HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #40

April / May 1994

$3.50 U.S.

$4.95 CAN.

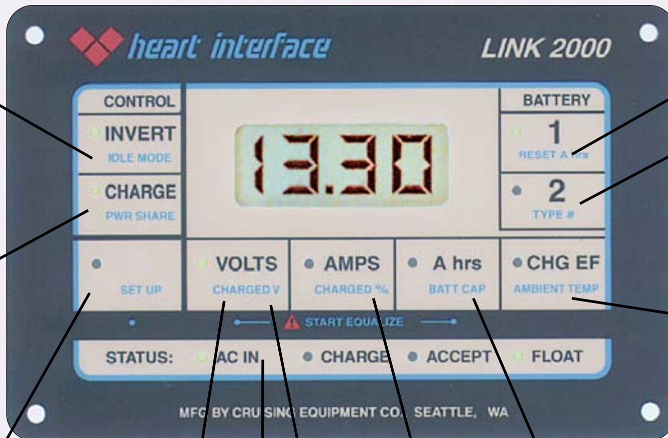
Display until June 1

Introducing the *LINK 2000*

Integrated Battery Monitoring and Inverter Control

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

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



Control

Green LED indicates on.

INVERTER may be turned On or Off independently from charger.

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

CHARGER may be turned On or Off independently from inverter.

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

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

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

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

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

Red CHARGE LED flashes when in equalize mode.

STATUS indicators for AC power and charge cycle state.

AC IN: Green LED on when AC is present.

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

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

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

Monitoring

Green LED indicates selection

Selects BATTERY #1.

RESET A hrs to zero.

Selects BATTERY #2.

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

Green LED indicates parameter displayed.

CHARGE EFFICIENCY FACTOR of selected battery displayed as percentage.

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

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

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

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

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

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

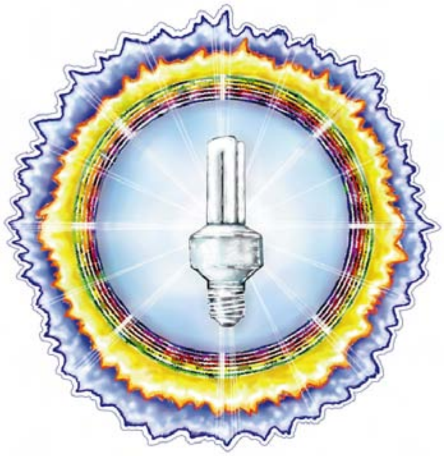
CHARGED V sets the Voltage the battery must be above to be considered full. Default value = 13.2V or 26.4V Sets default automatically for 12V or 24V systems. Range 13–40V in 0.1V increments.

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

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

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

Mfg. by Cruising Equipment Co. **6315 Seaview Ave. NW Seattle, WA 98107 (206) 782-8100**



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Issue #40 April / May 1994

Features

GoPower

Homebrew

Things that Work!

Cover: A Horlacher Sport Two electric vehicle and wind turbines in Switzerland. Story on page 51.

Fundamentals

Columns

Regulars

Access and Info

Access Data

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Flowers in the Spring

Every year Spring amazes me. Everything starts growing anew. This issue of *Home Power* celebrates renewable energy's spring — a time for new ideas and new devices. And spring seems to be happening everywhere for RE. A German company is marketing hydrogen hydride/ fuel cell systems. This spring sprouts a bumper crop of new wind generators. PV modules, made in Australia, are now finding homes here in America. Why RE is sprouting everywhere!

Maybe an idea obtains enough veracity to suddenly become apparent to everyone, everywhere. Maybe renewable energy's spring has finally arrived and we can enjoy its flowers.

Richard Perez for the entire HP Crew

People

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Linda Wallin-Smith
Michael Welch
John Wiles

"Think about it…"

"…But the truth is all life is one life. There is only one game in progress. There is one race, many different shades….Truth is truth. If you hurt someone, you hurt self. If you help someone, you help self. Blood and bone is in all people. It's the heart and intent that different."

The Real People
Mutant Message Downunder

Solec
full page
black and white
on negative

this is page five

Above from left to right: Betsy Hart, Paul Wilson, Jean Castonguay, and Sue Castonguay on the porch of the Castonquay's solar-powered cabin.

Two In Maine

Christopher LaForge

Last August Amy and I traveled to Maine to install two solar electric power systems in remote locations. While both systems were in the same area, they were quite different in their scope and intention. One system, for Jean and Sue Castonguay, was needed to power their "little cabin" on top of their "little" mountain. Long cables allow them to move the sun's energy to their shaded haven. The second system, for Amy's brother Paul Wilson and partner Betsy Hart, was needed to power their efficient passive solar log home while they finished construction.

A few years back, when Amy and I started working in the renewable energy field, Paul Wilson told us we'd have to get over there some day and build him a system. In the interim his original house burned to the ground (with notable fireworks) so a new one was in order. Two summers ago Amy and I joined Paul's neighbors (over 100 of them) in an old-fashioned house raising. The passive solar log home was designed with a roof angle appropriate for mounting photovoltaic (PV) modules. Betsy and Paul were finishing their passive solar home and wanted to solar power the rest of the carpentry. Our plans for solar electric systems began in earnest.

Paul had several friends interested in independent clean power sources. So we planned two systems. Working with Bob-O Schultze of Electron Connection, we used a computer program, the "Energy Master" developed by Richard Perez, to size the systems.

Jean and Sue's System

The cabin had been Jean and Sue's dream for many years while they roughed out the site and camped in a trailer. This system is an example of "long" distance power transmission from a sunny site to a shaded one. Their cabin is nestled in the trees 350 feet from their power shed. Three 1/0 cables transmit 220 vac from the power shed to their cabin.

The first step in figuring the size of the system — the number of photovoltaic modules, batteries, etc. needed — was to tally the energy consumption. Jean and Sue wrote down their appliances, the power consumed, and the estimated number of hours used per week. They listed appliances powered by ac and DC, and prioritized them in order to size the inverter. Jean and Sue sent us their consumption estimate worksheet (see Table). We worked up three options for them: a 12 PV design with a Sun Frost fridge (about $12,000), an eight PV design (62% of consumption) with the fridge (about $10,000), and the same design without the fridge (about $8300). After a site survey and much discussion, they chose the third option.

The site survey at Jean and Sue's cabin showed us a cabin shaded in a mature forest with an old dam on a creek about 300 feet to the south and west. The potential hydro site was much sunnier. By using our

Solar Pathfinder, we found one spot to be the best solar site within reasonable proximity of the cabin. (The Solar Pathfinder is an instrument that shows the amount of sun reaching a particular site over the course of a day, throughout the seasons of the year.) The sunny site lay about 350 feet from the cabin and would house the “energy shed”. We planned to build a solar powered system with the ability to add on a hydro unit and possibly a wind turbine as the years pass.

Jean and Sue's Energy Consumption

No.	*Inverter Powered Appliance*	*Run Watts*	*Hours /Day*	*Days /Week*	*W-hrs /day*	*%*
1	Chest Freezer 5 Cu.Ft.	110	8.00	7	880.0	23.8%
1	Mr.Coffee	900	0.50	7	450.0	12.2%
1	Refrigerator SunFrost RF-12	42	8.50	7	357.0	9.6%
1	Washing Machine	800	1.50	2	342.9	9.3%
1	Ceiling Fan	50	6.00	6	257.1	7.0%
1	Toaster	1500	0.17	7	255.0	6.9%
1	Television Set	85	5.00	4	242.9	6.6%
4	Lights-Compact Fluorescents	15	4.00	7	240.0	6.5%
2	Lights-Overhead Circle Fluor.	22	5.00	7	220.0	5.9%
1	Stereo	50	4.00	6	171.4	4.6%
1	Vacuum Cleaner	700	1.00	1	100.0	2.7%
1	Lights-Halogen Outdoor Flood	45	2.00	7	90.0	2.4%
1	Video Cassette Recorder	45	2.00	4	51.4	1.4%
1	Kitchen Mixer	300	0.20	2	17.1	0.5%
1	Sewing Machine	80	0.50	3	17.1	0.5%
1	Blender	350	0.05	2	5.0	0.1%
1	Can Opener	100	0.10	2	2.9	0.1%
	average energy consumption in Watt-hours per day				3699.9	

Long on Batteries, Short on PVs
Jean and Sue’s system was designed for “cabin” use, not full time living. Eight PVs charge the system all week during virtually no consumption. Eight Trojan L-16 lead-acid batteries store 1400 Amp-hours. On weekends and vacations the system experiences its large demand cycles. When the sun hides or a lot of folks show up to celebrate, Jean can fire up his 8000 watt diesel genset to charge the battery bank with the charger option in his Trace inverter.

The system supports a 220 vac deep well pump and other 220 vac loads (mainly power tools). Their Trace 2512 inverter teamed with the Trace T220 autoformer provides 110 vac, 220 vac, and 12 VDC to the power shed and ships 220 vac power to the cabin. At the cabin the power is used as 220 vac or split into two legs of 110 vac power. Jean and Sue’s main electrical loads will be lighting and home-making type loads. While construction continues though, the system will be providing much of the power to complete the building. The system design is a bit long on batteries and short on PV’s, but remember that this is a cabin and not a dwelling used year round.

The Energy Shed
Many hands make light work! Paul joined Jean, Amy and I in designing an energy shed that would be: 1) made in three pieces; 2) completely constructed and wired at Paul’s woodmill; and 3) put on trucks, driven to Jean’s site, and installed on the foundation. Jean likes to do things in a *big* way.

The three pieces consisted of: the battery pack (eight Trojan L-16’s) complete with interconnects and 250 Ampere DC circuit breaker; the shed with all components wired in and tested (the delicate equipment was removed for trucking); and the shed roof with the PVs mounted and wired (eight MSX-60 Solarex PV modules).

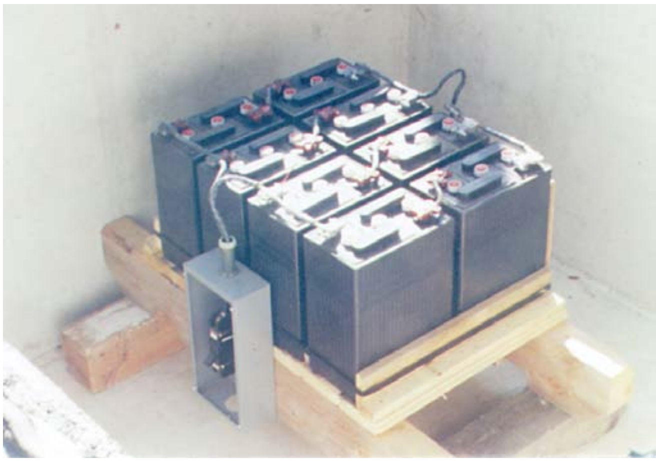
Jean had acquired a cracked septic tank from their local supplier and sank this perfect cellar six feet into the ground at our determined sunny site. Once all the construction was done at the woodmill, all that was left was to load ‘em up and move ‘em out! Having the roof on the ground made wiring the modules easy. Wiring the system and testing it at the woodmill was more convenient than doing it all on a remote mountain top.

Having Jean as a client solved many problems. He had laid 350 feet of 1/0 copper (three conductors) from the shed to the cabin. So the day we arrived, Jean put the power shed pieces together, using his pulp truck, and we made the connections on site.

Changes and Attitudes
The system can expand to meet future needs. The cellar has room for another eight batteries, the roof can

Above: A boom truck lowers the completed power shed onto its foundation.
Below: The roof, with PVs already mounted and wired, is set on top of the power shed.
Photos by Christopher LaForge

Above: Jean guides the batteries safely into their new underground home.
Below: The batteries wired up and ready to go.
Photos by Christopher LaForge



hold four more PV modules, or the Trace 2512 inverter can be stacked. There are many possibilities. In the long run, more PVs, a micro-hydro unit, or a wind turbine will be added to make the system "more renewable". For the short term Jean and Sue do most of their cabin work and living off solar generated electricity. Now they use solar power to put the finishing touches on their mountain hideaway.

The fact that Paul and Jean were in on the project made for many unique solutions. Jean has access to a lot of 1/0 and larger cable, equipment of all sorts, many skills, and one of the best attitudes toward a project I have yet to encounter. Working at Paul's woodmill (outside of East Livermore, Maine) was convenient, enjoyable, and — when the going got tough — supportive. Paul has a knack for overbuilding ("built

Above Left: The interior of the power shed with inverter, controls, instruments, and safety disconnects.
Above Right: An exterior photo of the completed power shed with eight PV modules on its roof. The batteries are housed underground to keep them warm during the winter.
Photos by Christopher LaForge

rugged") and a tendency to do a job right. Throughout the process of building, wiring and testing the energy shed, Paul was there with a grin and a skilled hand. If this sounds like the clients from paradise, so be it. These Mainers are good people.

The Frosting on the Cake — Paul & Betsy's System

Time was waning on our visit and we wanted to set up our family folk before we headed back to bring in the garden.

Paul and Betsy, like Jean and Sue, began the design of the system by figuring their estimated energy consumption. They don't have much interest in TV, but Betsy, who is an MD, uses a computer. They like simplicity so they won't be using lots of kitchen gadgets, but the Cuisinart does make great pesto. Paul and Betsy will power their well water pump and clothes washer as well as power tools, lighting, and communications. They were not sure of their final load profile, but they did know how much they wanted to spend initially. By starting small and planning for expansion Paul and Betsy get clean solar power now and the ability to grow as the need arises.

Jean & Sue's System Cost

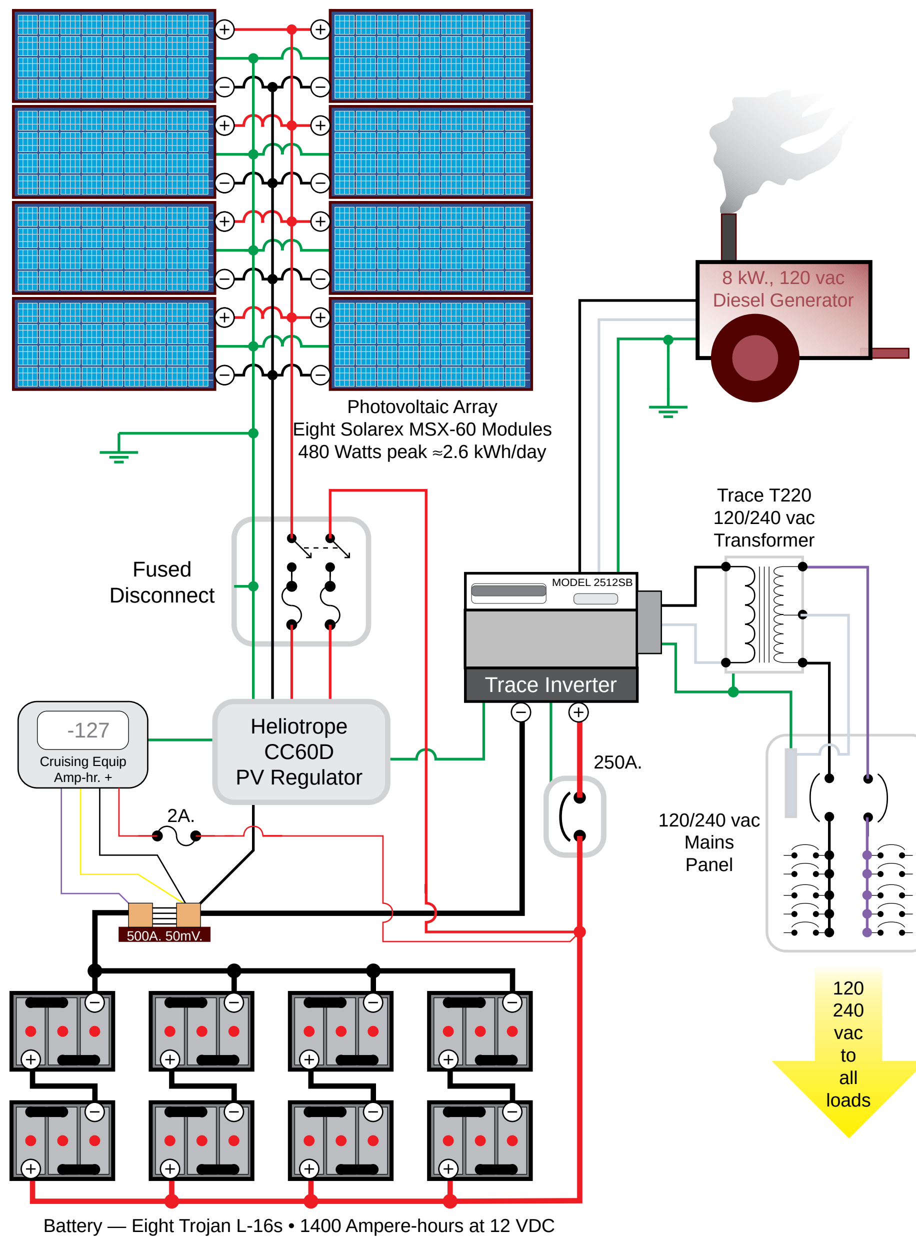
No.	*Item Description*	*Type*	*Item Total*	*%*
8	Solarex Photovoltaic Panels	MSX-60	$3,095.60	36.8%
8	Trojan Batteries	L-16	$1,560.00	18.5%
1	Trace Inverter/Charger	2512 SB	$1,521.88	18.1%
1	Amp/Volt/A-hr Meter w/relays	CE+	$370.00	4.4%
2	PV Mounting Racks	Solarex	$308.40	3.7%
1	Heliotrope Controller	CC-60D	$300.00	3.6%
1	Trace 120/240 Transformer	T-220	$295.00	3.5%
1	Heinemann Circuit Breaker	GJ1	$280.00	3.3%
1	Conduit,fittings, etc.,est.	3/4"	$200.00	2.4%
24	Hydrocaps	L-16	$180.00	2.1%
10	Battery Interconnect Straps	2/0 CU	$87.50	1.0%
1	Fused PV/Cont. Disc. Switch	30 AmpDC	$65.00	0.8%
2	Battery/Inverter Cables	Trace	$40.00	0.5%
1	Fused AC Disconnect Switch	30 Amp.	$38.50	0.5%
1	PV Interconnect Junction Box	Rainproof	$18.00	0.2%
50	PV to Battery Wire per ft.	#6 THHN	$16.50	0.2%
44	PV Interconnect Wire per ft.	#10 USE	$14.08	0.2%
1	Ground Rod w/Clamp	8'	$12.95	0.2%
2	Fuses	RK-5	$9.00	0.1%
28	PV Spade Terminals	3M	$5.60	0.1%
		Total Hardware Cost	$8,418.01	

You can design systems many different ways. Paul and Betsy used their budget and the idea of expansion flexibility to determine their design. We talked about how to slowly build up their system and chose components to that end. (For example, we chose a large charge controller and inverter).

We started with the idea that they wanted to spend something in the $4000 range. We designed a system that can handle a lot more PV's (60 Amps total) and that would provide the kind of power required by continuing construction (large surges for table saws, sanders etc...). Currently they have four 60 Watt Solarex MSX-60 photovoltaic modules to produce electricity from the sun, and four Trojan L-16 lead acid batteries for 700 Amp-hours of storage at 12 Volts. With a Heliotrope CC-60D charge controller and a 2500 watt Trace 2512SB inverter, they can get on with life well within budget.

Betsy and Paul plan to "load regulate" or conserve during cloudy days. When necessary, back-up charging is available by one of Paul's curious early projects — grid power from his

Jean and Sue's System Diagram



The Power Shed Concept

A power shed is a small building with the PVs mounted on its south facing roof. The energy processing electronics like instruments, inverters, and controls are located within the building along with the batteries. Here's why the power shed concept is catching on.

• ***Location.*** *Not every home has consistently great solar exposure. Photovoltaics make electricity directly from sunlight. No sunlight means no electricity. It is vital that the PV array be located in the sunniest spot possible. Note how both power sheds in this article were precisely sited using sun charts generated by a Solar Pathfinder™. The power shed allows placing the array in the best available spot.*

• ***Efficiency.*** *All the system's low voltage components are located in a single compact place. This keeps the low voltage DC power lines between the PV array, the controller, the battery, and the inverter as short and direct as possible. The power shed makes for high system efficiency and low cable cost. All power is exported from the power shed as 120 or 240 vac from the inverter.*

• ***Safety.*** *Let's face it, batteries and electricity can be dangerous. Installing the system in an outbuilding protects the PV-powered family from the potential chemical and fire hazards inherent in any system. If there is a disaster, such as a battery explosion or fire, only the power shed is affected and the home and its occupants are spared.*

wood mill through Maine's longest extension cord via the inverter's battery charger (SB) option!

A Temporary Energy Shed

They chose a system with great expandability and one that provided serious power — now, for construction and later, beginning life there. When the construction is done we will install the system permanently on their house, with the PVs on the large south-facing roof. But for the short term having the system outside the house and out of the path of traffic would make construction much easier. An old shed ("My first shop," said Paul) was forklifted out of the nearby woods and *voila*, the poor person's energy shed!

Betsy and Paul's home also uses a power shed. While less fancy, it does the job just as well.
Photo by Christopher LaForge

Even though this would be a temporary installation we still included all of the necessary safety devices in the setup. We installed fused disconnects and breakers in all the right places. We stress the importance of installing safety equipment and proper grounding on every system — even temporary ones.

The system is about half the capacity of Jean and Sue's and did not include the 220 vac autoformer. Their system is designed with expansion in mind. Once again the modularity of solar power systems work to make power an immediate reality even on a small budget. The current use of the system is construction — recent reports indicate great success. There's plenty of juice for the table saw, circular saws, drills, sanders, lighting....

The family system went up in two days, with plenty of great laughs, and we left Maine with two more dwellings powered by the sun.

*• **Hassles.** Building codes are just now catching up with what PV pioneers have been doing for years. Antiquated codes can increase the complexity and cost of a system installed inside a dwelling. If the system is located in an uninhabited and locked outbuilding, then the codes are more relaxed. Insuring the home will cost less if the system is located in a detached building.*

Power Shed Design

Here are a few rules of thumb for power shed construction.

*• **Location, Location, Location.** If you're building the shed make sure it's in the best place. A sun chart is essential.*

*• **Roof.** Make sure that the South facing shed roof is at the proper angle (your latitude) and has room for twice as many PV modules as you are initially installing. Every system grows, and it's great to have room on the roof to add more panels.*

*• **Battery Compartment.** Using a power shed is no reason to disregard safety procedures. The battery should have its own ventilated compartment within or under the power shed. The system is too valuable to risk a fire or explosion fueled by hydrogen from a gassing battery.*

*• **Door.** The shed should have a stout door with a secure lock. Affix a sign to the outside of the door reading, "Danger, Battery Charging Area, No Smoking." I like following this sign with another saying, "I get my electricity from the Sun."*

Richard Perez

Solar-powered Smiles

Jean and Sue report successful use of their system also. They are finishing their construction with solar electricity and enjoying their visits to their solar powered cabin. Plans for expansion are regularly discussed and reports are all charged with the "spark" so often found in solar-inspired hearts.

Great Northern Solar is headed back this spring for a couple more systems! Word is out and success breeds success. We like our work and our work likes us.

Access

Christopher LaForge is the owner of Nomadic Fusion, a welding and installation service; consultant with Great Northern Solar; member of the MREA and IPPP; and can be reached at Rt. 1 Box 71, Port Wing, WI 54865 • 715-774-3374

Solar Depot
four color
full page bled
on negative

this is page 13

It's *How* Cold?

Linda Wallin

My husband Keith and I moved to our place in the Big Sky Country of Montana in February 1980. We shoveled snow out from under two pine trees, pitched a temporary shack of poles, covered it with slab wood and reinforced construction plastic, lined it with cardboard, and smiled. Home Sweet Home! We lived in our makeshift quarters for three years, through all that nature could throw at us. We hired on to be tough.

In February 1983, we moved into our earth-sheltered, rock-roofed log home, which we built with a saw, broadaxe, and hand tools, with horses to help with the heavy work. We drilled two water wells, using a Stover & Sons machine. Each well was over 140 feet deep, through mostly hard sandstone. Kerosene lamps, a many-handed Servel propane refrigerator, and a barrel stove were our luxuries, while we saved for a solar electric system. We told the power company that they could put the two bucks per foot for bringing in ugly overhead lines in a convenient spot where the sun doesn't shine very often.

Tracking the Sun
In January 1993, we installed our dream machine, a Wattsun tracker, carefully gripping eight 64 Watt Solarex MSX-64 photovoltaic modules. It was mounted on a pipe mast, which extends six feet above the south eaves of our turf and rock roof. We lucked out, and had a window of warm Chinook winds blowing to melt the Christmas snow off the roof, so we could carry the sun generator to its launching site.

We had previously erected a platform of used pallets and bales of straw with a wooden guard rail. A couple friends from down the road came over, and for a bribe of homegrown roast beef and trimmings, helped us install the tracker frame on the tall mast. With three of us on the almost-scaffold — Keith and I each lifting a side of the Wattsun and one of our friends acting as anchor — we slid the collar over the steel well casing. We obtained the casing free for the asking from an oil field company which was leaving the area. We then used a wooden mallet to drive the connection snug, leaving the mounting bolts loose. Then we could rotate the tracker to rig up the modules.

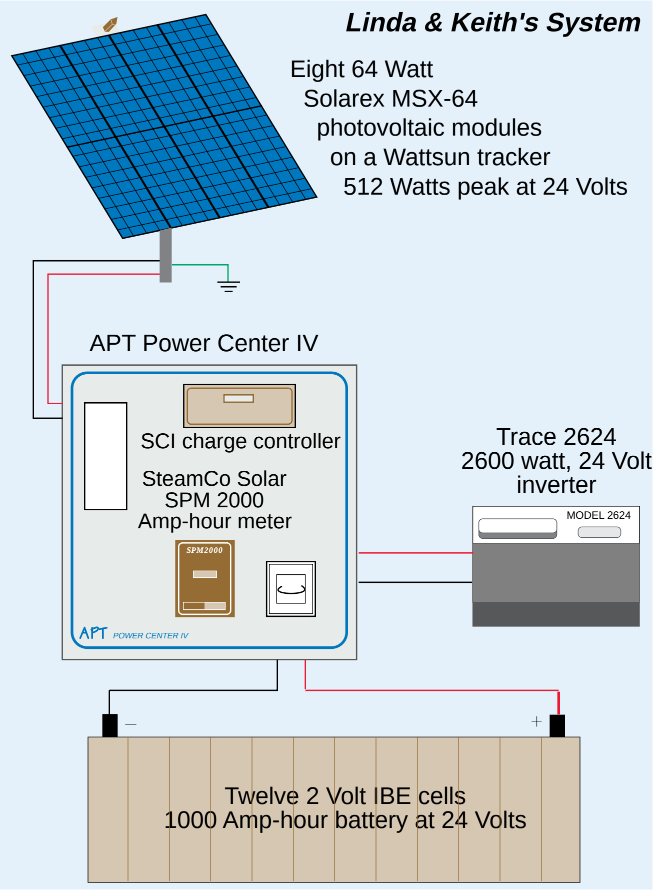
Wiring Fun
The Solarex photovoltaic modules went on easily, but after a half day in the breeze, we'd had about as much of that kind of fun as we really wanted. After a midday meal and a siesta, we decided to do the wiring on the solar circuit. Following the schematics we received from Sunelco, our dealer, we were able to bring the

© Linda Smith

current into the APT Power Center at 24 Volts DC with few problems. We did make several phone calls to the crew at Sunelco to make certain that we were still on track. They bent over backwards to help us with technical expertise.

We were familiar with direct current wiring, having done many emergency roadside repairs on heavy duty trucks in the past. We had also remodeled a few homes, and had better than average knowledge of standard alternating current circuitry. We had not worked with inverters before.

We got the juice into the house just in time. A day later, the outside temperature dropped to thirty-five degrees below nothing for the high. Nights were a lot lower than that. Let's put it this way, our brass monkey only took its mittens off once, and that was to salute us!



A Cold Tracker

The power for the Wattsun controller had been tapped into one module to give it 12 VDC, as per directions. When the weather was above zero, it worked perfectly, tracking the solar rays, which were low on the horizon. The reason for such a tall mast was to give us an advantage in short winter days as the winter sun reaches up over broken terrain and trees.

However, when the mercury stayed below zero for longer than seven days in a row, we began having problems with the Wattsun control unit. It would work fine all day, reset to the east after dark, then fail to get going the next morning. We'd be on the roof, with me holding a ten foot tall platform ladder for Keith as he eased up to the controller and replaced the fuses without gloves. The tracker would then usually be great until the next morning, when the process would be our first teeth-knocking chore. We called Ron Corio, president of Array Technologies. He suggested that we use silicon lubricants in the ball joints of the tracker, and instructed us to make a few internal adjustments.

