallel with the tail. When the wind diminishes, the pressure on the rotor decreases. Since the tail has moved "uphill", gravity pulls it back down to its original position. The rotor faces the wind head on again.

**The Rotor**

Bergey flies three blades rather than two. A three-blade rotor will yaw with the shifting wind much smoother than a two-blade rotor. When the blades of a two blade rotor are lined up vertically, they offer little resistance to yawing motion. However, when the blades move one quarter of a turn and are in a horizontal position, they exert maximum resistance to yawing. This continuous shifting of resistance to yaw jerks the wind generator as it hunts the wind. These vibrations eventually degrade the entire system. The inherent imbalance of a two blade rotor is totally eliminated by adding a third blade.

The blades are made of extruded fiberglass with pitch weights mounted about three quarters of the way out the blade. The blades are mounted on the magnet can at a greater angle of attack than what is ideal for operating speed. Greater angle of attack means that the blades develop more torque to get the rotor started from stand-still. As the rotor spins up, the weights flatten the pitch of the blade out by 4 or 5 degrees at the tip of the rotor. This improves upper end performance at higher rpms, where performance is really needed. The best part

of this design is no moving parts! As the blades are very flexible, Bergey offers an extra-stiff blade option for very turbulent areas.

**The Manual**
The BWC 1500 Owner's Manual covers the basics in 20 pages. However, Bergey does provide the 90 page Installation Manual for the BWC 1000, which is one of the most thorough documents on small wind generators and tower installation I have ever read. Beside the usual topics of assembly and installation, Bergey also covers legal restrictions, site considerations, tower selection, a very extensive section on tower anchoring for various locations and situations, another great section on wiring for all applications, tool requirements, and various schematic diagrams. They even cover such esoteric subjects as a life cycle energy cost analysis.

**Built to Last**
Bergey set out to develop and build a wind generator that would last the generations, the same approach taken with the famous Jacobs Wind Electric wind systems of yesteryear. Attention to detail is what sets this machine apart. All painted surfaces are coated with DuPont Imron, probably the most indestructible, as well as the most expensive, paint available today. The mainframe and tail boom are hot-dip galvanized inside and out. The slip ring brush cover is made of clear yet unbreakable Lexan. All hardware, as well as the tail pivot pin, are stainless steel.

The quality of the materials used by a wind generator manufacturer is usually reflected in the maintenance that the machine will need. Skimp on materials, and something will eventually rust off, resulting in necessary repairs if not an outright catastrophe.

**Installation**
We finally got around to installing the BWC 1500 last fall. The tower-top weight of the unit is 168 pounds, not something you want to carry up the tower on your back. Up went the gin pole and cables. We assembled the BWC, with the tail, on the ground in about half an hour. The next step was to hoist the genny up the tower via the gin pole with the help of a tractor. Getting the unit on top of the tower in place took less than two hours. Attaching the blades, tail pullout cable, and electrical wiring took another hour. Back on the ground, we spent another hour installing the control panel and a fused disconnect switch.

The entire operation, including wrestling the gin pole and hoisting cables up and down the tower was about a day's work. This was with an experienced crew of two: a ground person and a tower person. We weren't out to break any records. It was a nice way to spend an autumn day.

**The Controls**
It was time to throw the disconnect switch and crank the tail into the wind. The BWC came smoothly up to speed, and began pumping amps into the 32 Volt battery bank in the shop. The folks at Bergey told me that the controller tapers the charging current to maintain a constant battery voltage by cutting off a portion of the sine wave (remember, this is a three phase wild ac alternator, not a DC generator). Rather than regular rectifiers, the controller uses SCRs, that is silicon controlled rectifiers, or diodes with a gate for turning them on and off. The controller is compatible with both lead acid and nicad batteries.

**System Versatility**
The alternator stator is bolted onto the generator mainframe, making it easy to service of the stator in the field. If your system voltage requirements ever change, you need only change the stator and the regulator voltage card. This offers a certain degree of modularity to the BWC 1500. The BWC 1500 is offered with a water pumping option. This is a machine wound specifically for pumping water when connected to a three phase motor. There is a dedicated controller that allows the three phase motor to run at variable speed, depending the power output of the generator. With the addition of a battery charging controller, the water pumping unit will also charge batteries.

**Why a Bergey?**
The factory price for the 24 VDC BWC 1500 is $3095, plus another $815 for the controller (other voltages cost slightly more). That comes to just over $4000 with the shipping. A lot of money for a wind generator, you say? Well, not really, especially when you consider what you're getting: quality, quality and more quality. Like the Jacobs of a bygone era, this will probably be the last wind generator you'll ever need to buy. As they say down at the complaint counter, "you get what you pay for!"

The BWC 1500 was designed for village electrification projects in developing countries and remote/unattended telecommunications installations. Maintenance and repairs promise to be simple. For example, Bergey uses integrated bearing assemblies on both the rotor and the yaw. You won't be needing any fancy pullers or other such equipment. Anybody with an adjustable crescent wrench and a screwdriver can work on a BWC.

I asked about allowing the wind generator to freewheel. Freewheeling means letting the blades run without a load on them. Virtually all manufacturers turn white at the mere mention of letting their machines freewheel. With no load,

wind generators can reach dangerously high speeds, often self destructing. Mike Bergey's comment was "Let it go!" Thinking that he had misunderstood my question, I clarified myself. Mike's response was that I could let it freewheel in any wind speed that I wanted, that the BWC 1500 was built to survive. That's confidence in a job, (or in this case, a product) well done!

**Access**

Author: Mick Sagrillo flies a BWC 1500 at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54231 • 414-837-2267

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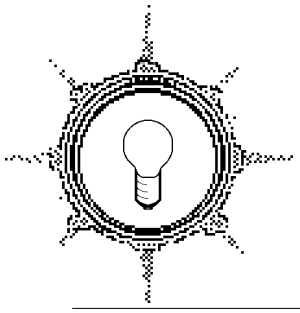

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| ☐ | ☐ | Wind generator | ☐ | ☐ | Batteries |
| ☐ | ☐ | Water power generator | ☐ | ☐ | Inverter |
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HP#29

# Things that Work!

*Things that Work!*
tested by Home Power

# Bobier's LCB40 Sun Selector

tested by Chris Greacen & Richard Perez

The LCB40 (Linear Current Booster) is a high current electronic switching DC to DC converter which allows our 24 Volt wind generator to deliver full power to our 12 Volt battery pack. The LCB40 increased our wind generator's power output by over 50% compared with direct connection to the batteries. It can also work the same electronic magic on photovoltaic modules and microhydros.

**The Voltage Mismatch Blues**

The wind generator at Home Power is an Australian-made Survivor S5000 rated at 500 Watts, with 800 Watts maximum output. She uses a rectified, three phase permanent magnet alternator, designed to charge 24 Volt batteries. From September through March we ran the Survivor connected directly to our 12 Volt battery pack. This didn't hurt our batteries, or the wind generator. But it put the electrical brakes on her, forcing her to run slower than she would like. The wind generator produced her rated current, but with the voltage clamped, she couldn't spin fast enough to produce the power she was capable of. During these winter months her maximum output was 38.8 Amperes at 14.8 Volts = 574 Watts. It was a respectable amount, and a terrific boon when it was cloudy and the PVs weren't producing.

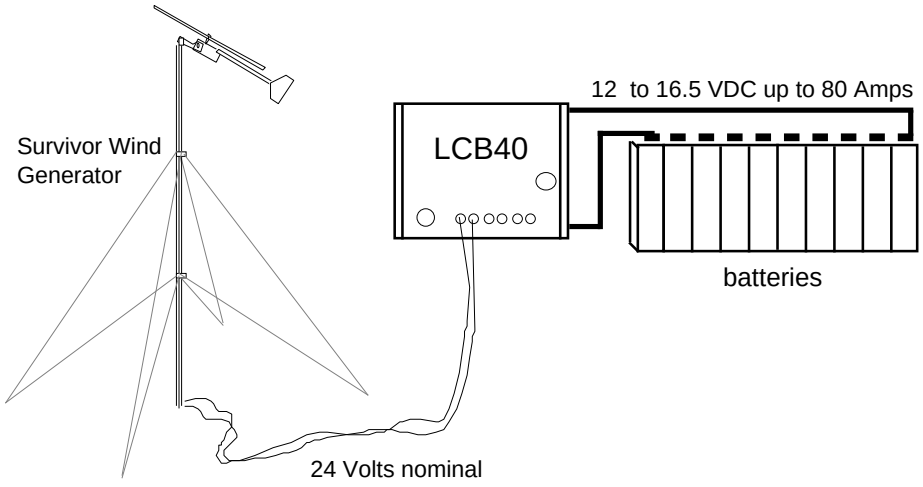
**Quest for the Holy Maximum Power Point**

We needed a machine which would allow the Survivor to run closer to her "maximum power point" – the combination of voltage and current which produces the greatest possible power. This was a job for a high current DC to DC converter (or Linear Current Booster - LCB). We chose the Sun Selector LCB40, a giant cousin to the LCB20 and LCB3-4-8 units widely used for solar water pumping and long distance power transmission. The LCB40 uses high speed power switching circuitry to efficiently convert high voltage, low current input to low voltage, high current output (up to 80 Amperes). You can think of it as a "DC transformer."

**Set Yer Own Power Point**

A knob on the front of the LCB40 lets the user set the input voltage threshold. Whenever the input voltage is reaches this threshold, the LCB converts the incoming power to lower voltage, higher current output. Whenever the input voltage is below this threshold, the LCB acts like an open switch, and no current flows. In this way, the user sets the "number of windings" of the LCB40 "DC transformer." The ideal is to tune the voltage threshold to the maximum power point of the power source. See page 34 in this issue for more on maximum power points.

We knew the Survivor was built to charge 24 Volt battery packs, so her maximum power point is a little higher than 24 Volts, with considerable variance with windspeed. After installing the LCB40, we set the voltage threshold to near 27 Volts. When it's really windy we raise it to around



30 Volts.

**PV Examples**

Most folks will probably buy LCBs for low-loss, long-distance PV power transmission. Wiring panels in series wastes less power to resistance wiring. See "Long Distance Power Transmission" by Paul Cunningham in HP #28. How many panels in series? This is limited by the open circuit voltage of the string. Multiply the open circuit voltage ($V_{oc}$) printed on the back of each panel by the number of panels in series. This must not exceed the voltage rating of the LCB. LCB40s come in 50 Volt, 100 Volt, and 250 Volt models. A number of series strings may be wired in parallel as long as the final output from the LCB does not exceed 80 Amperes. Set the voltage threshold on the LCB to your best estimate of the maximum power voltage ($V_{pmax}$). For PVs, multiply $V_{pmax}$ (printed on the back of each panel) times the number of panels in series to get Vpmax for the series string. If it's hot out, subtract 10% to 20%. See "Home Power Measures PV Performance" for $V_{pmax}$ at 50°C for various panels, HP #24, page 26. A properly adjusted LCB will help reduce line losses, and will cajole more power from your PVs. However, you probably won't see the 50% increase we see out of our wind generator. Our wind generator was originally operating far from its maximum power point, while your solar panels probably aren't.

**Battery Charging Voltage Regulator**

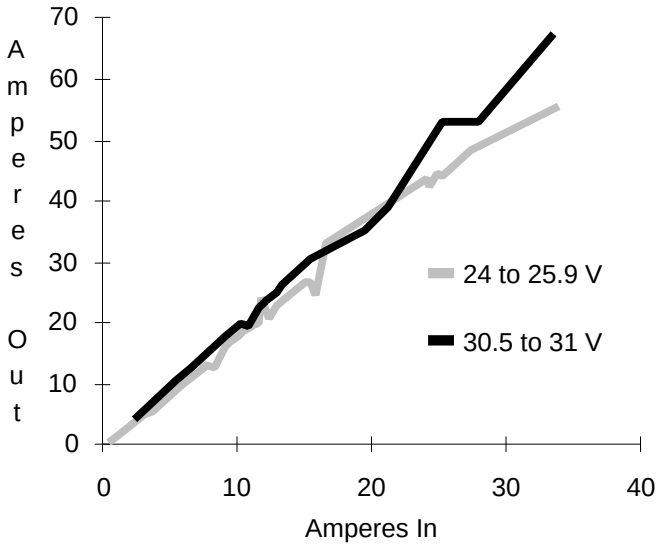
The LCB40 can be outfitted with a battery charge controller, making it the LCB40CC. The charge controller has a toggle switch for 12 or 24 Volt mode to match the nominal voltage of your battery pack. You can order a lead acid regulator (13 Volts – 15 Volts in 12 Volt mode, 26 Volts – 30 Volts, 24 Volt mode) or an alkaline regulator (extended to 18 Volts in 12 Volt mode, 36 Volts in 24 mode). You can also choose three different regulator types. The ECM1 ($99) is a switching series regulator, which gives pulsed charges to the battery. The OVL regulator ($50) is a constant voltage regulator. Both the ECM1 and the OVL are for PVs only. For wind or hydro turbines, a charge diversion (shunt) regulator option will soon be available for around $100.

**Packaging, Documentation, and Installation**

The LCB40 arrived well packaged in nasty styrofoam peanuts. The documentation for the LCB40 is short but adequate. It tells you what the LCB40 does and what you need to know to install and operate the unit within its operating range. Installation is very straight-forward. The LCB40 is 10" x 11" x 3" and mounts on a wall with two screws. There are four wires to hook up, positive and negative to the battery, and positive and negative from the charging source. We commend Sun Selector for providing large electrical terminals. These terminals, however, are exposed from the front, and present an electrical shock danger. To conform to the NEC®, the LCB would need to be encased in an additional metal enclosure.

**The Results**

We now have a pronounced increase power. During the windy winter months the Survivor put out a maximum 38.8 Amperes at 14.8 Volts = 574 Watts. In two months since we've installed the LCB40, we've seen a maximum current of 67.6 Amperes at 13.8 Volts (919.4 Watts). On a windy day, we regularly see currents over 55 Amperes. In our situation, the LCB40 delivers 60 to 90% more current out than is put into it, as shown below in the graph. Input and output currents were measured simultaneously with




Above: Current out verses current in for the LCB40 at two different voltage threshold settings. The voltage of our 12 Volt alkaline battery varied from 13.5 to 16 VDC.

Fluke 87 multimeters using 100 Amp, 100 mV shunts.

With a producer as large as a wind generator, this makes a tremendous difference. We're now cooking extensively with the microwave, and occasionally running electric heat in the office. We know this is disgusting for a renewable energy system, but we've got lots of power. What to do? Soon, the hydrogen electrolyzers...

**Efficiency**

There are two different ways we can look at efficiency here. Most important to us is systemic efficiency. The wind generator/battery system is now at least 50% more efficient than it was when the wind generator was directly

connected to the batteries. But with the wind generator operating closer to her maximum power point, how efficient is the LCB in transferring this power to the batteries? Even before we took measurements, we knew the LCB40 was efficient at its job because even when cycling maximum power, the unit was barely warm. Inefficiency in electronics shows up as heat. Efficiency was calculated as Ef = ($V_{out}$ X $I_{out}$) / ($V_{in}$ X $I_{in}$). Measurements were taken with three Fluke 87s and a Beckman 2020. As an individual component, the LCB40 is over 90% efficient in our application.

**The Bottom Line**

The LCB40 is very flexible. The LCB will enable you to optimize the energy output of your RE power producers by operating them closer to their maximum power points. The LCB40's suggested retail price is $560 for a 50 Volt model, and the 100 Volt model's suggested price is $680. The 250 Volt model's price will be announced soon. They're not cheap, but consider this: we're getting 50% more power out of our $3,000 wind generator. In situations where a substantial power producer is already in place, adding an LCB can be by far the cheapest way of putting more electrons in your battery. The LCB40 is especially appropriate for:

- Long distance power transmission in PV systems
- Enabling 24 or 48 Volt, or higher, wind or hydro generators to provide more power for RE systems with lower battery voltages

**Access**

Authors: Chris Greacen & Richard Perez, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179

LCB40 Maker: Bobier Electronics, Sun Selector, POB 1545, Parkersburg, WV 26101 • 1-800-222-3988

# Things that Work! Ananda's Power Center IV

*Things that Work!*
tested by Home Power

Tested by Richard Perez

Power distribution, overcurrent protection, and instrumentation can become a nightmare in large, low voltage, RE systems. Our system had grown to the point where we needed a separate room just to house the fuses, circuit breakers, shunts, disconnects, and distribution terminals. Ananda Power Technologies Power Center IV packed our roomfull of equipment into a single two foot by two foot box.

**A Growing System**

We were designing a special room just to house the controls, inverters, fuses, circuit breakers, disconnects, instruments, 120 vac distribution panels, and 12 VDC distribution panels. The list of components that were supposed to go on the three foot wide by seven foot tall wall seemed endless.

I broke out Claris CAD, a Computer Aided Design program, and tried to design the wall with all the necessary equipment in place. The wall was simply too small to house all the gear. Most of the space was occupied by fuses, disconnects, circuit breakers and instrumentation shunts. According to the NEC®, these components must be housed in metallic boxes and must be interconnected with conduit. Our wall shuddered under a writhing mass of conduit snakes. I gave up and called the folks at Ananda.

**A Power Center**

A power center is just that, the center of a power system. It is where all the power inputs, DC outputs, and battery input/outputs come together. A power center not only elegantly and efficiently makes all the connections, but also houses safety devices like fuses, circuit breakers, and disconnects. In our case, Ananda's Power Center IV allowed us to dispense with seven wall boxes and eighteen conduit runs. The Power Center IV allowed us to have the gear we needed without having to knock out the wall and enlarge the power room. Without Ananda's Power Center there was no way that we could cram all that stuff on a three by seven foot wall.