The problem continued, as did our deep freeze weather. We reported this back to him. His company had not had this kind of difficulty before, but he did have an idea. He made a version of the Wattsun controller with a long positive lead wire, which we ran directly to a 24 VDC circuit breaker on the APT Power Center. The new model has 8 Amp fuses in the box. Down in the comfortable house is an inline fuse holder with a 4 Amp cartridge. Instead of depending on a small nickel cadmium cell in the controller, we draw off our 1000 Amp-hour battery storage of industrial two Volt cells. Twelve IBE cells make up a 24 Volt 1000 Amp-hour battery. (See diagram on pg.15).

We have talked with Ron several times since then, all with positive reports. He said that he will make a cold weather model available to other customers, upon request.

Home-grown Power

Since the new controller was installed, we have not had to change any fuses. We have had eight 24 hour periods during which our power usage exceeded the solar gain. These gaps were not in succession. We sized the system to provide for ten days of excessive draw down, without firing up a propane-powered battery charger. As soon as a gap occurs in clouds, the Wattsun tracker zeros in on the rays, and the SPM 2000 digital monitor shows inbound, clean, and natural home-grown power.

We listen to Canadian Broadcasting Company offerings on AM from several prairie provinces, all many hundred miles away, so we had trouble with compact fluorescent lamps. The buzzing was unbearable, so we returned them and went to 24 VDC incandescent bulbs. The same type noise is a problem when we use our Trace 2624 inverter. We are working on corrective measures now.

All things considered, we are proud to be involved in alternative power, and have no qualms about recommending it to anyone.

Access

Linda Wallin, Box 356, Roundup, MT 59072

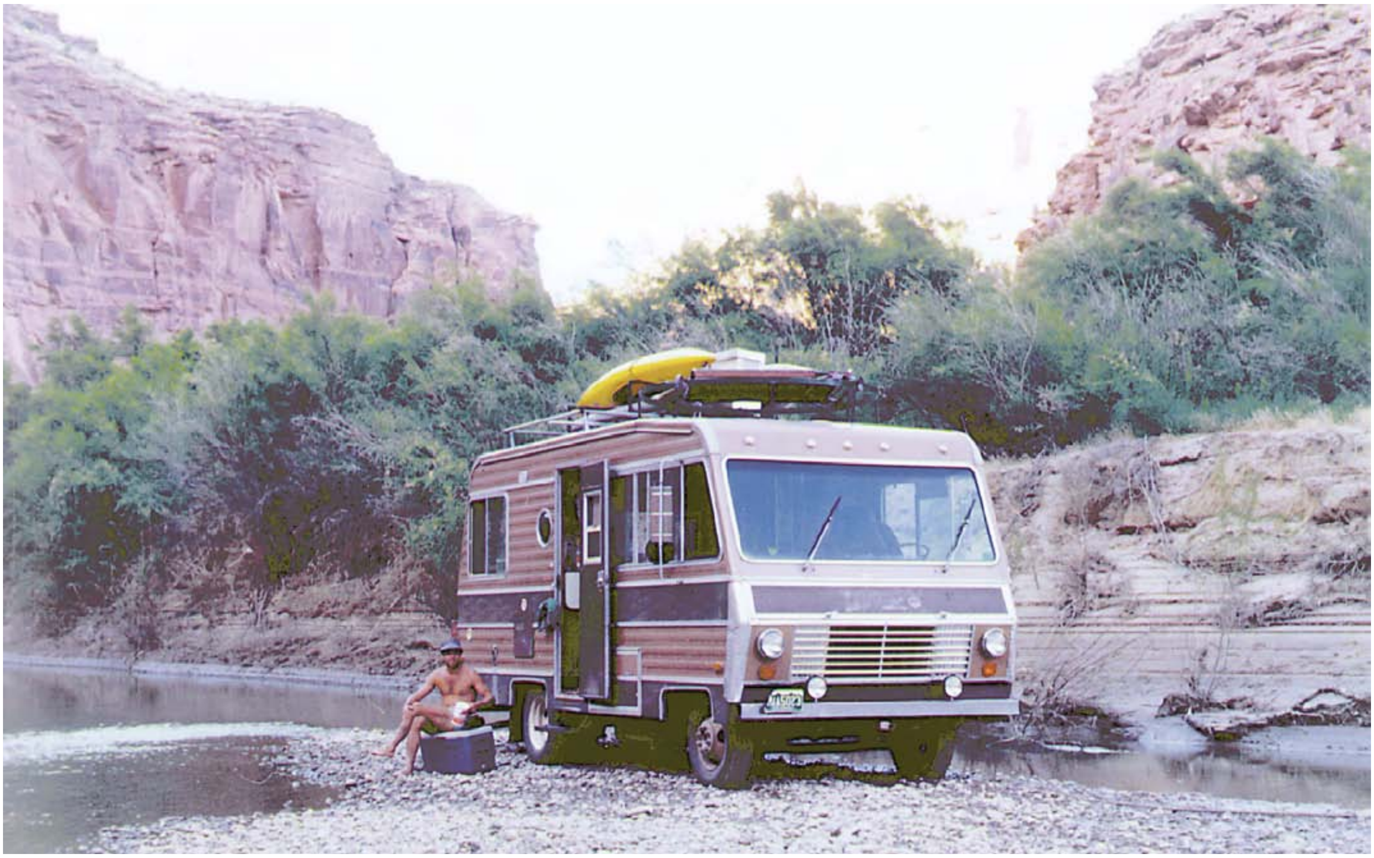
Burning Ring of Fire

Christian Brunner

After spending nine years in Germany going through the trades system as a Master Mechanic, I began to lose touch with the States. One year on the East Coast in our capital DC metropolitan area was enough to catapult me out West. In a time of "searching for what I want" I needed to be mobile, but having my "pack rat" tendencies, I opted for a 19 foot luxury villa on wheels to haul all of my tools and toys. I am a mobile mechanic. "Have tools, will travel." Before coming to Colorado, I had never heard of Zen and thought solar power was too expensive to consider. I met with some friends of friends, off-grid, behind Fort Collins in the mountains. Seeing their solar systems turned me on.

Around Christmas 1992, I visited friends in the lovely town of Crested Butte, Colorado. Before traveling to meet them, I arranged for an extension cord and 110 power outlet to be available. We got there wanting to have a nice evening and enjoy some good Colorado beer, but disaster had come upon me.

The landlord found out there was a dog — not just one, but two dogs on the premises, and too many people there. The only person on the lease was sunbathing in Costa Rica. So when I pulled up with my Dodge Titan, there was no power to be had. We spent the next five hours running around looking for a stupid 110 power receptacle that I could weasel my 200 foot extension cord in. At 10 below, my heater fan was running nonstop. A definite turning point in my life!



At that time I had already started on my plans for a solar electric system. After that journey, I ordered the stuff! Due to *Home Power* magazine, I was able to find companies and get info to help me along.

Ring Rack of PVs

Having the technical and electrical know-how and the tools, I began construction. I wanted to drive with the panels flat on the roof, yet be able to park anywhere and still get full sun on the array. That's when the idea of "the burning ring of fire" hit me.

Gary, of Indian Peaks Iron Works in Boulder, helped with structural know-how and the use of his shop. I rolled a 20 foot piece of band iron into a circle, welded legs on it and platforms on the legs. Then I riveted it on the roof of the Titan. The Burning Ring of Fire was born. The four foot by four foot sheet of QuadLam (four ARCO M52 in series) photovoltaic modules (100 Watts total) on a square rests on the ring. The ring can rotate 360 degrees and can be raised to any angle at the same time.

I used heavy steel for the ring and opted for electrical conduit for the QuadLam rack — strong, plated, and cheap. Conduit is great to work with, just avoid breathing the pretty green fumes when you weld! [*Ed. note: Zinc poisoning is a reality! Use heavy ventilation and safety precautions.*] I welded it together for next to nothing. A little dumpster diving does everyone some good — the true meaning of recycling!

Wiring PVs to the RV

Now I ran my wires. I welded a box for the six Trojan T-105 batteries (660 Amp-hours storage) and bolted it to the frame of the Titan. The batteries are fitted with the wonderful HydroCaps. I was able to hook right into the existing power system of the RV with breakers and all. I hooked up the Statpower PROWatt 800 watt inverter, SCI charge controller, and the newest addition to the system, a Cruising Equipment Amp-hour meter. What a nice but expensive piece of equipment! It's great to see at a glance what's up with your power bank. I run the following: an 800 watt microwave, a water pump, power tools, heater fan system, stereo, TV-VCR combo, juicer, blender "for the smoothies", and various interior lights.

Solar Freedom

I've been off-grid for over a year now and enjoy every minute. Positive events are snowballing in my life. Solar has given me the freedom I need. I plan on doing this for as long as it takes. That freedom was given in part to me by *Home Power* contributors. The examples

of people off-grid (I thank you all), and the tech info, and yes, the advertising (without which I never could have found such great prices) — I would not be here now without you!

The Titan has gone from the mountains of Colorado to the deserts of Utah. Helped in the building of sets for the motion picture *Geronimo*. Traveled across the states to Ohio, New Jersey, and then a four month stay with family in Maryland for Christmas. Now it's back out west, and talks of Baja are tickling my ear. Who knows? After that, no plans, no bills, no binds. Stop and stay where I want, for as long as I want. Everyone should take things a little easier. Life is so short and unpredictable — take the time to see our beautiful country. There is so much to enjoy.

I pull my work horse '65 Land Rover behind me as a commuter/desert vehicle. A 250 Kawasaki enduro is mounted to the front bumper. In my studies in Germany we found that 80 percent of the energy consumed by a vehicle's life span is in its production. Keep them old boys on the road!

I'm set on solar power. I don't like the idea of being bound to an extension cord or a stinky loud generator. When I do find my place in the states there will be a solar system along with it. Go Solar!

Access

Christian Brunner, POB 1429, Moab, UT 84532

Come Celebrate Summer Solstice!
June 17–19, 1994

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Solar Electricity
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Energy & the Environment
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Photovoltaic and Wind Electrical Systems

Keynote Speaker

Ingrid Kavanaugh
US Youth Advisor to the United Nations Environmental Program, Founder of Children's Alliance for Protection of the Environment

Admission

	Daily	Weekend Pass
Adult	$5.00*	$10.00*
Junior (13–17) & Senior Citizen	$2.50*	$5.00*
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*does not include evening concert

$35 yearly MREA membership includes: entrance into the 1994 Energy Fair, 1994 Energy Fair T-shirt, quarterly newsletter subscription & more

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Friday, June 17: 7:00 PM: Center Stage's "To Save the Planet" An Environmental Musical for children of all ages (1–100!). Performed by New Hope Productions Children's Theatre Troupe. Admission $4 Adults, $2 Children

Saturday, June 18: 7:30 PM: LJ Booth: Singer/Songwriter with agile fingerpicking, a wonderful sense of spontaneity, and inherent sensitivity. Admission $6

Special Guest Appearance — The Planetary Ranger

Saturday, June 18, 12:30 PM & Sunday, June 19, 12:00 PM Families will enjoy a fun-filled hour with The Planetary Ranger. An environmental enlightenment through song and stories.

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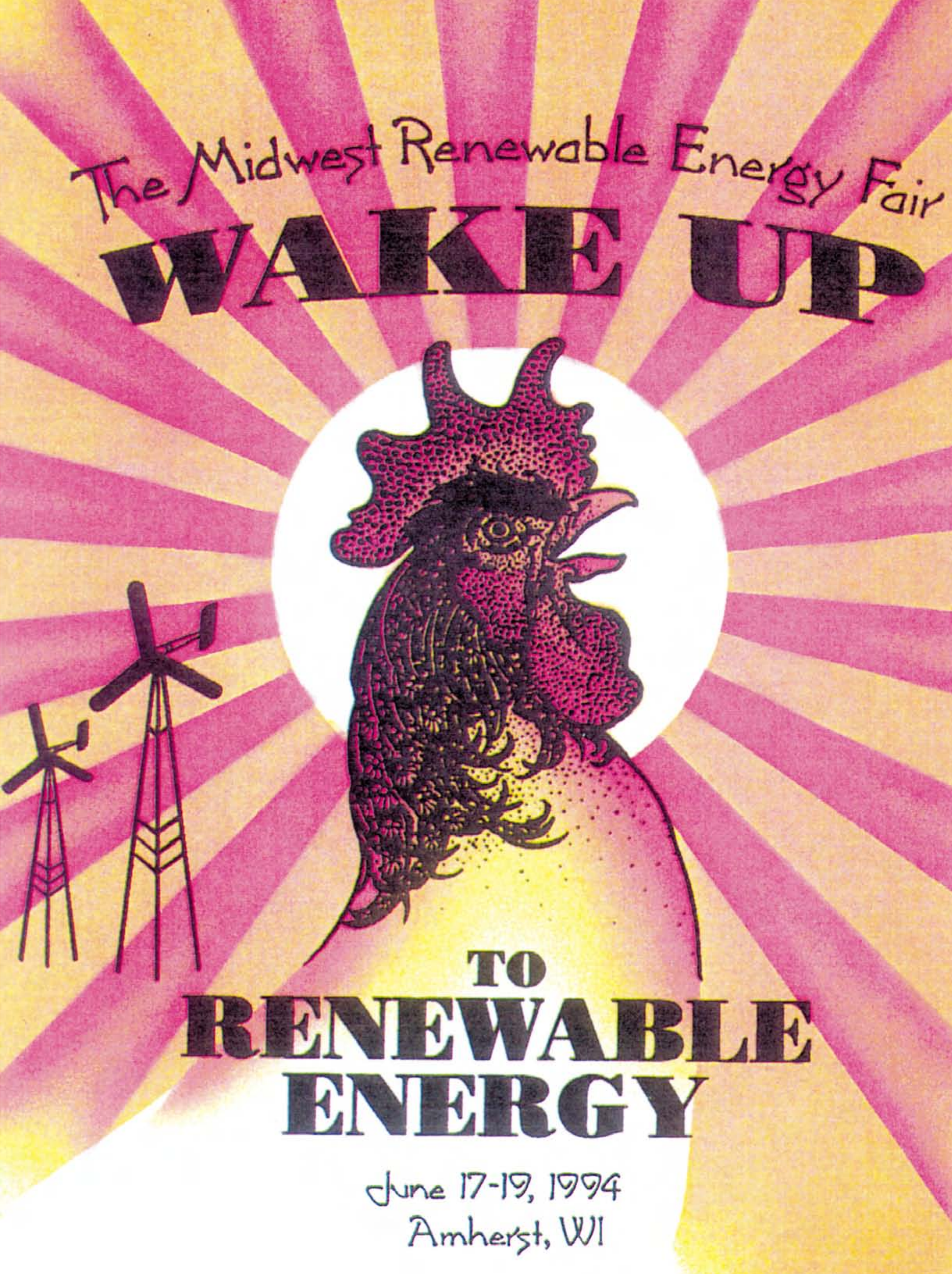

The Midwest Renewable Energy Fair
WAKE UP
TO
RENEWABLE
ENERGY
June 17-19, 1994
Amherst, WI

Getting Active About Passive Solar

Emilis Prelgauskas

Australia has traditionally had access to cheap and adequate supplies of energy. The environmental degradation generated from fossil fuels is dispersed over the large land mass away from the relatively small populated portion of the continent. In recent years environmental concerns and supply limitations on utilities has sparked some attention to energy conservation and efficiency. However, efforts in this area are more fragmented than in other countries — notably no weatherization industry is envisaged and a traditional HVAC (Heating, Ventilation, and Air Conditioning system) approach still holds sway.

Government attention to defining energy efficiency resulted in a "Five Star Rating System" for building design. Based on cold climates in Europe, it has some application in the cooler latitudes and high lying ground on the eastern seaboard of the continent. However, equatorial tropical and central continent arid climates are not adequately considered in this approach. Practitioners in Australia look to innovations in other countries with similar climates, notably in parts of the U.S.A., for guidance.

Energy Efficiency

The conventional view of integrating energy efficiency into building design by the HVAC industry is to focus on the efficiency of plant and equipment. Sometimes the focus is on appropriate fuels, and very occasionally the focus is on the environmental bona fides of the production process for those fuels. The results are high efficiency appliances, low wattage fluorescent lighting, and renewable solar energy.

Passive Solar

Building design looks to energy flow control to achieve energy efficiency. This includes insulation, thermal mass, barriers to wind chill, moisture and interior convection, and solar access for winter passive heating. There are several limitations to this approach. It assumes that the weather is predominantly the enemy. It takes a defensive stance to energy flow. It accepts untested some of the assumptions about comfort from the HVAC industry.

In arid climates, summer cooling requires the most energy; modest amounts of winter supplementary heating maintains comfort. Here, the passive solar approach has only limited application. A building built to passive solar layout and acting under summer conditions still warms internally. Occupants and operating equipment eject heat, irrespective of the effectiveness of passive solar features excluding external heat inflow. Homes become uncomfortable in mid-afternoon through the heat gain from householder, fridge, VCR, and other equipment operating through the day.

Air Conditioning

Consumers demand air conditioned buildings for comfort throughout the day; they've grown to expect a constant condition environment. Thankfully, the development away from reverse cycle to evaporative and subsidence tower type air conditioning systems is reducing the energy consumption for air conditioning.

Critics point to the reduced efficiency of these less energy intensive air conditioning systems. They compare low energy air conditioning performance to traditional reverse cycle constant conditions, and disregard the latter's demonstrated high energy consumption.

Micro-Climate

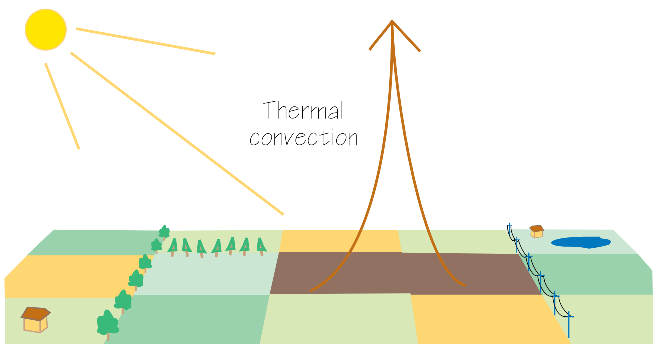
Proposals to create building comfort with nil energy input are subject to similar critique. Nevertheless, where comfort is defined as an appropriate mix of temperatures, humidity and airflow, air conditioning in arid climate areas can be achieved with no energy input. Instead, one uses the favorable aspects of the prevalent climate.

Application of micro-climate in building design takes a positive view of the weather. The forces of moisture, temperature, and wind are integrated to assist in internal space conditioning. Moisture can be introduced not only through subsidence tower design to create air flow, but can also be generated from internally and externally sited vegetation.

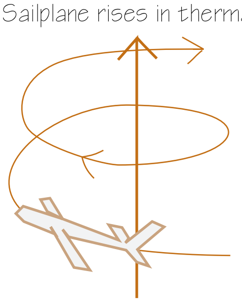
Traditional thinking uses wind forces directly by opening windows. In an arid climate, summer winds are hot and dust filled, making this approach impractical. Nevertheless wind can be used to generate high and low pressures around built form. This pressure difference draws internal air changes from adjacent external cool store areas. Temperature differences around buildings similarly generate internal airflow.

Below: Emilis Prelgauskas' home in Australia uses little energy for cooling during the hot dry summers. The building design makes use of prevailing winds and creates temperature imbalances to ventilate and cool the home naturally.
Photo by Emilis Prelgauskas

Thermal Flow



Sun shines on the land and warms it. Dark areas (e.g., pavement or freshly plowed earth) absorb more of the sun's heat than lighter areas. The air above these darker areas becomes warmer and rises.



Hot air rises!

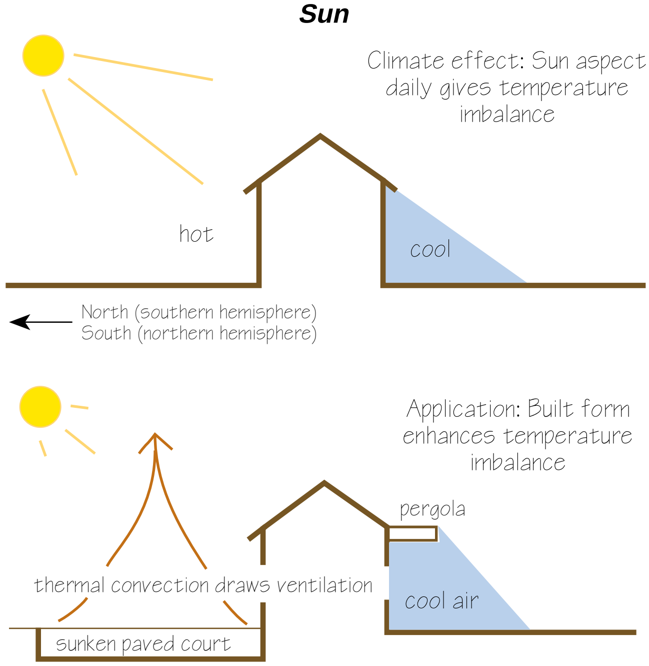
Empirical Experience
These temperature imbalances occur continuously in nature. Sun side features — features on the north side here in Australia and on the south side in the northern hemisphere — are heated above ambient temperature. Air in shaded locations falls below ambient. Warm air vented away by thermal convection is replaced by ground level inflow of cooler air. See diagram to the left for description of thermal convection, and diagram bottom left to see the application of this effect on buildings.

Sport aviators experience thermal convection first hand — such thermal convection from sun side features can exceed two meters per second. Now use this as a base line, and apply normal HVAC calculations to such a thermal (perceived as a duct). We calculate air volume movements of about 2.5 million cubic meters/minute inside the "duct". This suggests that such thermal convection applied to the sun side opening of a building generates about nine air changes per hour internally to the building.

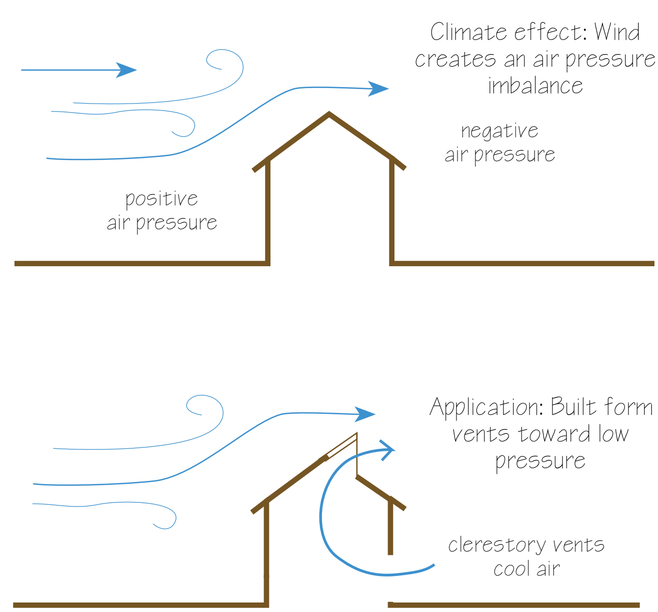
The task of designing buildings to achieve air flow without energy input involves integration. One must integrate building layout, landscape, and landform to maximize the sun side and shade air imbalances in terms of temperature, pressure and moisture.

Low Energy House
My home embodies these attributes — it is situated on a sun side open slope of sandy ground. My home incorporates a sunken pave courtyard on the exposed

Sun



Wind



sun side external walling with minimum fenestration. This wall is steel, with high reflectance, high R value insulation backing, and high thermal mass internal skin. On the shade side, covered pergola and ground level vegetation provides cool air for infiltration during the day. The majority of the building's windows face this space.

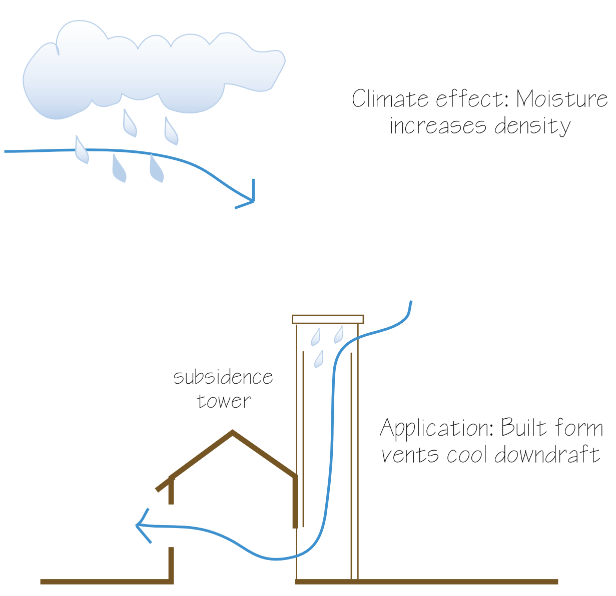
The Australian climate includes summer north winds. The building has a curved roof to a south clerestory. The low pressure created by the wind flow allows internal ventilation and air draw in from the external cool air store. See diagram on Wind on previous page, bottom right. Diagram below on Moisture shows how a subsidence tower could be used to cool a building.

The result is that this home has a total power draw of less than one kiloWatt, allowing power production to be entirely from photovoltaics without generator backup. The inclusion of micro-climate principle to the building design has also achieved full energy sufficiency and a minimum impact of the environment.

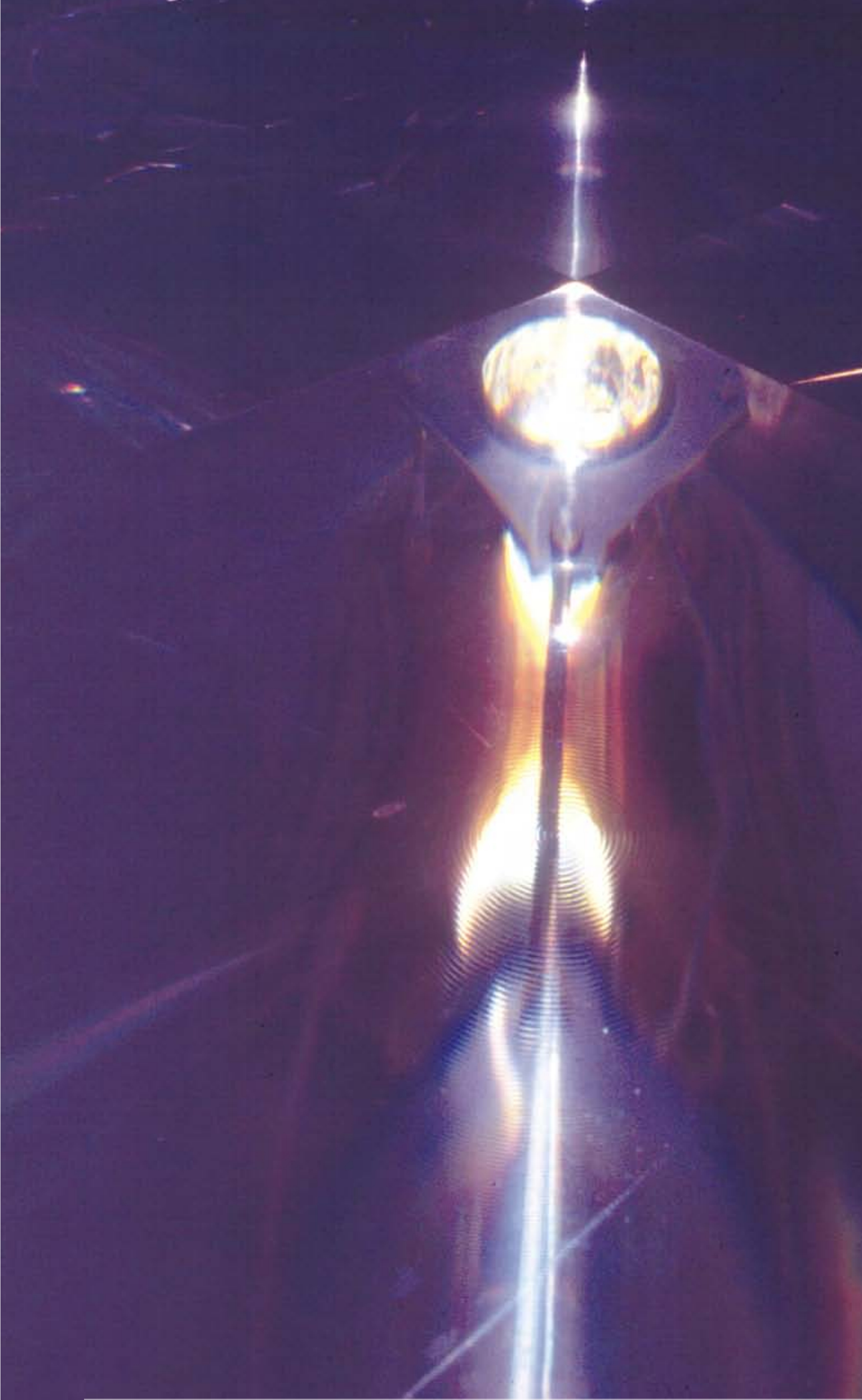
Access

Emilis Prelgauskas operates his architectural practice from this home built to the principles described in this article. The home is situated at Monarto, South Australia, which has an arid climate. The architectural practice specializes in energy inspections, retro-fit schemes and new buildings embodying energy efficiency. Emilis Prelgauskas, Architect, PO Box 1, Bridgewater 5155, Monarto, South Australia, Australia

Moisture



The Fire Within

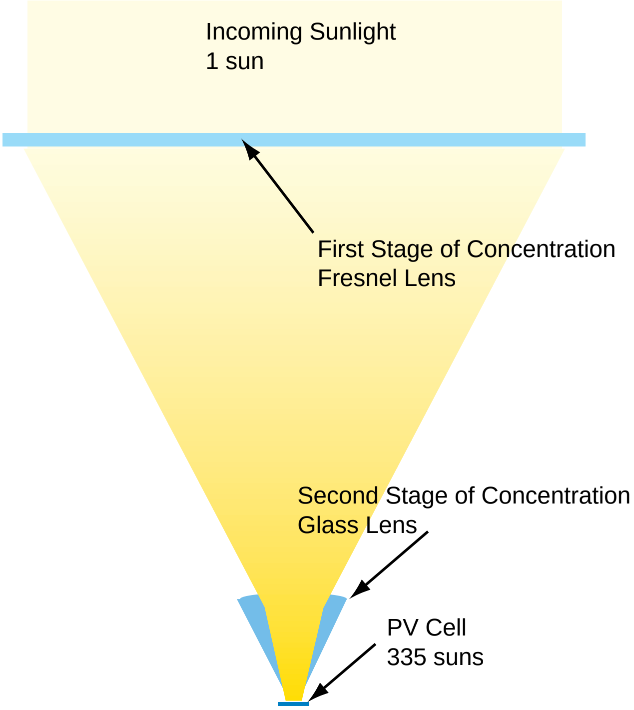


Richard Perez

A photovoltaic cell directly converts incoming sunlight into electricity. The more sunlight entering the PV cell, the more power it produces. PV concentrators gather sunlight from a large area and focus this light in a very small PV cell. PV concentrator technology has now come of age with 335 sun concentration and a price far below conventional flat plate modules of the same power output.