**Packaging and Docs**

The unit arrived via UPS in two boxes because it was too heavy to travel in a single box. The unit was well packed with a bare minimum of ecological nasties. The documentation is superb and goes far beyond just installing the panel. It also covers wiring, battery care, and general RE topics.

**The Test System**

Home Power's RE system in Agate Flat, Oregon is far from typical. Ours is large (cycling about 7 kiloWatt-hours each day) and needs to be heavily instrumented. Power inputs include a variety of PV modules (28 in all) ganged into four major arrays. Total PV power is about 1,150 Watts peak (80 Amperes at 15 VDC). We also use a Survivor wind generator capable of delivering over 60 Amperes (via a Bobier LCB40) into the battery. The battery holds 1,500 Ampere-hours at 12 VDC and is composed of 150 NIFE, HIP-10, pocket plate nickel-cadmium cells. We use both 120 vac (from three different inverters) and 12 VDC (directly from the battery) for appliances. Our system is designed and constructed to meet all NEC® requirements. And the *coup de grace* is that we want to be able to instrument every component and function. The instrumentation alone requires eleven shunts for current measurement.

The Power Center IV that Ananda made for us was designed specifically for our system. Although Ananda offers stock power centers, they will make virtually anything you require. In our case, we really put them to work. We not only wanted everything mentioned above, but we had other very specific requirements. We wanted the power center to directly connect to the 1.25 inch by 0.25 inch copper buss bar we used to connect the cells in parallel. We provided Ananda with a very specific system schematic, which specified everything. We also supplied Ananda with a scale drawing showing exactly where the

buss bars and cables would enter and leave the power center. The power center they made met all specs and bolted right up.

**The Results**

The Power Center IV we have contains eleven shunts, four 50 Ampere circuit breakers for the PV subarrays, one 100 Ampere breaker for the wind generator, three 20 Ampere DC load breakers, and three 400 Ampere main fuses/disconnects protecting the battery and three inverters. All circuit breakers are DC rated Square-D QO types and all fuses are Class T current limiting types. We still have two open slots for input breakers and five open slots for DC output breakers. Everything in the power center is well connected using heavy wire, #00 copper welding cable, and more buss bar. Voltage losses within the center are virtually nonexistent: less than 0.1 VDC for 330 Amperes flowing through the center and into our big inverter.

The net result of Ananda's Power Center is that we didn't have to build another power room. Instead, Ananda made us a two foot by two foot by six inch deep box that contained everything we needed. The power center is beautifully made and finished. For example, all the shunt leads are wired to a barrier strip with twisted pairs. All terminals within the center are plainly labeled. The center meets NEC® requirements. It is safe and very compact, which also makes it very efficient. The power center reduced our losses by reducing the heavy cable and buss bar that we would have used with separate boxes. The power center vastly simplified integrating all our various components into a system. It saved us mucho conduit, many boxes, and hours of rectal pain.

**Conclusions**

Folks who are designing and installing their own systems will find that the Ananda Power Centers provide simple, compact, secure interconnection for their RE components. In production versions, Ananda puts controls and the actual instruments (instead of just shunts) inside the power center. The power center will meet NEC® requirements and the system is well protected with overcurrent fusing and disconnects. The cost of regular production centers varies from about $1,150 to $1,395 and this includes 4/0 cables for the inverter and battery. Our power center was custom-made and is jam packed with goodies that are not normally used in most systems. Our center cost $3,000 and I figure that it was far cheaper than enlarging the power room, installing all the gear in individual boxes, and connecting everything with heavy cables inside conduit. According to Ananda, about half the power centers they build are custom-made at average cost of $1,600.

If you are a dealer doing code systems, then you will find an Ananda power center will simplify your design and installation problems. It fits in a small space, will pass the inspector's evil eye with ease, and costs your customer less in labor, piles of boxes, and yards of conduit. Ananda has attractive dealer pricing; it figures since these guys started out as installing dealers.

My compliments to Ananda Power Tech for building equipment of the highest quality. Further flowers for being able to take Home Power's demented requirements and actually make a center that works for us. Thumbs up, guys!

**Access**

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

Everything has an end but a sausage has two.
Check your mailing label!

Sun Frost
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NEGATIVE
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# Things that Work! 12 Volt Products' Heating Pad

*Things that Work!*
tested by Home Power

Tested by Karen Perez & Chris Greacen

Sore muscles? No inverter? Chilly, but don't want to turn up the thermostat or start a fire? Don't want to be bathed in electromagnetic fields (EMFs)? Well, here's the heating pad for you.

**Relief**
Since I entered middle age, sore parts have become a problem. You know, those small aches and pains that just appear and make getting out of bed tough. The 12 Volt Products heating pad has come to my rescue.

**The 12 VDC Specs**
This heating pad is 16 inches by 14 inches with two elastic straps to keep it in place. Its 18 gauge cord is six feet long with a cigar lighter plug. The manufacturer says it draws 2 to 3 Amps DC and the thermostat will maintain temperatures of around 165°F.

**The Test**
I have read so much about electromagnetic fields and ac heating pads that I wanted to compare our DC version with an ac model (see HP #23, page 24 for more on EMFs). I trotted down to our local discount store and picked up a 120 vac, three setting heating pad for $18.99. It came complete with warnings not to use with infants, invalids, diabetics, or bedridden folks. The 120 vac pad is cheaper than the 12 VDC model at $26.99. This test proved to me that cost isn't everything.

Chris and I set up two Fluke 87 multimeters, one to record the amount of power used and one to take heating pads' temperatures. We also used an ac milligauss meter for the ac EMF readings.

**Just the Facts**
The 12 Volt Products' heating pad temperature ranged between 126.3°F and 152°F (a comfortable 140°F average). When the heating pad was first plugged in it drew 2.2 amps at 12 VDC. After the thermostat started cycling, the average electrical consumption was 1.1 amps at 12 volts or 13.2 watts. What I really like is that the 12 Volt Products' heating pad makes no measurable ac magnetic field.

Then Chris and I tested the 120 vac heating pad. We put the 120 vac pad on the medium setting (average 130°F) The high setting was too hot (around 180°) for comfort anyway. After a warm up period, we started recording the data. The ac heating pad drew an average of 0.39 amps at 120 vac or 46.8 watts. Its magnetic field output was 30.13 milligauss. That's 150 times greater than our normal background ac magnetic field here on Agate Flat, and much more than I want close to my body for hours at a time.

**Which One?**
Which would you like to cuddle up with? A potentially dangerous power pig, or a heating pad that uses less than one third the power and has no dangerous EMF. An easy choice for me. Sometimes I take 12 Volt Products' heating pad to bed with me and sleep on it all night long. It's warm, soothing, safe, and kind to our battery.

**Access**
Author: Karen Perez, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179

Distributor: 12 Volt Products, POB 664, Holland, PA 18966 • 215-355-0525

# Things that Work! SBCI's Foldable Portable Cooker

*Things that Work!*
tested by Home Power

Tested by Kathleen Jarschke-Schultze

What comes in its own carrying case, saves time, energy and money, is efficient, looks good, can be mailed anywhere, opens a whole new dimension to your life, and is fun to use? The answer is Solar Box Cookers International's foldable, portable cardboard solar cooker.

**Packaging and Documentation**

The unit arrived in a cardboard box (23" x 27" x 4") via UPS, although it can be mailed anywhere there is mail service. The box is sturdy and has a black plastic carrying handle which is handy and probably kept it from being tossed around by the shippers. In opening the box, I found the instruction manual right on top. I like that.

The assembly instructions are great with step by step procedures using both easy to understand words and large, clear diagrams. I believe you could assemble this cooker using only the diagrams if you couldn't read English.

Amy Wilson (of Great Northern Solar) and I assembled the cooker in about 20 minutes. To disassemble it and put it back into its carrying case takes about six minutes. The assembly instructions take up the first half of the manual with extra instructions about using the oven in windy areas.

**The Box Cooker**

The cooker parts come already covered with aluminum foil. The window material is a double layer (thermal pane) of tough, 4 mm special polyester film which withstands high temperatures and long exposure to sunlight without getting brittle or cloudy. It is not puncture proof so it must be protected from sharp objects. It is already attached to the window frame. This means there is no gluing or taping involved. In fact, no tools other than your mind and your hands are needed to assemble this cooker. Even the outside of the cooker is covered in foil, which gives the cardboard some added protection from the elements. This does not mean you can leave it out in the rain, however, it simply means it will last longer in humid climates.

Above: SBCI's foldup solar cooker in action.
Photo by Kathleen Jarschke-Schultze

The Cooker uses one reflector that focuses sunlight through the window. This reflector folds down over the window and holds the heat until you are ready to eat. Inside is a 19" x 23" x 6.5" cooking area. The unit weighs eight pounds. It is a very attractive solar cooker.

The last half of the manual is instructions in English and Spanish, and diagrams on using the cooker. Cooking hints, times for various types of food, speed factors and safety tips are included. There is also a short part about how to teach others about solar cooking. The carrying case has instructions in English, Spanish, and pictures.

Solar Box Cookers International is a non-profit organization formed in 1987 to promote solar box cooking for health and environmental benefits worldwide. SBCI

provides educational materials and training on how to make, use, and teach others about solar box cookers.

**Performance**
The SBCI cooker performed well in the field, literally. I cooked a variety of foods, including chicken, rice, and muffins. The one reflector design does not reach the higher temperatures of the multi-reflector solar cooker but the food still gets cooked. I also used a variety of cookware; black pots, Visionware®, and black muffin tins. I was pleased that so many types of cookware fit easily into the cooker. I was able to cook several dishes at once.

**Conclusion**
I am very impressed with this kit. It is quick to assemble, looks really nice, works very well, and costs $50. It can be shipped easily. It stores and travels easily. The documentation is wonderful. It is the best one-reflector kit I have seen.

**Access**
Author: Kathleen Jarschke-Schultze continues to cook with the sun c/o Home Power, POB 130, Hornbrook, CA 96044

Maker: Solar Box Cookers International (SBCI), 1724 11th St., Sacramento, CA 95814 USA • 916-444-6616

Win a PV Panel! Enter Home Power's Build a Solar Cooker Contest! See HP #28, page 48, or call 916-475-3179 for details. Hurry, contest ends 1 July 1992.

Ecologic
camera-ready

# Solar Food Dryers

Larisa Welk and Lucien Holy

A request from a reader for an inexpensive solar food dryer spurred much response from our readers. Here are two types of solar food dryers we would like to share. One is for humid climates, two others for drier climates.

## Solar Food Dryer for Humid Climates

Larisa Welk

We dehydrate nearly all our food from our 1/4 acre garden except tomato sauce, salsa, pickles, sauerkraut, juices, and some fruit sauces. We also put spuds, roots, and squash in a root cellar. Who needs a freezer? Our pantry is crammed with organic, nourishing foods for our simple, a la Nearings cuisine.

For years I tried about every solar dryer design imaginable. The only common factor in all those attempts was their very limited usefulness here in the humid upper Midwest. None of them could reliably turn food into a non-moldy finished product. Some didn't work at all if not tracked periodically during the day. It was with this background that the "idea light" came on in my head.

**Cat on a Hot Tin Roof Theory**

One day I needed to dry a bunch of greens and the current solar dryer was full (a couple of handfuls was all it could handle). I had an old window screen lying around and a corrugated metal roof built over our old trailer-house. Using a ladder to get to the roof, I put the screen down first and put the food on it. I wanted to keep the sun off the food itself so I covered it with a piece of black cloth. Then, to keep everything from blowing away or being bothered by flies, I covered it with a storm window that I had on hand.

Later that afternoon I thought I'd see how it was doing. The greens in the "dryer" were still quite limp when I crawled up the ladder to take a look at the stuff on the roof. Much to my surprise, the roof-top greens were crispy dry! It looked as if I had finally stumbled on something that worked. I tried several other foods on the roof before I was convinced enough of the design to build a unit at ground level for easier access.

**The Basic Design Principles**

I found through experimenting that the primary ingredients for this dryer were: corrugated, galvanized metal roofing, screen, black porous cloth, glazing, and slope.

The sun shines through the clear glazing onto the black cloth, heating up the air space under the glazing. The corrugated metal provides air spaces under the screen for the warm, moisture laden air to move. The air moves passively upward along the slope, carrying away the moisture from under the trays of food. The galvanized metal also gets hot and reflects heat back onto the food. This combination really gets the job done.

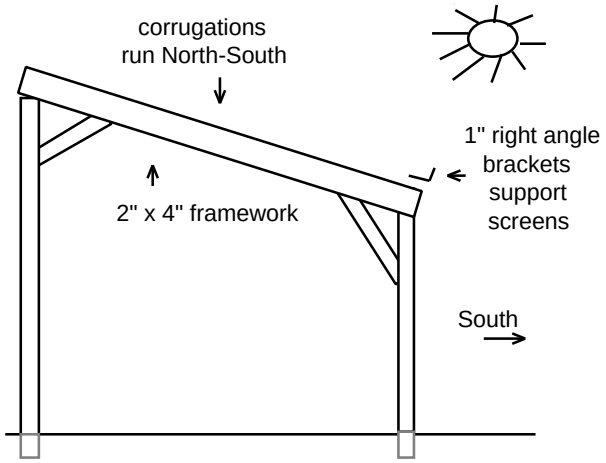
**The Deluxe Super Dryer**

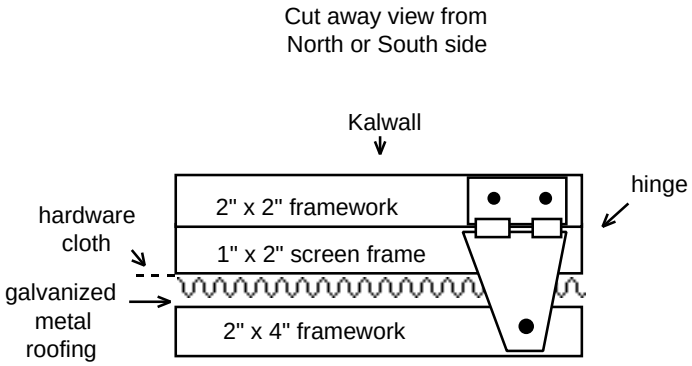
Using these basic principles, I built a 4 foot x 12 foot, waist high "shed" (I store extra wood under this roof). The 4 foot width enables me to reach easily from either side. You could make this wider if you wanted. The roof pitch is approximately 15 degrees. The legs are treated wood and stick into the ground about 6 – 8 inch. Next I built twelve 2 foot x 2 foot screens made from 1 inch x 2 inch pine and $^1/_4$ inch hardware cloth. This size of screen is easy to handle. They were 2 foot x 4 foot and I cut them in half.

The glazing is Kalwall® Sunlite® and is the most expensive part of the system (it holds up better than glass in hail storms and weighs less). My neighbor has since built a dryer and used acrylic glazing. It was much cheaper but time will tell which material lasts longer. The framework for the glazing is attached to the dryer with T-strap hinges on both the north and south sides. These were made into loose pin hinges so you can open the dryer from either side by pulling the pins and lifting the lid. A prop stick holds the lid open.

For cloth I've found polyester double knits resist fading better than natural fibers (at last, a worthwhile use for this stuff). Be sure to hem the edges so you won't end up with fuzz or fibers in your food.

I use fiberglass screen on the trays to keep the food from contacting the galvanized hardware cloth and also over the top of the food to keep it from sticking to the black cloth. I cut the screen double the size of each tray so it can be folded over the food. Stainless steel screen would be the best but I don't know of an economical source. If I used it I would still probably use hardware cloth




underneath for rigidity and because having removable screen facilitates pouring food into containers and makes cleanup easier.

**What It Can Do**

Even in Minnesota the sun can dry all of these foods easily: apples, green beans, peas, corn, cabbage, broccoli, cauliflower, peppers, kale or any greens, herbs, melon, fruit leathers, strawberries & other berries, plums, beets, onions, mushrooms, squash, eggplant, tomatoes, asparagus, celery, bananas, etc. The dryer can also be used to crisp bean pods for threshing, small grains before storing, and to dry corn before shelling and grinding. When using the dryer this way, I do not use the black cloth since I do not want these items to get too hot (I save seed from my beans and corn).

**Techniques**

When using a solar dryer, an accurate weather forecast to ensure proper timing is essential. Really wet foods (corn, melon, strawberries, etc.) will take at least two good days of full sun. The first day is the most critical. The food needs to get dry enough to coast through the night before finishing off the next day. Sometimes food will not be finished until the third day or longer, depending on the weather. If food is nearly dry, a raining spell will only postpone the process but the food won't spoil. Greens and herbs will be done in one day. My definition of "dry" is crispy for all vegetables, though fruits can remain somewhat pliable.

Foods need to be cut in uniform pieces for best drying. For example, you'll need to dry celery stalks separately from the leaves. Placement in the dryer is important also since the warm, moist air rises. Foods entering their second day in the dryer should be below freshly cut up foods. Herbs can always go lower where it is not quite as hot. Foods dry faster if stirred once or twice although this isn't absolutely necessary. Melons and other sticky foods should be peeled from the screens when partially dry and flipped before they become permanently bonded.

The only foods I steam blanch are sweet corn, peas, green beans, and asparagus. Because of the length of time it takes to pick and prepare the 18 to 24 dozen ears of corn we normally do in one batch, we pick it in the evening and steam blanch it immediately. I spread the ears out all over the kitchen counters to cool for the night. Early the next morning I cut the already somewhat shriveled kernels from the cobs and have it all out into the dryer before the sun starts it work. If I started in the morning with picking, it would take until about 1:00 pm for all the corn to be blanched, cut, and into the dryer – too late for corn in this humid climate.

Be sure to put away your dried goodies before the evening dew has remoistened them, but do allow the foods to cool off if you bring them in during the heat of the day. Store dried foods in airtight containers (a good use for all those extra canning jars you won't be needing) in a cool, dark place.

**Improvements**

In eight years of use, there are a couple of improvements I would make. I would build all the trays and glazing framework out of cedar instead of pine. Half of the original dryer has been rebuilt so far since the pine didn't hold up, even though the wood was painted with linseed oil.

Furthermore, I would make the slope of the unit adjustable so it would work better later into the fall when the sun is lower in the sky. Other than that, this dryer has been a real workhorse. Some of my neighbors use the dryer on my off days so it is often filled to capacity. With nearly 48 square feet of tray space, it can preserve enough food for a very large family or a group of smaller families.

# Solar Food Dryer for Hot Climates

Lucien Holy

Some older books on food dehydration recommend sulfiting even though it is now known to be very bad for asthma sufferers. Besides, another name for sodium bisulfite is "Sani-flush" toilet bowl cleaner! Yummy! Another treatment is sulphur dioxide created by burning sulphur. That is very polluting and breathing the fumes can damage your respiratory system. Treatment with ascorbic acid (Vitamin C), citrus juice, or nothing is more to my taste.

The problem with many solar food dryers is that they are often solar ovens with vents. One design even has reflectors. If it looks like an oven, then on a good day it will become an oven. A solar oven is compact, tightly sealed and reaches up to 300°F. Even simple box ovens go over 200°F. In contrast, the requirements for food dehydration are a constant change of air, roomy interior, and a temperature of under 120°F (the temperature at which nutrient loss begins) with little or no chance of reaching cooking temperature. After all, food drying is a long process, and you don't want to constantly monitor and adjust the unit to avoid ruining the food through excess heat. Direct sunlight on the food is undesirable as it tends to bleach out color and flavor, and dry unevenly.

**TAP**

The solar device that does these things is not a solar oven, but a Thermosyphon Air Panel (TAP), which is a vertical solar air heater. My final designs are based on a separate TAP collector and dryer box. A box is the ideal shape for the dryer section, and is easily modified. Oven-like designs result in cramped space, poor ventilation, uneven temperatures, and odd shelf arrangements.

Most old solar dryer plans require 50 or more hours of work, a shop, and money. Worse yet, they work well for someone, somewhere, but I have found that dehydrators must be designed for a particular conditions and uses.

You can quickly make a simple mockup with cardboard boxes and Saran Wrap® glazing (staple or tape on). Using a thermometer, you can quickly arrive at a new design that works under your conditions. You can, for example, enlarge your collector in a few minutes with a razor, tape, and cardboard. Cardboard solar ovens, popularized by Joseph Radabaugh's book "Heaven's Flame" proves the practicality of this technique.

**Collector**

I use a collector about twice the size of my dryer section. One advantage of using a separate TAP is that the area ratio can be anything you need.

**Insulation**

In a hot climate you don't need insulation because the temperature difference between the 110° – 120° inside air and the outside in the sun is very little. In a cool sunny area, insulation will improve performance. You can use corrugated cardboard or use a double box with the space filled with wadded newspaper. Since the insulation is on the outside you may also use hard foam.

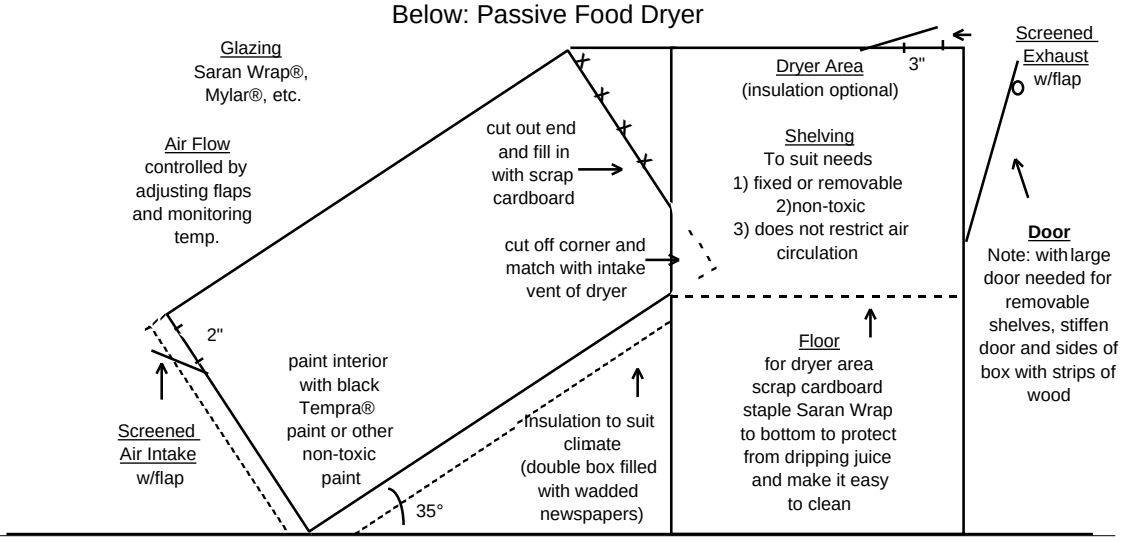
**Glazing**

I use Saran Wrap® glazing for my experiments because it costs 2¢ per sq. ft., is easy to apply, heat resistant, and food safe. Just tape or staple it to your collector. Oddly enough, it worked so well that it became my standard glazing, even for box ovens at 220°F! It is very thin and very clear and passes more light than the usual glass, Plexiglas®, Kalwall® and Sunlite®, etc. For oven use apply it with a loose fit because it shrinks when heated, Saran Wrap's® "cling" quality makes it unnecessary to tape the 11 1/2 inch wide sheets together, just overlap them one inch.

**Air Flow**

Moving air by the thermosyphon method requires a vertical layout. If you want a really large collector, like 4

Below: Passive Food Dryer



foot x 8 foot, then it can get rather awkward. If I were to go to a really large unit I would use a horizontal collector with positive air flow provided by a solar-powered fan. These are available in several sizes and are not expensive. Solar vents are perfect because they produce airflow in direct proportion to sunlight. I have built a small unit of that type because, stored vertically, it only takes up 1 sq. ft. of area in my apartment

**Tape**
The best tape for solar use is aluminum duct tape like Reflectex®. By the way, this tape makes quick, easy, durable reflectors. Just apply rows to the backing until it is covered.

**Shelving**
I'll leave the shelves up to you, to suit your needs. If you use the usual aluminum screen, then you don't need a frame for most sizes. Do not use lemon juice on your food to be dried if you use aluminum screens. Use non-toxic materials, wood dowels or strips, netting or cheese cloth, etc. Remember, it must allow air flow.

**Passive Food Dryer**
This passive design uses two L=23 inch W=13 inch D=10.5 inch cardboard boxes with dryer dimensions of L=13 inches W=10.5 inches D=10 inches. The one disadvantage of corrugated cardboard construction is that it deteriorates when exposed to the elements, especially moisture. I brush on 50/50 polyurethane varnish and thinner. This not only water proofs and preserves the cardboard, but saturates it, bonding the fibers together for a very durable material. Cure well in the sun before using.

**Active Solar Food Dryer**
This unit is based on a gadget from "Northern Hydraulics" catalog. A solar powered fan with built-in solar cells for $9.99. It's too feeble for its claimed purpose (but that is what makes it so cheap!). It is just right to provide a steady, gentle air flow in a small food dehydrator. This style lends itself to very large units.

**Access**
Larisa Welk & Bob Dahse, RR3 Box 163-A, Winona, MN 55987

Lucien Holy, 8015 Spencer Hwy. Apt. #58, Deer Park, TX 77536

Northern Hydraulics, POB 1219, Burnsville, MN 55337-0219

**Reader Response**
*We would like to thank all the wonderful readers who sent in information on different solar food dryer designs. It was hard to choose which ones to publish. There is definitely interest in this subject! Kathleen Jarschke- Schultze.*

**List of Books on food drying:**
*Dry It, You'll Like It* by Gen MacManiman, Fall City, WA 98024

*How to Dry Foods* by Deanna DeLong, HP Books, POB 5367, Tucson AZ 85703 • 602-888-2150

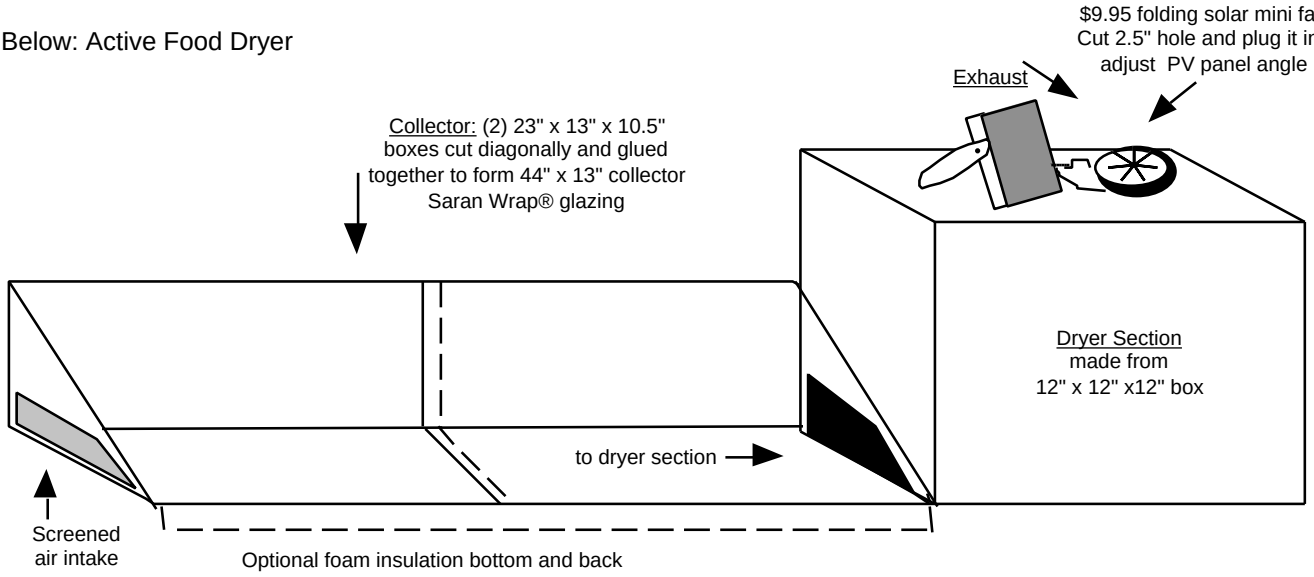
*Understanding Solar Food Dryers* by Roger G. Gregoire, P. E., VITA, 1600 Wilson Blvd., Ste. 500, Arlington, VA 22209 • 703-276-1800

*Food Drying at Home* by Bee Beyer, JP Tarcher, Inc., 9110 Sunset Blvd, Los Angeles, CA 90069

*Solar Drying: Practical Methods of Food Preservation* International Labour Office, CH-1211 Geneva 22, Switzerland

*Solar Food Dryer* by Ray Wolf, Rodale Plans, Rodale

Below: Active Food Dryer



Press, 33 East Minor St., Emmaus, PA 18049

*A Handbook for Solar Food Drying* State Energy Office; 335 Merchant St., Ste 110. Honolulu, HI 96813 • 808-548-4080

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# Things that Work! PC-Solar

**Things that Work!**
tested by Home Power

Reviewed by Dan Lepinski

Computer programs to make better use of solar energy in buildings are beginning to make their appearance. Some require that you have a PhD to interpret the results. PC-Solar is a pleasant exception.

**The Program**
PC-Solar is a computer program that's intended for use by architects, designers, engineers, contractors, and builders. It has but one purpose: to assist with the design of windows and shade overhangs. PC-Solar will run only on IBM compatible computers. It requires at least 640K of RAM, DOS 3.0 or higher, and a VGA monitor. A hard disk is mandatory as PC-Solar, stored in a "compressed" form, expands out to nearly 1.5 MB when installed. A Hewlett-Packard (or compatible) laser printer or 9 pin dot matrix printer will provide printed copies. The manual doesn't state the minimum processor required, but based on my experience, the bigger and faster the better.

**Getting Started**
You don't have to be a computer genius to use PC-Solar. The instruction manual is well written and guides the first-time user through the simple automatic installation procedure. Both 5.25 inch 360K disks and a 3.5 inch 720K disk are included in the program package.

To me, a well written program means I don't have to wear out the manual and telephone trying to learn how to use it. PC-Solar succeeds on both counts. Although I am not an architect, I was able to run PC-Solar immediately.

**The Instruction Manual**
PC-Solar is provided with a concise and clearly illustrated 22 page manual. Terminology is often explained with examples that help to visually explain some of the complexities in something as deceptively simple as windows and overhangs. Numerous references to other sources of information are also included.

**Performance**
I did not note any defects or incorrect answers. In fact, PC-Solar kept me from accidentally entering some incorrect values. At no time did the program freeze or crash my computer. The manual does warn that some invalid data can be entered that will result in some bizarre results. It is up to the user to make sure the information you enter is accurate. Mistakes are easily corrected by editing on the screen. I tried the example in the manual and understood the results without difficulty. A real life example of our planned solar home also worked well.

I particularly enjoyed the "animation" feature included in PC-Solar. It creates several window models on the screen showing the effects of different seasons and times of day on the sun angle and shading. It takes a little time for the computer to set up the animation, but the results are worth the wait. This is a really neat feature.

PC-Solar calculates angles and displays shading for all sites in the contiguous 48 states. An internal list of more than 30,000 U.S. cities and 45,000 ZIP codes makes calculating latitude and angle information a snap. PC-Solar can also calculate solar angles, and display or print solar collector incidence charts to help orient solar collectors to the optimum angle for energy collection.

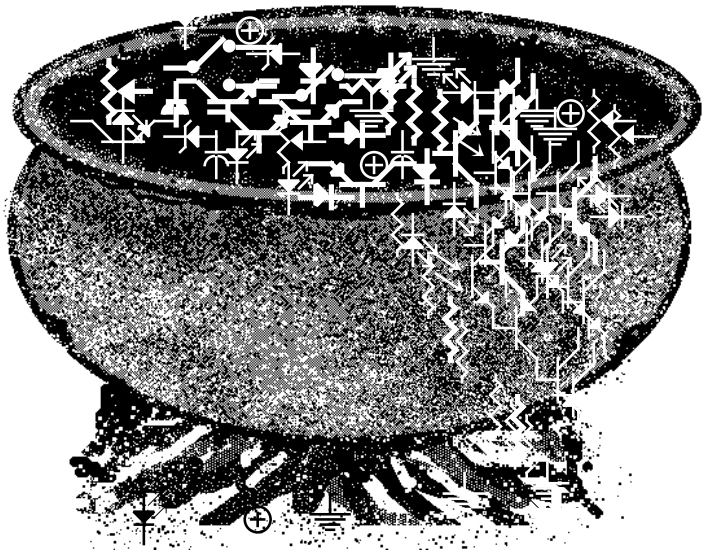
**Cost**
PC-Solar is $45 a copy within the United States or $55 elsewhere. Site licenses for only $15 per additional computer are also available. Group purchases in quantities of 10 or more are offered for $27 per person. Considering the obvious work that went into the software, this is very reasonable. PC-Solar carries a 30 day money back guarantee. This says a lot for the authors and their confidence in the program. In addition, free updates are offered if any formulas are found to be in error.

PC-Solar can be a useful tool to anyone designing windows, shades, and overhangs. It is a quality software package that should be found in the office of any solar-minded designer, architect, engineer, or builder.

**Access**
Author: Dan Lepinski, 5905 NE 111th Street, Vancouver, WA 98686 • 206-573-6596

PC-SOLAR, 3-D Software, Carlos Portela, POB 1373, Poway, CA 92074 • 602-795-0284

Homebrew



# How To Run A 4.5 Volt Radio Off A 12 Volt Battery

## (A Beginner's One Piece DC Power Supply)

Joel Chinkes



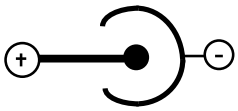
*DISCLAIMER: This is designed for the complete beginner, but not for the complete klutz. It is possible to hurt yourself and/or damage your property if you are not careful. If you try this stunt at home, be prepared to take responsibility for your own actions.*

Need to run a 4.5 Volt (or 9 Volt) radio off a 12 or 24 Volt battery? Ever wish for a circuit diagram with only one piece in it? Try this! It's as uncomplicated as one bean salad: "Open can; eat."

I now run my 4.5 Volt shortwave radio directly from my 12 Volt photovoltaic battery system. Maybe you have a similar problem (opportunity?) with an appliance that runs on batteries or DC wall-cube adapter. This method will not work if your appliance uses low voltage ac. If your wall cube adapter says 120 volts ac input, OK, but if it says any number of ac volts output, this solution is not for you.