How It Works

In a vastly simplified nutshell, a PV cell has the happy ability to deliver 335 times more electric power if you feed it 335 times more sunlight. The strategy behind concentrators is to use inexpensive optical materials like glass and plastic to harvest vast quantities of sunlight. The concentrated sunlight is then focused on a miniscule PV cell. The principle is the same as using a magnifying glass to concentrate sunlight which ignites a bit of wood.



The only really expensive component in any form of photovoltaics is the actual PV cell. Photovoltaic cells are made from hyperpure silicon that is precisely doped with other materials. A single silicon wafer (most modules contain 36 of these wafers) could have been made into hundreds of computer chips or thousands of transistors. The hyperpure silicon substrates used to make PV cells are to say the least, very expensive. After all, the same amount of hyperpure silicon used in a single 50 Watt PV module could have been made into enough integrated circuits for about two thousand computers….

The materials used to make a concentrating PV module are virtually the same as a flat plate module, but the proportions are radically different. Flat plate modules use about 200 times more hyperpure silicon to make the same amount of power produced by a concentrator module. The remainder of the materials used by both flat plates and concentrators are aluminum, glass, and plastic — all inexpensive and easily recyclable.

So why aren't we all getting concentrated?

Only within the last year has PV concentration become viable. There were hundreds of technical problems to overcome before the concentrators became working realities. These problems boiled down to three major issues — tracking, reliability, and cost.

In this technical saga, I will use America's foremost PV concentrator developers, Midway Labs, Inc., as an example of performance and development. We, at Home Power, have been testing Midway's PV concentrators for over four years now. We've seen their concentrators mature from a technical curiosity to the most PV power for the buck. Here is how Midway Labs has increased concentration from 90 suns to 335 suns and reduced cost by 50%.

PV Tracking

Five years ago only a few people owned tracked PV arrays. Tracking means mounting the array on a movable platform which follows the sun's apparent daily motion. It is now commonplace to see systems with eight or more modules using a PV tracker to follow the sun. Anyone who runs price vs. energy output through a calculator will find that it is cost effective to track eight or more flat-plate PV modules, rather than adding more modules.

Only within the last three years has tracking become reliable and precise enough for concentrator use. A flat-plate module doesn't care if it's 10° from perpendicular. Midway uses advanced non-imaging optics to obtain 335 times magnification and still have a 1.75° acceptance angle, which is very wide for a concentrator. If a PV concentrator is not directly pointed at the sun, then its output is virtually nil.

The early versions of the Midway we tested used single axis tracking activated by the sun's heat. This scheme

Below: Midway concentrators at work on Agate Flat, Oregon. Note the Wattsun control head upper right.

was nowhere near accurate enough for concentration. The current Midway concentrators use two-axis Wattsun electric trackers that keep the concentrator within 0.25° of perpendicular to the sun in two dimensions. Over the last year, our Midway concentrator at Agate Flat has always pointed directly at the sun whenever it's shining.

Reliability

Flat-plate PV modules are super reliable. Concentrators faced the additional complexity of requiring a super accurate tracker, and getting rid of the increased heat focused on the PV cells. Electronic two-axis tracking solved the first problem. Hard electrical engineering work solved the second.

The PV cells used in concentrators are different from those used in flat plate PV modules. Actually, the concentrator cells are even more refined and even more expensive. They are designed to operate at the elevated temperatures and increased light levels produced by solar concentration. The reason that the concentrators are so inexpensive is that they only use a very small amount of this PV material. A single cell in Midway's concentrator is about the size of a dime (less than 2 square centimeters). This miniscule PV cell produces 9.5 Amperes under operating conditions. A single PV cell used in a flat plate module has an area of 100 square centimeters and a current of 3 Amperes. A Midway cell is producing over 150 times more current per square centimeter of expensive PV material. The problem with focusing all this sunlight on this small of an area is heat.

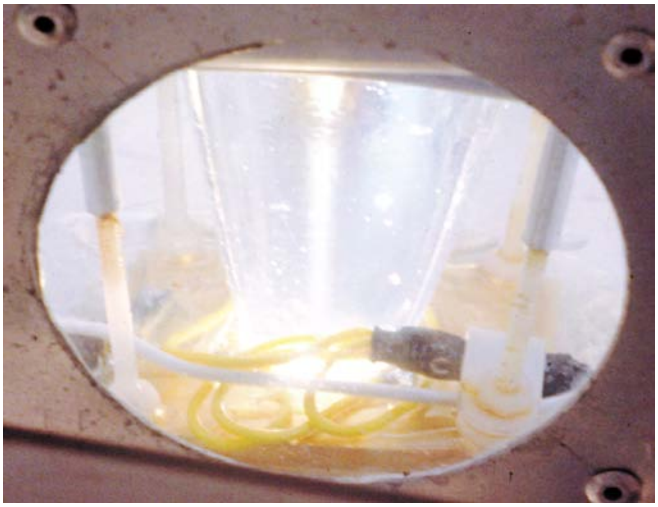
PV cells have the unhappy characteristic of frying and dying if they get too hot. Midway heatsinks each cell to the bottom of an enormous aluminum enclosure called a bay. This bay conducts the heat away from the PV cells so they stay cool and happy. The bay also holds the first stage Fresnel lens concentrator and the second stage glass concentrator. It took months of R&D for Midway Labs to find a satisfactory method of applying the conformal coating to heatsinks to protect the individual cells from intense light energy. After a summer of high temperature operation here on Agate Flat, our Midway PV concentrator is still making power.

Cost

The table here details the cost relationships between three different PV applications — a flat-plate untracked array, a flat-plate tracked array, and a concentrated tracked array like the Midway 8 module model. These retail cost figures show the distinct advantages of PV concentration. This table assumes six hours of average sunshine on 265 days per year. This is a conservative estimate of solar insolation and performance.

Time to Concentrate?

	Flat Plate Stationary	*Flat Plate Tracked*	*Concentrator Tracked*
# Modules	16	12	8
Peak Watts	960	720	680
W-Hrs./Sunny Day	5760	6048	5712
PV Cost	$6,400	$4,800	$4,300
Tracker/Rack Cost	$400	$1,450	$0
Total Cost	$6,800	$6,250	$4,300
$/KHW over 10 Yrs.	$0.45	$0.39	$0.28



Above: A look inside a working Midway concentrator.
Below: A view of the back of the Midway concentrator showing the Wattsun tracking mechanism.

Applying PV Concentrators

PV concentrators should be installed at site that receives dawn to dusk sun almost all of the year. Concentrators are more difficult to install and orient than flat-plate modules. If you are not handy with a wrench, then hire someone to install and tune your concentrator for you. Installation and tuning is well within the abilities of the average shade tree mechanic. So is the cost….

Concentrated Labor from Focused People

Over the last five years I have gained a profound respect for the dedication and abilities of Paul Collard, Rebecca Janowitz, Bob Hoffmann, and the rest of the crew at Midway Labs. These folks really know how to harvest sunlight. They created a solar electric power source that is now more cost effective than any other. Their PV concentrators are 36% less expensive than untracked conventional modules, and 27% less expensive than tracked regular modules. At less than $6.50 (based on retail price) per tracked watt, their concentrators are now the best deal in PV.

Everyone gets his fair share of sunshine. What counts is what you do with it.

Access

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Midway Labs, Inc., 1818 East 71st Street, Chicago, IL 60649 • 312-667-7863 • FAX 312-667-6577

Computers, Printers, and Inverters

Elliott S. Frank

When we first moved off the grid, I mentioned to a friend, also an engineer, that I'd be running my Macintosh SE off an inverter. The inverter, in turn, would be powered by a battery bank replenished by solar cells up on the roof. No generator. My friend said that I should get an uninterruptible power supply (UPS) to protect my computer from the vagaries of an inverter.

After pricing a UPS, I decided that the best course of action prior to spending any money would be a short course on power supply design. In my case, self-taught. I'm passing on the results of my self-education in this article. It's a bit simplified, and can probably be amended by any electrical engineer who has ever had to design a power supply. It does provide enough content to understand about how electronic gear will behave when powered by an inverter.

Power Supplies

While the problems of distributing electricity from a central generating station are better solved by ac, electronic devices require a constant (DC) voltage. This DC can come either from a battery (à la your Walkman), or from a power supply. The power supply takes the ac from the distribution network (the wall socket) and produces the DC voltages needed to power the circuitry. Power supplies are either internal, hidden inside the case of the electronic device, or external, like those little epoxy-encased "bricks" that plug into a wall socket and dangle a six-foot cord ending in some weird non-interchangeable plug .

Power supply designs come in two major flavors. There are "linear" power supplies and "switch-mode" or "switching" power supplies. Shape and location do not identify whether a power supply is a linear supply or a switching supply. The design assumptions built into each kind of supply make the difference as to how they function when ac power is supplied by an inverter.

Linear Power Supplies

The linear supply is usually the simpler design. The basic elements of a linear power supply, starting from the wall plug, are a transformer, to convert the input voltage to the voltage(s) needed by the equipment, a rectifier to convert the ac to DC, and a filter to smooth the irregularities in the DC voltage caused by the rectification.

One key in understanding how a linear power supply behaves on inverter power is the transformer. Transformers are designed to operate at both a particular voltage, and at a particular frequency. A transformer designed to operate at 60 Hz will be both warmer and noisier at 50 Hz. Noisier, as the mechanical resonances have been tuned to deal with 60 Hz power. Warmer, because the lower number of transitions per second result in more inductive heating. Running the same transformer on modified-sine-wave 60 Hz power from an inverter will also cause hum, as the "stair-step" transitions in the voltage will cause the plates of the transformer to move microscopically in response to each change in the voltage.

Another key to understanding linear power supply behavior is the filter. The filter design is usually based on filtering out the residue from running a continuous ac waveform through the rectifier. Rectifying modified-sinewave power results in a DC voltage with transitions for which the filter may not have been designed. The result is that a linear power supply may pass an "inverter hum" through to the circuitry it powers.

If an electronic device is designed to amplify a signal, whether from an radio signal or a CD player, a power supply that provides constant voltage regardless of load is desirable. A linear power supply has that characteristic. Add to that the low parts count and simple electronics content of a linear power supply, and you can understand why most audio electronics devices use linear power supplies.

The low component count also identifies why many of the little "bricks" are linear power supplies — a low DC voltage, with a low constant current requirement, can be generated at a low cost.

A linear power supply without a switch in the primary side will draw some modest amount of power as long as it is plugged in, whether or not the power supply is providing DC. The ac power is maintaining a magnetic field in the transformer core, and the transformer primary winding is also a resistance between two sides of the ac wiring. This results in a “phantom load” — a device that is drawing power whether or not it is switched on. (See *HP*#37 for more on phantom loads.)

Switching Power Supplies

A switching-mode power supply operates by transforming the input voltage at a high frequency — anywhere from 15 kHz to 150 kHz. The input voltage powers a high-frequency oscillator. The basic elements starting from the wall plug are oscillator, transformer, rectifier, and filter.

A switching mode power supply has a transformer, but the transformer is operating at a much higher frequency. Since the physical size of a transformer is related to its frequency of operation, the transformer in a switching-mode power supply can be a tiny ferrite ring. By moving the rectification to a much higher frequency, it is also easier to design a filter that removes all of the voltage changes that result from rectifying ac power.

Most switching-mode power supplies are designed to provide stable voltage levels, regardless of the input power characteristics. An electronic device labelled “120–250 vac, 50–60 Hz” probably has a switching-mode power supply. Since the input voltage is powering an oscillator, it does not need to draw power equally across all portions of the ac waveform. As a result, a switching-mode power supply operates equally well on utility power, on a generator, or on an inverter.

Most computers use switching-mode power supplies, as digital circuitry only operates in a digital fashion as long as its power-supply voltage is maintained within some very narrow and specific limits. The constant load presented by digital circuitry also matches a basic characteristic of switching-mode power supplies.

Since the input side of a switching-mode power supply is powering an oscillator, it could draw power whether or not the output of the oscillator was being rectified. As a result, almost every device with a switching-mode power supply has a switch in the input side of the power supply. Computers that power up from a keyboard switch use a battery to power the circuitry that monitors the keyboard.

Printers and Power Supplies

Computer printers can be divided into three major classes by the printing mechanism: impact, ink-jet, and laser. Each responds differently to inverter power.

Impact printers use some form of hammer to press a ribbon against the paper. Daisy-wheel printers press an entire character against the ribbon, dot-matrix printers press microscopic wires against the ribbon. Both systems use at least two electric motors and an electromagnet.

The motors in the printer are used to position the paper and to position the carriage assembly . The motors can be either “synchronous” motors or “stepper” motors. In a synchronous motor, the motor runs continuously, with the rotational speed at some multiple of the input ac frequency. Discontinuous operations, such as moving the paper or positioning the carriage assembly, are accomplished by use of an electromagnetic clutch. A pulse of current causes the clutch to engage, allowing the shaft rotation to be transmitted to the mechanism.

In a stepper motor, an input pulse to the motor results in the shaft moving a fixed fraction of a rotation. These motors are driven by a pulse train, not directly off the input current. Since the clutch assembly for a synchronous motor can be inside the motor housing, there is no way to simply examine the motor and determine if it is a synchronous motor or a stepper motor.

The striking device uses a pulsed electromagnet to hammer the wire or the character against the ribbon. All of these pulses are generated by the controlling circuitry in the printer. Pulses are only needed when the printer has to move the paper, the print carriage, or strike a letter. Since the power supply in an impact printer is called on to provide power for a varying load, a linear power supply is usually built into an impact printer.

The carriage mechanism in an impact printer is moving a mechanical device, so the power requirements for an impact printer may be rather substantial, up to 100–150 Watts. This large linear power supply may hum when powered from an inverter. Similarly, synchronous motors may hum, due to the modified-sine-wave power from the inverter.

Ink-jet printers also require at least two motors: one to move the paper and one to move the carriage device. Since the carriage device is an ink reservoir and some electronics, it is a smaller load than that the impact printer needs to move. The smaller mechanical load requires a smaller motor to move it.

Some ink-jet printers move the power supply out of the chassis, into a “brick.” Since the load is variable, and ink-jet printer pricing is highly competitive, this may well be a linear power supply. The power requirement for ink-jet printers is also low. The power supply for the Hewlett-Packard DeskWriter is rated at 22 Watts.

Laser printers fuse plastic beads containing pigment (“toner”) to the paper, using some combination of heat and pressure. A motor is required to move the paper though the mechanism. Another may be needed to position the mirror that deflects the laser beam to create the character images on the drum, and a third may be required to rotate the drum.

While all of the motors in a laser printer may be stepper motors, and hence insensitive to the characteristics of inverter power, the primary power-consuming component in a laser printer is not inverter friendly. Since a laser printer works by fusing the toner particles to the page using some combination of heat and pressure, a heating element is required. This results in each laser printer having a several hundred watt electric heater built into it. As Gary Burton, who installed our original solar electric system put it, "There are two things that you don't want to run off an inverter — electric heaters and phantom loads."

Solar Power and UPS

An uninterruptible power supply (UPS) is usually some form of a battery, an inverter, and a switch to run the load off the inverter when the input power is interrupted. The merits of the various designs — hot standby, continuous operation, and others — continue to be debated by the manufacturers of the devices.

Recognizing that a solar electric system is the same components as a UPS, scaled up to household size, the only missing feature is the "warning" that a UPS provides when the battery voltage falls below a given value. Adding a voltmeter across the inverter battery provides the same information as the little red light on the front of the UPS.

After my self-education, I decided not to buy the UPS. We did replace the impact printer with an inkjet, and put all of the little "bricks" that power the modem, the CD-ROM drive, and the printer on a power strip that's used to power and to shut down the entire computer configuration.

Access

Author: Elliott S. Frank, 18060 Two Bar Road, Boulder Creek, CA 95006-9736 • 408-338-2707. Elliott has been living off-grid since 1990 with 1,000 Watts of PV modules and a variable number of cats (currently six).

Solar Heating Basics

Tom Snyder

The principles of solar heat have been known for thousands of years. A black surface gets hot in the sun, while a lighter colored surface remains cooler, with white being the coolest. Enclose black metal in an insulated box with a transparent cover and *voila*, a solar collector.

Taking a shower with solar-heated water, or heating a house with solar-heated air or water, (or drying corn in the Midwest) is a natural and simple method for both conserving energy and saving our fossil fuels. When a solar heating system has been designed and installed correctly, it can be aesthetically appealing and also add to the value of your home.

The value of any improvement to a home can be both subjective and objective. With solar heating, the panels can be, subjectively, a real eyesore. On new construction, they can be worked into the building design to be almost invisible, while on existing construction it can be a real challenge to make them fit in.

The Four Parts of a Solar Collector
A solar collector consists of the exterior framework, insulation, glazing, and collector plate.

Framework
Many choices for the framework of solar collectors are reasonably available. Wood, plastic, steel or aluminum have all been used with varying degrees of success, but nothing is as good as aluminum. Aluminum weathers the elements with very low maintenance, and has color choices baked on, so there is no need to paint the exterior of your solar panel.

In the spring of 1972, I tried to build a 4 foot by 8 foot solar panel out of standard dimensional lumber, i.e., 2x4s, 4x8 plywood, and glass from a discarded patio door (thermal pane). Two problems immediately became apparent: first, how to make the panel weather tight and have little upkeep, and second, the unbelievable weight. It weighed over 400 pounds!

You might choose plastics for the framework of a solar panel because they are light weight. But over the years, plastics have proven to be a poor choice for the major parts of a solar panel. For the exterior, plastic has a nasty habit of degrading from the sun's ultraviolet rays. Plastic discolors and eventually becomes brittle and cracks. Plastic also has a high coefficient of expansion. This means it expands and contracts so much that making the joints weather tight is difficult.

You might think steel is a good choice because it's strong, but the few panels I have worked on that were made of steel had two major problems. One, the panels need painting regularly and two, they react chemically with the copper interior. One manufacturer tried using steel for the interior plate (the black absorber), but it took a long time to heat up and did not give its heat up as easily as copper.

There are two ways to construct a panel with aluminum. The first, usually chosen because a do-it-yourself person has the materials readily available, is to use 2x4 lumber and cover this with aluminum coil stock. This is available from lumber yards in rolls two feet wide. Coil stock is the same aluminum used by contractors to make seamless gutters. The most appealing color is bronze, but it can also be ordered in other colors as well as white.

The second choice is to use extruded aluminum. This is manufactured to be the framework without any other materials, such as wood, for strength. All major solar panel companies during the 1970s and 1980s used this method, as it is light, durable, and reasonably easy to use. Figures A and B below show these two methods of building the frame.

Insulation
Insulation in construction of solar panels and plumbing is very critical. Poorly insulated panels are guaranteed to perform below expectations, so use time and materials wisely. The best material that is easily

End View — Solar Collector Frame

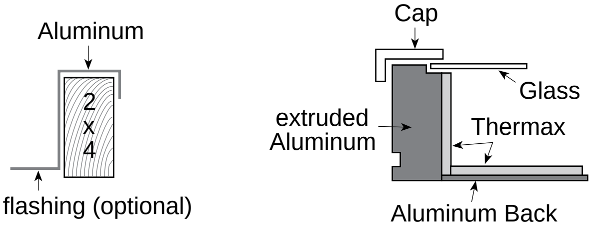


Figure A **Figure B**

available at lumber yards has many brand names, such as Tuff R and Thermax. Both of these brand names are fiberglass reinforced polyisocyanurate with an R value of 7.2 per inch, but the Tuff R doesn't retard flame spread as well as the Thermax. This material can usually be identified in new construction by the silver aluminum covering on both sides of the 4x8 sheets. It comes in common thickness of 3/4 and 1 inch, but the lumber yard might have sheets 4 inches thick that were used for protection during shipping. Just ask! A major problem with polyisocyanurate is that it degrades from ultra violet rays from the sun. It has to be protected, usually by enclosing it inside the aluminum frame of the panel.

If you're going to use batts of fiberglass insulation, be sure to use low-binder fiberglass, such as used in ovens, so it will not outgas or deteriorate with the heat. See Figure E. Fiberglass doesn't keep the wind from penetrating the interior of the solar panel as well as the rigid insulation described above, nor does it offer the R-value.

Glazing

Glazing of a greenhouse or solar panel refers to the clear covering on the front of the panel. For an excellent article on glazing, see *HP*#30, page 28. In the case of a solar panel, if the collector plate is constructed of the best materials, (i.e., copper with black chrome selective surface) only a single layer, or lite, is required because an increase of R value is not beneficial. A few companies did use double insulated glass because of the heat loss — heat radiated off the selective black chrome surface through just one lite. But the amount of sunlight that got through the two layers of glass was less than with one lite.

Collector Plate

This is one part of the solar panel that is the easiest for the DIY person to become totally frustrated with! If you are constructing an air panel, construction of the plate involves building an air chamber that is airtight. This can be done with nothing more than a rivet gun or screws and an excellent grade of pure silicon caulk. Just remember the temperature inside can vary from 20°F below to 300°F above zero. See Figures C and D on right.

Construction of a liquid plate requires soldering and brazing of copper pipe and physically bonding the copper pipes to the copper sheet. The more physical contact between the sheet and the pipes, the more heat transfer to the fluid moving through the pipes. See Figure E bottom right. The other frustration is that normal black paint will outgas, or boil, off the metal under the extreme heat. Also, under normal cases, black paint will radiate heat, rather than absorb it for transfer to the fluid. After many attempts at constructing plates for liquid, rather than air panels, I have concluded it would be the same as a DIY building an inverter from scratch. It can be done, but the frustration and time are not worth the effort. If your desire is to just get some warm water, then follow the articles on thermosiphon solar hot water heaters (*HP*#22 and *HP*#31).

Back view — Air Solar Collector Panel

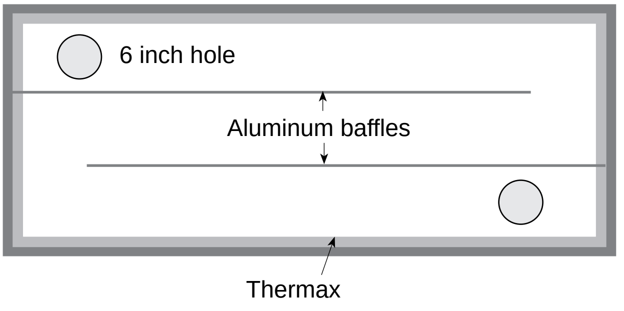


Figure C

End view — Air Solar Collector Panel

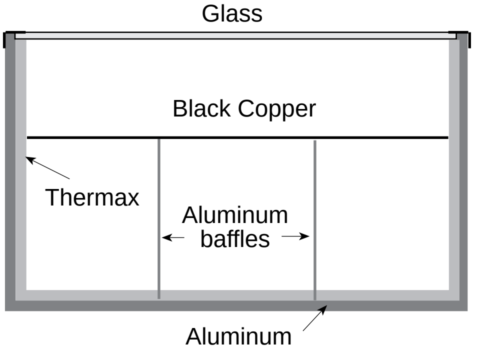


Figure D

End view — Liquid Solar Collector Panel

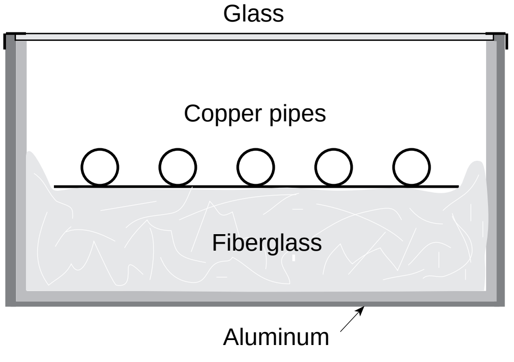


Figure E

Rather than build your own collector plate, there are copper absorber plates on the market that have a black chrome surface that absorbs 97% of the sunlight, so there is no need for double glazing for increased R value. Also these plates are tested for leaks and overcome all the other problems associated with DIY collector plates mentioned above.

With care in construction and use of quality materials, you can build a highly efficient 4x8 foot solar panel. Such a panel can heat 35–45 gallons of water from 55°F to 145°F which would be enough for 2–3 hot showers per day. In extreme cases, I have seen ten 4x8 panels heat 500 gallons from 60°F to 200°F in about eight hours.

Access

Tom Snyder, c/o Iowa Renewable Energy Association, 611 Second St. SE, Dyersville, IA 52040 • 319-875-8772

Used copper absorber plates, contact Tom Snyder or:

Hydronic Energy Inc., 3307 104th St., PO Box 3779, Des Moines, IA 50322 • 515-276-4935

Semco, 2021 Zearing Ave NW, Albuquerque, NM 87104 • 800-245-0311 • 505-243-3212

Washing Machines

Homebrew

Bruce Johnson

A year ago last fall we took a giant leap into the mid 20th century in clothes washing technology here at the Hagen-Johnson homestead. Our "new" washer has worked out so well that we want to share the experience with other *Home Power* readers.

Back in the Old Days

Up until the fall of '92, we did all of our laundry in an old Maytag wringer washer that was directly powered by our Aeromotor water pumping windmill. I'd rigged it up in the early days at our place and it has performed well ever since. I just removed the transmission from the Maytag and fitted a three inch V-belt pulley to the agitator shaft underneath the tub. A V-belt is connected to the pump rod of the windmill. Another pulley changes its direction from vertical to horizontal. Then it wraps around the agitator pulley and hooks to a spring. As the pump rod goes up and down the agitator goes back and forth. I outfitted the wringer with a chain drive and a hand crank. Over the last fifteen years, this setup has washed a lot of clothes and never failed to bring big grins on the faces of visitors to our place.

During the months of fair weather, this is a downright pleasant way to get the laundry done. During the winter, this method loses some of its appeal and the stack of soiled clothes would pile up.

Enter the New

On a trip to the local market last fall we found a late model Maytag wringer machine in nearly new condition. We felt mighty lucky! Now all we needed to do was pull out the ac hog motor (800 watts to be exact) and replace it with an efficient 12 VDC motor. We admired the new beauty for about a week while I thought about the conversion. The permanent magnet motor that I had on hand wasn't going to fit in as easily as I had hoped. I was involved in a little building project at the time and didn't want to take too much time away from that.

What I needed was a motor that would just bolt right in. I had exactly that sitting right there in the shop: an old Delco generator off a General Motors car from the late 1950's or early 1960's. That's right, it just bolted right onto the stock Maytag motor mount. I didn't even have to drill any holes. The only change was to put a five inch pulley on the generator-become-motor to drive the Maytag transmission input shaft at a one to one ratio with the motor.

I expected that this arrangement would work well enough to get us through the winter but that I'd some day be tinkering with it again for increased efficiency. It works so well that I think it will stay in its present form for a long time to come. The motorized wringer washer draws just 17 Amps at 12 VDC while churning away a full load of wash. It draws about the same when running clothes through the wringer. This washer has every bit as much power as it did with the ac motor that took nearly four times as much power.