**Lose Your Wall Cube**

A wall cube is a plastic box with a small transformer in it, meant to be plugged into an ac outlet. Its DC output is usually delivered through a wire with a barrel connector on the end. The barrel slips into a little hole on the side of the appliance. The barrel connector makes contact with both the inside (pin) and the outside (wall) of the hole, for plus and minus.




My radio's cube eats normal 120 volts ac house current, and creates 4.5 Volts DC. On solar, it seems a little silly to run an inverter to boost 12 Volts DC to 120 volts ac, and then transform back to 4.5 Volts DC. The conversion from DC to ac to DC wastes energy. The second-hand DC has ac ripples and noise in it. Also my inverter has a radio frequency howl that interferes with shortwave reception.

Next to the power supply hole is a symbol molded into the plastic. Your symbol probably looks like the one above, except that plus and minus might be reversed — so watch out! Alas, there is no industry standard on polarity on these plugs.

My radio also runs on 3 "D" cells, nominally rated at 1.5 Volts each (3 times 1.5 Volts = 4.5 Volts). Battery powered circuitry cannot be picky about input voltage. New batteries start out peppy, but their voltage gradually fades. The radio must be designed to run on a wide range of voltages, to accommodate the waning batteries. A new battery might measure 1.65 Volts. So you don't have to be fussy when building your homebrew DC to DC adapter.

**Home-Brew**

My own high-current adapter uses an off-the-shelf voltage regulator. A voltage regulator is installed at the tail end of a power supply. The power supply industry routinely takes 120 volt ac grid power and creates low-voltage DC output to run computers, TV's, anything with microchips. They guarantee that power supply circuits produce the rated voltage regardless of (moderate) variations in input voltage or output current load.

Voltage regulators always need a higher voltage input than they show at the output. They cannot be used to "step up" a DC voltage. To pick the right voltage regulator for the job, I went up to an electronics parts store. The professional electronics store has a comprehensive catalog of parts called the "ECG® Semiconductors Master Replacement Guide." It turns out that semiconductors are cheap as sand, which is what they are made from in the first place.

Regulators come in two flavors, fixed and adjustable. With adjustable ones you have to build a circuit around them to adjust the voltage. I wanted to simulate a few "D" cells of approximate voltage, so I just picked the closest available fixed voltage regulator. This is called "engineering".

**Use What Works**

Look in the ECG® Catalog under Linear IC (Integrated Circuit) for the Voltage Regulator Selector Guide. You will find a variety of useful output voltages to match any need, and the input voltages they will run on.

In my case I chose the ECG309K. Rated at 1.5 Amps, 20 Watts, it eats DC voltages between 7.5 VDC to 35 VDC, and puts out exactly 5 volts DC. It cost me $4.50, but I saw one in a mail-order catalog priced at $1.39 + post. It has two leads, input and output. Its metal case serves as negative ground. The LM309K is an equivalent part made by another company. If you want to run a 9 Volt appliance, you can use the LM7808 or the ECG964.

Why pick a 5 Volt regulator, when my radio needed 4.5 volts? I guessed that my radio was designed to operate on anything from 3.5 to 5 volts DC with no problem, because it is also battery powered. It has worked well in the four years since I built the circuit.

The ECG® Catalog assumes that you are building a power supply to convert ac to DC. Since your battery powered input is smooth DC to begin with, you can safely ignore all their unnecessary filtering advice.

**Sink The Heat**

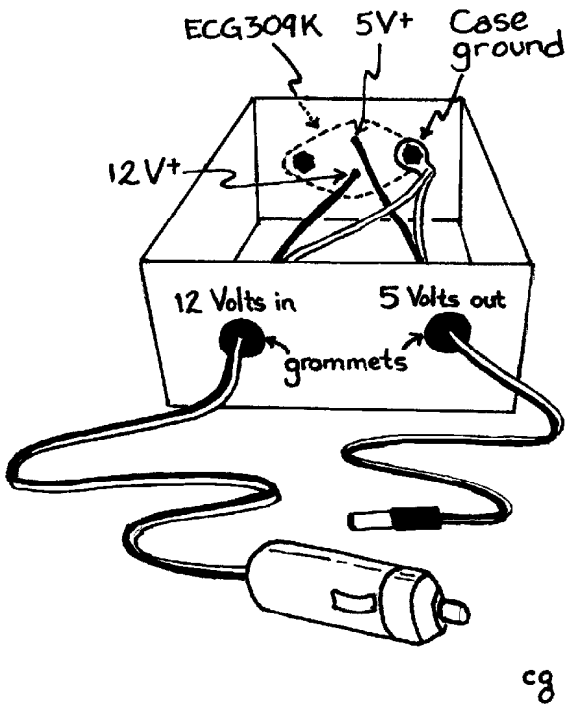
To see an electric circuit designed to run red-hot, take a peek inside your toaster. You do not want your voltage regulator to glow. The regulator will get warm, making it a "source" of heat. That heat needs a "sink", to keep it from melting. Engineers use the word "sink" to mean "place where stuff disappears or gets used up." The opposite word is "source" which is where stuff comes from. You can describe most of the known universe in terms of sinks and sources. You must have a heat sink to get the full rated wattage out of a voltage regulator.

If you use a regulator with twice or ten times the needed power rating, it will not break a sweat. Just install your regulator and the shiny metal box you bolt it onto will allow what little warmth there is to radiate safely away. If you cut it close on the amperage or wattage of your regulator, you might need more of a heat sink.

How hot is hot? Test your heat sink by holding your finger on the voltage regulator with your circuit operating. If it's painfully hot, either use a bigger heat sink or select a regulator with a higher amperage rating.

**Final Assembly**

Bolt your regulator to your metal box with star washers, which dig into the metal box. Attach a solder lug (a washer-like thing you can solder to) to the bolt. Solder the ground wires from the 12 V and 5 V cords to the solder lug (see HP #18, page 35 "How to Solder — The Basics"). The metal box, the metal case of the regulator, and two of your four wires must all make good contact. Use rubber grommets to keep the input wires from chafing in the side holes.




**Avoid SPD**

Twelve Volts, or whatever, goes in one pin of the regulator, and five Volts, or whatever, comes off the other pin. In the "positive TO-3 case style" for the ECG309K, the shell of the regulator is common ground, and the two pins of the regulator are +12 and +5 Volts. The catalog description of each regulator will tell you which pins to use. Be sure to look these up for the regulator you use. You will experience SPD (Sudden Parts Death) if you are sloppy.

Use a large enough metal box, so the wires inside will be well separated. The larger your box, the cooler the regulator will run. You can use lamp cord for your input and output leads. Make sure to put a fuse in your positive input lead, and be careful not to mix up plus and minus when attaching your connector plugs. A mistake here will also cause SPD. Solder a barrel plug to the output end, watching out for polarity. When done, take a voltmeter and measure the voltage and polarity you are about to feed to your appliance.

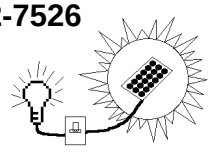
You could add an on-off switch and pilot light, on the input and output side. You could add panel voltmeters and ammeters to track results, or tail fins too, but be sure to call them "heat sinks".

**Parts List:**
- Voltage Regulator, sized to fit your application
- Voltage regulator mounting kit (optional if you are handy with a drill)
- Input power connector (male cigarette lighter plug)
- Output power connector (probably male barrel plug)
- Shiny metal box (also acts as heat sink)
- Rubber grommets to protect wire entry to box
- Wire, nuts, bolts, solder and a fuse

**Access**:
Author: Joel Chinkes, c/o Home Power, POB 130, Hornbrook, CA 96044 The author has been living "off the grid" since Feb. 1987. He knows all the words to "Ramblin' Reck From Georgia Tech" and is a Life Member of Mensa.

Maker: Phillips ECG Inc., 1025 Westminster Dr., POB 3277, Williamsport, PA 17701 • 800-233-8767





# Terms of Empowerment

Therese Peffer



A person new to home power encounters a lot of new terminology. There are terms for electricity, then labels and numbers on wires, and then equations for energy and power. Understanding these is vital for understanding home power. Here is a start!

**Electrons**: negatively charged particles that revolve around a positively charged nucleus to compose a neutral atom. Atoms are basic building blocks of all substances.

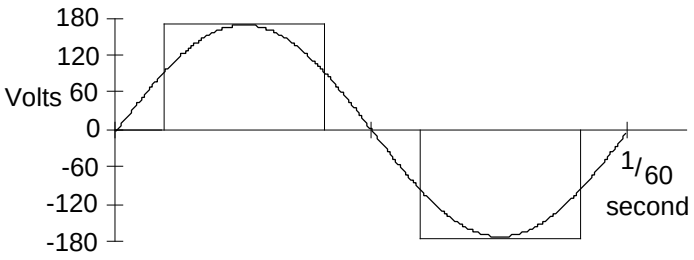
**Electrical current**: The flow of charged particles. The number of electrons that pass by a point per unit of time. The common symbol for current is I. Current is measured in Amperes (A); one ampere equals one coulomb of charge, or 6.25 x $10^{18}$ electrons, per second.

**Direct Current (DC)**: Current flows in one direction in a wire. Photovoltaic modules deliver DC current; batteries store and deliver DC current.

**alternating current (ac)**: Current changes direction. First it flows in one direction, then the other to make up one cycle. In the U.S., ac current has 60 cycles per second. Alternating current is what the utility, ac generators, and inverters deliver. A utility circuit rated at 120 volts root mean square (rms) ac varies between +170 volts and -170 volts. An appliance drawing 10 amperes rms has a current that varies between +14.14 and -14.14 amps rms.

**Resistance**: The quality of a material that opposes electron flow. Metals, especially copper, and ionized liquids such as battery electrolyte conduct electricity well and have low resistance. Wood, rubber, and plastic do not allow electrons to flow easily, have high resistance, and are insulators. Resistance is measured in Ohms (Ω). The cross sectional area of material affects its resistance. As a large pipe carries more water, a large wire has high ampacity (ampere capacity), and less resistance.

**Voltage**: The "pressure" or electrical potential difference between two points that causes the electrons to move. The common symbol for voltage is E; voltage is also known as the electromotive force. A larger voltage causes more electrons to flow for a given resistance than a small voltage. Voltage is measured in volts (v).




Alternating current forms a sine wave (thick line). Most inverters produced a modified sine wave (thin line).

**Wiring snippet**

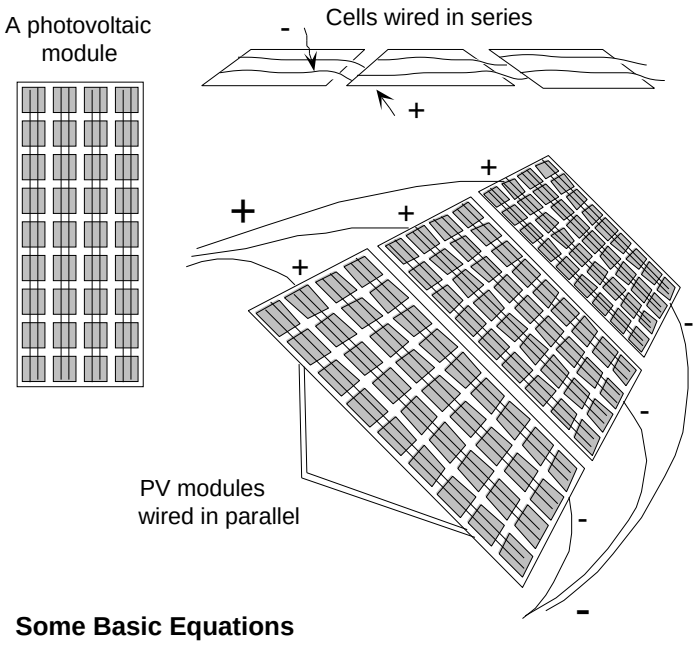
Wires are standardized in size using the American Wire Gauge (AWG). 4/0 AWG wire (meaning 0000, and pronounced "four aught") is as big around as your thumb. Number 8 is slightly thinner than a pencil. Wires are made of low resistance materials such as copper or aluminum. The wire or cable can have a single strand or many fine strands like welding cable. Our batteries were wired in parallel using #00 (2/0 or double aught) wire, but it would have been much easier to bend had we used #00 welding cable. Wires can be bare or covered with insulation. USE (Underground Service Entrance) wire is insulated and can be buried. It is also UV resistant and withstands the sun's ultraviolet rays.

**All together now!**

The sun shines on the cells in a photovoltaic panel. The cells are wired in series – the negative side of one cell has a wire connected to the positive side of the next cell and so on. The voltage of the cells is summed just like two 1.5 Volt flashlight batteries connect in series to make 3 Volts. On a sunny day a PV module produces about 3 Amperes of Direct Current at 15 Volts.

Our PV modules are wired in parallel with #10 AWG USE wire – the positive leads are connected, and the negative leads are wired together. The current is summed up over the modules in parallel, but the voltage remains the same, much like batteries may be connected in parallel to increase the capacity (measured in Ampere-hours).

Wire running 125 feet from the PV modules to the house is 1/0 (aught gauge). Since this is not USE, we place it in conduit (plastic pipes). To reduce the amount of magnetic interference we wrapped the two wires (carrying current to and fro) around each other to make a twisted pair. The wire is connected to a charge controller which determines the voltage of the battery. When the batteries are full, the regulator prevents any more electricity from travelling to the battery and thus protects them from overcharging. The DC electricity is converted to 120 volts ac through an inverter.




**Some Basic Equations**

***Ohm's Law: I x R = E.*** Current times Resistance equals Voltage. Ohm's law is good for measuring the loss in voltage over the length of a wire. Look up the resistance of a wire per foot in wire tables, and multiply by the current that you plan to run through the wire. Another use is measuring a current with a shunt. A shunt has a determined resistance. We have a 500 Ampere, 50 milliVolt shunt in line with our amp-hour meter. The resistance is 0.05 Volts / 500 Amperes = 0.0001 Ω. Since we know the resistance, when we measure voltage across the shunt, we can find the amperes of current.

***Power: I x E = P.*** Current times Voltage equals Power. For Direct Current, multiply the number of Amperes by the amount of Volts to get Watts, the term of electrical power. For the PV module, 3 Amps x 15 Volts = 45 Watts. Power produced or used over a certain time is Energy, expressed in Watt-hours. For example, a 50 watt stereo playing for 4 hours draws 200 watt-hours of energy.

**Trying to clear up the confusion**

In HP #27, I mentioned a discrepancy with my compact fluorescent light. The 18 watt bulb draws 0.26 amps, but I calculated 0.26 amps x 117 volts = 30.4 watts! A few readers wrote to remark that I had neglected the power factor. What is a power factor?

Power is figured differently for ac circuits. Both the current and the voltage of alternating current change direction constantly. For resistive loads, the current and voltage are in phase – they follow the same rhythm and reach their peaks and valleys at the same time. Resistive loads resist the movement of the electrons. The energy dissipates as heat and is used to an advantage in incandescent lights, electric heaters, and toaster ovens. Some loads that are not completely resistive such as compact fluorescent lights cause the current and voltage rhythms to be out of phase – they no longer rise and fall together.

When I multiplied ac volts x amperes, I had calculated apparent power, measured in voltamperes. The equation for true power is $P = I \times E \times \cos\theta$, where $\theta$ is the phase angle between current and voltage, and I and E are rms values. $\cos\theta$ is called the power factor, and equals the ratio of true power (watts) to apparent power (voltamperes). (For a resistive load, $\theta$ is zero, and $\cos 0$ equals 1.) For my fluorescent light, the power factor equals 18 watts/30.4 voltamperes = 0.6.

Appliances which have a power factor less than one require that more power (apparent power) be available from either the utility or the inverter. To power my light, the inverter drew 15.18 VDC x 1.8 Amps = 27.32 Watts from the battery. The inverter required 27 Watts to light the lamp, but the lamp only consumed 18 watts. The discrepancy between 27 and 18 watts is the inverter's inefficiency made worse by the low power factor! The 18 watts on the name plate assume use on the utility grid, not use in a system that makes its own power.

**The bottom line**

Both the utility and the home power system would like to see a power factor of 1. If you're connected to the utility grid, the meter measures the true power, and the utility pays the difference due to a low power factor. If you produce your own ac power, you care about the power factor of your appliances. The name plate wattage will be less than your inverter requires. One solution is to buy fluorescent lights with a high power factor (0.9).

Just the very basics were covered here. More can be found in a high school or college physics book, and it helps to put your system together!

**Access**

Author: Therese Peffer, c/o Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179

# Kids Corner

Dear Home Power ,
I am 10 years old and am writing on a computer run by solar power. We live in the country on 120 acres all run by solar energy. I really like the idea of solar power and encourage people to use it . If we all used solar power the environment would be a whole lot better . So let's make it a goal to use solar power and help save the environment.

Love
Cerrithwen Genetti
Stewart Pt, CA

Cerrithwen Genett,

Dear Home Power. Penalosa 1G
My name is Aero sallee. I am 9 years old. My famliy powers our home completely with solar and wind power.
I have one m 51 arco solar panel, which is hooked to two sets of nicad Batteries 24 amp hours a set which are 48 amp hours. They are hooked to one light, a very small tv in our Room, and one light in my Sister LaDae's Room. we are Building a solar oven in home-School. In my Room I have a lot of little motors and wires and Stuffs, that I like to play with. I want to Build a little Solar powered car.

Aero Sallee

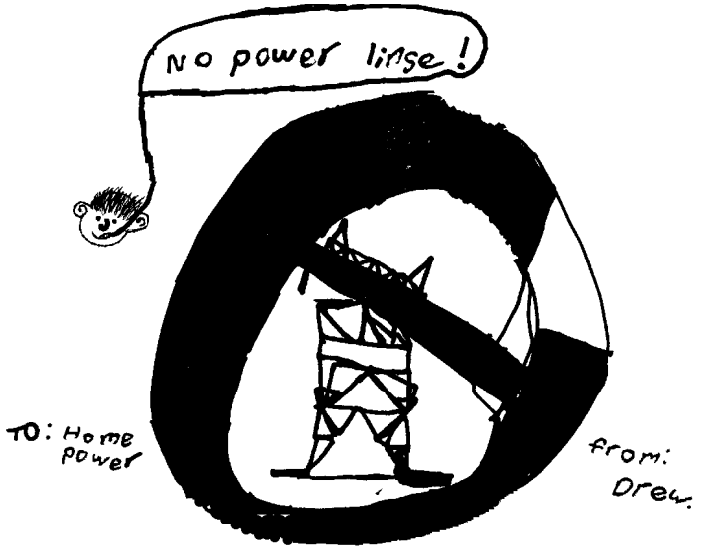
P. S. I have helped my Dad carve several wind charger props.

Reduce Purchases

If you got a car that is not good, start to repair it. Then get what it needs. Then start it and use the old instead of buying the new one. Solid waste is a problem to the world you can solve it by recycling, reusing, and Reduce Purchases.

by: Joseph Fabian Zodarte

*We welcome pictures and writings from kids of all ages. Thanks, Aero, Cerrithwen, Drew, and the Fourth Graders from Penasco, New Mexico! –Therese & the HP Crew*




## Solid Waste

Solid waste is a big problem through out the world. To prevent this you can start by recycling News papers, cans, and bottles. Recycle means that you can make something again.

Reuse means that you use something again and again. Reuse paper! If you do, you are trying to save the earth from solid waste dumps and trees being cut down. Then the earth can last for many years.

Raymond Lopez

You do not have to go to the store to buy packaged corn or food like that. You can grow them in your garden. You can plant a lot of grain, vegtables, & fruit.

You might have to go to the store to buy the seeds but other wise you dont have to go and use up all that plastic and cordboard for packaging. Solid waste is a global problem and a big waste.

Christine Montoya

Some people reuse paper and glass bottles. people use glass bottles for jam, Caning food and for vases. People use paper for making projects. It is better to reuse than to have many machines use a lot of energy.

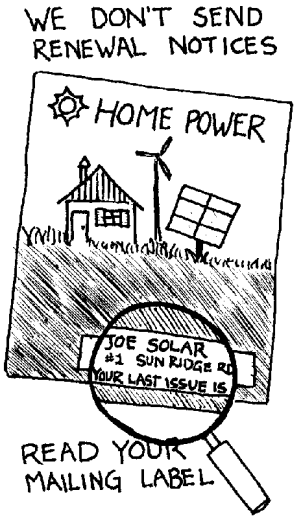
Reuse your purchases. If you have shoes faded put shoe shine on your shoes. If your Clothes are faded dye them. Every person must have at least one old car don't buy a new one. Fix it. More people should reuse their purchases and stop solid waste from growing.

Nicole Romero

Sunnyside Solar
camera-ready

Atlantic Solar
Products
camera-ready

C. Crane & Co.
camera-ready

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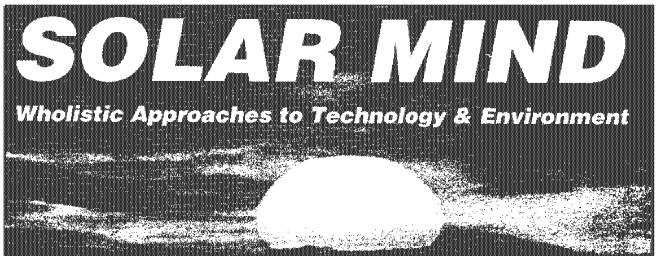


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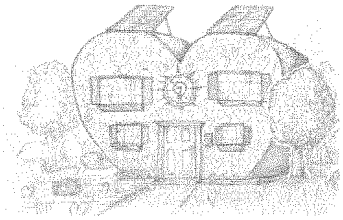
# Home & Heart



Kathleen Jarschke-Schultze

I was holding off writing this column until we returned from our first energy fair of the season. I didn't realize how exciting it would be.

**REEF '92 Rollin' and Rockin'**
The HP crew had traveled to Northern California's Lost Coast region to attend REEF, the 1992 Renewable Energy & Efficiency Fair in Arcata. We spent the eve of the fair with our good friend, Michael Welch, of the Redwood Alliance. His Great Dane, Denali, welcomed us graciously with many sniffs and presented herself for rigorous petting from the crew. Denali is the largest dog I have ever seen, but quite the gentle giant.

The next morning we set up our booths at the fair site, Redwood Community Park. The park provided a solar exposed meadow surrounded by beautiful, towering redwoods. As we set up we greeted many fellow participants we know and see throughout the season at other energy fairs: Dave Katz from AEE, Larry Schussler from Sun Frost, Bob Maynard of Energy Outfitters, Greg Williams from Six Rivers Solar, CCAT of HSU, and of course Bob-O was there representing Electron Connection. It's so good to feel the familiarity and comradery of RE advocates.

**A Fair Start**
Amid the staccato beat of hammers the solar stage grew and spread its wings of PVs into the sun. Redwood Alliance provided the panels and inverters while AEE brought the batteries and sine wave filter. Soon the sun powered microphones carried the soft singing of a women's a cappella group throughout the park.

Free shuttle buses, used to conserve fuel and parking, brought the fairgoers up into the Arcata hills and to the fair. REEF opened at 10:00 am, the earthquake struck at 11:06 am.

**Quake and Shake**
I'm a Californian. I know what an earthquake feels like. There is nothing like it. I was talking to two women at the booth. The ground jerked and started rolling. The two women put their arms out for balance, then decided sitting on the ground was the best place to be. I lifted my eyes to the magnificent redwood trees that surrounded the park. They lurched and swayed with the rolling of the ground. My first thought was, "Please don't let the trees fall on the fair." My second thought was that Bob-O and I were the only EMTs at the park that I was aware of.

The quaking stopped. People shook their heads then continued the conversations that had been interrupted. The music from the solar powered stage played on. As the day progressed we heard quake reports from newly arrived people. One woman had been working on her computer on the campus of Humboldt State University nearby when the quake hit and grid power shut down. Altogether 23,000 Pacific Gas & Electric customers lost their power. Many gas line leaks had to be repaired, some caused fires.

The epicenter was 40 miles south of us. Most of the damage was in the towns of Petrolia and Ferndale. Witnesses said power lines flapped into each other and shorted. Eighteen to twenty houses were shaken off their foundations. Many windows shattered. More than 95 people were hurt. No one was killed.

Unaware of the extent of the damage further south REEF proceeded through the day till 7:00 pm. Over 2,000 people attended, gathering RE information, participating in a variety of workshops, buying RE products and seeing solar power in action, even after a major earthquake.

**That Evening**
After breaking down the booths, loading up, and helping clean the park grounds, the crew headed off to the Humboldt Brewery for dinner.

Dinner was an epicure's dream. We started off with pitchers of the Brewery's own Red Nectar Ale and an appetizer of prawns, marinated in red nectar served in a sauce of chilies, garlic and a hint of an elusive spice. After repeated tastings, Bob-O identified the spice – anise. The crew's dinner choices included ribs, ravioli stuffed with cheese and crab and Albacore Salad. All were superb, a special treat after a long day.

**That Night**
Back to Michael's where we had dossed out in the loft of his cabin, dormitory style. We got to sleep around midnight. We woke up around 1:00 am to that now familiar rolling sensation. The house shook but nothing came loose. It was a while before we could sleep again.

At 4:20 am the rolling started again, punctuated by jerks this time. We were all instantly awake. We were quiet as the rolling continued for long moments. As the quaking quieted we all started talking. We all agreed the last

shock seemed stronger than the second and tried to guess the Richter rating. Karen and I looked out the loft window towards town and could see many small flashes like lightning, which we guessed to be transformers blowing. It took even longer to get to sleep after that.

**The Morning**
We took a quick trip to see Larry and his crew at Sun Frost in the morning. After a Sunday brunch of larger quantities of excellent Mexican food at ¡Hey Juan! Burritos in Arcata, we headed out through the mountains back to Home Power Galactic Central.

**Shed Some Light**
Pat Walker of LotsaWatts Solar has found the Lights of America instant on fluorescent and light diffuser at the Price Club store in her area.

**Wet Dryer**
I have built an active solar food dryer as per Lucian Holy's plans. I made mine larger, as I have a large garden. So far, the weather has not cooperated. I welcome the rain though, and will report on my testing in a future issue.

**Access**
Author: Kathleen Jarschke-Schultze just paid up her earthquake insurance and can be reached c/o Home Power Magazine, POB 130, Hornbrook, CA 96044 • 916-475-3401

Pat Walker, LotsaWatts Solar, POB 167, Big Bend, CA 96011• 916-337-6687


## Finding and Buying Your Place in the Country

by Les Scher

Reviewed by Dan Lepinski

There is a quiet revolution. Urban dwellers tiring of city headaches and hassles are heading back to the country in ever growing numbers. For those of you participating in the rural revolution, this book should be your real estate shopping Bible.

Since the author is a real estate attorney, I anticipated much legal mumbo-jumbo throughout. Instead, I discovered an exceptionally thorough and highly organized book written in plain English. Mr. Scher brings the complex issues of finding and purchasing rural homes and land right to the level of the non-attorney -- but he doesn't talk down to you in the process.

You are guided every step of the way. The book opens on the subject of "Looking for Land" and concludes with an extensive checklist useful for evaluating a prospective piece of property before you purchase. It covers easements, property surveys, water rights, climate, and a wealth of other topics vital to the rural real estate customer. In our own search for land, I have found the book to be an invaluable source of information.

While most real estate transactions favor the seller, Mr. Scher has produced an exceptionally strong tool for the buyer. Of note are the sample contracts included in the book. All too often, we hear of a real estate deal that went sour after the buyer took possession. By following the Mr. Scher's guidelines, the buyer should be able to avoid or resolve the legal issues before the purchase is finalized.

The author has included over 100 illustrations which visually simplify otherwise verbally complicated material. The concept of a picture being worth 1,000 words certainly applies here. In addition, there is a comprehensive section of reference materials listing sources on land, alternative energy information, federal and state government information offices, and a host of other resource centers too numerous to cover.

Mr. Scher has recently revised his book for a third time. This new revision is scheduled to be available from the publisher (Dearborn Press) in mid-May of this year.

My own conclusions? Simple! I wouldn't go skydiving without a parachute. I won't sit on the middle of a lake in a thunderstorm. And I certainly wouldn't consider purchasing rural land or real estate without the aid of this book. This book is a fantastic tool for the rural shopper. It really belongs under the heading of "Great Books".

If you're considering the purchase of a rural home or land, "Finding and Buying Your Place in the Country" could well be the best investment you could make.

**Access**

*Finding and Buying Your Place in the Country* by Les Scher (ISBN # 0-02-008400-5) is available from your nearest bookstore for $25.00. Revision three is published by Dearborn Press.

Book Author: Les Scher, Attorney at Law, P.O. Box 780, Garberville, CA 95440 • 707-923-2128

Book Review by Dan Lepinski, 5905 NE 111th Street, Vancouver, WA 98686

Todd Forbes
camera-ready

# HAPPENINGS

**NATIONAL**

**Home Power Indigenous Materials Solar Cooker Contest** We challenge you to invent, build and test a solar cooker using materials, skills, and tools available in any developing nation of your choice. Simplicity and buildability are in — high tech is out! Send us your design by July 1, 1992. The top final designs will be built by the Home Power crew for the Solar Cookoff at SEER '92. 1st prize: a Solarex MSX60 PV module, 2nd prize: a Powerstar 200 inverter, 3rd, 4th, 5th prizes: an Osram compact fluorescent or a Kyocera Jetski PV module. See the April / May (HP #28) issue for more details.

**Sun Day 1992 –** Public Citizen and nearly 200 citizen groups (including Midwest RE Assoc., Great Lakes RE Assoc., Redwood Alliance, & just about every RE Assoc. and environmental group you can think of), businesses (including Jordon College, Snowbelt Solar, Lake MI Wind & Sun, Integral Energy, Solsource & Home Power), government officials and others announced plans to sponsor SUN DAY 1992: A Campaign for a Sustainable Energy Future. SUN DAY advocates a national energy policy that, at a minimum, reduces the total energy use by 10 percent and triples the current contribution of renewable energy (RE) technologies by the year 2010. SUN DAY sponsored Earth Day renewable energy events throughout the U.S. on April 22, 1992. The focus of SUN DAY 1992's sponsors will be developing local and state-level coalitions to advocate for policies supportive of SUN DAY 1992's goals. Participating organizations will provide information, encourage model programs, lobby for RE friendly legislation, hold conferences, and distribute information to schools, and colleges. For more info and to find out how you can help contact: Public Citizen, attn. SUN DAY 1992, 215 Pennsylvania Ave SE, Washington, DC 20003 • 202-546-4996

**The Union of Concerned Scientists (UCS)** has announced a year-long campaign to change the public perception of solar power, wind power, and other renewable energy sources. UCS will help interested people to plan and carry out educational activities and political actions that promote greater use of renewable energy. Although the public likes the idea of using renewable energy most people, including industry leaders, utility planners, and government officials, think of renewables as futuristic, backyard novelties. In actuality, RE technologies could provide a much greater share of the nation's energy supply. However, current energy policies have prevented renewables from penetrating energy markets in a significant way.

The first step in changing the policies is to help people understand the tremendous potential of RE technologies. Public education will be a major focus of the "Renewables are Ready" campaign. UCS activists will also focus attention on policy-makers and work on changing the regulatory climate to encourage the growth of renewables. A set of eight posters is available covering solar architecture, electricity from renewables, and alternative-fuel vehicles. They're nice for setting a RE tone at schools and local education events. All 8 posters sell for $14 plus 20% shipping. For more information, contact the Union of Concerned Scientists, 26 Church St., Cambridge, MA 02238 • 617-547-5552

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

**Renewable Energies/Conservation Directory** will be a listing of folks who have implemented conservation and renewables in their homes, and are willing to share their stories with others and at the same time help answer individual questions. Categories: 1) USERS: those employing a particular technology; 2) Providers: businesses who deal in renewables/conservation. Providers will be charged $25 to defray the cost of the directory; 3) Networkers: users or aspiring users interested in getting together to knock a few ideas around; 4) Homegrowns: those who are using a renewable system that they have built from scratch; 5) Owner-installed: those who purchased a system but installed it themselves; 6) Educators: those who know enough about a topic that they are willing to share their knowledge in a lecture, slide presentation, or forum with school or community groups (this is a most needed category!). If you're interested, send your name and address (phone optional) and category (s) to Julie Weier, Midwest Renewable Energy Assoc., POB 249, 116 Cross St., Amherst, WI 54406 • 715-824-5166

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

**Audubon Solar Brigade** If you pay an electric bill every month, let them know you'd like to see more utility solar power. The National Audubon Society's (NAS) Solar Brigade is an effort to coordinate a million people nationwide to demand 10% solar in ten years. Send a SASE to the NAS, 950 Third Ave, Dept. AB, New York, NY 10022 or call 212-759-6354 for more information, or to become a Solar Brigade leader. In a similar vein, a roving video/slide show and a free Audubon Technical Guide on energy efficiency are available by calling 212-546-9195.

**BRITISH COLUMBIA**

**Low Impact Living Systems**: Examine practical appropriate technology with Bob McCormic, Bunky Hall, & Ralph Keller from May 25-30. The workshop includes assembling a home photovoltaic system, constructing a passive solar water heater, and a look at functioning micro hydro projects. $630 includes tuition, vegetarian and seafood meals, and dormitory accommodation. Hollyhock Farm, Box 127 Manson's Landing, Cortes Island, B.C. Canada V0P 1K0 • 604-935-6465

**CALIFORNIA**

**SEER '92 Solar Energy Expo & Rally** in Willits, CA will be held August 7-9. For more information, contact SEER '92, 239 S Main St, Willits, CA 95490 • 707-459-1256.

**North San Francisco Bay Chapter of the Electric Auto Assoc.(EAA)** holds meetings on the third Saturday of each month at the Citibank conference room in Novato, CA. For information on the EAA and the chapter nearest you send an SASE to 1249 Lane St, Belmont, CA 94002, or call 415-591-6698 (9 to 5 on weekdays).

**AlTranEx'92** Sept. 9-13, at the Santa Monica Civic Auditorium, will feature an electric vehicle endurance competition, exhibits of electric cars, natural gas, alternative fuel-flexible, solar, hybrids, conversions & human-powered vehicles; photovoltaic & energy efficient products, and environmental organizations. The Expo is being held in association with Alternative Transportation News, Energy West Publishers, & Greenbrokers. For more info contact Greenbrokers, 279 S Beverly Dr, Ste 369, Beverly Hills, CA 90212 • 310-285-0093

**Solar Cooker Conference** June 19 & 20 at University of the Pacific, 3601 Pacific Ave., Stockton CA 95211. The conference will explore solar cooking to benefit people, environments, and the quality of life on Earth in the coming decades. There will be speakers from all over the world, from sociologists to physicists to business people.