Saving More Than Watts

A fact that might be overlooked by some not familiar with wringer washers is that they are naturals for water conservation. They work just like a suds saver on an automatic only no extra tub is needed. There's no pump, solenoid valves, or controls either. The procedure works like this: Start out with warm soapy water and a load of your lightest colored, least soiled laundry. Wash for seven to fifteen minutes and then wring them into a basket. Wash as many loads as you

Below: The old wringer washer powered by the water pumping windmill.

care to, working your way down to the really grubby work clothes. Then drain the truly dirty wash water and refill with fresh rinse water. Run the clothes through the rinse in the same order. They need not agitate long for the rinse, a couple of minutes should do. Then just run them through the wringer again and head out to the solar clothesline. It takes us about two hours to do five or six loads using about 34 Amp-hours. This amounts to about three hours of full sun on our panels. If the wind generator is going too, we may even have amps going into the batteries while we are washing.

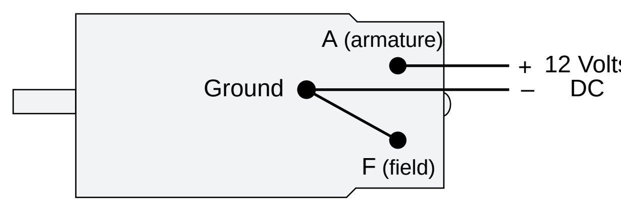
You Can Do It Too

Finding a good wringer washer may be the hardest part of being able to repeat our experience. Though it's been many years since they were popular, Maytag continued to make them up through 1991, according to our local Maytag dealer. Amana and Speedqueen also continued to make them, but I don't have experience with them. Check over the machine you find as you would any other piece of equipment. Look for oil leaks where the pulley shaft goes into the transmission. Look for wear on the rollers of the wringer. Don't lay the washer on its side for the trip home. That will cause it to leak oil.

Finding the old Delco generator shouldn't be too hard. Any late '50s to early '60s G.M. car or truck should have one. Ask at salvage yards or at a shop that does starter and alternator repairs. A Ford or Chrysler unit would work too, but probably wouldn't bolt onto the Maytag bracket as easily. Once you find the generator all that you need to do to "convert" it to a motor is to complete the field circuit. The field is the electromagnet

Above: The Delco generator, used as a motor, bolts right on to the Maytag motor mount.
Below: Wiring a generator for use as a motor.

Wiring the Generator
(view from above)



that surrounds the armature. One side is already connected to the positive (A or armature) lead inside the unit. Connect the other side (the post marked "F" for field) to ground as in the diagram above. Look at the photo to see how the generator bolts to the Maytag motor mount. When installed, the weight of the motor keeps the belt in tension.

Below: The new wringer washer powered by an efficient (and recycled) DC generator-turned-motor.

On the unit I used, the fan and the pulley were separate pieces. This made it easy to change to a larger pulley and yet retain the fan. I used a five inch pulley to match the one on the washer transmission. These generators have an oddball shaft size that's between 5/8 inch and 3/4 inch. A piece of 3/4 inch O. D. copper tubing makes a near perfect shim for fitting a pulley with a 3/4 inch bore.

Be sure to use wire of adequate size to carry the current the washer will use. We use 10 feet of #8 copper wire from the batteries to the heavy duty outlet where the machine plugs in. At the battery end is a 35 Amp, DC rated circuit breaker. At the plug I installed a mechanical timer switch coupled to a 50 Amp relay. This way we can set the wash time and then go about other activities.

We sure hope this information might help a few *Home Power* folks. It's sure made wash day more pleasant for us, at a price we can afford both in dollars and in watts.

Access

Bruce Johnson & Barbara Hagen, 7605 N Post Rd, Spencer, OK 73084 • 405-771-3551

Timer ($3): All Electronics, POB 567, Van Nuys, CA 91408-0567 • 800-826-5432

50 Amp relay. ($5): Fair Radio Sales Co., POB 1105, Lima, OH 45802 • 419-223-2196

Things that Work!

Things that Work!
tested by *Home Power*

The Folk Ram Pump

Michael Welch

Tested by Michael Welch, Cara Smith and classmates of Humboldt State University's International Development Program (Susan Brinton, Christopher Herbst, Christine Parra, David Potter, Jon Raybourn, Dav Camras, Daniel Oros, Mike Orr, and Wallapa Wongsuwan).

The Site

Cara Smith of Fieldbrook, California had a problem. Every year in August, her spring flow reduces to a mere trickle. As the Northern California drought got worse year after year, so did her spring's ability to supply her household needs. She needed a permanent solution to her problem.

Fortunately, a nice creek crosses Cara's property, and it flows year round. But, it is 360 feet in elevation below her water storage tank, which gravity feeds to her home. I had been looking for a site to adequately test the Folk ram pump, and this seemed like it would work. I had been attempting to test the pump on my own system at my home. While it worked well enough for me, my flow was too small to really put the pump through its paces.

So what is a ram pump anyway? Ram pumps use a downhill water pressure to pump a portion of that water even higher uphill to a holding tank. No other source of power is needed.

We enlisted the help of HSU's International Development Program to design, build and test the ram pump system. But that's a story in and of itself that we may tell in a future *HP* article. For now, suffice it to say that this academic program prepares students to help third world countries with their development requirements, and strongly emphasizes appropriate technology to meet these countries' needs.

The Pump Arrives

When I received the Folk ram, I was surprised to see that it was in pieces. Normally, Jim Folk ships his pumps completely assembled, ready to install. But, Jim knew that I was very interested in the workings of his pumps, so he sent it to me disassembled, with a labeling tag on each component explaining the why's and the how's of its design and use. I really appreciated that, but any other customer can expect the pump to arrive well-packed and already assembled.

His largest pump, however, is too heavy to ship by UPS, so it comes in two pieces easily bolted together.

This pump is heavy-duty. Its body is thickly cast and machined from high-grade aluminum alloy, and the inner components and the bolts make use of stainless steel. The internal "valves" are made of thick, bonded rubber seals.

A feature of the Folk ram not found in most ram pumps is a strong rubber diaphragm which separates the delivery water from the pressurized air chamber. This diaphragm keeps the air from mixing and exiting with the delivery water, thus eliminating the need for a "snifter valve" to replenish the air chamber.

Other features of the Folk ram pump include larger-than-usual impetus and check valves for faster reaction time and a large air dome to minimize delivery water pressure pulsations and thus decrease friction loss. The impetus valve stroke length is easily adjustable to change the frequency of pump cycles, which changes the amount of water the pump uses and delivers.

Installation

The Folk ram arrived with adequate instructions on how to install, maintain and run it, but there is some room for improvement. Jim Folk told me that he wanted to do a better and more detailed manual for the pump.

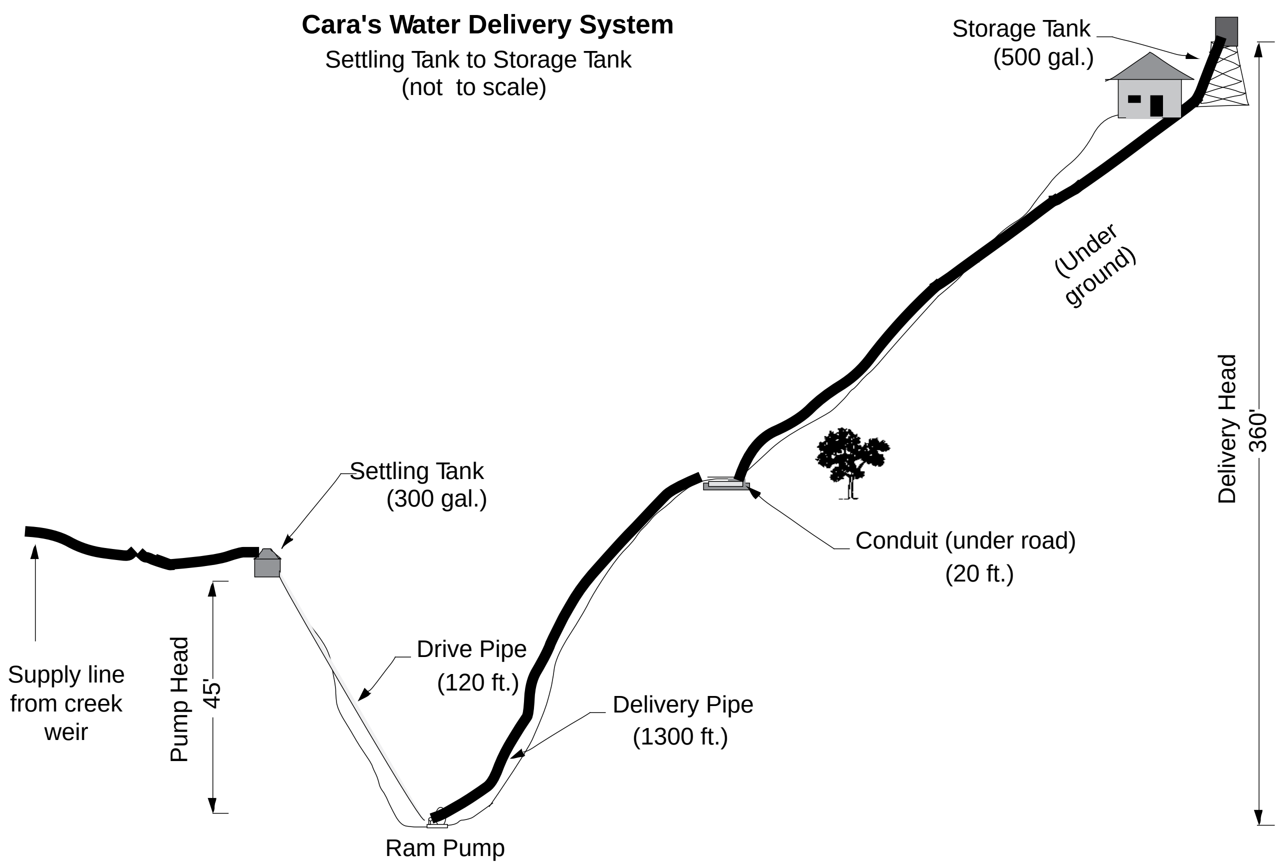
One great thing about Jim Folk is that it is as important to him that the pump works well as it is to sell the pump in the first place. If you have problems with your installation or operation, he will work with you in detail. It's just how he is, and most people can really appreciate it. For example, there was a problem with the bonded rubber the pumps used in their valves. When Jim discovered the defect, he automatically sent every pump owner a new set of valves, using improved materials, and he did it free of charge.

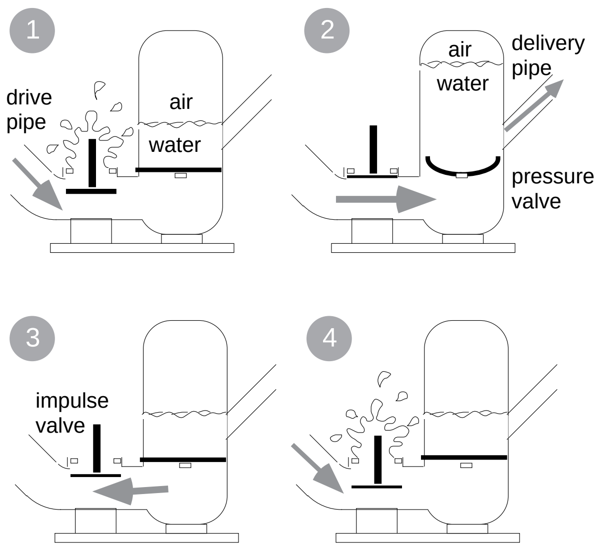
Long distance water pumping systems have so many variables that every installation is different. In our case, the terrain was very steep and somewhat rugged. In order to get adequate vertical drop to run the pump, we had to snake the supply pipe 420 horizontal feet from the source to a settling tank, and then go steeply down the hillside to the pump site with the drive pipe. The cost of having to run such a long horizontal distance was a reduced supply available to the pump. While Cara's creek flows at about 72,000 gallons per day, our 420 feet long, two inch diameter supply pipe with five feet of head between the creek inlet and the settling tank would make 5,400 gallons per day available to the pump.

Most installations will be more straightforward than ours, and less expensive as a result. The price of the

Cara's Water Delivery System

Settling Tank to Storage Tank
(not to scale)





How a Ram Pump Works

All ram pumps work on the principle of momentum which is controlled by a cycle set up by the interaction of two valves in the pump.

When the impetus valve is opened (this must initially be done by hand to start the pump cycling), water begins to flow down the drive pipe and through the impetus valve as in Figure 1. When the drive water reaches a certain velocity, water friction slams shut the impetus valve as in Figure 2. The momentum of the water carries past the closed impetus valve, forcing open the flapper valve and pushing water past it to pressurize the air chamber above the water level. In Figure 3, the water pressure above the flapper valve overcomes the spent momentum below it, forcing the flapper closed again. The water that made it past the flapper in Figure 2 is then forced by the extra air pressure up the delivery pipe. Since the momentum of the water coming down the drive pipe was stopped, the impetus valve falls open, allowing the water to flow down the drive pipe again as in Figure 4 (just like Figure 1), starting the cycle over again.

This process occurs over and over again until something happens to stop the cycle. Ram pumps can cycle anywhere from 25 to 300 times per minute. The frequency of the cycle is adjustable by changing the length of the stroke of the impetus valve. A longer stroke produces a lower frequency. This means more of the supply flows to and through the pump and more is pumped up the delivery pipe.

The stroke is adjusted to restrict the amount of water used to the amount available, or if supply is unlimited, to regulate the amount delivered to match the amount needed.

pump remains a fixed cost for everyone, but the installation costs can vary widely. Because of the long supply line and the uncommonly high delivery elevation, Cara's installation costs were about double the average installation. I estimate the average to be about $1,000 for system components including the Folk ram pump which runs about $695. Labor is not included in these approximations.

A typical installation includes a 1.5 inch steel drive pipe from the source to the ram pump, a poured concrete foundation to secure the pump, a one inch poly delivery pipe to the household supply tank, and valves and unions to control flow and allow access to the various components of the system.

Pump Performance

Because the Folk ram's capabilities could easily outstrip our supply, we choked it back so it wouldn't run out of water. When a ram pump stops cycling, it needs to be restarted by hand. Once we had the pump properly set, it just kept running on and on for months without the need for further attention. This reminds me of a ram pump story I heard:

Friends were hiking near the New River in the Trinity Mountains of Northern California. This river is peppered with old gold mining claims. Far away from any other form of civilization, the hikers were surprised to come to an otherwise pristine spot where they heard a muffled "ka-chunk ka-chunk ka-chunk...." Taken by surprise, they were unable to discover the source of the mechanical noise until they dug down several inches through the forest humus finding a rotten board covering a hollow box. The box contained an old ram pump that had been operating on its own, unattended for as long as it took the box cover to become buried under many layers of duff.

Commercial ram pumps are known to provide years of trouble-free service. We expect that the Folk ram will furnish Cara with water for decades to come.

Even with the pump choked back for the decreased supply, we obtained delivery rates of 600 gallons per day. This is a far cry from the 2,400 gallons per day that this pump could achieve under the same drive and delivery heads with unlimited access to the creek's supply. However, it was more than adequate for Cara's needs which max out at 475 gallons per day. Jim Folk states that, under ideal supply, drive, and delivery conditions, this particular model of his pump will produce up to 5,000 gallons per day. He has a second model that will produce up to 25,000 gallons per day.

For you folks with super low flow situations, this pump may still work for you. For several months, I had this pump installed on my own spring which was flowing at about 1,500 gallons per day, with 26 feet of drive head, and 158 feet of delivery height. This is really running the pump on the low end of its capabilities, yet it still was able to provide my home with about 190 gallons of water per day.

Conclusion

Folk ram pumps are well-made, dependable, and work as promised. While there are other ram pumps available, the Folk has features that are unique and proven. At $695 for a pump that will likely outlast its owner, it is an excellent buy. A larger model is available that lists for $995. These pumps are handmade in Conyers, Georgia.

Access

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

Ram Pump Maker: Folk Water Powered Ram Pumps, 2770 White Court N.E., Conyers, GA 30207 • 404-922-4918

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EV Happenings

Michael Hackleman

Hawaii. David Rezachek and crew pulled off a stunning conference and show, the Hawaii '93 EV Conference and Trade Show (Dec 8–12), in the wake of the ARPA (Advanced Research Project Agency) meetings. Some representatives of the five EV consortiums in the USA stayed on, helped out, and mingled with anyone interested in the technology. Thanks to Advanced DC Motors and the Hawaiian Electric Vehicle Association, I was able to attend. When I wasn't speaking, I was listening. Many days of seminars and panels. Good stuff. Industry is awakening to EVs. Jonathan Tennyson's island electric (Sunray) was there. I drove Tom Carpenter's offroad 4WD electric conversion (Kawasaki Mule), too. Patience, *HP* readers; articles are underway.

Nine vehicles entered the road rally and Pali Challenge (the local EV killer hill). Vehicles ranged from a Ford Taurus conversion to Joe Stevenson's ZAP, an electric-assist bicycle. Everyone completed the hill climb and coastal route except the G-Van, which blew something during regen coming down the back of the Pali. The GM Impact was present, but sat out the event at a HECO (Hawaii Energy Company) equipment yard. It was damaged by a Geo Storm mule (with an Impact drive train) in a mid-ocean dance when the tie-downs loosened in their shipping container. Some good-humored soul couldn't resist adding an "ed" to the license plate bearing the name of the car. The Storm mule acted as the rally's pace vehicle. I get the feeling that GM is worried about bad press. Come on, guys. Your prototypes are lions. Chirp the tires a bit. It's okay. People will *like* it.

California: Jananne Sharpless, mentioned in last *HP* issue and a CARB (California Air Resources Board) spokesperson who told U.S. Automakers to "meet the California 2% mandate in 1998

Top Left: Two Kewet El-Jets and a Horlacher GL88 sit at a charging point in the 1992 Tour de Sol in Switzerland. The Kewet, made in Denmark, uses a fiberglass body and steel chassis. The 10 hp compound DC motor pushes its 1,540 pound mass to 43 mph from a 48V battery pack. In the USA, it is sold at Green Motorworks, North Hollywood, California. The Horlacher is a tandem two-seater, weighs 638 pounds, uses 50 W-h/mile, and reaches 50 mph.

Right: Paul Schweizer, a Horlacher engineer, stands by the City Two prototype, an evolution of the one pictured in the crash tests. SMUD is now testing it in Sacramento, California.

Below Left: The Sunray is Suntera's prototype commuter vehicle, designed by Jonathan Tennyson and manufactured on the big island of Hawaii. It is a 1,500 pound two-seater, uses a 12 hp series motor, reaches 60 rpm, and accelerates 0–50 mph in eight seconds. Its eight foot length makes it an ideal street car; two Sunrays will fit in one parking space!

or sell cars elsewhere" has been booted out of CARB. Reportedly, she is working at CEC (California Energy Commission). The CEC is on the endangered list itself, with Governor Wilson wanting to replace it, the PUC, and a few other watchdog agencies with something new and different. From watchdogs to watchkitties.

The three-day Disneyland World Clean Air Road Rally will put 100 EVs on the road in the Los Angeles area April 7–11. Qualifying and scrutineering is Thursday and Friday. The three-leg race starts at the LA Conference Center. Saturday: 25 miles, Santa Monica Pier. Sunday: Queen Mary, 35 miles, Long Beach. Monday: 25 miles, Disneyland. Want to participate or attend? Call Peter, Becky, Chris, or Donna at 818-565-5652.

EV Racers: Snow White is the only serious challenger the Hackleman-Schless team faced with our Formula E racer at Phoenix last year. It's rumored that owner-builder Bob Schneeveis ordered a 1000 Amp, 250 V controller. He isn't saying what for. If it goes in Snow White, acceleration will be measured by G forces instead of seconds — *if* he can keep the tires on the rims. He's also building a 700 pound EV rocket to run in some SCCA Open class, too. He's moving the technology into the races. *Lots* of people are watching them. Bob says, "I just want to have some fun." The Hackleman-Schless team will not be at Phoenix '94.

Otmar "Regen Man" Ebenhoech is the likely candidate to build the controller for Schneeveis. I visited him at his shop near Stanford University and he showed off some latest-issue IGPTs. Industry translation for IGBT is Isolated Gate BiPolar Transistor. California translation for IGBT is Insanely Gnarly Bitchin' Transistor. Otmar is doing all kinds of R&D for different companies, building production controller prototypes. Apprentice-types, take note.

Pure vs Hybrid EVs: Do you wonder why GM and other automakers mix their messages about EVs? I do. My read is that there are factions *inside* GM that believe in electrics, but the power people in these companies think *engines.* This explains their support of *hybrid* EV's because, guess what, it has an engine!

It's time to use alternatives to gas guzzling cars and reclaim the land, clean air, and clean water. Relative to energy sources, anything non-oil, non-nuclear, and non-carbon should be subsidized. But — more cars won't work. Anyone that rationalizes their need for a car is running on too many cylinders. Remember, you want what it *does* for you. There *are* alternatives. Can you list *any?*

Cover Story: This issue's cover photo is a Horlacher "Sport Two" prototype parked in front of a community-size wind-electric turbine. It brings home a unique virtue of EV's — sustainable sources of electricity are available to power them.

The Sport Two is a recent release from Horlacher AG. Although Horlacher is not an auto manufacturer, prototypes abound — lightweight vehicles that are energy-efficient *and* crashworthy. The Sport Two is constructed from FRP (fiberglass reinforced plastic) using foam core parts, and includes an "impact belt" laminated into the body chassis unit. The vehicle has a GVWR (Gross Vehicle Weight Rating) of 1,210 pounds, including 550 pounds battery weight. It can reach 77 mph with its 12 kiloWatt ac drive, yet uses a frugal 100 Watt-hour/mile in normal driving, i.e., stop-go, uphill-downhill, and cruising at speed). It won the 1993 Swiss Tour de Sol in the prototype class. I saw one at the Electric Grand Prix in Los Angeles and liked it *immediately*, particularly the way the doors slid back. I wish someone would take up manufacturing it. It'd be an instant hit everywhere.

Thank you, Bill Warf (Pacific EV, Sacramento, CA, 916-381-3509), for the detail on the vehicle. In Hawaii, I leafed through an impressive photobook Bill has put together. He loaned me a dozen prints, three of them on the Horlacher crash tests, re-printed here.

Below Top: The Esoro E301 prototype is a 4-seater with a 25 hp motor, 75 mph top speed, a 150 W-h/mile cruise efficiency, and a curb weight of 1,364 pounds.

Below Bottom: The Landis & Gyr prototype is a regular entry in the Swiss Tour de Sol, weighing only 836 pounds, and reaching a top speed of 75 mph.

Right, Top, Center and Bottom: A Horlacher City is crash-tested against an Audi 100.

Bill’s writeup: “The crash test was part of ongoing work by Horlacher AG in optimizing the hard shell, ultra-stiff vehicle concept. In the test, the 600 kilogram City was traveling at 32 mph and the 1260 kilogram Audi 100 was traveling at 16 mph. You can see the result from the photographs. The static deflection of the City was 150 millimeters while the Audi deflected 350 millimeters. Present thinking in mass produced automobile construction is to use large plastic deformation of the steel vehicle structure for occupant protection. Horlacher is testing a new approach to crash safety where the compliance of the body-chassis is more proportional to the vehicle mass. The theory is that in traffic composed of a mixture of heavy conventional automobiles and light weight vehicles, occupant protection can be achieved by engineering the structures such that the light vehicles are hard and stiff, and heavy vehicles are big and soft. Air bags, pre-tensioned seat belts, and sufficient run down distance inside the vehicle also help to safely decelerate the vehicle occupants in a crash.”

That’s the news for this issue. Good reading.

Access

Michael Hackleman, PO Box 63, Ben Lomond, CA 95005

One Step Closer

Solutions and Progress in Vehicle Development

Denet Lewis

As increasing numbers of people become aware that pollution and the wasteful use of resources are a global problem, our attention must turn toward solutions. In this article, I want to discuss one real and productive direction: the development of lightweight, energy efficient cars.

My first encounter with a solar car occurred when I was eight years old. My parents gave me a toy car kit with a single solar cell and a small electric motor. From that point, I was hooked on electric cars.

A High School Solar Car

A number of years later, when I was a junior in high school in Hawaii, I jumped at the opportunity to build a real solar car. It all began with the actions of one individual: electric and solar car builder and designer, Jonathan Tennyson.

On his return from the 1987 World Solar Challenge in Australia, Jonathan came up with the idea that high school students could build solar cars as a part of their educational curriculum. He approached the Hawaii Department of Business and Economic Development (DBED) and with their help, the Ka'ahele La (Tour of the Sun) was formed. After a successful three-school pilot study in the 1988-90 school year, the program was expanded the following year, with every high school given the opportunity to submit proposals. A three and a half day solar car race on the Big Island, then, would identify the winning team and vehicle that would represent Hawaii in the 1990 World Solar Challenge in Australia!

Our team, Konawaena High School on the Big Island of Hawaii, had one of the six winning proposals. We felt the need to gain an edge over the cars from the other five schools. Designing a lighter car seemed to make the most sense. As president of the Konawaena team, I insisted that we construct our chassis out of carbon fiber. The adults on the team were reluctant to use this expensive material because of our limited $12K budget. I solved the problem by getting the carbon fiber donated. As a result, our frame weighed only 33 pounds.

It was hard work to build the car, but it paid off: we finished the race 66 miles ahead of our closest competitor. It was a wonderful feeling seeing all six entries running off power from the sun.

Racing in Australia

The World Solar Challenge has the reputation of being the world's toughest race for solar vehicles. The race runs over 3000 kilometer, across the arid Outback. Our school was competing with 36 teams from around the world. These ranged from small teams like our own, to entries sponsored by major auto makers, like Honda. In fact, we were the only high school team from the USA. In the end, we placed 4th in the lead-acid battery class, and were 18th overall! We were also the first high school team to ever officially *finish* the race!

I was particularly impressed with the design of the race entry from Western Washington University (WWU). They placed 5th overall and were the first "two seat" car to finish the race. I talked with several team members, and met Vehicle Research Institute director and creator, Dr. Michael Seal. I discovered that WWU had a vehicle design major. Once I returned to Hawaii, I applied for admission.

The Viking Program

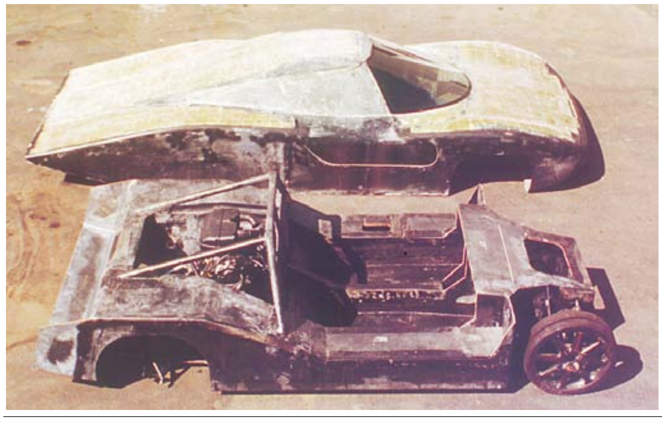
I was accepted! I discovered, after arriving at WWU, volumes of information and stunning facilities at the Vehicle Research Institute (VRI). Some twenty cars (all in the Viking series) have been built there. My favorites are Viking #6 and #7. Viking Six proved that a car can get high mileage and be both light and safe. The car achieved 118 mpg at 50 mph, and passed the crash test at 43 mph! Viking Seven proved that a car can accelerate rapidly (zero to 60 in 5.3 seconds!) and still get 50 mpg on the highway. After studying these cars, I realized that consumers could be driving safe, fuel efficient cars. However, I feel that high mileage per gallon does not go far enough. Auto makers need to reduce the pollution output from vehicles, particularly carbon dioxide.

This desire to reduce pollution motivated me to join the team that was constructing the Viking 21 (see *HP*#31). Viking 21 is a solar electric, CNG (compressed natural gas), parallel hybrid car. That is, electric motors drive the front wheels and a motorcycle engine drives the rear wheels. In normal driving, the car starts off as an electric vehicle. At about 35 mph, the internal combustion (IC) engine is started and the electric motors are disabled. In cities, where the pollution problem is extreme, Viking 21 uses electric propulsion. On the freeway, it utilizes high-energy density fuel for superior range. This lets the driver use each system in the ranges where they are most efficient. For higher performance, both systems can be used simultaneously. I feel that there are many people in this country who would consider buying a hybrid car, where they are not ready for a purely electric vehicle.

The New Viking Project
The VRI team is currently working on the new Viking 23. This is an improved, carbon fiber version of the Viking 21. With the weight saved by using carbon fiber, we will be able to install more batteries, thus extending the range in electric mode. Viking 23 will also use more efficient solar cells to decrease dependence on the electric utilities. We hope this vehicle will demonstrate, to the public and auto manufacturers alike, that a practical, low emission vehicle is possible.