**Sacramento Summer Solarbration Capitol Solar Cook-off** June 26, 11am - 2pm. Contact Solar Box Cookers International • 916-444-6616

**Solar and Electro-Expo** September 19, Plaza Park, San Jose, CA. The expo combines exhibits and seminars on solar water , PVs, and conservation technologies. Contact Mary Tucker, Northern Calif Solar Energy Assoc., POB 3008, Berkeley, CA 94703 • 408-277-5533

**COLORADO**

**Solar Home Workshops** will be held at the Solar Technology Institute (STI). These workshops are for owner builders and persons seeking careers as solar professionals. • Wind Power-May 26-29, Hydrogen Energy- June 1-4. • Photovoltaic Design & Installation- July 6-17. • Advanced PV for Remote Homes (Richard Perez guest instructor)- July 20-30. • Photovoltaic Design & Installation- Sept 7-18. • Advanced PV for Remote Homes (Richard Perez guest instructor) -Sept 21-Oct 1. • Micro-Hydro Electric Systems-Oct 5-8. • Solar Home Design & Construction- Oct 12-22. • Advanced Passive Solar Design- Oct 26-Nov 5.

See ad on page 91. For a detailed description of SOLAR HOME PROGRAM WORKSHOPS, costs and scholarship information; write STI, POB 1115, Carbondale, CO 81623-1115 • 303-963-0715

**Red Rocks Community College Solar Workshops:** Photovoltaics Workshop 3-14 August, Solar Domestic Hot Water Workshop 17-21 August, Solar Controls Workshop 24-28 August. Contact Jim Klima, Red Rocks Community College, 13300 W. 6th Ave., Lakewood, CO 80401-5398 • 303-988-6160 ext 320

**FLORIDA**

**SunDay Challenge AE Vehicle Rally** on June 14, 1992 sponsored by the Florida Solar Energy Center (FSEC) in conjunction with the 21th American Solar Energy Society Annual Conference, from Orlando to Coco Beach, FL. The rally will include electric commuter and solar/electric vehicles and other alternative fueled vehicles. For more info contact FSEC.(see below).

**FSEC Photovoltaic System Design Workshop** Sept. 15-17, Dec. 9-11, 1992 at the Florida Solar Energy Center (FSEC), 300 State Road 401, Cape Canaveral, FL 32920. The registration fee is $300; target audience; solar industry, engineers, government agency reps and interested individuals. Call JoAnn Stirling at 407-783-0300, ext. 116.

**The Florida House Foundation** is building two model homes incorporating passive solar architecture, energy and water efficient appliances, solar electricity and hot water, and edible landscaping. Contact The Florida House Foundation, POB 21583, Sarasota, FL 34276 • 813-924-6833

**IDAHO**

**Backwoods Solar** will be holding two one day workshops on photovoltaic equipment and installation, June 27 and Sept. 5, 1992 (both are Saturdays). Each workshop is limited to ten people. The cost is $40.00 per person, non-refundable pre-paid, which includes lunch and a text book ($30 per person if 2 people share the text book). For more information contact: Steve or Elizabeth Willey, Backwoods Solar Electric Systems, 8530-HP, Rapid Lightning Creek Rd., Sandpoint, ID 83864 • 208-263-4290

**INDIANA**

**3rd Annual Planet Fest '92**, July 10 - 12, in Bloomington. Workshops and booths on a veritable plethora of sustainable lifestyle topics, solar powered performance stage.Send a SASE to PF'92 c/o EBPX, POB 1328, Bloomington, Indiana 47402-1328

**MAINE**

**Hands-On Workshops** will include; solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch. For information on sites and dates contact Richard Komp, Maine Solar Energy Assoc., RFD Box 751, Addison, ME 04606 • 207-497-2204

**MASSACHUSETTS**

**Solar and Electric Vehicle Symposium (S/EV'92)** Boston, October 9 - 10, 1992, sponsored by the Northeast Sustainable Energy Assoc. (NESEA). "With clean air legislation currently passed in the Northeast, the EV market is about to explode, and new EV and components for EVs are announced monthly," says Nancy Hazard of NESEA. The S/EV'92 will be a forum for advancing the electric vehicle market, infrastructure and technology. Interested parties include NESCAUM, Electric Edison Institute, the DOE, GM, Ford, Trojan batteries, the E.P.A., and Unique mobility. Call 413-774-6051

Solar Electric Inc. Workshop, June 6 and Sept 12, in Worthington. $35 per person/ $45 per couple, see NEW HAMPSHIRE entry for details

**NEW YORK**

**3rd Annual Cortland County Energy Fair** July 11-12 at the Cortland County Fair grounds. Events include workshops, vendors and exhibitors, live music, home tours, a parade, and mountain bike rodeo. Contact Paul Yaman, POB 306, Cortland, NY 13045

**Solar Electric Inc. Workshop**, June 20, in Plattsburgh (W. Chazy). $35 per person/ $45 per couple. Call 603-525-3394

**ONTARIO**

**Solar Powered Summer Solstice Concert** in Toronto, nine hours of live blues, jazz, folk, and rock bands, Saturday, June 20. Contact Greg Allen 416-962-6193.

**VERMONT**

**Sunnyside Solar Workshops** one day workshops on photovoltaic home electric systems: 1992 dates include: June 6, July 11, August 1, Sept. 19, Oct. 3, & Oct. 24. The workshops are limited to 8 persons, fee $95/person. $35 advance registration required. For more info contact: Sunnyside Solar, RD4 Box 808 Green River Rd, Brattleboro, VT 05301 • 802-257-1482

**WASHINGTON**

**Renewable Energy Fair & Symposium** at the Bellevue Community College, 13 June, with Electrathon racing on 14 June. Contact Olof Sundin J-121, 3000 Landerholm Circle S.E., Bellevue, WA 98007-6484 • 206-641-2515

**WISCONSIN**

**Solstice Celebration of Sun Power** The 3rd annual Midwest Renewable Energy Fair (MREF) is June 19-21, 1992 at Amherst, Wisconsin. The Energy Fair introduces the public to a wide spectrum of renewable energy technologies and their contemporary applications. For more information about the Energy Fair contact: Midwest Renewable Energy Assoc., 116 Cross St., Amherst, WI 54406 • 715-824-5166

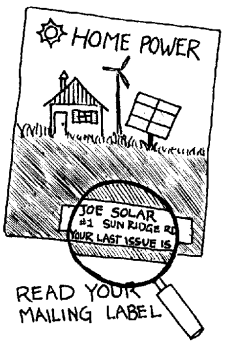
## *the Wizard Speaks…*

**Where Everything Grows**

Consider the acorn. Plant it in ground and a tree grows. The acorn contains within it all the information for the growth, evolution and maintenance of the oak tree. The information resides in the DNA program matrix of the acorn. Just think what could be done if we could decipher the programming language of the DNA molecule. We could grow our houses, power systems, transportation and much more.

Since complete understanding of the programming language of nature will take time, research should be started now. The fruits will be well worth the effort.

The basic operation of DNA is understood today. Attention should now be directed at the differential spiral structures and the dead areas of the DNA strands. It is also necessary to understand the unfolding mechanisms whereby the program appears to change as growth proceeds to new levels. Chaos Theory may be helpful here. Someday we may all be gardeners in an organic paradise.



# Letters to Home Power

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

**Code Reform**

Dear Richard; After reading John Wiles' article on page 57 Issue #26 I feel compelled to respond. If you wish, let this be an open letter to Home Power readers.

In several past issues of HP I have been reading John Wiles' article on the NEC code as it relates to PV and alternate energy industry. For the most part, with a few exceptions, his "interpretation" of NEC codes has been fairly reasonable and has shown a common sense approach to electrical safety and reliability. The information he gave in this last article taxes the limits of common sense. Before you get the wrong idea, let me say I feel the PV and renewable industry need to conform to standards of safety and reliability as well as ease of interconnect and standardization if the industry is to grow and gain more acceptance by the general public. What we don't need is a mindless adherence to codes that over complicate, confuse and overprice equipment and installation costs. Just because the NEC is almost universally accepted as an authority doesn't mean it is perfect and can be universally applied.

Case in point: In spite of his and the NEC's advice, I for one, and I know I am not alone, do not recommend grounding a current carrying conductor in a stand-alone PV or wind system. I have had more strange problems than I can remember that immediately disappeared when only the equipment ground was used.

The second issue I wish to address is the overuse of expensive and hard to find breakers. On page 58, figure #1 and #3 need only one breaker. When the PVs are disconnected from the controller through the breaker, the system is dead. Period. I have yet to see a power generating pump.

The third issue is the ridiculous use of a 75 amp fuse or breaker and #6 AWG cable on a 4 panel pump system. I don't care how many amps an LCB or current booster can deliver, the system is still limited to 240 watts. It's watts, or if you will, heat that will damage a wire not just amperage. A 4 panel pump system using a 20 amp fuse and 10 AWG wire is more than adequate. The only reason to use larger wire would be to prevent line loss on long runs. The only reason that a current booster would be delivering 55 amps at 4 volts would be locked rotor on the pump or a dead short. In either case I would want the 20 amp fuse to blow and protect my pump and controller. Also, most current boosters only boost current in surge conditions when full voltage is not available. In this latter case 240 watts is not even available making the 75 amp breaker even more ridiculous. Also, I have yet to see a current booster that can easily accept #6 AWG.

I design and install electrical equipment in aircraft for my living and even as strict and "rule crazy" as the FAA can be I must say aircraft systems are not as overbuilt as John Wiles and the NEC are recommending. My favorite bumper sticker is "Question Authority". I feel it is not only time to question NEC authority but also a good time to have those people active in using and building alternate energy equipment help write the codes. Some of the finest equipment built, is built for alternate energy markets by manufacturers who are at the leading edge of safety and reliability. Most of those products carry no UL approval. I had a UL approved surge protector almost burn my office to the ground. The problem was a complete lack of quality, not a stamp of approval.

Thanks for listening. I am open to response and constructive criticism. Larry Elliott, 27250 Willard Rd., Bend, OR 97701

*You speak for many of us in the RE biz, Larry. Section 690 of the NEC needs to be ripped up and rewritten to reflect the fact that MOST PV systems operate at less than 50 VDC. The concept that neither the framers of 690 or Mr. Wiles seem to grasp is the one of self-limiting wattage that you point out. A shorted PV output will deliver the full rated amperage (Isc), but the voltage, in that circumstance, drops to near zero.*

*In the PV-direct pumping article that you mention (HP#26), Fig. 1 is correct by NEC standards because disconnection of ALL ungrounded conductors from ALL sources is required (690-15). Ridiculous, but correct. I agree that the pump in Fig. 3 would be much better protected by one over-current device upstream of the controller rated at 125% of the PUMP'S GREATEST RUNNING AMPERAGE DRAW. The whole scenario illustrates the ignorance of the NEC's provisions as they apply to PV. By strict interpretation of NEC his analysis of the example is correct and NOTHING gets protected except the electrician who can disconnect the power source and work on a dead circuit. The over-current devices, which are set at 125% of PV or LCB output capacity, will NEVER blow. How can they, when the power production source (the PVs) can't produce 125% of*

*its own maximum output? This business of blindly following the blind has got to stop if we're to survive our own follies. Thanks for your letter.— Bob-O*

**New Under the Sun**

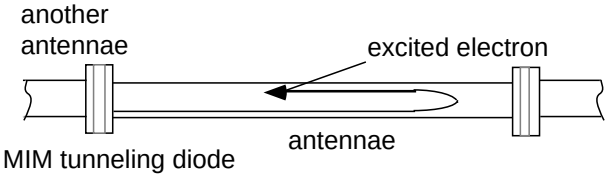
Dear Home Power: I have just finished reading the article on Lumeloid & Lepcon films written by Don Lancaster from Radio-Electronics (Feb. 92 issue), and it was very interesting new material to me.

Mr. Lancaster gave us your name to gather more information so we can study this technology more closely. It will be greatly appreciated if you could send us any information you might have. If it has a price please let us know how much. Thank you..

Mr. Timmermans, POB 1500, Grande Cache, Alberta, Canada, T0E 0Y0

*Lumeloid, and a similar product named Lepcon, are fascinating new concepts in photovoltaics. They do not, however, exist yet. The inventor, Alvin M. Marks optimistically predicts three years more R&D work is needed to bring them into production. We were sent a collection of papers which explain how these materials will hopefully work. The physics theory behind the design of Lepcon and Lumeloid is optimistic but possible. After all, plants do much more difficult things with energy from light. But manufacturing these things will be very difficult, if not impossible with existing technology. There is room for surprises though: in 1935 Dr. Marks surprised experts by introducing a 1000-to-1 cost reduction in materials that polarize light. Dr. Mark's Lumeloid is very similar - though much more complex - than the polarizing polymer film he invented 47 seven years ago.*

*A Lepcon panel captures the energy from light waves using tiny metal antennas, resonant with the frequency of the light. Just as in a radio antennae, electrons are shaken back and forth by the electric field of the light wave. The excited electron is allowed to pass through a one way valve, a metal-insulating-metal tunneling diode at one end of the antennae. These antennas/tunneling diodes are strung in series to raise the voltage, and these strings built in parallel to increase the current. Marks claims these will be 80% efficient and can be produced for $0.50 a watt. Seems very optimistic to me.*




*Below: Lepcon antennae/diode element*

*Lumeloid is similar except a long chain carbon molecule called polyacetylene is used for the antennae – similar to photosynthesis in plants; and an organic donor/acceptor complex is used instead of the metal-insulating-metal tunneling diode. In the donor/acceptor complex the excited electron tunnels from a donor porphyrin ring to an acceptor quinone ring. Somehow these molecules are hooked head to tail, and electrodes are attached to the final head and tail of each string. Dr. Marks seems to think that the Lumeloid cell will be cheaper to manufacture ($0.01 a watt) but may only last 6 to 12 months in the sun.*

*It's not hard to predict that Lepcon and Lumeloid technologies will both run into problems constructing the microscopic antennas and rectifiers in the necessary series/parallel configurations without too many performance-robbing short circuits or open circuits. If these cells work, they would revolutionize energy sources for the whole planet. But I'm not going to hold my breath. Texas Instruments Spheral cells will be on the market much sooner - they already have working models. But even these won't be seen until 1995. Meanwhile there's plenty of applications for the panels available today. —Chris*

**Cutting Edge**

Dear HP; After struggling and failing to make a multi-strand large gauge wire that was cut with wire cutters to fit into a connector or lugs, I found a good solution. A plumber's tubing cutter placed on the wire, turned in the direction of twist of the wires, and used in the normal way leaves a very clean round cut with the strands twisted tightly together. Remove the insulation and the exposed wire slides right into its final resting place.

Thanks for a great magazine. It's sure helped get me through some rough spots in designing and installing our power system. Here's ten dollars for another year. Jack Rogers, HCR Box 106 B, Bridgeville, CA 95526

*Great idea, Jack! I tried it on a piece of 2/0 THHN and, while it's a little slow, it worked pretty slick. The average homeowner-installer isn't likely to have a behemoth electrician's wire cutters on hand, and the tubing cutter beats a hacksaw all to heck. Thanks for the tip! Bob-O*

**Castle Besieged**

Dear Home Power; We were quite interested to read (in the Feb/March 1992 issue) your lead story about Mike and Waldi Rook's home—the design, remote location,

and use of alternative energy sources are very similar to our project. However, by paragraph six, we gasped with dismay and bewilderment! With all the apparent care and concern to build a comfy, energy efficient home... why 3100 total sq. ft.?!!! That's a huge living space for (implied in the article) only two people! The materials, energy, and money invested in a building of such size are great given their impacts on already beleaguered ecosystems (especially the forests, air and water), other life, and the homeowner's life. Even when we can "afford" to be extravagant, it's important to judge what price is paid beyond one's mortgage—what can the Earth and future generations afford? H.D. Thoreau is still correct..."The cost of a thing is the amount of what I call life which is required to be exchanged for it—immediately or in the long run." Please, HP, don't miss opportunities to remind us all that bigger is not always better, and certainly not necessary for happy and healthy shelter.

We believe that an even greater impact from one family's wasteful use of resources is its poor example. Too many out there don't even think about waste, alternatives, a new paradigm of a sane and less impactive life. Those who know better really must realize that we teach by doing, by trying as much as possible to live what we believe. Mike Rook said "...We've given up nothing by using the sun for our electricity, we've just learned to use it efficiently." We suggest that space and materials be conserved and enjoyed—by also using them efficiently, and with gratitude.

"Live Simply So That Others May Live" is not just a lovely thought, but a code of action that we must incorporate into all our lives. And, more sane and less complicated lives at that! From the shack, Allen and Renée Cook, 15060 Kelly Canyon Rd., Bozeman, MT 59715

*Well, Alan and Renée, first off, know that we (five of us on the Agate Flat HP crew) live and work within a 627 square foot building. Until six months ago, it was only 416 square feet. Karen and I have lived like this for the last 22 years. And we are happy doing so. While I share your concern for waste and choose also to live simply, I am not adamant that others do so also. Alarm bells go off in my head when I hear, "a code of action that we must incorporate into all our lives." This is America, and one's choice of lifestyle is one's own. If you knew Mike and Waldi, then I'm sure would would feel differently about them and their castle. They, with their own hands, built a home that will last more than a century. In terms of materials use, it is more effective than ticky-tacky built to last 25 years. In terms of space, that's up to the dweller. If you want a bowling alley in the living room, then fine, just power the setup with RE so I don't have to eat your pollution.*

*Home Power is about renewable energy. My goal is to spread the use of renewable energy throughout our country and the world. As long as using RE is associated with "doing without", then this goal will remain unfulfilled. To this end, you have lately been seeing some upscale systems within our pages. Please consider this tactic our attempt to convince mainstream America that RE can indeed cut the mustard. You will be seeing more smaller systems in the future issues. After all we all started out together, just two hippies in a PV-powered tepee. While I am content to be a forty year old hippy, I don't ask everyone to take this trip. It's really up to each of us. And that's what freedom is all about. — Richard*

*Wouldn't you like to educate all of the energy and resource-guzzling industrialized world about renewable energy? If our industrialized world hooked up to decentralized renewable energy, would we learn in the process to waste less of all resources? That's my hope. I think decentralized RE inherently teaches us to be aware of what we consume. Spreading this message means installing renewable energy systems in places which will make the Rook's house look like a hut. In the broad perspective, I think renewable energy is most effective if it poses simply as a tool. Power whatever you want, and we'll work to see that it can be done with RE. — Chris*

**EV Perk**

Dear Richard and Karen; I just finished converting a Fiat x1/9 to electric power. I'm about to drive it 28 miles one way to work. The drive involves a long 6% uphill grade, so this inaugural voyage will be a true test for the practicality of electric cars. I work as a solar panel engineer for Hughes Aircraft's spectrolab Subsidiary. I'd love to laminate a few thousand of our 21% efficient gallium Arsenide/Germanium (GaAs/Ge) solar cells onto the vehicle's roof! I am planning to run my house on solar energy. While the car is away from the house the PVs will power the refrigerator and other loads when electricity costs are high. You see, I have a digital time-of-use (tou) meter installed at my house because as an electric vehicle user I pay only 4.5¢/kWh between 7 PM and 11AM. During the day I pay 13.5¢/kWh (11AM to 7PM). That's why my PV will save me a lot of money. Sincerely, Gregory S. Glenn, 12561 Indianapolis St., Los Angeles, CA 90066

*You bet, Greg! As more utilities move to TOU metering, PVs will look even better. My congratulations on the EV,*

*keep us posted on how it pulls that long grade — Richard*

**Surplus Review**
We have bought many items from surplus catalogs, especially Jerryco. The ammeter that reads our power usage is an old X-ray gauge for $3.50 each. Some of our cable is old power company line etc. I wish you would have a regular column on low-budget items and sources. What to look for when buying odd stock (sometimes I think I might be able to use something but I'm not sure and I don't want to take the chances either in safety or cost). Maybe you could even offer a service to surplus places by reviewing applicability of their offerings to AE users and supplying that info to all of us. I don't want to get absurd about it, but it seems to me if you are going to offer "Rook's Castle" you could offer hard-scrabble AE. Here's my renewal and keep up the great work. Cheers, Jeff Mann, Old Stage Rd., Arrowsic, ME 04530

*My favorite catalogs are the ones from the surplus parts houses, Jeff. Unfortunately, we don't have the bucks or the time or the personnel to test all the wonderful Junque that's out there. More's the pity. We will, however, print any and all info about junqueing from readers.*

*A fair number of folks like yourself have asked to see more low-ball RE. We're looking for some small systems to feature. One problem is that a lot of small systems (and a fair number of big ones) put in "on the cheap" are sadly lacking in the safety department. In some cases, the system owners understandably don't want the notoriety. In others, we don't exactly want to promote those kinds of cost-cutting measures. Ya know?— Bob-O*

**Connections**
We like your magazine as it is the only grass roots RE information that we can find. Your mag helped us believe in, design, and install our PV/gen set hybrid system. There is no information available in Canada (magazines, catalogs, newsletters) that we can find. We know there are more like us on our side of the border and would like to hear from or about them. Keep up the great work and information. Clint and Karen, Box 94, 150 Mile House, B.C., Canada, VOK 2GO

*Yours is not the only letter we have received about connecting up with other RE users in a particular area. Sometimes we get requests for a mailing list of subscribers in the reader's location. Home Power does not give out mailing lists of subscribers for any reason, but occasionally we'll print a letter. If you want to get to know local RE users I suggest taking out an ad in the local paper, or one of those 'ads only' papers that are distributed free. Another option is to place an inquiry on any public bulletin board available. These can usually be found at cafes, grocery stores, hardware stores and laundromats. Bob-O and I picked up our coveted HP #1 by reading a notice at the local laundromat.*

*The MREF is putting together a directory of folks wanting to share their RE experience with others (see p.79 this issue).— Kathleen*

**Resource Directory**
Dear Home Power Crew; Attached is my renewal for a first class subscription for another two years as well as the readers survey on the Home Power (HP) book. (That has got to be one of your best ideas yet.) I specially like the appendix of your 900 RE businesses. Everyone interested in RE knows that the hardest thing is finding where to go for Information and Commodities. Maybe once or twice a year you could update the RE businesses with a column or two in HP Magazine. But however it is printed put me down for a copy.

Here is something else to think on. How many of those 900 RE businesses have gone public? With our savings accounts making squat, it might be a good idea to try something else. Besides can you imagine the boost it would have on the RE market if all the HP readers would buy just one share in one company. How about a RE stock index list in HP. If not does anyone know of such a list? Keep up the good work and we'll see you all at SEER '92. Thank you, Jim Miller, 4920 E. Holly, Phoenix, AZ 85008

*The PV Network News puts out an annual resource directory, Solar Electricity Today. Beside solar it also covers hydro, wind, pumping, inverters, motors and tools, trackers, lighting refrigeration and lighting. It is $7 from PV Network News, 2303 Cedros Circle, Santa Fe, NM 87505 • 505-473-1067. Also there is Solardex, a Resource Guide for Renewable Energy & Conservation. The last comprehensive issue update was March 1992. Mail $10 to Solardex, 109 Fire Lane, North Cape May, NJ 08204-3417 - Kathleen*

**PVs on Track**
Dear Home Power People; Enclosed is $10 for my subscription renewal. Your magazines are always very informative, but in issue #27 the black and white photos have unusually poor contrast.

Your unfortunate battery experience suggests the desirability of battery containment. An insulated but unheated outdoor enclosure does not really protect lead-acid batteries from extreme cold weather. Perhaps an externally vented acid resistant enclosure would allow smaller battery banks to be kept indoors at room

temperature with reasonable safety and protection against battery leakage or explosion. What materials could be used to build a box to contain leakage of electrolyte?

The arguments of thermal vs. electric PV trackers are interesting, but what about trackers vs. more PV panels? In higher latitudes, trackers give the biggest boost to summer PV output which may not be particularly useful for general household needs. An equivalent value of additional PV panels would give more output than a tracker during short winter days when lighting loads peak. So far your system reviews have not detailed seasonal variations in power supply and demand on different PV systems. I realize that this would require considerable instrumentation and I'm not criticizing your work, just suggesting possible avenues for future research.

As for trackers, how well do they perform in very windy conditions and in snow and ice? What is the total output each month vs. fixed panels at a given latitude? These would be good subjects for objective analysis. It could begin with a mathematical prediction based on cloudless days, followed up with actual field tests. I'm sure many people would be interested to know whether trackers are cost effective for their situation. Clive Ellis, 2039 Manzanita St., Klamath Falls, OR 97601

*In response to your comment on the photos, Clive, we send our masters off to the printer and when the magazine comes back to us what is done is done. We constantly strive for better quality and clarity in HP. Sometimes our printer does too… - Kathleen*

*Clive, I've seen some large containers with tight fitting lids made by Rubbermaid™ that would hold one or two L-16 type batteries. They'd be pretty easy to connect with PVC conduit for the battery interconnect cables and vent to the outside with small plastic or rubber hoses.*

*Starting this fall, Home Power will be doing the kind of research you suggest. We'll be tracking (pun intended) the outputs of three identical 8 module arrays. One array will be on a thermally-activated tracker, one on an electrically-activated tracker, and one fixed array. Stay tuned.— Bob-O*

**Wonder Washer**

Hello Folks; I'd like to share a bit of my tinkering that turned out well; a washer motor swap. But first a little background. Our first child was born in 1980 and the weekly 30 mile round trips to the laundromat grew old and smelly quickly. I tried operating our Kenmore washer with an old 3 1/2 HP Briggs engine but it worked poorly and was a pain. After the birth of our second child in 1982 the buckets of smelly clothes doubled. We soon moved back across state to my hometown and into an old frame house and onto Alabama Power. We had bought PVs through Joel Davidson in 1981 and I continued to use them for lighting but wanted to expand their usefulness. We bought a Heart 1200 to run the 1/2 hp jet pump and the washing machine. Unfortunately the Heart wouldn't start the well pump and got very hot running the washer. I grew uncomfortable using the washer on the inverter so I finally plugged it back into company power. But I never gave up hope of repowering the washer.

In 1986 I bought a rather compact Bosch PM motor from Surplus Center (Lincoln, NE) rated 1 hp at 24 VDC, 2500 RPM. That September I removed the old 1/2 hp AC motor and bracket. I welded a couple of 3/16" x 1" x 4 1/2" strips to the motor end of the bracket, drilled 4 holes and mounted the Bosch motor. A 2" motor pulley put the washer speed about right on 12 volts. I screwed a double pole 30A AC relay to the back of the cabinet and connected the old AC motor wires to the coil of the relay. The fused 12V supply goes to the normally open relay and from the opposite side of the points to the Bosch motor. The washer cord is still plugged into an AC power source. When the washer control energizes the old motor circuit it activates the AC relay instead and in turn the Bosch motor. That's it! I washed a 2 day pile of clothes and could hold my hand on the motor. Amp draw was 16-21 depending on the washer cycle. I was thrilled. This was almost too good to be true so I tacked a calender to the wall beside the washer and October 1st 1986 began putting a pencil mark for each wash load on that date. Here is a summary:

| | # of Loads | |
|---|---|---|
| Oct.-Dec. 1986 | 102 | |
| 1987 | 578 | Aug. 5 Lindsey born |
| 1988 | 715 | |
| 1989 | 654 | Dec. 26 Sarah born |
| 1990 | 830 | |
| 1991 | 791 | |
| January 1992 | 83 | |

And it's still working! I replaced the drive belt and the fill hoses last fall. Any problems with the conversion after over 5 year's use and 3,700+ loads of clothes? Occasionally the relay points will stick and I'll have to thump on them with my finger. Good ole Steve Willey helpfully suggested a capacitor across the points which I'll do when I find one. Hard to believe this is the same second hand washer given to my wife by her mother back in 1978, the same one I briefly ran with a lawn mower engine. Thanks for your time, Michael C. Gibbs, RR1 Bx 16, Ranburne, AL 36273

*Wow, Mike, that's great. Talk about exhaustive testing. You have taken the environmental refrain Reduce, Recycle and Reuse two steps farther, Research and Re-work. One thing I found out in doing a conversion on our washer is that washers are different. Even washers of a certain brand, while maintaining a certain familial similarity, can be very different when it comes to parts and power usage. That said, congratulations, you do good work. - Kathleen*

**Hot Hose**

Dear Friends; Tom Brandolini's solar heated shower letter in HP #27 moved me to try 200 ft. of 5/8" el cheapo mesh reinforced garden hose up on my asphalt shingle roof. I'm now down $48 (hose, adapter from an old shower head supply to one of two "Y" connectors [with shutoff valves], assorted hose ends). R & D cost money!

Today, early March, it's 80° in the shade, the roof shingles are at 130°, shower water is 110°, way too hot for me. Thanks to the "Y" connectors it's easy to blend in cold water to suit.

At full flow, no blend, the hot water lasts 1 minute 24 seconds before you feel it cool down. Water storage is about 3 gallons, delivery is 2.2 gallons 1 minute, full flow.

Up on the roof the ticket seems to be to lay the hose out in back and forth straight lines, weighting the turnarounds down with bricks or some such.

I wasn't that smart at first, so I tried laying a close-spaced spiral out on the patio floor, fastening the coils to a 12' 2x4 with finishing nails bent over. 200' was only 4' diameter. Second version spaced the coils 3/4" apart. One to 1 1/2" spacing would be more like it, would let the roof recover heat faster and there would still be enough room on the 2x4 for another 100' of hose (300' total).

Getting 200' topside is a pain. The coil spacing gets messed up and it's a chore to recover the patio layout. I flopped it over to put the coils in best contact with the roof.

The $48 hurts. That's a year's worth of electric water heating at 20 minutes a day. At least I won't have to spend it again next year, but I wonder if your readers have cheaper solutions to the hot water heating problem. Regards, Art Rhoads, 1321 Hollyhock Circle, East Jacksonville, FL 32211

*Well, Art, there is no really cheap DHW if you have buy every little part you use. We must all learn to improvise with the materials at hand, to the greatest degree. I refer you to HP #11 page 19, for another type of passive DHW project that gave us lots of hot water through years of use in the non-freezing seasons. - Kathleen*

**Northern Exposure**

Hi; Hello from the frozen north and thanks for your invaluable magazine. We were pulling 24 Amps at 12 Volts, 6 hours of the day today. Daylight is about 7:30 to 19:00 now and gaining about 6 minutes each day.

Our batteries were full about 17:00 so we cooked dinner, or supper depending on where you are from, in the crock pot. What our system needs is more batteries. On a bright sunny day around here we are scrambling to use the excess power. We usually eat breakfast off the electric skillet and then do laundry or do small construction projects. I say small construction projects because our Turbo Trace 2012 will not start our table saw. It will power all of our other Craftsman power tools from a skill saw to a half in. drill including grinders, scroll, saws and belt sander.

This letter is coming from a Corona Portable PPC 400 and a Star impact L.Q. daisy wheel printer, I have a personal problem reading a dot matrix in a letter. These have all run off the Trace 612, 2012 and the Statpower 200 without any problem whatever since 1987. We also operate a G.E. vg 7620 VCR with Samsung 19" color TV and a Nikon 8mm Vn 810 video camera off the inverters mentioned. We have not tried the VCR and the TV on the Statpower 200.

The laundry gets done in a J.C. Penny compact washer with an extractor. We have not used our old Maytag gas engine wringer washer since we got the Pencraft at a yard sale for $50.

We live on a remote Homestead in the Alaskan outback, 21 miles by snow machine from the end of the road, 20 miles from Homer, Alaska on the beautiful Kachemak Bay. Please don't sigh and think that this is the life. People pay dues wherever they live, the dues are just different. Don't get me wrong, we love it. It isn't an easy life, we home school a 14 year old and a 5 year old, both daughters. We chose it, live it and love it, but I wouldn't recommend it to many people.

Now for the main reason for writing: please send HP #14. I cannot find mine and I need the information on noise filtration from the 2012 inverter. If there is more information or your readers have any ideas please send them. We are going crazy from the speakers buzzing on the 12 volt DC am/fm cassette stereos and 110 AC stereo systems. Also the SunFrost makes an annoying buzzing on the VHF Radio phone when it is on standby or when transmitting. Please also send HP #4. Enclosed is $24 MO to cover back issues and two more years of HP, we run out on #30.

Please don't ever forget the EXXON VALDEZ and what reliance on fossil fuels really costs us before and after the pumps. I helped pick up and catalog too many of my dead, wild, friends from bears to puffins and everything in between. It still really hurts.

Keep up the excellent work and drop a note if you plan on visiting Kachemak Bay on the Kenai Peninsula Alaska. Sincerely, Dennis W. Wade, POB 1848, Homer, AK 99603-1848

*Well, Dennis, I wish we could say we have the noise problem totally licked, but we don't. Standard solutions like additional filtration of the secondary side of the units power supply work. Line filters work. And sinewave inverters work. All these solutions are either difficult or expensive. Best thing is to pack a small inverter into the stereo store and see if the stereo you are buying is quiet. You can cure the buzz on 12 VDC stereos by adding a choke like the RS# 273-104 found at Radio Shack. Add a large capacitor (100,000 µF. or more) to the power leads after you wrap each in its own choke. This usually does the trick on 12 VDC audio gear. — Richard*

**Battery Containment**

I disappear from social interaction the day Home Power arrives. Richard – I placed a large piece of swimming pool liner (free from the pool store backyard) in the bottom of my ventilated battery box to contain any spill before it leaked into the ground. Thanks for the tip on Muriatic Acid - the folks at Minn. Pollution Control here had NO idea how to handle such a spill as Potassium Hydroxide and Cadmium. Jim Marquarat, 1500 Duluth St., St. Paul, MN 55106

*Thanks for the pool liner tip, Jim. The credit for any science I know goes to Wally Novak, my Physics teacher at Portsmouth High School, Portsmouth, NH. While the acid will neutralize the caustic electrolyte, it dosen't deal with the for the cadmium, so look sharp and dispose of the neutralized residue properly. — Richard*

**Modified Windcharger**

Dear Home Power Folks; I want to share some of my experience with a modified Windcharger in response to Peter Donovan's letter on Pg. 92 of HP #27.

We have an old Windcharger with 6:1 gear ratio and an 11" blade. The generator that was with the unit was rewound from 32V to 12V. However this proved unsatisfactory as the commutator was unable to take the increased amperage at 12V. It was a two pole generator. I would think the chance of success of rewinding a four pole generator would be much better.

While I haven't mated an alternator to the unit, I have successfully adapted a different generator to it. It is one I found in a surplus catalog 10 years ago. It was listed as being four pole, 24V 40A. The four field coils were wired in series for 24V so I reconnected them in a series-parallel combination for 12V. By running the generator at 12V I get the same amperage at 1/2 the RPM.