A Personal Project
In my vehicle design classes, I am working on a design variation of a parallel hybrid car. This design is for an electric car that utilizes a small four-stroke moped engine in place of a larger IC engine. It differs from other hybrids in the smaller engine size, and less overall weight. Of course, I will maximize engine output to keep the car at freeway speeds, kicking in electric propulsion to climb hills or accelerate faster.

Right: Denet Lewis and the Viking 21 frame.
Below: The completed Viking 21.
Below Bottom: The frame and body of the Viking 21.



A Thermal Photovoltaic Generator
Perhaps consumers need to move away from internal combustion technology altogether! To this end, Dr. Lewis Fraas and WWU are working on a possible alternative: a prototype of a thermal photovoltaic (TPV) generator. The TPV uses solar cells that operate at 30% efficiency in the infrared spectrum. To generate infrared radiation, we use a ceramic tube and a natural gas burner. This way, natural gas is converted into electricity with almost no moving parts and minimal emissions. The electricity produced is used to power a series hybrid vehicle. We may be able to remove the ICE altogether from the Viking 23 and replace it with the TPV unit.

Into the Future
Although it is impossible to predict the future, I see a combination of pure electric and a variety of hybrid cars on the roads. Regardless of the power source, future cars can be built safer, lighter, more aerodynamically, and with less rolling resistance. In the long run, I expect, first of all, pure electric cars to win out as we improve batteries and infrastructure. Second, government, industry, and the public will work to create zero emission zones in densely populated metropolitan

areas. Third, economic incentives will be set up to encourage people to drive clean vehicles. Finally, I expect the cost of gasoline to be raised so that it matches its *true* social and environmental cost.

Automotive details aside, as a world community, we must deal with pollution on a global level. I would like to see the United State of America take the lead in demonstrating its commitment to valid and viable solutions, starting with transportation and the environment. I want all of us to make this our future.

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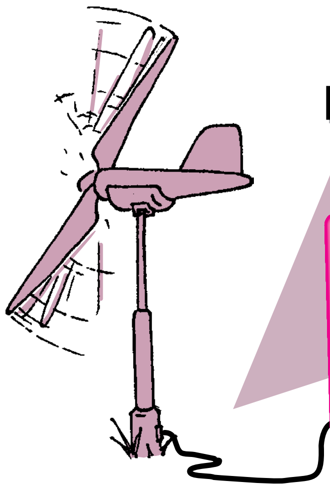

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High School Electrathon Racing

Alan Kearney

The general response from my advanced auto students was, "You've got to be kidding, this car doesn't make noise or burn rubber." I had just shown them a videotape of the Electrathon race at SEER '91 in Ukiah, California. Their response was understandable. Vehicles racing at the SEER track that day had difficulty maintaining 25 mph.

A few months later, six of these students got to drive different Electrathon vehicles at a "builders' workshop" hosted by Gene Karas at Analy High School. When we got back to our own class (I teach Auto Mechanics and Computer Applications), their excitement was contagious. In early 1992, we formed our club, the Willits High School Electric Car Club (WHSECC), to build an Electrathon race vehicle.

The WHSECC is an after school, extra-curricular activity. Students must satisfy Willits High School requirements for scholastic standards ("C" average with no failing grades) to participate in club activities. Every student in high school was encouraged to participate in the construction and racing of our vehicle.

Fundraising

Raising money was a difficult task in our town. Every school activity is under-funded and each group goes around town with their hand out every year. Tenacity helps here. We approached potential supporters in person, followed by a brochure mailer I designed on my Mac. As a last resort, I would call them personally for one last try. Once we had made some progress that we could show, contributions — in the form of money, materials, technical support, and contacts with different equipment manufacturers — came more easily.

We found that public relations is very important. We kept contributors up to date on our progress. A local newspaper reported on races we won and the general progress of the vehicle. We entered a local (but widely attended) car show and drove the car in the Fourth of July parade this last summer. The clear plastic shell over the nose area was there more to display our contributors' logos than to reduce wind resistance!

Costs

We kept the cost of building the car to a minimum. Altogether, we spent $500 cash and used about $800 worth of materials. Local businesses donated materials. For example, the roll bar is all welded aluminum tubing, custom built and donated by Advanced Manufacturing & Development. We don't have any way to weld aluminum at the high school so this was a tremendous help. The local NAPA auto parts store donated the 4-point safety harness. Little Lake Auto Parts donated two 30 pound batteries for test driving the vehicle and a local hardware store donated boxes of bolts, etc.

Electrathon: America Answers the Challenge

Mark Murphy

An article in *Alternative Transportation News* (March 1990) caught my eye. Some crazy Australian had brought over a tiny electric fighter plane with wheels instead of wings — an Electrathon class racer. The format seemed designed to create an exciting, low-cost competition while minimizing the liability risk for sponsors and owners of impromptu racing sites. I *knew* this was something I wanted to do.

I have designed and raced human powered recumbent, three-wheeled streamliners for several years. Electrathon appeared to be an electric powered version of these, so I began with a basic HPV design and added batteries and an extra wheel. Since I was familiar with the advantages of a "cyclecar" three wheeled layout — two steered wheels forward and one wheel in the rear — I chose this design.

As with any design, I began from the inside out. First, I placed the rider in a comfortable position, designing the vehicle around him (or her). The battery, wheels, motor and controls are located to achieve good balance and function — without driver interference.

Another kindred spirit, Gary Raymond, joined me at this point. To save time and money and create a team atmosphere, we decided to build two machines. As a further incentive to finish the vehicles in good time, we decided to hold an Electrathon event as part of the 1992 Earth Day Festival in Thousand Oaks, California.

We spent hours speeding around parking lots, testing combinations of components, varying the gear ratios in a bare, converted HPV. At first, we ran without a controller, just a circuit breaker, on or off. We jetted around the invisible course, inches off the ground, launched with a 50-foot tire burnout each time we tried something new. Next, we built a chassis from box section steel tubing. We settled on 1.75 x 20 inch plastic mag front wheels and Ackermann steering geometry with zero offset. The rear wheel is slightly larger, a 1.75 x 24 inch plastic mag. Cable-operated hydraulic discs handle braking.

Gary soon developed an excellent power train: a 12 Volt Bosch motor driving a bicycle chain-and-sprocket arrangement. A stock Curtis PMC controller and potbox completed the power circuitry.

I worked on the body design. I wanted a classic aerodynamic form, slightly shortened for easy transport. I wanted the options of HPV, human-electric hybrid, and Electrathon racer. This meant leaving room in the nose for pedals. Thinking of manufacturing them myself, I opted to use off-the-shelf components.

The Aerocoupe is the result. This body-shell is vacuum formed ABS plastic. The material is durable, easy to trim and paint, and recyclable! Blown from acrylic, the canopy is very good optically. With a final length of 102 inches, a height of 38 inches, a 36 inch track, and a wheelbase of 56 inches, the estimated CD of the finished vehicle is a very respectable 0.20 drag coefficient. The curb weight of our vehicle was 124 pounds (less battery).

Climbing in is like putting on a pair of pants — one leg at a time. Inside, it's much like a sailplane cockpit. Sitting so low, the speed feels magnified by the short course and tight turns. To spectators, it seems silent. Inside, it's a cacophony of sound: chains running over sprockets, the motor whining, the road noise and shock transmitted by frame and body — what it must feel like sitting inside a giant power tool!

What's it like in a race? So far, we have finished in the top five, and we are having the time of our lives. Top speed is about 60 mph (dependent on gearing) and the range, of course, is 25–35 miles. Battery capacity, speed, and driver skill affect these figures!

Electrathon vehicles and events are growing fast. There are dozens of Electrathon events annually along the west coast, from San Diego to Seattle, including the Phoenix races, the International Electric Grand Prix in Los Angeles, and at SEER. High schools and colleges alike are catching on, building Electrathon class racers as a kind of "rolling textbook" on the basics of electric vehicle design. Join the fun! Maybe I'll see you at a race soon!

Access

Aerocoupe CycleCar info: Blue Sky Design, PO Box 26154, Eugene, OR 97402

The Electrathon Design
Our goal was to race safely in as many different events as possible each school year. For this reason, we used a combination of the designs of the southern and northern California groups. The front axle uses two steered 20-inch wheels. The rear axle can also handle a 20-inch wheel, so that it qualifies for Electrathon America events. However, we prefer to use a small 12-inch Go Kart wheel here because it is easier to spin up to speed using direct drive and offers a bit of suspension.

At SEER '92 (Solar Energy Expo & Rally), we geared our vehicle for 25 mph, the speed vehicles ran the year before. However, the competition ran at 35 to 45 mph, using transmissions (bicycle derailleurs) on their drive wheels and more aerodynamic body shells.

Batteries
Using Australian (and Electrathon America) regulations, vehicles are limited to 60 pounds of batteries for drivers weighing less than 180 pounds. These must be "wet" lead acid type with no modification to the battery (no lightening by removing plastic or drilling holes in the battery posts) or electrolyte (no "spiking" the acid).

Some entries from the Northern California group, Clean Air Revival, used two 40–45 pound, 12 Volt Gel Cell batteries, heated to 160° F for racing performance. These batteries cost $100 each and have a shorter life because of the heating and fast discharge rates. We don't try to compete with these individuals.

Weight and construction of batteries are a constant source of discussion and rules proposals. If only we could find a battery manufacturer willing to sponsor the races *and* supply identical batteries to each driver the day of the race!

Construction Details
The WHSECC vehicle uses three wheels to avoid the rolling resistance of the four wheel design. The 20 inch "free style" wheel was chosen for its strength. Vehicles with larger bicycle wheels and 3/8 inch axles break down on the rougher race courses. Admittedly, larger wheels are a benefit at events like SEER or tracks using banked quarter-mile ovals.

The main chassis and front axle is aluminum box tubing. Suntools, a local company, donated 50 feet of it to the project. Phil Jergensen showed us how to drill holes every 1.5 inches. This allowed us to easily vary the configurations during the design process. For example, our first vehicle had a tricycle layout (one wheel up front and two in the rear). While this simplified steering and brakes, the vehicle would tip over on fast, tight turns. We quickly rejected this for the current motorbike layout.

Drive Train
We selected the Bosch electric motor for our drive train since Clark Beaseley has made it a track winner! We obtained one from him at fairly low cost ($225, plus tax and shipping). Its high speed (3400 rpm) presented some problems when direct-driving the rear wheel.

We used a stock Curtis PMC unit for the controller. Microphor, another local company, donated the controller, the Curtis Battery Fuel Gauge, forty feet of #2 gauge wire, and a digital volt meter to the project. The ammeter, fuses, connectors, and the custom-built wheels were purchased or donated by Earthlab. Our wheels are made from a utility hub which takes a 5/8 inch sealed bearing. These are custom spoked to 48-

Electrathon: an emerging race format

Michael Hackleman

A new breed of racer has found its way from Australia onto USA streets. Electrathon! I remember vividly the first time I saw Clark Beaseley's bright red racer. I had encouraged him to bring it to the annual EVAOSC (Electric Vehicle Association of Southern California) rally in 1989. He pulled in with the sleek machine bungeed to the roof rack of his car!

I drove it that day. What a feeling! Accelerating quickly and nimble as a cat, it was an exhilarating experience. Already a veteran of several races and the antics of dozens of novice drivers, the racer squeaked, rattled, and chain-whined its way through the streets. My brain filtered out these idiosyncrasies. What I noticed was the speed, the response, and the faces of astonished adults and excited children. This was what driving was supposed to be about. I can't remember what Clark called it. I named it that day: Slingshot.

Clark Beaseley brought his Slingshot racer and the concept of Electrathon racing to the USA from Australia in 1988.

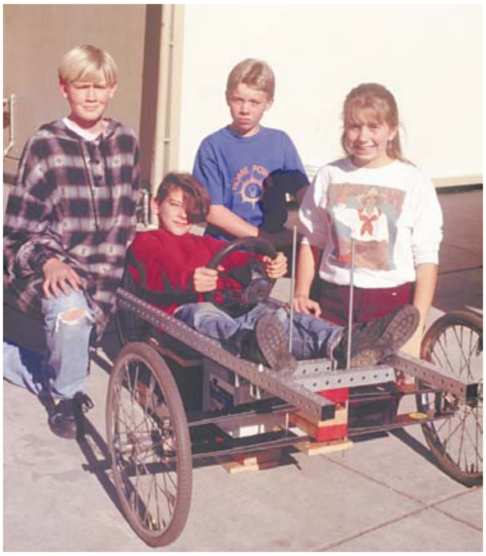
spoke Araya rims using the “four cross” pattern. This design allowed us to use stock Go Kart 4.5 inch drum brakes.

The front wheel spindles are 5/8 inch (grade 8) bolts welded to seamless, thick-walled (1/4 inch) steel tubing. The spindles pivot around a similar 5/8 inch bolt that acts as a king pin. Of course, the inside wheel must turn tighter in a turn than the outside wheel. We fabricated the steering arms from 1/4 inch steel plate. Bent in and back, these yield the Ackermann steering needed to reduce tire “scuffing” (and wear) in turns. The connection of the tie rod point at the steering post is adjustable so that we can change the steering radius of the vehicle. We use zero degree for camber, zero toe-in for low rolling resistance, and ten degrees positive caster for steering stability on bumps.

We elected to use no suspension for reasons of simplicity. Consequently, we usually break eight spokes at each race. We carry a spare front wheel in case we have a tire failure. A double coil auto valve spring has been inserted into the front king pins for suspension for SEER ‘94. We hope this will reduce the spoke breaking problem. Also, we install “DT” brand (Swedish) spokes whenever the Japanese spokes break. The new ones are 18 gauge stainless steel.

Safety is very important to us. Our driver must wear a long sleeve shirt, long pants, and gloves. The battery is enclosed in plastic and we have the required seat belts, roll bar, main electrical disconnect switch, and rear view mirrors. Our brakes will stop the vehicle in 40 feet at 25 mph. These vehicles are considered motorcycles in California, so the driver must wear a helmet. Registration is $7 per year. In this area, the

Now, more than four years later, the sport of Electrathon racing is growing quickly. Nationwide, I estimate that as many as a hundred Electrathon-qualified vehicles exist. Why the popularity? There are several reasons.



One has to do with the challenge. The format for Electrathon racing is simple. How far can you go with 64 pounds of lead-acid, deep cycle batteries on a closed course in one hour’s time? With all drivers ballasted to 180 pounds, kids and adults compete evenly.

Cost and competiveness are other factors. Unlike the prohibitive cost associated with racing solar cars and the fluctuating rules of the stock and open classes at Phoenix, the Electrathon format rewards strategy and reliability over cost and sophistication. More than a decade of evolution in Great Britain and Australia stands behind it, too. A competitive design need not exceed $1,200 in total cost.

Simplicity is a third factor. Tool and fabrication skills taught at the high school level are sufficient to build an Electrathon racer. I’m excited at the implications of this. What better arena to educate and train young people than a high school auto shop! As well, competition is not a good word for this sport. The races I’ve attended feel more like a good outing with friends and peers than the crazy win-lose weirdness I find with other sports. Sure, you’d like to come up with the trophy, but it all seems more like good sport, participation, and the refinement of skills.

The ability to compete *often* is another attractive quality of Electrathon racing. Currently, dozens of races are run each year in California, most of them in parking lots. Linking up with other events, like the Electric Grand Prix, Phoenix, and SEER, has been a smart move for Electrathon organizers. This provides additional incentive for a builder-owner to go the distance required for a competition. Like other sport racing, points accumulation through many races each year decides the overall champion.

A few years back, Electrathon racing was challenged by a new breed of vehicles that included designs based on go-carts and “leaners” (vehicles with wheels that lean into the turns) from Clean Air Revival and Bob Schneeveis. These fast hounds began racking up trophies. The races looked different, too. Certainly wilder and maybe a little intimidating to slower vehicles. Things heated up, a struggle ensued to define the qualifications of an Electrathon racer, and a division occurred.

When the dust settled, Clark Beaseley had formed Electrathon America to further the sport in the traditional style. Ten bucks will buy the Rules book, which includes a healthy section on design and construction tips for the novice. The package includes an application to enter Electrathon races, and a newsletter with race results and the dates and locations of upcoming events. The rules contain three specifications that exclude the race-busting designs. One, the minimum wheel diameter is sixteen inches. Two, leaners must be automatically self-righting. Three, the driver must be fully enclosed in the vehicle. Sorry, no bail-and-fly designs (bail if you see the crash coming, fly if you don’t).

I am currently involved in a project, building an Electrathon vehicle with a dozen seventh and eight grade girls and boys enrolled in a Problem Solving class at a nearby junior high school. We purchased a Murphy AeroCoupe shell and are using Jergensen aluminum box-beam for the main chassis. The students lack materials-working and tools-handling skills but are enthusiastic and imaginative. In addition to competitive racing, the vehicle will be made street-legal. If we can get some sponsorship, I’ll bring a giggle of children and the car up to SEER ‘94 in July. See ya then!

terrain is too hilly for the vehicles to travel far afield. I live in town and could easily commute to school (3/4 mile) in the vehicle.

Our Racing Experience

We have competed in four races to date. The first race track was so rough and bumpy that we broke 25 spokes and blew a tire after 45 minutes. This prompted us to carry a spare wheel and tires. In the second race, we finished ahead of all other high schools at De Anza College Days. Our third race was at SEER '92. We were the only high school to compete because of the conflict of north/south politics. The fourth race was at Santa Rosa in the fall of 1993. Our driver tried to keep up with the "Gel Cell" powered car from the San Francisco Bay Area and ran the batteries dead after 50 minutes.

Knowing how to read your instruments is as important as their quality. To do this, WHSECC team members keep track of the number of laps and the elapsed time in the races. This is reported to the driver every 15 minutes via a chalk board. Prior to each race, we make timed test laps on the track with a spare (second set) of batteries. We calculate the battery reserve and best gear ratio to use on the track, and make the needed changes. Our "racing batteries" are maintained at a full charge by a solar panel right up to race time.

Project Benefits

The importance of this project is difficult to limit to a few points. I like that we are instilling an awareness of alternative energy sources in these students. It's a good place to apply practical math skills and problem solving. We have taken our vehicle to two other high schools and school board meetings in our area, hoping to spark interest in students and teachers alike. The students are easily interested. The teachers are more difficult to sway because it means donating time and energy. I estimate that we have 400 hours of construction time in building this vehicle.

Access

Alan Kearney, Willits High School, 299 No. Main St., Willits, CA 95490 • 707-459-7720

How to get involved!

Are you interested in Electrathon or other types of ultra light vehicle racing? Some enjoy the original Electrathon design and an oval track marathon race concept. Others enjoy exploring new designs and a road race to test their skills. Whatever your pleasure, ultra light vehicle racing is happening!

Electrathon America: For a rule book which contains construction tips, send $10 to 1251 West Sepulveda Blvd., Suite 142, Torrance, CA 90502. The $10 covers a newsletter with upcoming races. Clark Beaseley has a video describing different designs of Electrathon racing to help spark plans for your design.

Clean Air Revival: Contact Gene Karas for a rule book and racing in the Bay Area and all over California, for high schools, Explorer scouts, adults, and others interested. Gene Karas, Electronic Tech Instructor, Analy High School, 6850 Analy Ave., Sebastopol, CA 95472 • 707-824-6460

Explorer Scouts: (co-ed, 12–20 year olds) are getting involved in ultra light vehicle racing. Join the Scoutarama at Rohnert Park soccer stadium on June 4 for a demonstration. Contact Matt Myers, 2240 Professional Dr., Santa Rosa, CA 95403 • 707-546-8137

Oregon: Portland General Electric is sponsoring a six race Electron-run championship involving 20 high schools all over Oregon. Races are happening April 23 in Aurora, May 7 in Gresham, and May 21 in Salem. Contact Lon Gillas for details: 503-434-4332.

Michigan: Jordan Energy Institute is hosting the Michigan High School Electrathon Competition on June 11. Twenty-one high schools from all over Michigan will compete in this first annual event. If you'd like to display your electric vehicle, or take a ride around the track, come to this event at the Berlin Fairgrounds. For more information about the race or JEI's Associate Science degree in Electric Vehicle Technology, contact Paul Zeller, 155 Seven Mile Road, Comstock Park, MI 49321 • 800-968-3955

International & National series of ultra light vehicle racing: for information, contact Steve Van Ronk, Global Light & Power, 520 Pine St., Sandpoint, ID 83864 • 208-263-5027

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Good Books

Convert It

A Step-By Step Manual for Converting an Internal Combustion Vehicle to Electric Power

Written by Michael P. Brown; with Shari Prange

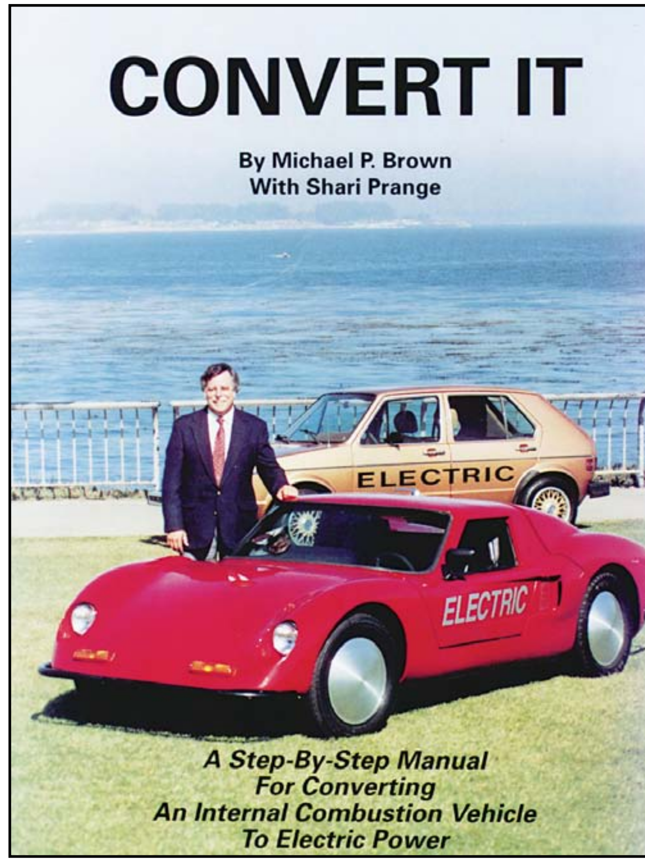
Reviewed by Richard Perez

Don't even think about converting it until you have read this book.

Mike Brown has been a professional mechanic for 28 years and been converting cars to electric for 14 years. He and his partner, Shari Prange, own and operate Electro Automotive, one of America's most experienced EV converters and parts suppliers. Their hands-on experience is distilled in this step-by-step, easy to understand book.

Convert It will save the first-time car converter from making scores of expensive mistakes such as choosing the wrong vehicle for conversion. This book contains a heavy dose of reality. Mike tells you, up front, what you are getting into — the joys and the limitations. The book is super complete with sections on safety, batteries, choosing a donor car, electric motors, controls, instrumentation, suspension, tools, and more.

Convert It makes it possible for the average shade tree mechanic to convert a vehicle from gasoline to cleaner electric power. The information in this book is well



organized and presented in an easy to digest conversational format with many photos and diagrams. *Convert It* is 11 inches by 8.5 inches, 125 pages, and has an ISBN# 1-879857-94-4.

Access

Convert It is available from Electro Automotive, PO Box 1113, Felton, CA 95018. Cost is $24.95 plus $3 U.S. postage or $8.50 postage outside USA. California residents, please add sales tax.

Electric Vehicle Chargers

Shari Prange

One of the most critical components for good electric vehicle performance doesn't even function while the car is being driven — the charger. It is also the component most likely to stimulate debate about appropriate specifications. While there is no consensus on the right answers, I can at least help you to ask the right questions, and evaluate the choices yourself.

Volts & Amps

The charger's job is to take alternating current (ac) from the power source and convert it to direct current (DC), as well as to alter the voltage to suit that of the battery pack.

Electricity flows "downhill", from a higher voltage to a lower voltage. For this reason, the voltage coming out of the charger must be higher than the nominal voltage of the battery pack.

Amperage (current) is also critical. Too little current will not achieve a full charge. Too much current will damage the batteries. The amount of current the batteries can accept is inversely proportional to the state of charge. Very low batteries can accept more current than nearly full batteries.

If a charger does not have enough output to bring the batteries all the way up, the car will not achieve its full potential for range. If the charger sends too much current to the batteries, it will cause them to gas, and will shorten their lifespan.

Home-Built Chargers

Early EV chargers were crude home-built affairs. They slammed juice into the batteries indiscriminately, and resulted in batteries that gassed a lot and required frequent waterings. This kind of abuse shortened the batteries' lives. If the charger was a little more sophisticated, it might include a timer-controlled automatic shut-off, or a dial which the owner could adjust every hour or so to taper the amperage. Neither method provided very accurate control, and the second required frequent attention.

Above: A transformerless 110 volt ac input charger (bottom left); a booster transformer for 120 volt output (top left); and a transformer-type 220 volt input charger (right). Photo by Shari Prange

Today, there is no reason to use a home-built charger, since there are good EV chargers commercially available. There are also several reasons not to use a home-built unit. Commercial units include numerous safety features in the form of circuit breakers, fuses, and ground fault interrupters to prevent shocks or hazardous electrical faults.

They also provide internal shielding to prevent electrical noise and spikes from feeding back into the ac lines. This is especially important when so many of us have sensitive electronic equipment on those same ac lines.

110 or 220 Volt Input

For home use, chargers come in two sizes — 110 volt input, and 220 volt input. In general, a 110 volt charger will bring a 96 volt pack from completely discharged to completely charged in about 12 hours, and a 220 volt charger will do it about half that time.

At first glance, this would make the 220 volt charger seem to be the easy winner. However, there are other considerations. These chargers have traditionally been the size of a bread box and weighed 70 to 150 pounds, so they haven't been practical to carry onboard. They cost more too. Also, 220 volt outlets are not as readily available as 110 volt outlets, and there are several different plug styles as well. This makes it difficult to charge on 220 volts anywhere except at home.

At least the first drawback will soon be eliminated since K & W will be offering a compact and lightweight 220 volt input charger.

In recent years, the 110 volt charger has been the most popular, because it has been available in a package smaller than a toaster and weighing only 10 pounds. It is very convenient to carry onboard, and allows charging anywhere with a grounded 110 volt outlet.

The difference between the lightweight and heavyweight chargers is the result of the different technologies used. The heavy chargers use heavy transformers to change the voltage. The lighter units “chop” or “switch” the input current and use only a portion of it. They are similar in principle to chopper controllers.

There are also some chargers that will accept either 110 volt or 220 volt input. New charging technology is being developed that will decrease the charging time for 110 volt chargers through various techniques, such as more precise monitoring of the batteries’ state of charge and rapid pulsing of the charging current.

Output Voltage
Output voltage varies from charger to charger. In some brands, it is necessary to specify the battery pack voltage, and that is the only voltage for which that charger will work. Other chargers offer the option of slight internal modifications to change from one size battery pack to another. The alteration is not as simple as flipping a switch, but certainly much less hassle than buying a whole new charger if you change your battery pack size.

Be aware that charging a 120 volt car from a 110 volt source may require a booster transformer in addition to the charger.

Set It & Forget It
Modern chargers require very little monitoring. They have the ability to sense the level of charge in the battery pack, and automatically adjust their output current to an appropriate level. They will start with an output of 20 to 30 amps for a completely drained pack, and gradually taper to a low amperage “finish charge” that equalizes the batteries. Some chargers will automatically turn off; others hold at the finish charge level.

Input Requirements
It’s best to have a dedicated circuit for the charger, with no other load on it. This is generally a 20 or 30 amp service, whether it is 110 volts or 220 volts input.

Of course, when charging away from home, such a circuit may not be available. Many chargers have adjustable output current. The charger current can be adjusted to suit the circuit available, and the car will charge at a lower (and slower) rate.

Safety Features
Modern chargers also incorporate various safety features, such as fuses and circuit breakers. The heavier chargers use transformers, which provide internal isolation of the input and output current. This eliminates the possibility of high voltage current flowing into the chassis of the car.

The smaller chargers do not use transformers. To compensate for this, they include a ground fault interrupter (GFI). This system requires the battery pack to be isolated from the chassis, and not use the chassis as a ground. If there is any current path between the battery pack and the chassis, the GFI will shut off the charger. This is similar to the GFI required in many areas in new construction of bathrooms, spas, and other areas where electricity, water, and humans may meet unhappily.

Shopping for Chargers
When you are shopping for a charger, you will need to evaluate all of these factors, and decide on the unit that best meets your needs overall.

Some features, particularly those relating to safety, are not negotiable. As a minimum, a charger should have fuses or a circuit breaker, and a GFI if it is transformerless; it should have an automatic tapering feature on the output current; and it should come from a reputable manufacturer and be enclosed in a sturdy protective case.

Other features will need to be weighed to suit your needs. The questions to ask are:

1. How big is it and how much does it weigh?
2. What input voltage(s) does it accept?
3. What output voltage(s) does it provide?
4. How energy efficient is it?
5. How fast will it charge my car?

Charging the 12 Volt System
The final aspect of the charging system is the car’s 12 Volt accessory battery. Some chargers have a separate circuit for charging this battery at the same time the main pack is being charged, but this feature is not common, especially on the smaller 110 volt units.

Of course, it’s possible to use an ordinary automotive 12 Volt charger separately on this battery. However, there is a better way: the DC/DC converter.

The car no longer has an alternator to keep the 12 Volt battery charged. As you drive, this battery will deplete itself. A “12 Volt” system is really designed to operate at about 13.5 Volts. This is what a typical alternator — or a fully charged 12 Volt battery — puts out. Accessories that are designed to operate on this 13.5

Above: A DC/DC converter installed in a VW Rabbit conversion to keep the 12 volt Accessory battery charged. Photo by Shari Prange

Volts will not work as well when the battery falls to 12.5 Volts or lower. Headlights become dim, and turn signals and wipers become lethargic.

You could install an alternator to run off the motor, but a DC/DC converter is more efficient. A DC/DC converter taps off the main battery pack, drops the voltage down, and keeps the accessory battery continually charged, just like an alternator. The car's 12 Volt system stays strong all the time, and there is no need for another charger for the 12 Volt battery.

Be sure you are getting a DC/DC converter that is designed to be used in a vehicle. There are many converters commonly available for use with computer hardware, but they will not stand up to the temperatures, dust, moisture and vibrations of a normal automobile in motion.

No single charger combines the best of all features. Which combination you consider the best will depend on how important each feature is to you. The important points can be boiled down to the few basic qualities: effectiveness, safety, reliability, and convenience. The charge you get out of your electric car will only be as good as the charge you put into it.

Access

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

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DC to DC Converters

James Van Bokkelen

Jocelyn and I live in a farmhouse built in 1799, which my family has owned since 1919. The roofs have north-south ridgepoles, and the intervening outbuildings are shaded by the larger buildings and trees. The outside is pretty much as it was 100 years ago, and I don't want to be the one to make big changes.

When I started to think about PV, I decided I'd need to build a "power shed" 75 feet south to house the PV array and battery pack. Then Jocelyn brought her love of horses into my life, and the shed turned into a 24 foot x 48 foot three-stall barn. The battery bank (48 Volt, 2100 Amp-hours of Trojan L-16s), charge controller and wiring center share space with the tack room. The PV array (44 Solarex MSX-60s) is on the steep lower section of the gambrel roof, which gives it a near-optimum tilt for winter at 42 degrees north latitude.

The house has an 18 foot deep dug well, with a suction pump in the cellar lifting 10 to 14 feet depending on the water level. Last summer, when all our normal rain wound up in Iowa, the well was a bit over-strained by the horses and irrigating the garden. It's also close enough to the road so I worry about contamination. The drought gave us an incentive to address the issue.

Drilling & Plumbing a New Well

New Hampshire law requires wells to be 75 feet from septic tanks and 20 feet from animal enclosures. Leaving room for a future replacement leach field near the house left us drilling near the solar/horse barn. The driller wound up going down 340 feet, with 31 feet of six inch casing (required from ground level to bedrock). They also installed a pitless adapter four feet underground. We wrote the check ($7/foot drilled plus $7/foot of casing) and started scratching our heads about the rest of the system.

Winters get pretty cold up here, so a pressure tank could go in the house cellar or a big (maybe 4 feet x 6 feet x 6 feet deep) well pit. Otherwise, the tank and plumbing would have to be festooned with heating tape, which the PV system wouldn't be able to power anyway. We didn't want to ditch across the driveway and wrestle pipe through the crawl space if we could avoid it, so we looked at some non-conventional alternatives first. Small commercial DC pumps are efficient, and if we matched the flow rate with our summer irrigation needs, no tank would be required. Filling a five gallon horse bucket from a garden hose already took several minutes, so a one to three gallon per minute flow rate wouldn't be an issue there either.

Then we hit a snag: 48 Volt pumps are uncommon. Windy Dankoff's 90 Volt non-waterproof Flowlight can be used on 48 Volts, but our well's water level wasn't stable enough. We needed a submersible, and they're available in either 12 V or 24 V. Vanner's Voltmaster is available for 24 V to 12 V conversion, but the only way you can handle 48 V is to use three of them, at considerable cost. 110 vac is available in the solar/horse barn (that's where the AES 5 kiloWatt inverter lives), but even a 1/3 hp ac submersible would pump far more than our soaker-hose setup needed.

Powering the Pump

I could have built a conventional transformer/rectifier power supply running off the inverter, but I didn't want to for a couple of reasons: First, we wanted to be independent of the inverter. Second, I wanted something more efficient, if possible.

It seemed like my only way out was to build Chris Greacen's DC-DC buck converter circuit (*HP*# 37), using the high-voltage version of the LM-2576 chip to do 48 V to 24 V. I began, but couldn't find a suitable Schottky diode (the 1N5822 won't take the higher voltage). Windy Dankoff had already shipped me the SHURflo 9300-series pump (which he distributes as well as manufacturing his own FlowLight line). The ground was going to freeze soon, so I called a digital hardware wizard I once worked for seeking pointers.

He sent me catalogs for a number of commercial vendors of packaged high-efficiency DC-DC converters: Vicor, Power General and Computer Products all had units with usable voltage ranges and wattages. After hurrying through the literature, Vicor got my first call because their "Express" telephone order line seemed set up for quick response on small orders. Their VI-200 family of DC-DC converters is available as follows: the part number is "VI-2w x-yz" (see table).

I ordered the VI-233-IW (48 V to 24 V at 100 W, –40 to 85° C operating range) for $232. It arrived the next day via UPS. The unit is 0.5 inches thick, on a 4.6 x 2.4 inch aluminum heat sink plate, with solder pins. It came with a test log showing an efficiency of 86% at both ends of the operating temperature range. Possibly because I told Vicor my plans, a comprehensive Applications Manual arrived via mail a few days later.

Vicor VI-200 DC-DC converter specs (VI-2wx-yz)

w =	Volts in	x =	V out	y =	Grade	z =	Power*
0	12 V (10–20 V)	Z	2 V	E	0 to 85°C	Y	50 W
1	24 V (21–32 V)	Y	3.3 V	C	–20 to 85 °C	X	75 W
W	24 V (18–36 V)	0	5 V	I	–40 to 85 °C	W	100 W
2	36 V (21–56 V)	1	12 V	M	–55 to 85 °C	V	150 W
3	48 V (42–60 V)	2	15 V			U	200 W
N	48 V (36–76 V)	3	24 V				
4	72 V (55–100 V)	L	28 V				
5	150 V (100–200 V)	4	48 V				
6	300 V (200–400 V)						
7	150/300 V (100–375 V)						

*100, 150, 200 W output not available in all input voltages

Installing and Using It

Chip Mauck of Sunweaver Energy Enterprises, the supplier of my PV system, helped me get the pump into the well and wired. We used his "pitless adapter tool" ten feet of one inch threaded black iron pipe with a tee and a pipe handle on top) to drop the pump 60 feet down. This put it 34 feet below the apparent "static" water level, giving about 50 gallon of draw down potential. I removed the pitless adapter's built-in check valve and installed a 1/16 inch drain-back hole in a tee just below it. This keeps the pipe into the barn normally empty. I buried the power wires in an extra piece of poly pipe beside the water line.

We hooked the VI-200 up to the pump and battery, wiring the voltage sense pins –S and +S directly to the –OUT and +OUT respectively. I left the Trim and Gate lines unconnected and used an SPST toggle switch to control the pump. Vicor recommends switching the +IN line, because both output lines float high when the -IN line is interrupted. We mounted the converter and switch in a plastic weatherproof box.

Since there's 20 feet of pipe to fill, it takes about 30 seconds for the water to arrive after switching the pump on. All the above-ground pipes sloped so no pockets of water stay behind to freeze, and everything has worked fine through a number of sub-zero nights. Flow rate is a little less than two gpm.

Afterthoughts

As usual, 20-20 hindsight turns up some things I'd change if I were doing it again: First, if the converter runs hot this summer I'll need better heat sinking. I'd do this by replacing the plastic box with a metal one and using thermal heat-sink grease (available from Radio Shack and elsewhere). Second, I should have gotten a unit with screw terminals and avoided soldering — this is Vicor's "BusMod" packaging option, specified by adding "B1" to the part number. Third, since the SHURflo pump can take up to 30 V, I wish I'd ordered a 28 V output.

Other possible applications that come to mind are: Using 5 V or 9 V gadgets that normally use an ac power cube in a DC-only environment; Replacing one or more inefficient 5, 9, or 12 VDC power cubes with a single central supply; Using power from an EV's main battery pack for lights and accessories instead of lugging and charging an auxiliary battery.

People using Vicor VI-200 series converters in climate-controlled locations could save up to $80 by specifying a narrower operating temperature range. You probably want to specify the wider input voltage range (W or N instead of 1 or 3) if you've got an alkaline battery pack.

Access

Author: James B. Van Bokkelen, Far Acres Farm, 45 Hilldale Ave., South Hampton, NH 03827

DC-DC converters

Vicor, 23 Frontage Rd., Andover, MA 01810 • 508-470-2900 (Express order line 1-800-735-6200).

Computer Products, 7 Elkins St., South Boston, MA 02127 • voice 617-464-6600 • FAX 617-464-6612

Power General, 152 Will Drive, POB 189, Canton, MA 02121 • voice 617-828-6216 • FAX 617-828-5060 or 3215

Pump Manufacturer/Distributor: Windy Dankoff, Photovoltaic Systems Specialist, POB 548, Santa Cruz, NM 87567 • 505-351-2100

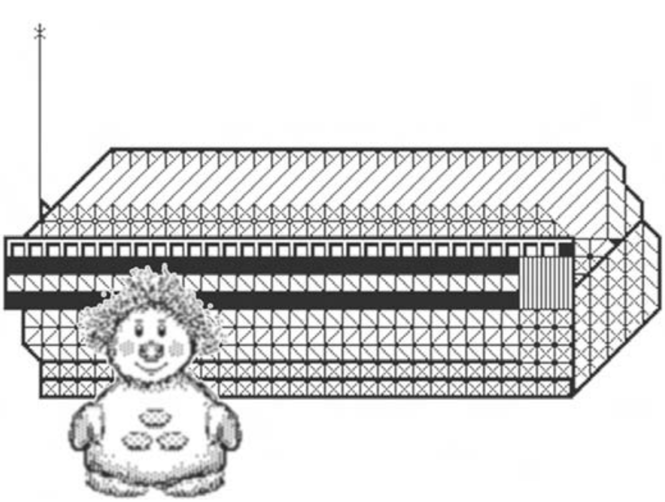
PV Dealer/Installer: Sunweaver Energy Enterprises, Rt. 4, Northwood, NH 03261 • 603-942-5863

Mail Order Shoes

Richard Perez

Ever have to buy your shoes via a mail order catalog? I did when I was younger and overseas with my Air Force family. The only thing wrong with these mail order shoes were that they never quite fit right. They were well made, but painfully unsuited for my feet. If they hurt badly I could send them back. If they only pinched a little, then I'd grin and get used it. Buying a renewable energy system is much like buying mail order shoes.

The most important element in a renewable energy system is the user. Many RE systems are designed, sold and installed with little or no consideration for the system's users. Everyone focuses on the hardware, not the human needs that the system should satisfy. It's time for RE users to demand their rightful place at the center of the system's design. We don't have to be satisfied with "home power system #6" from a catalog. We don't have to buy our system from a dealer or installer who hasn't designed our needs into the system from the very beginning. It is easy to calculate the rated performance and cost of a pile of hardware. Determining if this hardware is right for the system's users is entirely another matter. A well designed system supplies the user's energy needs from the locally available natural energy sources.



Energy Requirements

Some folks choose RE because the electric power grid is located at an unaffordable distance. Some folks choose RE because it provides sustainable energy without pollution. Some folks refuse commercial power and go with the security of their own RE system. While the stated reasons for adopting RE are as different as the people using the systems, we all have one thing in common — a need for energy.

Our energy needs have three distinct requirements which the system must satisfy.

1. a list of appliances

2. a reliability requirement

3. a degree of user participation.

These three requirements are determined by the humans using the system, not by hardware, technology, or even by natural forces. This article is about assessing these human requirements. You will find no equations summing things up here, but a softer, more human look at RE systems

Our Appliances

Every home or business has a specific list of energy consumers — appliances. Every system design begins with an accurate and thorough analysis of the loads. Each appliance has its own characteristics — power type (12 or 24 VDC or 120 vac), amount of power required (watts), and duration of appliance use (time). From these characteristics the designer can accurately estimate of the energy requirements of each appliance. The total energy consumption can be easily calculated by summing up the requirements of all the appliances. See page 7 of this issue for a sample load table.

The system's load table shows where inefficient appliances are being used. During the sixteen years that I installed systems, I rarely designed the hardware portion of the system before revising the load table at least three times. The load table is extremely important. Glossing over inefficient appliances or inefficient appliance usage, causes either a needlessly expensive system, or eventual power outages and their associated disappointments.

Every dollar spent on efficient appliances will save three dollars in system hardware. If you are designing your own system, then spend the time and effort to do a thorough load analysis. If you are having your system professionally designed and installed, then giving your system's designer misinformation is akin to lying to your doctor or lawyer. By way of a small tip to system designers everywhere, everyone underestimates the amount of time that they spend watching the TV….

Part-time, Full-time, or Overtime

Each of us demands a different type of service from our renewable energy system. For example, the system for a weekend cabin has radically different requirements than a system which powers a home or business. What it really comes down to is what type of duty cycle the user requires from the system.

Consider part-time usage like a weekend cabin. Here the system is in use for two or three days with at least four or five days to recover between use periods. The occasional usage demands of the cabin's user allow for a smaller and less elaborate system. Energy only needs to be stored for a couple of days. The energy source has several days to refill the storage before the system is required to once again deliver power. Part-time systems are easily designed and installed by first-time RE users.

A home is always occupied; the system must provide power every day. The full-time system's energy storage capabilities must be greater than part-time systems. The full-time system must recover from cloudy or windless periods more quickly than the part-time use system. Full-time systems require design work by an experienced person. But even a full-time home is flexible in its energy demands. For example, if the batteries are depleted, we can put off running the washing machine until a sunny day. Strategic energy use can really stretch a home power system's abilities.

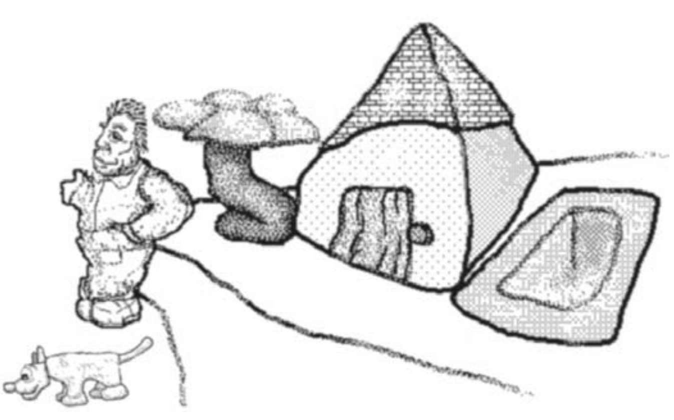
Some systems power businesses or essential services that don't have the luxury of putting off work until the sun shines or the wind blows. I call these overtime systems. For example, the RE systems which power mountain top communications equipment cannot tolerate even momentary power outages. Another less demanding example is *Home Power Magazine*. All of our computers, scanners, and printers are powered by renewable energy. We have magazine deadlines and simply cannot put work off until the sun comes out. Overtime systems are designed to deliver continuous power regardless of natural energy fluctuations. Here the renewable energy sources are oversized in order to provide almost immediate recovery from extended cloudy or windless periods. Overtime systems usually have at least two energy sources and extended energy storage. Overtime system design is work for an accomplished expert.

Every time the duty cycle of the system increases, so does its design complexity, size, and cost. A full-time system requires much more hardware and expense than a part-time system. In a full-time system, design flaws that are invisible in a part-time system are apparent within weeks of the system's installation. When the system's duty cycle hits overtime, then even the smallest design defect can interrupt the system's constant flow of power. Overtime systems gain their constancy at high costs. Building a system with near 100% reliability costs many times more than building a system with 98% reliability. We are not talking about component failure here. We are talking about the natural vagaries associated with making power from renewable energy sources like sun, wind, and falling water.

User Participation

Every system should be designed with user participation in mind. Some folks are willing to operate the system with an eye out for natural power production. Other folks want to treat the system as a virtually limitless source — like they were plugged into a utility.

The best form of user participation is knowing when to use the system's full power and when to decrease power consumption. Even this small degree of user participation pays off because the system can satisfy the user with less hardware and thereby less cost. For example, no battery is 100% efficient. Merely using the power when it is produced by the energy source offers a 10–20% dividend over retrieving the same amount of energy from battery storage. A careful user considers the amount of energy remaining in storage. Even if the energy sources are producing, a discharged battery is an excellent reason to reduce power consumption. Wait until the battery refills, then start using the energy as it is produced. And if the sun is shining and the wind is blowing and the batteries are full, then it's time to make a cake in the toaster oven, or run some clothes



through the washer. Using what nature offers, when she offers it, is not only good manners, but cost effective. A system which dances when nature plays can be much smaller and cost from 25 to 75% less.

Site Evaluation

Site evaluation means surveying a specific location for renewable energy resources. The most common resources are the sun, wind, and falling water. Each resource is different and requires different survey methods. Check out the index in *Home Power* #36 for many articles about the technical specifics of surveying a site for a particular RE potential.

What counts from a human perspective is that an accurate site evaluation is performed. While it may seem a waste of money to spend several hundred dollars on a site survey, it is actually the best money you will ever spend on your system. Since solar energy is the most commonly used renewable energy resource, let's look at a solar site survey.

Solar is the easiest renewable energy source to estimate. A combination of a sun chart (like that provided by the Solar Pathfinder™) and some local weather savvy are all that is really needed. If you are doing your own system, then borrow your neighbor's Solar Pathfinder and find the best location for your solar array. If none of your neighbors have a Solar Pathfinder, then buy one (about $195) and lend it to your neighbors when you're done. If you are paying to have your system professionally done, then your designer/installer will do sun charts of several proposed PV array locations. If your designer doesn't do sun charts, then look for another designer. The sun chart is a ground zero solar site survey; don't install a single module system without one. The site survey is critical, yet many people buy and install PV systems without it. When I was a designer/installer I batted cleanup on many user installed PV systems. In about one third of the systems, I was able to radically increase the PV array's power output by relocating the array. Install your PV array where it receives the most sunshine, not where it is most easily or conveniently placed.

Both wind and hydro site survey are more complex, but not difficult (see pg.86). Again, it is important to actually do the survey. Please don't just read up on the process and make some intelligent guesses. Assumptions made now will come back to haunt you later.

Power Possibilities

The site survey tells what kinds and amounts of natural energy are available at the site. Then the system's designer and user have to make a choice of which resources to use. In some cases, the choice is clearly made by nature. In most cases, the user can choose between two or more renewable energy sources. It is very important for the system's designer to realize that the system must not only capture the available RE sources, but also match the requirements of the user.

Each RE source has different user interfaces. For an example, consider maintenance. Almost all small RE systems are maintained by their users. The degree of user participation demanded by a wind or microhydro system is greater than a PV system. Photovoltaics have what computer folks call a "transparent user interface". Mick Sagrillo, a noted wind maniac, says of PVs, "They just sit there and smile at the sun." If you aren't into maintenance, then using PVs as a power source has advantages over using wind or hydro. The only routine maintenance required by PV can be accomplished with a squeegee. Both wind generators and microhydro turbines are machines with bearings, brushes, and moving parts.

If you are installing your own system, then the physical installation of PVs is easier than installing a wind generator with tower, or burying the pipe for a microhydro. But a wind generator properly installed in a suitable site is far more cost effective than using PVs. The same is true for sites with microhydro potential. Microhydro systems will deliver energy for about 20% of the cost of a PV system. If nature gives you wind or falling water, then by all means use it. Just be aware that these power sources do not tolerate funky design or installation.

Choosing Energy Sources

Choose a source that you can live with. If you are considering a part-time system, then PV is your best choice. For full-time systems, go with the energy source that best suits your site, budget, and lifestyle. If you are considering an overtime system, then you will have at least two power sources. The most common overtime choices are PV/wind and PV/microhydro.

Many full-time or overtime systems also have an engine/generator as a second or third power source. The big trick with engine/generators is to only use them occasionally. If you are running your generator more than 150 hours a yearly, then you need to upsize or add RE sources. When it comes to supplying large quantities of power on demand it is hard to beat the engine/generator. As the occasional backup power source, they are very effective. As the primary power source for the system, engine/generators are a nightmare of noise, expense, and maintenance. In full-time or overtime systems adding an engine/generator is less expensive than oversizing the RE sources and battery to compensate for extended sunless and windless periods. Including the engine/generator in the system means that user participation must increase. Somebody's got to change the genny's oil….

If you are blessed with microhydro potential, then please accept my envy, bite the bullet, do the work or pay the installation bill. Of all of the easily tamed natural power sources, 24-hour-a-day hydro pays the biggest dividend.

When choosing and sizing a power source, consider what the system will look like in five years. Is your family, and thereby your energy needs, growing? Adding a few more PV modules is easy (provided wiring and controller is large enough), but expanding wind or hydro requires planning. A wind tower will only hold so large a generator. The pipes delivering water to the hydro turbine will only transfer a finite amount of water. If you are considering either wind or hydro as a primary source, design the system for expansion. The cost of initially oversizing the tower or the pipe is small in comparison with replacement at a later date.

Energy Processing

Energy processing equipment includes charge controllers that prevent overcharging the batteries, inverters which convert battery stored DC power into 120 or 240 vac, and instruments which provide information about the status of the system. Most of these electronic marvels didn't exist ten years ago. Now they are standard equipment in almost every system.

Inverters have a definite limit to their power output. Once again the user needs to look ahead about three years in order to determine inverter size. A load analysis gives inverter power totals for a specific set of appliances. Most systems are in a constant state of change with old appliances being replaced by newer (and more efficient) ones. The demand for electric power tends to grow rather than diminish. An inverter should be oversized enough to supply future expansion rather than having to be replaced with a larger model. The same is true of power source regulators, particularly in part-time PV systems.

System instrumentation was once the province of engineers. Now these instruments are affordable enough to find their way into almost all systems. And with good reason. Information about the system enables the user to more effectively use its power. The minimum instrumentation for a part-time system is a battery voltmeter. Full-time and overtime systems should also have a battery ammeter and battery ampere-hour meter.

My experience is that even non-technical folks will pay attention to the instruments. Eventually everyone is able to relate the meter's information to real questions like, "How much energy is left in the battery?" What is very important and often overlooked is the placement of the instruments. If non-techies are to learn the behavior of their systems from these swell instruments, then the instrument must be constantly in the users' faces. Mount the system instruments in a high traffic, high occupancy area. My first choice is the kitchen, then the family room or dining room. Instruments located in the power room or power shed only give crisis data. Most users only look at them when the lights go out.

Energy Storage

The batteries are still the weak link in every stand-alone (without utility grid) power system. Of all the system's components, the electrochemical cells that store the system's power are most prone to failure. The larger the battery, the higher the statistical probability that a single cell will cause battery problems. There is very little a user can do about this except to religiously perform regular battery maintenance. Most of the avoidable battery mistakes are made in the system design phase by specifying too little storage for the system. An undersized battery must work harder on a daily basis. During low energy input periods, it is discharged more deeply. All these factors contribute to early battery failure. The battery prognosis is the worst for systems with a single energy input. Part-time systems need only store energy for a few days. Full-time RE systems should have a minimum of four days of storage. Overtime systems need at least seven days of energy storage. The battery can be downsized and its average state of charge increased by adding a second energy source to the system.

In almost all full-time or overtime systems, a second energy source is cheaper and more reliable than oversizing the battery and using a single energy source. I'm mentioning this here and now for a reason. Including a second RE source during the initial design phase can reduce the system's dependence on its weakest and shortest lived component — the battery. I know that designing a system with a single input is difficult and expensive enough. I know that few owner/builders are familiar with more than a single source, and few dealers are either. Stand back from the initial design and take a long look at your second power choice. Chances are that developing that second power source is more cost effective than oversizing the battery or running an engine/generator.

An Open System Architecture

I'm much more comfortable making measurements with the voltmeter, than with discussing these softer aspects of RE system design. The essence of this softer side is, “Know Thyself”. Or in the case of a dealer, “Know Thy Customer”. If you are designing a system for yourself, then be realistic about your abilities and requirements. For example, if you are not comfortable with electricity and electrical tools, it’s OK to seek the help of someone who is. If you are designing for others, then get to know your customers. For example, a customer who won’t change the oil in his car cannot be relied on to maintain that shiny new wind generator, or keep his hydro’s trash rack clean.

Ten years ago most home power pioneers were amazed to get a system working. Nowadays we have an armada of hardware that can generate thousands of distinct working, affordable systems. It’s time for us to stop accommodating the hardware, and to have the hardware accommodate us. RE technology can deliver a system that fits the user perfectly. All we have to do is ask the human questions during the design phases of the system.

Access

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Water Pumping for the Independent Home: ac or DC?

Windy Dankoff

The grid-connected world uses alternating current (ac) power, because it's suited to long-distance power transmission. Our battery-stored energy is direct current (DC). Renewable energy homes can use both: DC directly from the battery, and ac through an inverter. Should we use a special DC pump, or a more conventional ac pump? The answer is not simple, because it involves about a dozen interdependent factors.

Ac Pumping

Ac pumps are common, inexpensive and reliable, so let's check them out. Like most large appliances, ac pumps use "induction" motors. This motor sucks a lot of power to start, until it comes up to speed. You know how a motor might growl while starting, maybe dimming the lights a bit, then will "click" into cruising speed? During start-up, an induction motor draws a "starting surge" as much as ten times the running power. Some inverters can handle this surge, and some cannot. So, what kind of inverter does it take to power a water pump?

Inverters: Form & Function

Inverters come in two forms (*HP* #36 has more details). The "switching-based" inverters (StatPower, PowerStar) are efficient, and easy on the budget. The largest ones appear to have the power capacity (around 1500 watts) to handle a water pump, but they cannot handle the starting surge, in most cases. The "transformer-based" inverters (Trace, Heart, Dynamote, for example) are heavy beasts. They are specifically designed to handle such surges.

Generally speaking, a 1/2 horsepower (hp) pump motor requires a 2000 watt inverter to work reliably. A 3/4 hp pump needs a 3000 watt inverter, and so on. This represents "comfortable" sizing to allow for a few hundred watts of other loads to be run at the same time. Still, there will be a voltage dip when the pump starts. You'll notice a quick dimming of lights (and perhaps a computer crash).

Spinning on a Wave

Inverters vary in function as well as form. Trace and Dynamote now build transformer-based inverters that produce "sine wave" power. This describes the "natural" form of alternating current, like that produced by a spinning generator. The current alternates direction smoothly, like the swing of a pendulum. (Imagine it swinging back and forth at 60 cycles per second.) Most inverters produce something called "modified sine wave" power. The waveform is a bit choppy, like a pendulum being tapped by a hammer. These inverters are very efficient, and not too expensive. It's a compromise.

The electric utility grid supplies sine wave power. Ac appliances and pumps are designed for this sine wave power. However, an ac pump can run well on a modified sine wave inverter. Hundreds of them have been running this way since the mid '80s. Nevertheless, a pump will start faster, draw less surge, run cooler, and use a little less power spinning on a sine wave.