To adapt this generator to the Windcharger I used the front end plate off the original generator in place of the front end plate of the "new" generator. Luckily they both used the same bearing, so that fit fine. The new generator had a 1/2" larger diameter outer case so I made some spacers out of 1/4" square steel rod to go around the circumference of the original end plate. This centered it in the new generator. My machine shop consists of a hacksaw, a file and a drill and that's all that was needed. A friend with a lathe turned down the shaft a small amount so the gear could be attached.

This unit has been in use for about 10 years. It now supplements our PV system, but at first it was our only source of power. It starts charging in a 7 MPH breeze and puts out 40A in an 18 MPH wind.

Over a year ago I obtained a blade activated governor from Thomas E. Hill Jr. (mentioned in HP #17 pg. 30). It's a ruggedly built unit and operates like the governor on late model Jacobs machines. Unfortunately it still hasn't made it to the top of the project list. So I can't yet report on adapting it to the Windcharger. The Windcharger air brake governor works reasonably well to 30 MPH or so, but I wouldn't trust it in a storm. We keep the Windcharger furled whenever we're away from home and there's any chance of high winds.

Hope this might be of some help. Thanks for the great work you are doing. Bruce Johnson, 7605 N. Post Rd., Spencer, OK 73084 • 405-771-3551

*Hi, Bruce, thanks for sharing your wind generator expertise with our readers. — Richard*

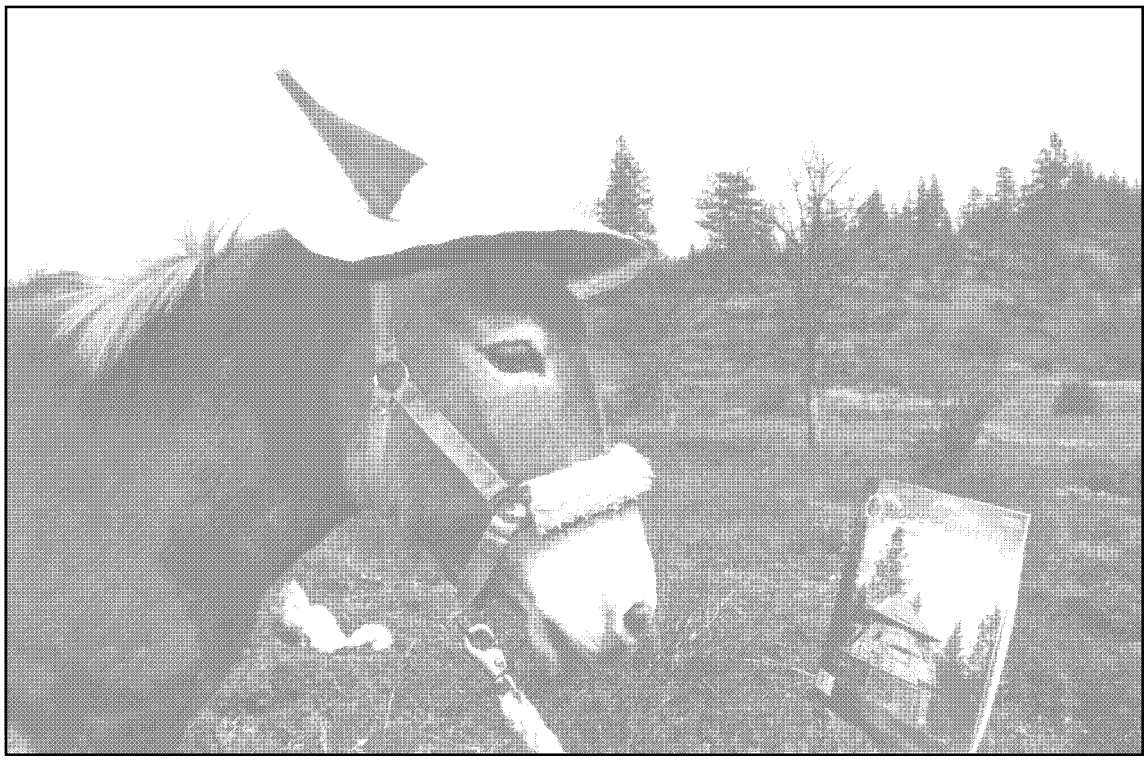
**City Solar**

Dear Sirs/Mdm; Now that my favorite magazine newsshop has grown unfamiliar with Home Power I'm pleased to give you the business directly. You have one of the most interesting magazines on the racks. And it's so full: if you have to choose one day between a skinnier monthly and this fat bi-monthly, please know that the product as published today is well worth the wait.

I'm curious. How many "dense urban" subscribers do you have? I would imagine that most of your readers live

"remotely". But I would hope that I'm not alone foreseeing a variety of applications of ideas from the pages of Home Power here in the city. The appeal of ingenuity and independence isn't strictly a rural, back-to-the-land phenomenon, as I'm sure many of your readers already know. Considering the price of electricity and the waste of energy here on every block, there must be some grid inter-tie or even energy independent living going on somewhere in New York City. I've understood that NYC code and insurance requirements (to cover elec. utility workers) are the highest hurdles here, after cost-effectiveness. But there must be some pioneers. How about an article? At the very least, your readers should understand that PV powered emergency phones line the Beltway beside the Verrazano Narrows and the drive through Prospect Park (Olmstad's best park) in Brooklyn, just as they do in more "likely" (remote) solar territory. The message that cost-effective applications of solar technology are here now even in New York is lost on most New Yorkers, of course. But therein lies the opportunity. As much as I feel compelled to applaud our local utility (Con Edison) for its conservation efforts and programs (compact fluorescent light-bulb giveaways, free energy audits, etc.) it would give me great joy to see a group of independent-power visionaries give it a run for its money right in the heart of the grid. If Home Power has inspired other urbanites, perhaps you could even give us a column. Keep up the good work (and grow slowly). Sincerely, Bill Epes, 246 Union St., Brooklyn, NY 11231

*Well, Bill, about half our readers live in urban areas. The other half live in some of the most remote places you could imagine. Most of the core HP crew, those who actually do the day to day grunt work on this magazine, live in the outback. We can only write about what we know. So how about it urbanites, let us know how you are using RE and conservation in the city. — Richard*



"Don't be a fool," says Hijo the mule, "Eventhough I'm barely able, I still read

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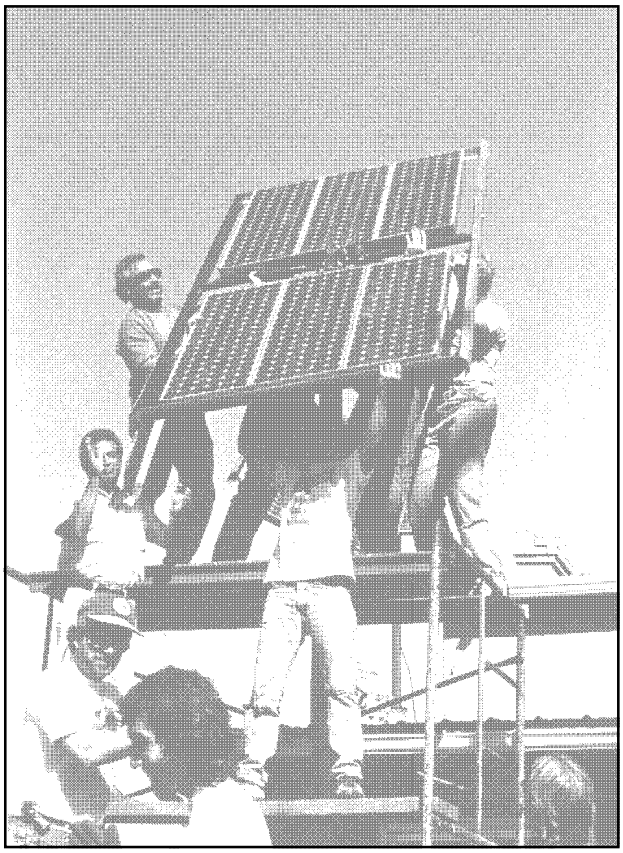

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# Q&A

**Wire We Here**

Dear HP; After reading several articles about wiring, I still feel there must be a better way for those of us who do not use an inverter and are running on 12 volts. I have put terminal blocks in some junction boxes instead of using wire nuts. I find the process of wiring up and stuffing #10 wire into boxes to be difficult if not impossible. Is there some info on what type of terminal blocks to use and if there are any out there that would make it easier to put both positive and negative blocks in the same box and still be safe? I seem to be having a problem with the disconnect switch coming from the panels to the batteries. I used #6 wire to carry the output of the panels (18 Amps) about fifteen feet to the fused disconnect. The wire itself does not feel hot under load but the box itself gives off a lot of heat and there does seem to be some discoloration of the wire insulation where it joins the lug. The connections are all screw type, I have tightened them all though they were really not loose and there is no evidence of corrosion, etc. The switch itself has an arm which is split in two and closes with a spring action on the contact from the input. Any ideas?

Finally, I bought a lot of "Thinlite" fixtures from several people who had originally been 12 Volt but had switched to the grid. Many of them do not work. Is there any easy way to determine what is wrong with them? I called the company, but they said they do not give out diagrams as that is "proprietary information." At $35-$50 a shot I suspect they should be worth the fixing. Jeff Mann, Old Stage RD., Arrowsic, ME 04530

*Jeff, I can't find anything in the NEC that specifically prohibits you from mounting terminal blocks within a junction box. There are, however, rules about the maximum number of conductors that are allowed in a given size box. For 10AWG wire, you need to have 2.5 cu. in. of box space per conductor. A spliced or tapped conductor, ie. one that is connected by two terminals of your mounting block, counts as two. A "mounting yoke or strap containing one or more devices" (which pretty well describes your terminal block, I think) counts as 2 conductors. So, a junction box containing 4 wires connected through a terminal block mounted in the box would need to have a minimum of 25 cu.in. of volume. In this example, you'd probably use a 4 x 4 x 2 1/8 box with a 30.3 cu.in. capacity. Fortunately, as of 1990 all boxes are required to be marked with their cu.in. capacity. So you can leave your calculator home when shopping.*

*It's hard to guess what the problem is with your safety switch box, but I'd try cutting off an inch or so of wire and carefully re-stripping it. You might have inadvertently cut off some wire strands either during your initial installation or by over-torquing the connecting screw. Removing the screw and polishing the connector with some fine emery cloth wouldn't hurt either. You'll disconnect the PVs first, yes? On the fluorescents, if all the dead "Thinlite" fixtures in the world were laid end to end...they'd be much easier to crush with a Cat before recycling. Nuff said? Bob-O*

*I have owned six Thinlite 12 VDC fluorescents; they all died within a year of installation. Even when they were working, they ate expensive, special fluorescent tubes like peanuts. I would not recommend them to anyone. The failure is usually in the transformer (a custom-made job) or the final transistor (grossly underrated and poorly heatsunk). They are not worth your time to fix as they will surely fail again. Put your energy into something that lasts. If you want good, efficient, and long lasting light, buy 120 vac OSRAM EL-series fluorescents. If you have more than three lights, then it is cheaper, quieter, and more efficient to buy the OSRAMs and a small inverter like the PowerStar 200. — Richard*

**Cold Charge**

Dear Folks; I have a question about the statement I came across in a woodworking magazine on care of cordless drill batteries. It states, "On the other extreme, don't recharge or use your battery when it's below 32°. This can seriously damage the chemicals within the battery and cause one or more cells to short."

I use my Makita 6093 cordless drill outside all winter (often below 0°F) and charge the battery in an unheated building. I thought NiCads could take the cold. Ernie Soya, 44 Nota Rd., Wauconda, WA 98859

*Sintered plate nicads (like AA, C & D) can be discharged and recharged at well below 0°F. The problem with the Mikita and other rapid chargers is that they use a temperature sensor to determine when the battery is full. If the battery is very cold, then the sensor never operates and the battery can easily be overcharged. If you are using such a charger in the cold, only leave the battery in the charger for 1.5 hours. After 1.5 hours of charging, the battery is full. If you wait for the automatic temperature sensor to terminate the charging process, you may damage the cells from overcharging. — Richard*

**Panel Puzzle**

Dear Richard; I have some questions about solar panels I hope you can help me with. 1) In low light conditions, such as a cloudy or cloudy-bright day, does a single crystal PV panel perform any better than a polycrystalline cell panel such as Solarex and Kyocera? 2) Also the ads for Electron Connection say Kyocera PVs (the finest kind)– what makes them better than other brands? I hope to buy some PV panels soon and can't decide if I want the Hoxan 4810 or Kyocera J-51. Both panels seem to be a good value. 3) A friend of mine has a solar array of 3 ARCO M75s and 1 Solarex panel. The Solarex blue anti-reflective material has turned to a brick red color on some of the cells. Will this cause a loss in the cells' output? Have you seen this before? Thank you for your help, and for such a great magazine. Yours truly, James A. Fasano, Rte 35 POB 193, Townshend, VT 05353

*In dim light conditions, the single crystal cells will outperform the multi crystal types. This is because the single crystal types have higher conversion efficency. However, this is a moot point since neither technology will produce squat without sunshine. In reality, there is very little difference between one brand of PV and the next. Kyocera does have the best warranty in the industry (12 years!), and we have found their modules to be consistently under rated. On the other hand, Solarex tests and rates each module individually, and this rating is super accurate. Hoxan modules are very well made, meet specs, and carry a ten year warranty. Choosing a PV module is a little like ordering ice cream; I like Ben and Jerry's Cherries Garcia, how about you? The discoloration in your friend's module is common among older modules that used ethyl vinyl acetate (EVA) as a pottant. It seems that EVA pottant outgasses acetic acid which attacks the tantilum pentaoxide anti-reflective coating on the cells. This usually produces a miniscule power loss in the module. In some cases the attack is more severe and the acetic acid eats the metalization on the cell. If the current handling traces are affected, then the cell can lose an appreciable amount of power. Run an IV curve on your friend's module, and if it is below spec, then I'm sure that Solarex will make good on their warranty. — Richard*

**Modified Cheap Trick**

I enjoyed your article in HP #27 about the benefits of using a true sine wave to power delicate electronics, like TVs and radios. A year ago I was disappointed with the lack of filtering on my "Statpower Prowatt 250", which produces the modified sine wave. In true HP fashion, I was looking for a low cost solution to the interference problem. One day it occurred to me that a hundred ft. extension cord might make a good low pass filter. Sure enough, the distributed inductance and capacitance of the cord (16AWG) eliminated all the interference; it doesn't seem to matter if the extension cord is coiled, linear or in a tangle. While still not as good as a sine wave inverter, this easy-to-do trick may help some of your readers utilize the inverters they have. Toby Schneider, POB 333, Pearce, AZ 85625

*Great idea! And the price is right. It would be interesting to compare the efficiency and the filtering ability of your extension-filter with the commercial ferro-resonant transformer filters. Chris*

**Hydrogen Hurdles**

Dear Home Power: I have a few questions I would like you to answer for me. 1) What is the BTU comparison of one kWh of electricity through resistance heat verses electrolysis of water and combustion of the resulting hydrogen? 2) How many cubic feet of hydrogen at atmospheric pressure will be in a 100 cubic foot tank at 150 PSI? 3) What is the BTU per cubic foot of hydrogen? Thank you for your assistance in this. Your time and help are greatly appreciated. Sincerely, Lee Porter, 5543 E. Sugar Creek Rd., Preston, ID 83263

*1) If you put one kWh through a resistance heater you will get all of that energy out as heat. Electrical heaters are nearly 100% efficient (at making heat). An electrolyzer is best at around 75% efficient (25% showing up as heat). Burning the hydrogen is nearly 100% efficient (at making heat). So the entire process: electricity --> Hydrogen + Oxygen --> heat is at best 75% efficient. This does not mean that electrical resistance heating is better than burning hydrogen. What if your power is generated in the summer, but you want heat in the winter? Keeping the energy stored in a battery until winter is a poor option since batteries' self-discharge around 6% a week. Storing it as hydrogen is comparatively inexpensive, and if there's no leaks, there is no self-discharge.*

*2) A 100 $ft^3$ of gas at 150 PSI will expand to 1020 $ft^3$ at 14.7 PSI (atmospheric pressure at sea level). This is easy to calculate using the ideal gas law: $P_1V_1 = P_2V_2$.*

*3) There are 2850 BTUs per cubic foot of hydrogen at 150 PSI. Propane has 2560 BTUs per cubic foot.*

*Some sources of hydrogen information are Fuel From Water, by Michael A. Peavy, 2nd ed. Louisville, KY: Merit Products, 1988, and The Phoenix Project, by Harry Braun, Phoenix, AZ: Research Analysts, 1990.— Chris*

# Home Power's Business

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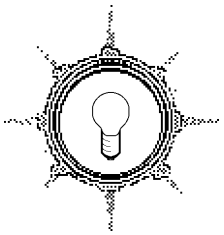

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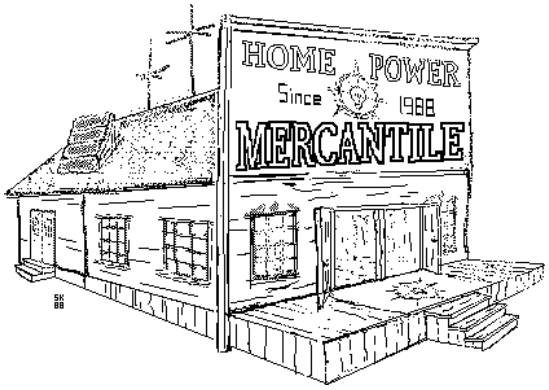


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