Efficiency of ac vs. DC Pumps

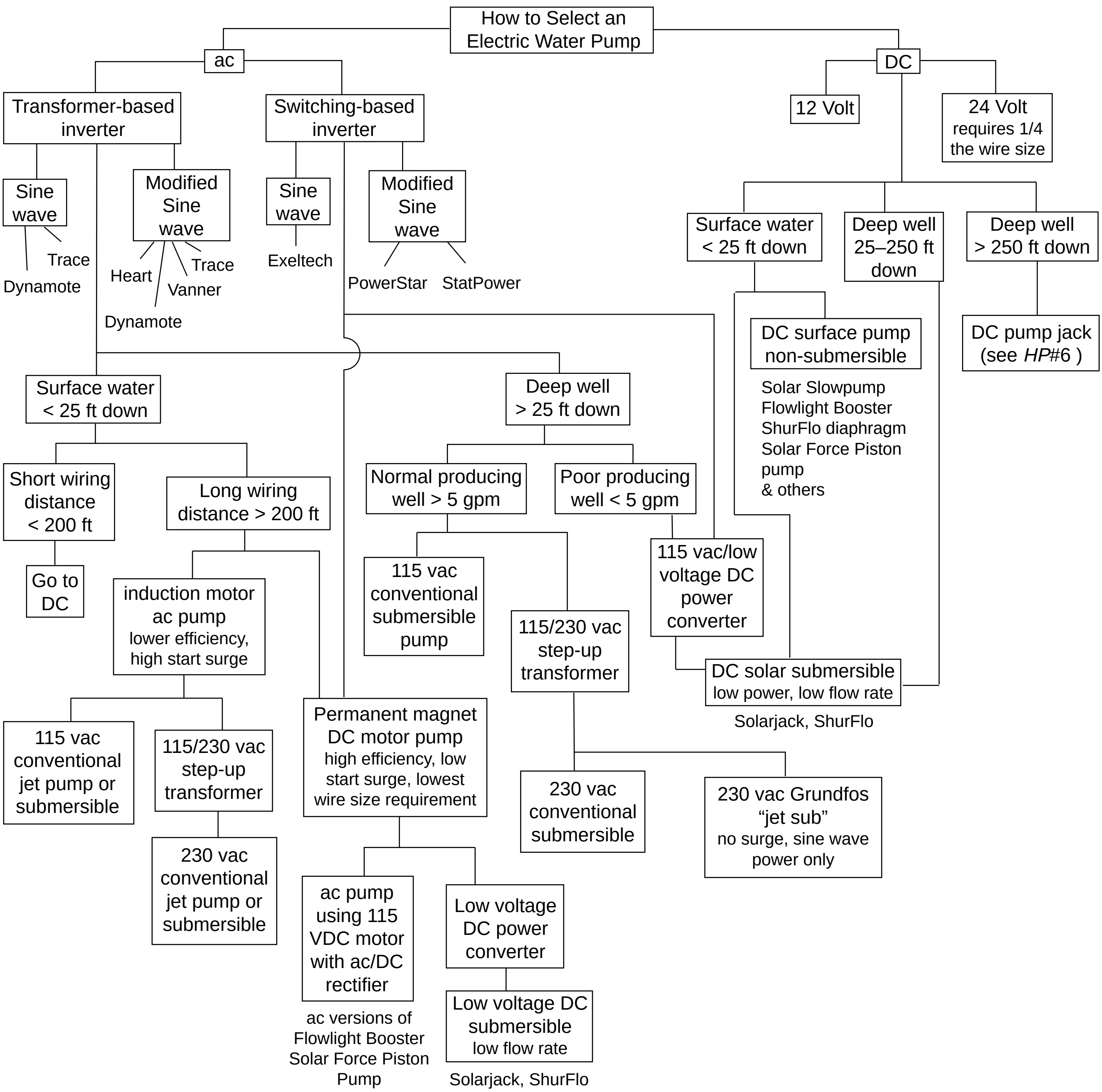
An inverter can run a pump with only a 10% power loss (90% efficiency) which is not bad. On the other hand, ac pumps can be quite inefficient. They are designed for low cost and "common denominator" marketing, at the cost of energy consumption. Typical efficiencies range around 30%, meaning that only 30% of the power entering the motor is converted to water flow and pressure.

The DC pumps that have been created for solar pumping range around 50% efficiency. So, with inverter losses eliminated, they do the job on half the energy. As this is a new field, there is not an optimum pump available for every job. But, as huge markets open up in Africa, India, Australia, Mexico, and even in the U.S., expect to see more DC pumps available.

Heads or Tails?

To select the pump system for your renewable energy home, let's start with these four considerations:

1. Is the right DC powered pump available to fit your water source and your needs? If so, then it is probably the most efficient way to go. The shallower your water, the better the chance that the right DC pump is available. Some DC pumps cost little more than ac. Others cost much more. Keep reading.



2. Consider the "cost vs. benefit" of efficiency. The more water you need, and the less energy resource you have (sun, wind or whatever), the more important it is to have a very efficient pump. On the other hand, if your water requirements are low and the energy yield of your system is generous, then energy efficiency is not so critical. It doesn't hurt to be efficient, though.

3. Will your home power system (and your inverter) be capable of powering an ac well pump? If you need a powerful inverter for other loads besides a pump, that's a good reason to consider an ac pump. Of course, the pump combined with other loads may dictate a larger and more costly inverter.

4. Is your water source located close to the power system? If so, running DC power to your pump may be economical. If the distance is hundreds of feet, you have three other possibilities:

a. Run a DC pump on its own "dedicated" power system, located near the source. (I discuss the relative merits of dedicated vs. integrated systems in *HP*#38.)

Selecting an ac Submersible Pump for Inverter (or Generator) Power

Submersible well pumps are particularly hard for inverters to handle, and small generators can have the same problem. Here are some tips for selecting a "sub" that will perform best. (For more painful details, see "Running ac Submersible Pumps on Inverter Power" in *HP*#17.)

1. Shop around for the most efficient pump you can find to fit your well and your water volume and pressure needs. Higher flow pumps tend to use energy more efficiently (less Watt-hours per gallon pumped). Shop for the highest flow rate you can get for the horsepower, without exceeding your well's capacity or the capacity of your (proposed) inverter. Prepare to share the intimate details about your well — depth, static water level, and recovery rate. Your well driller might have this info if you don't. An older well might need to be re-tested by a driller.

3. Pick a pump with a "Franklin" brand motor. Most pump manufacturers use Franklin motors. They have the best starting characteristics.

2. Get a "three-wire" pump rather than a "two-wire". It employs an above-ground control box that reduces surge requirement and eases maintenance.

4. Avoid pumps with a "Solid-State" control box. They are not tolerant of extreme dips in voltage during starting surges. If your pump of choice has one, either get a relay kit to convert it to a conventional starter, or substitute a different brand of control box.

5. Get one or two spare "start capacitors" from your supplier. They tend to fail if slow starting occurs. Obtain ones with slightly higher "MFD" rating than the original. You can replace a bad one easily yourself.

6. See if the new "Jet Sub" by Grundfos will fit your needs. Its newly developed electronic motor starts with no surge at all. But, it will only run on a true sine-wave inverter. It won't work on a modified sine wave inverter.

7. See if you can get your pump of choice with a 115 volt, rather than the usual 230 volt motor. Otherwise, you will need a transformer to step-up your inverter's output. The transformer costs money, and loses another 5–10% of the power.

8. Don't skimp on wire size. Check the pump manufacturer's recommendations.

Warning: A 115 v pump requires larger wire than the more common 230 v pump. Be sure your installer uses the proper wire.

9. Size all piping, including your house plumbing, a size larger than minimum, to reduce friction (if it isn't too late). If you do this, you can run lower water pressure. A cut-out pressure of 35 psi may suffice, instead of the usual 50 psi.

b. Run a long ac line from your inverter to an ac pump. The higher ac voltage requires much smaller wire, which can be economical for a long distance.

c. Run a long ac line from your inverter to a DC pump — either a low voltage pump (using a step-down converter) or a 115 VDC pump (with a rectifier for ac). Why? These pumps have a low surge requirement, are very efficient, and are available as small as 1/8 hp. This further reduces wire size, pipe size, and energy requirements.

Can I Go Now?

I offer this as a "road map" to point you in the right direction and to steer you around some pitfalls. Where two paths compete, compare the cost of each one as a whole energy system. Not all the territory is charted, but it's all been traveled before. So be a wise driver. When in doubt, stop for directions!

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Windy Dankoff, PVSS, P.O. Box 548, Santa Cruz, NM 87567 • phone/FAX 505-351-2100 Windy builds solar pumps for outlaws, missionaries, cows, and apple trees. He teaches solar pumping at Solar Energy International in Colorado. For course information, call 303-963-8855 • FAX 963-8866.

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More on Methane

Al Rutan the Methane Man

Almost two years have passed since the last mention of methane in these pages. *Home Power* issues 26, 27, 28, and 30 described the basics of methane production from animal feces. I discussed a low pressure storage tank, tank insulation, pH balance, animal treatment, and heat retention. I'd like to share some new information I have learned since then. Some things worked and other things didn't, but all facts whether positive or negative are part of the mastering process.

Currently, my methane demonstration is being upgraded. I am discarding the plastic tank that served as a digestion vessel for the last year in favor of a metal tank. Why the change? For several reasons. First, the problems.

Bonding Difficulties

The primary difficulty is maintaining a vapor tight seal between the fill and overflow pipes and the tank. The plastic tank didn't cost much when new, so it was too tempting to pass up. But experience has shown that it was not a good choice. The tank material is polyethylene and the pipes are PVC plastic. While it's possible to weld polyethylene with heat and produce a bond, it isn't something that an amateur can do easily. I attempted to produce a vapor tight seal with various types of glues and epoxies, which was achieved with some success.

But the tank was often moved from one location to another by the trailer on which it is mounted. The sloshing within the tank caused the pipes to break the bond with the tank.

A second reason for replacing the plastic tank is that it is too short; the tank is three feet in diameter and only five feet long. The best proportion for a tank is three to five times as long as the diameter. This rule of thumb became obvious when new material was introduced into the tank at the fill pipe. What exited through the overflow was working nicely, still bubbling like crazy.

Slurry Still Working

The supposed "waste" or "spent" bucket wasn't spent at all, but continued to be active after it had been forced out of the tank. A short tank is truly an inefficient design. The fill and overflow pipes are just too close together. Also, the fill and overflow pipes should not be in line with each other. One should be at either the right or left side of center and the pipe at the opposite end of the tank should be on the other side of center. It doesn't make any difference to which side of center the pipes are placed. But it's important that the pipes at the ends of the tank not be in line with each other.

Such a placement of the pipes provides another important advantage — the best position for the stirring mechanism. On the plastic tank, the stirring mechanism was vertical with a crank at the top. After a short time, I learned that this was a poor design for a stirring device. The seal at the top is difficult to keep vapor tight. If the bearings for the stirring mechanism are below the water line, then any leakage is no more than a little moisture, but not vapor.

When the Tank Gets "Cranky"

Also an oversight in the vertical stirring device design was the omission of a bearing point at the bottom end of the shaft. It was left to "float". With the resistance of the material within the tank, the pressure on the one bearing at the crank end of the shaft tended to distort the cover of the tank as the crank was turned.

Ideas that Worked — the Heat Bath

That's the bad news. So what's the good news? The water bath for providing heat to the tank. I originally thought that this would be an effective way to transfer heat from whatever source to the tank. In actual operation, the concept worked even better than anticipated.

Heat is supplied from a two foot square hot water box placed below the level of the water bath. The placement of the source of hot water under the water bath allows the water to circulate via a thermosiphon: hot water rises in a closed circuit of water. The connecting pipes are two inches in diameter — one for supplying warm water and another for the return of the cooler water. The pipes from the hot water box connect to an 18 inch deep metal water bath underneath the tank. The tank is placed on supports six inches above the floor of this water bath.

Above: The new metal tank methane digester on its trailer.
Photo by Al Rutan

More Art Than Science
Let's back up for a bit. People will sometimes ask, "Does it take a degree in engineering to understand the methane process?" My answer is, "Not at all. What is most helpful is the experience of baking bread, or making wine or beer. Each of these skills is both an art and a science. There are some things that must be known. But basically, it's experience with the process of fermentation. And in the final analysis, the skill is more an art than a science."

For bread to rise — which is the critical test of whether or not it will be a handsome loaf — and for wine to ferment, the temperature conditions have to be, as we say, just right. The same is true of the methane process, which is another example of fermentation. Methane production occurs virtually automatically in old landfills, but we're talking about maximum production from a minimum amount of input. As for good bread, heat supplied during the rising process needs to be just what bread wants and free of drafts. For maximum methane production, the optimum temperature needs to be supplied evenly.

Written in South Africa some years ago, L. John Fry's book *Practical Building of Methane Power Plants* observed that pipes supplying heat to the slurry had to be hotter than the optimum temperature in order to get enough heat to the mass. This caused two unfavorable effects. The methane organisms in the proximity of the pipe were cooked to the kill point. Such heating caused a crust to form on the heating pipe that eventually caused the heat within the pipe to be insulated from the slurry.

Using pipes for the heat transfer is not the way to go. But body warmth for the process is essential, as is the right temperature for causing bread to rise or beer to ferment. So the next question is, "How best to heat the tank?"

The Key to Even Heating
In my book, *The Do's & Don't's of Methane*, the proposal to solve the problem was a false floor within the methane tank. This would separate the active slurry from the water beneath; the warm water provides heat transfer to the slurry above. The false floor thus acts as a double-boiler.

The source of heat is below the slurry, providing heat at the very lowest point. Because the heat transfer is spread over the entire lower surface, there are no hot spots that produce a kill temperature or crusting problem.

Thermosiphon Provides Effective Circulation
Setting the tank in some sort of a water bath was a given. But the surprise benefit in this design is how easily and how well the principal of thermosiphon worked for the heat transfer. The water heater provides heat from either a small gas burner or solar panel. This warm water moves up into the water bath, circulating so effectively that one would assume there is a circulating pump somewhere in the system.

But there is no pump, just a closed circuit of water moving by a heat differential. In the 18 inch deep water bath, the hot pipe enters the bath at the mid point — or nine inches above the floor. The return pipe at the opposite end of the bath is as low as possible. With only a nine inch difference between the input and the return pipes, the circulation is wonderful.

The reason for the input entering the bath at the midpoint is to provide as much of a strata of warm water above the input as possible. And it works amazingly well. The water bath heats the tank evenly and effectively from the bottom up so that the working temperature within the slurry is even and constant. This approach to handling the heating problem has been designated the Rutan Design.

What's in the Words

As I write this, a new methane display is being constructed. It consists of a new trailer — a 16 foot car hauler — fitted with metal tank three feet in diameter and ten feet long. The tank has three windows so that one can watch the methane activity within the tank. It will be heated with a solar collector, using some stored gas for backup. With the right kind of feeding and management, this size is large enough to provide the cooking and heating needs for an energy efficient homestead.

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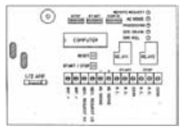

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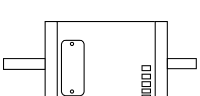

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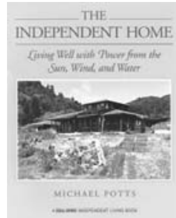

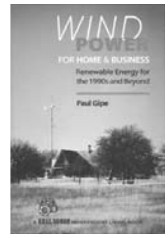

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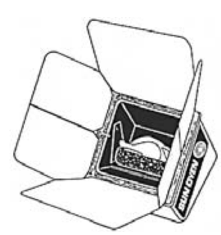

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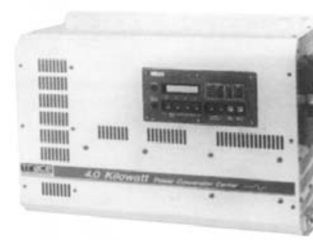

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Site Analysis for Wind Generators

Part 1: Average Wind Speed

Mick Sagrillo

You've decided that it's time to consider a wind electric system. It sure seems windy in your area, at least part of the time anyway. And you could really use the power!

But how can you tell if a wind generator will really do well at your site? How do you know if you have enough wind, and where the wind is? And if it turns out that you do have a good resource, where's the best place to put the tower?

Tools

The common response to the above questions is that you must monitor the wind speed at your site for a year or two to find out if a wind generator will work for you. For a residential-sized system, this is nonsense! PV installers don't record available sunlight forever, so why do it for wind? Actually, PV installers have a couple of tools at hand to help them site PV arrays. We can do the same for wind generators.

In order to correctly site and size a wind electric system, it is helpful to have the following information about your location:

- average annual wind speed
- prevailing wind directions
- vegetation and buildings at the site
- surface roughness
- the type of energy storage

What we need to do is quantify your resource in general terms first. Once that is done, we can fine tune your resource for your specific site. So, let's analyze each of these tools and see how to use them.

Options

Because it is so easy to address, let's consider the type of energy storage first. If utility electricity is available to you, by all means, consider a utility tie-in system. By using the grid, you eliminate the need for a very expensive and time consuming component: the batteries. In a grid intertie system, the utility stores your electricity in the form of a credit whenever the wind is blowing. When the wind is still, you reclaim that credited power. In this case, your primary concern is producing enough electricity over extended periods of time to offset your consumption of utility-generated power. Daily or weekly production is irrelevant.

If yours is a remote system utilizing batteries rather than the utility grid, then you can actually do with less wind than the minimum cost-effective grid intertie system. Any renewable source of energy is more cost effective than running, maintaining, and fueling a gas or diesel generator for several decades.

In the case of a utility intertie system, a ten mph average annual wind speed is usually considered the cut-off. Below ten mph, the wind generator cannot be justified on a purely economic basis compared to purchased utility power. With a stand-alone system, wind generators are certainly cost effective in the nine mph and even the eight mph average wind speed ranges. These numbers refer to wind speeds at the height of the blades, referred to as hub height. The big question is, how do you get these numbers for your site?

You What???

Determining your exact average annual wind speed is difficult, expensive, and time-consuming. But, Mick, you say, you just told us that monitoring the wind for a year or so was nonsense. What gives?

While it is necessary to have an idea of your average annual wind speed, you do not need an exact measurement. We're not prospecting for a wind farm here. Therefore, monitoring wind speed at hub height for several years is unnecessary.

So how do we get this elusive number called average wind speed. We guess. Don't laugh! It's done all of the time, and fairly accurately, I might add. What we need to do is get a ballpark idea of the average annual wind speed for your area. I'll explain how it was done at my site, and we can work backwards from there.

Conventional Wisdom

When we moved to our homestead in Wisconsin, we investigated the use of a wind generator because it always "seemed" so windy. Conventional wisdom said to check the airport and weather bureau data for our area. We found that the average annual wind speed at the Green Bay airport, 35 miles away, was barely nine mph, hardly worth considering due to the cost of electricity we were buying from the utility.

After replanting the same peas in our first garden four times (they kept blowing out of the ground), we asked the neighbors what they thought. A few could remember wind generators in the area in the '30s and '40s, but they had all disappeared when the REA strung power lines through the area after World War II. That winter, our most frequent visitors were the county snow plows. Our corner of the country was plowed three and four times a day for the school buses and milk haulers (we live in dairy country). We quickly learned that leaving the homestead for a few hours could very well mean half a day of snow shoveling to get the car back home again.

After a few years of battling the wind and its effects, we decided to monitor our average wind speed. While the Green Bay airport and National Weather Bureau could still only muster a paltry nine mph annual average, our site turned up a surprising 13 mph at 100 feet after a year's monitoring. As we suspected, we did indeed have a respectable resource. So much for conventional wisdom!

Lessons Missed

We actually had positive indications from several sources around us, but failed to see their value. The first was our intuition. While gut feelings are hardly scientific, it's pretty hard to discount the breeze that blows your laundry all over the township every time you use the clothesline.

Our second indication was the problem of continuously drifting snow. Crews work full time in our area to keep the roads open. Other areas of the country experience similar problems with dust, dirt, sand, and dried bits of vegetation constantly "sandblasting" the neighborhood.

Our third indication was the collective experience of various old timers and the locals. Living in the area, they have spent considerable time with environmental factors that newcomers like us may have discounted or never experienced.

Our fourth indication was the vegetation in the area. We'll get back to this one in a bit.

We made the same mistake most folks do when first investigating wind energy: attributing the final word on average wind speed for our site to professionally collected data at a less than ideal location.

Assumption is the Mother of all Screw-Ups

Our problem occurred when we unquestionably accepted the value given to airport and weather data, considering their location versus ours. We discovered that weather bureaus monitor wind speeds at or slightly above street level, where people live. They do not monitor wind speeds at 80 or 100 feet, where wind generators live. And as we saw in Tower Economics 101 *(HP*#37) jumping from street level to 80 feet substantially increases the average wind speed and, therefore, the power available in that wind.

Similarly, airport data has limited value. Because airplanes traditionally had problems taking off and landing in windy locations, airports were sited in rather sheltered locations. Virtually all airports are sheltered.

Most of the time the "professionals" really don't get it right. Without exception, all airports and weather bureaus I have visited have located their anemometers on the tops of buildings, next to trees, or in low spots on the terrain. In other words, their sampling equipment is either sheltered, or severely influenced by turbulence, or both. This helps to explain, for example, why the measured average wind speed at my site is greater than that recorded for the Green Bay airport. Taken at face value, professionally recorded wind speeds make a lousy yardstick for determining wind generator installations.

Making it Useful

Does this mean that we should discount airport or weather bureau averages? Not at all. What it does mean is that their average wind speeds are in all likelihood very low baseline numbers, really just a starting point for our consideration. Virtually all wind generator sites I have seen have higher wind speeds by at least a mile per hour or two when compared to the nearest airport or weather bureau. Many times the disparity is three or four miles per hour, as we found at our site.

Consider the location, topography, surrounding vegetation and buildings, and the monitoring height of the recording station equipment (airport or weather bureau). By comparing these to your location, you can get a feel for the potential differences between the sites. Then by using the graphs in "Tower Economics 101" (*HP*#37), you can make an educated guess as to your average annual wind speed at hub height.

You may be in for a surprise when you call or visit your nearest wind recording station asking about the physical location of the monitoring equipment. Believe it or not, a very common reply is, "We're not really sure where it is." This response doesn't do much to build confidence in their numbers!

Shear Factor

Another way of using nearby airport or weather bureau figures is to extrapolate their numbers to your location using a concept known as "shear factor". Based on their numbers and the topographical difference or similarity between your site and theirs, you can theoretically estimate your wind speed at any proposed height. I'll use our site again to explain how it's done.

Surface Friction Coefficient
from *The Wind Power Book* by Jack Park

Description of Terrain	α
Smooth, hard ground; lake or ocean	0.10
Short grass on untilled ground	0.14
Level country with foot-high grass, occasional tree	0.16
Tall row crops, hedges, a few trees	0.20
Many trees and occasional buildings	0.22 – 0.24
Wooded country; small towns and suburbs	0.28 – 0.30
Urban areas, with tall buildings	0.40

Table 1

How windy is it?

Table 2

Height Correction Factor, H
from *The Wind Power Book* by Jack Park

Height	*Surface Friction Coefficient, α*								
feet	**0.100**	**0.140**	**0.160**	**0.200**	**0.220**	**0.240**	**0.280**	**0.300**	**0.400**
10	0.895	0.857	0.839	0.802	0.785	0.768	0.735	0.719	0.644
15	0.933	0.908	0.895	0.870	0.858	0.846	0.823	0.812	0.757
20	0.960	0.945	0.937	0.922	0.914	0.907	0.892	0.885	0.850
25	0.981	0.975	0.971	0.964	0.960	0.957	0.950	0.948	0.929
30	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
35	1.016	1.022	1.025	1.031	1.034	1.037	1.044	1.047	1.063
40	1.029	1.041	1.047	1.059	1.065	1.071	1.083	1.090	1.121
45	1.041	1.058	1.067	1.084	1.098	1.102	1.120	1.129	1.176
50	1.052	1.074	1.085	1.107	1.118	1.130	1.153	1.165	1.226
55	1.062	1.089	1.102	1.128	1.142	1.156	1.184	1.199	1.274
60	1.072	1.102	1.117	1.148	1.164	1.180	1.214	1.231	1.319
65	1.080	1.114	1.132	1.167	1.185	1.203	1.241	1.261	1.362
70	1.088	1.126	1.145	1.184	1.204	1.255	1.267	1.289	1.403
75	1.096	1.137	1.158	1.201	1.223	1.245	1.292	1.316	1.442
80	1.103	1.147	1.170	1.216	1.240	1.265	1.316	1.342	1.480
85	1.110	1.157	1.181	1.231	1.257	1.283	1.338	1.366	1.516
90	1.116	1.166	1.192	1.245	1.273	1.301	1.360	1.390	1.551
95	1.122	1.175	1.203	1.259	1.288	1.318	1.380	1.413	1.585
100	1.128	1.184	1.212	1.272	1.303	1.335	1.400	1.435	1.618
105	1.133	1.192	1.222	1.284	1.317	1.350	1.420	1.456	1.650
110	1.139	1.199	1.231	1.296	1.330	1.365	1.438	1.476	1.681
115	1.144	1.207	1.240	1.308	1.343	1.380	1.456	1.496	1.711
120	1.149	1.214	1.248	1.319	1.356	1.394	1.474	1.515	1.741
125	1.154	1.221	1.257	1.330	1.368	1.408	1.491	1.534	1.769

Let's be daring and assume that the recording station knows the whereabouts of their anemometer, and that it is on the standard 30 foot tower it's supposed to be on. You visit their location and find that the anemometer is in a very well-exposed site, far from the influence of any trees or buildings. The recording station tells you that the average wind speed at the site for a 35 year period of time is 9.0 mph. What does this translate to at your site?

The first thing you do is estimate the similarity of your site to theirs and assign your site a surface friction coefficient from Table 1.

Assuming that their site is wide open and your site is like ours, a farm with the usual buildings and trees plus a nearby wooded area, you might choose a surface friction coefficient of 0.24. We have a 100 foot tower that we would like to use to mount the wind generator. At 100 feet, we will easily pass the "30 feet above anything within 500 feet" rule (see Tower Economics 101). What kind of average wind speed can we expect at this height?

If we look across the 100 foot row in Table 2 to the column labeled 0.240, we find a correction factor of 1.335. Multiplying 1.335 by the recording station's figure of 9.0 mph means that we can expect an average annual wind speed of 12.0 mph at our site. While this is still below the actual measured average wind speed of 13.0 mph at our site, it's a lot closer than 9.0 mph!

The one caveat in using this technique is the assumption that the recording station's anemometer is not surrounded by trees and buildings. If it is, the shear factor technique of estimating wind speeds does not work very well.

Flagging
Another useful tool to help determine the potential of a wind site is to observe the area's vegetation. Trees, especially conifers or evergreens, are often influenced by winds. Strong winds can permanently deform the trees. This deformity in trees is known as

"flagging". Flagging is usually more pronounced for single, isolated trees with some height.

Pictured here is a pine tree in my yard with an obvious wind swept deformity. The upper part of the tree is swept back and away from the solar shower next to it. On the upwind side of the tree, the branches are noticeably stunted. On the downwind side, they're long and horizontal. The flagging was caused by persistent winds from, more or less, one direction.

Ecologists have been using flagging in trees for decades to ballpark the average wind speed for an area. (Vegetables don't lie!) Pick up any ecology book and you will find a diagram similar to the one bottom right on the page that quantifies an area's wind speed as a function of tree deformity.

Note that you can get an idea of the average wind speed by the amount of flagging. Comparing the picture to the diagrams, we could categorize my pine tree as Class III, an 11 to 13 mph average wind speed. The monitoring done at my site certainly bears this out.

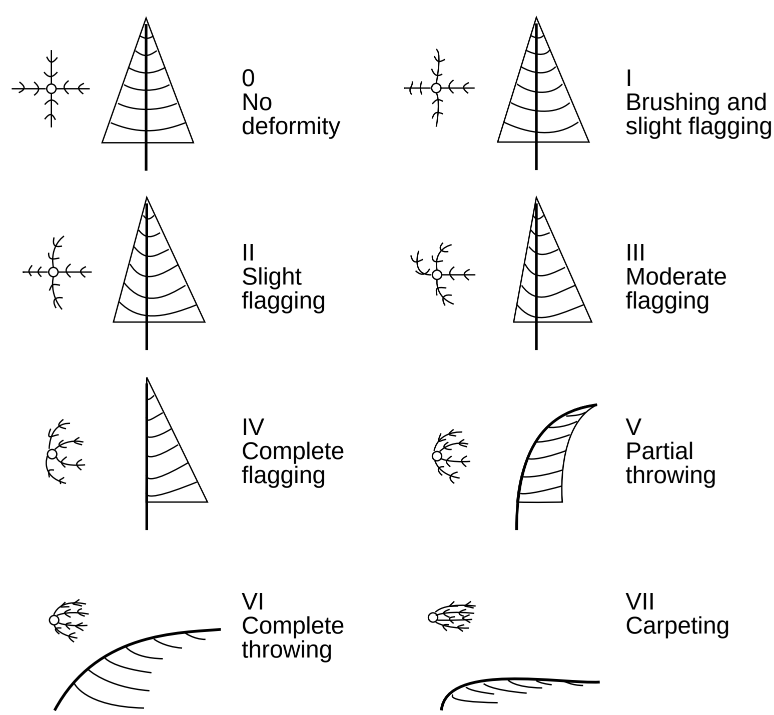
If you do not have any conifers in your area, look around at the deciduous trees. They may also show evidence of flagging. Look around especially for single trees, or trees on the outskirts of a grove. Unless they have grown considerably above the common tree line, trees in a forest will not show flagging because the collective body of trees tends to reduce the wind speed over the area.

While the presence of flagging positively indicates a wind resource, you should not conclude that the absence of flagging in your area precludes any suitable average wind speeds. Other factors that you are not aware of may be affecting the interaction of the wind with the trees.

Tools Revisited
So far, the tools that we have available to us for approximating our wind resource are:

- The various experiences of your area's neighbors, especially the old timers
- Any flagging that might be observed in the surrounding areas
- Local wind generated problems (snow drifting, severe soil erosion, tumbleweeds)
- The average wind speed established by the nearest airport or weather bureau, which can be used as our baseline
- The average wind speed for your site as determined by the shear factor
- Your gut feelings based on all of the above

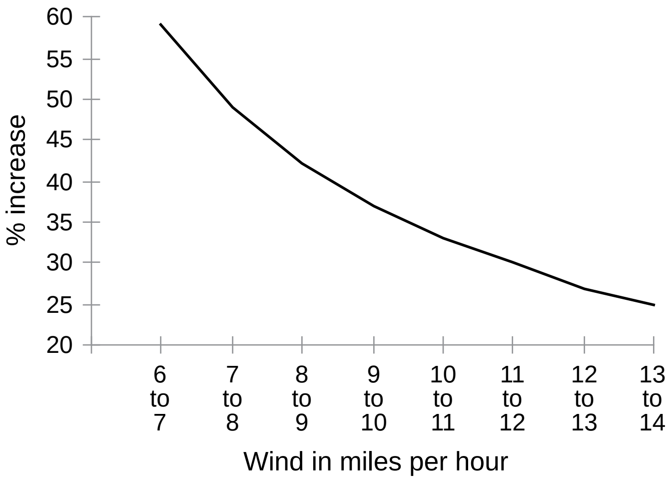
Above: Moderate flagging on a tree tells you how much wind is blowin' through.



Griggs-Putnam Index of Deformity
from *Wind Power for Home & Business* by Paul Gipe

Index	I	II	III	IV	V	VI	VII
Wind Speed (mph)	7–9	9–11	11–13	13–16	15–18	16–21	22+

Power Increase vs. 1 mph Wind Speed Increase



Remember from "Tower Economics 101" that even small increases in wind speed can yield substantial increases in power to the wind generator because velocity is cubed in the power equation. This is especially true at lower average annual wind speeds, as depicted in the graph above.

The Bottom Line

So what is the bottom line number for an acceptable average wind speed? Because there seems to be such a disparity between monitoring stations (airports and weather bureaus) and actual wind generator installations, we can actually fudge a little here. For a utility intertie system with a good exposure compared to the monitoring station site, an average wind speed of eight mph at the recording station or at ground level at your site is acceptable. Remember, our economic cut-off point (if you're doing this to make money) is ten mph at hub height when we're competing with cheap utility power.

For a battery charging wind system in which the monitoring station has nearly identical topographical exposure to your site, an annual average wind speed as low as seven mph at the recording station or at ground level at your site is acceptable. If the monitoring site is very sheltered compared to your site, this number could drop to about six mph. However, I wouldn't consider any site with average wind speeds less than these.

Next time we'll take a look at maximizing the usefulness of your site.

Access

Mick Sagrillo gets blown around a lot at Lake MIchigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

20 Watt DC Quartz Halogen Light

Things that Work!
tested by *Home Power*

Therese Peffer

What do you look for when you look for lighting? Ever since I discovered compact fluorescent lighting, I look for efficiency — both in wattage and the fixture. I want lighting that doesn't draw too much power from my PV-powered system and I want the fixture to maximize the light's output. I found a 12 Volt DC light that fit the bill: a 20 Watt quartz halogen light from Low Voltage Lighting.

Most ac compact fluorescent lights draw between 5 and 23 watts and cost up to $30. The advantage of these efficient ac lights is that you can use them in your regular fixtures. These lights are great for ac applications — folks with grid power or folks who produce their own electricity and use inverters to convert DC to ac.

What about those who want DC lights? Some want DC lights for emergencies or maintenance times when they need to shut off ac power. Some (like me) don't want to purchase an inverter just for a light and radio. And the type of light depends upon the application. Sometimes you want a strong focussed light for reading or close work, and sometimes you need a diffuse light for a general area.

My introduction to DC lighting left me unimpressed. The DC light in my parents' travel trailer were similar to a car taillight bulb and the fixture splayed the light all over the ceiling. As long as you read near the ceiling, the light was just fine. Years ago here at Home Power Central, 12 Volt lighting consisted of car taillight bulbs with Mazzola margarine containers as a "fixture". The decorated recycled fixtures actually did a great job at concentrating the light, but sometimes the containers melted. And DC compact fluorescent lights require a ballast (read mini-inverter) which is expensive.

A good option for DC lights are quartz halogen. Halogen lights are more efficient than incandescent lights, but not as efficient as compact fluorescent lights — they still get warm. But if you are looking for an inexpensive light that's much nicer than car taillight bulbs, halogen is it.

Over a year ago I installed a 20 Watt, 12 Volt halogen light as a reading light in my trailer. The light came from Low Voltage Lighting in Vermont. These folks make 35 and 50 Watt 12 Volt lights as well. (These look like incandescent lamps with an Edison base). I chose the 20 Watt Osram Coolspot because it has a small built-in reflector to concentrate the light and a glass cover. I have heard that halogen lights can cause cancer, but a glass covering protects against the harmful cancer-causing radiation.

The installation was simple. The halogen light comes with an Edison base, so it fits in typical fixtures. The lamps have no polarity constraints, so a simple modification of a common fixture allows use of the light. I took a clip-on light fixture (a portable ac lamp base with a clip attached) and adapted it to 12 Volt. I added a longer piece of lamp cord and a special 240 Volt plug (found at hardware stores) to match my 12 Volt system outlet. The special plug prevents folks from plugging the 12 Volt light into a regular ac socket.

The halogen light has been in use for over 1000 hours. It has withstood temperature swings from 25°F (while the trailer is warming up) to 95°F (okay, I overestimate the fire sometimes). This is not a car taillight bulb, but a 20 Watt light whose reflector maximizes the light's output. I like the warm light of the halogen light for reading and writing. The reflector allows a soft focus of light on the task at hand.

The light is rated at 20 Watts, so it's easy on my PV-powered system (I have more power to turn up my radio). I measured it recently: 1.76 Amps at 12.54 Volts, or 22 Watts.

This halogen light sells for $12–14 depending on where it's purchased. Look for this light at Alternative Energy Engineering, Backwoods Solar Electric, Real Goods, or Sunelco (see ad index). If you are looking for a 12 Volt light that doesn't draw much power, casts a nice warm light, and is inexpensive, 12 Voltage Lighting's 20 Watt halogen bulb fills the void.

Access

Tested by Therese Peffer, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179

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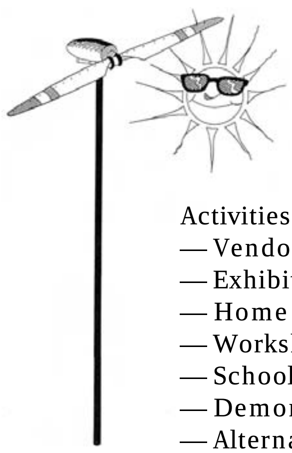

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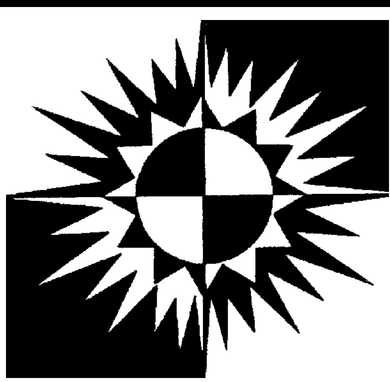

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Batteries Can Be Bad News

John Wiles

Batteries represent the largest source of stored energy in a renewable energy system. How large? Consider that eight to ten batteries in an electric vehicle can accelerate a 2000-pound vehicle to 40–60 mph a number of times before they are discharged. Consider also how much of this moving energy would be released if the vehicle were crashed each time into a brick wall — assuming, of course, that the vehicle could survive the multiple crashes. A short-circuit on a set of four to sixteen or more PV batteries can release all this stored energy in a very few seconds if the system is not properly protected.

In the last Code Corner (*HP*#38), overcurrent protection for module wiring was covered. This article will deal with the methods of protecting the renewable energy system from the high levels of energy stored in the batteries. This energy, when released slowly in the proper channels, does the work needed and poses no safety hazard. Released in a few seconds in the wrong channels, this energy can cause explosions, fires, burns, shock, and equipment damage.

More Than Just Cable Is Required

Although renewable energy systems are usually reliable, short circuits can, do, and will occur. Batteries can fail in several ways. Inverters can fail and at times catch fire. All of these potential problems indicate that disconnect switches and overcurrent protection are needed throughout the system. Disconnects will be covered in the next Code Corner in some detail, but for the time being, the DC ratings need to be understood.

Ratings

Any device such as a switch, fuse, relay, or circuit breaker used in the direct current (DC) portion of a renewable energy system must be rated to handle the necessary DC voltages and currents. The only way to be certain that the ratings are appropriate is to establish that Underwriters Laboratories (UL) or other recognized electrical testing laboratory has tested and listed the product for DC use. Assurances by dealers, distributors, and even manufacturers may not tell the full story or satisfy inspection officials. The UL mark and the DC data printed on the device are the only way to be sure.

In addition to the normal DC operating ratings for voltage and current (e.g., 24 Volts and 100 Amps), fuses, and circuit breakers will have a DC interrupting rating. This rating (Amps Interrupting Rating (AIR) for fuses and Amps Interrupting Capability (AIC) for circuit breakers) indicates the levels of short-circuit current the device can safely interrupt or break. Short-circuit currents are usually much higher than normal overload currents. Where overload currents from a stalled motor or overloaded DC appliance might be in the hundreds of amps, short circuits where cables are crossed or insulation has failed are generally tens of thousands of amps.

Short Circuits vs. Overloads

Most renewable energy sources (PV, wind, hydro) are limited in the ability to generate high short-circuit currents. Batteries, on the other hand, are not so limited. A single 6 Volt, 220 Amp-hour golf-cart battery can deliver 6000–8000 Amps of current into a direct short across the terminals. While this current can be maintained for only a fraction of a second, the battery can deliver 4000–5000 Amps for a number of seconds until the terminals melt. Larger banks of batteries connected in series and parallel can deliver far larger amounts of short-circuit current. The resistance of battery connectors and wiring will reduce the magnitude of the short-circuit currents, but these resistances are very low and the currents in most PV systems can be more than 10,000 Amps.

Fuses and circuit breakers that must open or trip when these high short-circuit currents flow must be rated to withstand the stresses involved. The AIC or AIR is very important. While some low-voltage (65 Volts DC or lower) circuit breakers have AICs of 25,000 Amps, most standard DC-rated circuit breakers and fuses have an AIC/AIR of only 5,000 Amps. When these low AIC/AIR breakers and fuses open with higher short-circuit currents, they may be destroyed, catch fire, or not open at all. These devices with low interrupting ratings must be protected with other devices which have current-

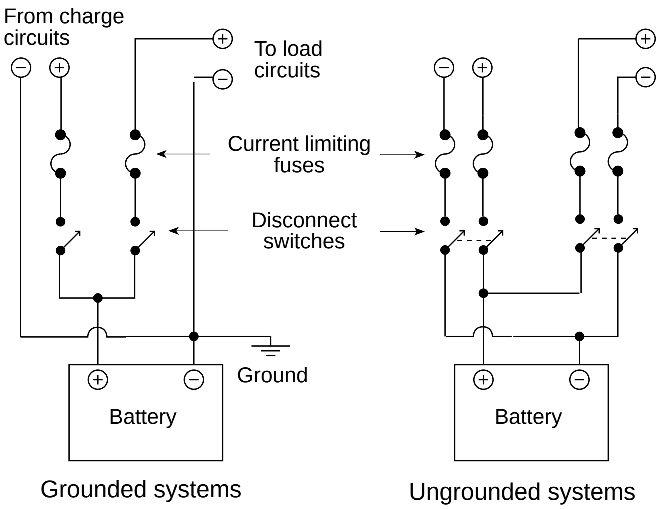

Figure 1. Battery disconnects and fuses

limiting capabilities or replaced with devices that have the necessary high interrupting rating.

Current-limiting fuses open so fast under short-circuit conditions that the let-through current is substantially reduced. Under normal operating conditions (overloads and other high-current, but not short-circuit conditions), these fuses may be either of fast-acting or time-delay design. Current-limiting fuses should be used on each circuit into and out of the battery.

Not Grounding Can Cost More

On a grounded PV system, the fuses and disconnect switches should be placed in the non-grounded conductor (usually the positive conductor). Figure 1 shows two current paths out of the battery, one for the circuit to the charge control circuit and one to the DC loads. Each path has a disconnect switch in the circuit between the battery and the current-limiting fuse. The disconnect switches allow the battery voltage to be removed from the fuse so that it can be serviced safely. Both the switch and the current-limiting fuse are requirements of the National Electrical Code (NEC). The current-limiting fuses protect the other fuses and/or circuit breakers in the PV source circuits and DC load circuits. The charge controller relay may also be afforded some protection due to the speed of the current-limiting fuse.

In an ungrounded electrical system, fuses and disconnect switches must appear in both conductors, thereby doubling the number of components required (Figure 1). This requirement gives a good economic reason for grounding even the 12 Volt system.

Current-Limiting Fuse Specifications

The current-limiting fuses should be DC-rated, branch-circuit devices with a UL DC listing. Fuse types or classes RK-5, RK-1, and T are available with the necessary ratings and are frequently used. These will normally be known as 250 volt ac fuses but will be marked with the DC ratings of 125 Volt DC and 20,000 Amps of DC interrupting capability. Fuses without the DC rating and the UL listing mark on the DC ratings should not be used. Littelfuse, Bussmann, and Gould Shawmut manufacture appropriate fuses. Actual fuse part numbers will vary from manufacturer to manufacturer.

Inverter Wiring Protection

If the inverter is connected directly to the battery with a separate circuit, then that circuit needs overcurrent protection and a disconnect. These are required because the inverter might fail and cause either an overload on the cable or a short circuit. Since there are no other devices (switches, fuses, or circuit breakers) on this circuit, a current-limiting fuse is not needed. For this circuit, a switch and fuse with the appropriate DC voltage and current ratings are needed. As before, UL Listing and marking will ensure that the devices can do the job.

In this inverter circuit, a better choice might be a DC circuit breaker which replaces the switch and fuse with a single device (Figure 2). A UL-Listed, DC-rated circuit breaker in an enclosure is significantly more compact than a similarly rated switch and fuse combination. DC-rated, UL-Listed fused disconnects are available from the major electrical equipment suppliers like Square D and Siemens. Rainshadow Solar has the high-current circuit breakers by Heinemann in an enclosure that can be connected to two-inch conduits. Ananda Power Technologies has the UL-Listed Power Center (see ads in this *Home Power*) which contains a fused disconnect along with other circuit devices.

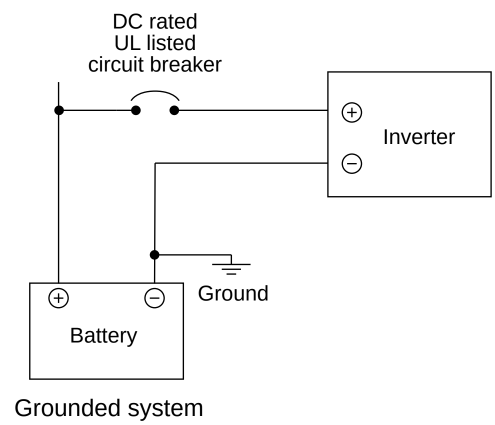

Figure 2. Inverter disconnect and cable overcurrent protection

Sizing the Overcurrent Device
The charging circuit overcurrent device should be sized to protect the cables from the charge controller. These cables should have an ampacity of 125% of the maximum short-circuit current that the modules or other power source can produce. The overcurrent device should also be rated at this value or less. Normal practice is to size the cable slightly larger than the calculated value would indicate, then select the overcurrent device rating less than the cable ampacity, but more than the 125% calculated value. This will protect the cable and eliminate nuisance tripping or blowing.

The circuit to the DC load center would be sized in a similar manner, except the cable would be sized to carry 125% of the maximum load currents anticipated on this circuit or the sum of the individual branch-circuit overcurrent devices on the load circuits. An overcurrent device with a rating equal to or less than the cable ampacity would protect this cable.

The inverter DC input cable is a little more complex. An example should clarify the procedure. Start with the rated (by UL or ETL) continuous power output (e.g., 4000 watts), the lowest battery voltage that allows the inverter to produce the rated power (e.g., 22 Volts) and the inverter efficiency at full power (e.g., 85%). The cable ampacity and the overcurrent device rating should be equal to:

$$125\% \times \frac{4000}{22} \times \frac{1}{0.85} = 267 \text{ amps}$$

A 300 kcmil (three hundred thousand circular mils), 75°C cable would be needed between the inverter and the battery to provide this ampacity. Two number 2/0 AWG, 75°C cables could be paralleled (allowed by the NEC in 1/0 and larger gauges). The ampacity would be 280 (derated by 20% from 350 amps because four conductors are in the conduit).

Conductors rated at 75°C must be used because commonly available fuses and circuit breakers can only be used with conductors up to 75°C. The use of conductors rated at 90°C or higher at full ampacity is not permitted by the NEC and would cause failure of connected fuses and circuit breakers.

The 267 amps is not a standard rating for overcurrent devices and the NEC would allow the use of a 300-amp circuit breaker or fuse to protect these cables. Although not specifically mentioned in the NEC, a 250-amp time-delay breaker might also be used.

A 250-amp breaker with a normal curve 1 delay function would carry 312 amps for at least two minutes and as long as 18 minutes (tolerance specification). When the normal operating tolerances of circuit breakers and fuses are considered, a 250-amp device might carry 267 amps for an indefinite time. It is unlikely that the inverter would be operated at full power from the batteries for extended periods at this low battery voltage. Only an external generator and separate battery charger pumping 267 amps into the batteries while the inverter pulled 267 amps out would support such an operating situation.

In this admittedly worst-case scenario, which the NEC requires the components to meet, undersizing the overcurrent device may result in nuisance tripping at the times when the system is operated at full power and low battery voltages. Although the 250-amp breaker is readily available, a special-order, non-standard 275-amp breaker (not UL-Listed) might be obtained from the source listed above to prevent any problems.

Surge currents due to motor starting are not used to calculate either the cable ampacity or the fuse or circuit breaker ratings. Both fuses and circuit breakers generally have the necessary time delays built in to handle these overcurrent surges without difficulty. Some fast acting (non-time delay) fuses may not be able to handle the larger or longer surges and the fuse manufacturer's literature should be consulted.

While the calculated cable sizes can provide the needed ampacity, voltage drop considerations might indicate, however, that larger cable sizes be used. At 267 amps, the voltage drop in 16 feet (8 feet one way) of two paralleled 2/0 AWG cables would be about 0.206 volts. Starting a large well pump motor might result in four times as much surge current and the voltage drop would be 0.8 volts. At low battery voltages this might pose problems for the inverter.

Figure 3 shows the combined protective devices and cable sizes associated with the battery for a grounded, 24 Volt PV system with a maximum 100 Amp PV charging current, a 100 Amp DC load current, and the 4000 watt inverter.

Cautions
Some caution should be exercised in using high-current fuses with cables that have an ampacity less than the overcurrent rating of the fuse. A 400-amp fuse requires that at least a 600 kcmil cable be used. At 75°C this cable has an ampacity of 420 amps. Two 250 kcmil cables could also be paralleled for an ampacity of 408 amps (derated by 20% from 510 amps for more than three cables in a conduit). Using smaller cables (with less ampacity) than these would indicate that the fuse cannot protect the cables from overloads.

While welding cables are frequently specified and used in inverter to battery wiring, the NEC and many

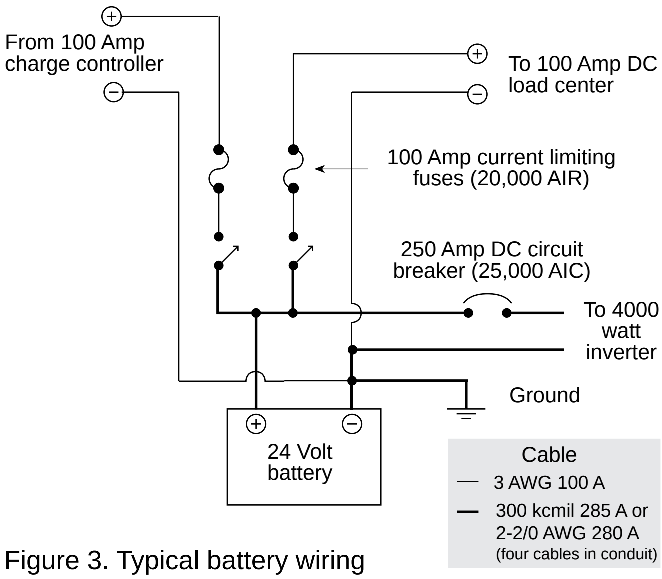

Figure 3. Typical battery wiring

inspectors will not allow these cables. They have no recognized ampacity ratings, they are frequently not tested or listed by UL, and the insulation may not be suitable for use in conduit. The temperature rating of welding cables may be as high as 105°C which works well with the high-temperature terminals on welding machines, but not with the 75°C terminals on batteries or overcurrent devices. The NEC acknowledges the use of welding cable connected to welding machines and then only in welding cable trays.

Access

Author: John C. Wiles, Southwest Technology Development Institute, POB 30001/Dept 3 SOLAR, Las Cruces, NM 88005 • 505-646-6105

National Electrical Code - 1993, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

ask NREL

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

Question: I heard on the radio that there's been a recent breakthrough on thin-film photovoltaics by the Government and Uni-Solar — 10% efficiency and cheaper than utility electric power in some areas. What can NREL tell us about the new technology and when can we buy a module?

Answer: On January 18, the U.S, Department of Energy and United Solar Systems Corporation (USSC) held a press conference to announce a milestone in the development of amorphous silicon photovoltaics. USSC makes amorphous silicon PV modules under the trade name Uni-Solar. NREL measured an efficiency (power out/power in) of 10.2% on a module made by USSC. Before NREL measured the efficiency, USSC illuminated the module for 1,000 hours under full sun conditions. This 10% efficiency is a significant advancement because the efficiencies of all other amorphous silicon modules sold today are in the range of 4–6%.

Amorphous silicon PV modules have an annoying characteristic of losing electrical output for a time after the modules are initially placed in service. After 3–6 months outside, the power output becomes relatively stable. All amorphous silicon PV manufacturers rate their modules using this stabilized power output, not the initial power output. Rather than waiting for 3–6 months, NREL and manufacturers illuminate test modules continuously for 600–1,000 hours to estimate the stabilized power output. The lights are set to the intensity of full sun, and the modules are operated under load and kept at a temperature of 50°C. Whether these test conditions are the best or most accurate is still under discussion.

When can you buy one? USSC is building a new manufacturing plant in Newport News, Virginia. The equipment is being built now, and the company expects the plant to be operating in 1995. Sorry, I don't know the month. USSC's goal is to produce modules in Virginia with 10% stabilized efficiencies. Rather than modifying their current manufacturing equipment, they will build a new and larger plant.

The price of these new modules? Nobody is talking exact numbers. The press releases stated, "The new technology is expected to bring down the cost to 15¢/kW-hr, and eventually to 12¢/kW-hr." The exact price will be dependent on the order size and "what the market will bear". The manufacturing plant will produce 10 MW of PV per year. For comparison, all of the U.S. PV companies produced just over 20 MW of PV in 1993. USSC will have to price their modules under the current prices to get the sales volume up. USSC's large production volume should result in lower prices. However, don't expect anything less than $3.00 per watt.

Just a note in passing: Advanced Photovoltaic Systems (APS) should have their new amorphous silicon manufacturing plant operating this March. APS's plant also has a capacity of 10 MW per year. APS will have to competitively price their modules to get the sales volume up. In a free economy when supply is greater than demand, prices usually fall. We will wait and see.

Access

Author: Byron Stafford, NREL

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

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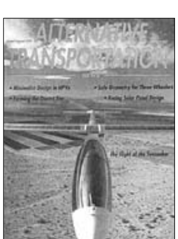

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Buying a Nuclear Dinosaur

Michael Welch

The San Francisco *Bay Guardian* is an independent newspaper whose masthead quotes Wilbur Storey as saying, "It is a newspaper's duty to print the news and raise hell." One of its writers, Martin Espinoza, broke an interesting story which could eventually affect us all.

First, you need to know that this newspaper has long been a thorn in the side of Pacific Gas & Electric Co. PG&E is a northern California company that is the largest investor-owned utility in the world, and arguably the most politically powerful entity in California. PG&E owns two nuke plants. The first is Humboldt Bay Nuclear Power Plant which is shut down in a "mothball" condition called SAFSTOR. (We call it UNSAFSTOR since it and all its high level nuclear waste sit on an active fault capable of producing an 8.0 earthquake). The second is the infamous Diablo Canyon nuke plant, which is also near a potentially lethal earthquake fault. Diablo Canyon is the tool that PG&E uses to gouge California ratepayers for 11 cents/kiloWatt-hour.

I know, I know.... You are going to say that this utility is also famous for its forward-looking energy saving activities and use of renewable energy technologies, but the fact is that this is mostly public relations hype. For example, have you heard about PG&E's Photovoltaic Research & Development Department? It consists of one person. He's a friend and a great guy, but give us a break here! And, did you know that PG&E actually gets paid a lot of ratepayer money not to build more power plants? Did you notice that PG&E appears to control the California Public Utilities Commission, who was kind enough to gut the rate regulations promoting the use of privately owned and competing cogeneration facilities? And guess who gave PG&E more than they originally asked for in the Diablo Canyon Rate?

Proceedings?

PG&E public relations teams manage to put a smiley face on everything they do. Last year they publicly and pleasantly promised to freeze electricity rates. Nice of them, until you find out that it was a response to quell a looming ratepayer revolt. Even then an internal memo surfaced suggesting that it was a part of a plan to set up future rate increase requests.

Anyway, enough utility bashing (for now). The second player in the *Bay Guardian* story is the Sierra Club. Long known as a mainstream defender of the wild, many activists believe they spend too much time compromising and not enough time fighting for what is right. In fact, a strong argument could be made that Diablo Canyon would not have been built in the first place without the Sierra Club's help. Just to avoid leaving you hanging, let me explain.

Originally PG&E intended to build a nuke plant in the Nipomo Dunes area of Central California, but locals took up a crusade to save the dunes. A noble endeavor, for sure, but instead of fighting the nuclear power plant, the Sierra Club joined with the locals to fight only the dunes site and ended up taking up PG&E's pro-nuclear cause. They gave their support for building the plant in another location in exchange for saving the dunes. With the Sierra Club solidly on the side of PG&E, the building of the plant was a foregone conclusion.

Back to the Bay Guardian story…

The article reports that the Sierra Club (SC) is testing the waters with a new idea that would be a previously untried concept in public energy policy. SC wants the State of California to issue bonds to purchase all currently operating nuclear power plants within the state, shut them down, decommission them and deal with their radioactive waste. This would include two PG&E reactors at Diablo Canyon, and the two operating Southern California Edison reactors at San Onofre.

Boy, does this idea engender mixed emotions. As a long time opponent of nuclear power, I am attracted by the opportunity to shut down two of the industry's scariest plants. After all, the only way to be truly safe from nuclear accidents is to not operate nuke plants, and the only sure way to avoid contamination from nuclear waste is to quit producing it in the first place. Plus, there is the added possibility that other states might try the same tactic if it is successful here. Sort of a chain reaction of nuclear plant buyouts and closures starting in California.

So why am I not jumping for joy? See above, it's a matter of trust. Can we trust the SC? I know we can't trust PG&E. Something tells me that PG&E will come out smelling like a rose on this deal, and if that happens, it will be the taxpayers who end up getting the short end of the stick.

Take a look at what it might cost for this buyout. Diablo Canyon has a value of about $5 billion (based on construction costs), and estimates of decommissioning costs range from 20% to over 100% of construction costs. That means that it might cost Californians $8 billion to buy and decommission Diablo, and presumably about the same for San Onofre. Now we're talking real money. By the time the interest on the bonds is considered, it could cost California taxpayers $20 billion dollars.

Is it worth it? Folks could put up a strong argument that California, or any state for that matter, can't afford the cost. But on the other hand, how do you put a price on the safety of our communities and the well-being of our environment? A major nuclear accident at either of these plants could easily end up costing the public that much. The fact is that they shouldn't have been built in the first place and both of these earthquake-prone plant sites make the reactors into accidents waiting to happen.

After consideration of the pros and cons, I say go for it, but keep careful tabs on the utility to make sure we taxpayers and ratepayers don't get overcharged again. Let's pay the utilities fair value for these plants, and let's not forget to consider the true costs and benefits when negotiating the buyouts. Let's also not forget that PG&E ratepayers are currently paying three times the going rate for power, which, Espinoza's article points out, is costing the California economy more than a billion dollars per year.

I'm sure that PG&E hasn't forgotten this either, and may be worried that the public will want to force legislation creating rates that are more fair. Additionally, the article points out that in the future, major power users may be able to negotiate with other power producers for cheaper electricity, and that local utilities may be forced to allow access to their power grid for that purpose. If that's the case, then PG&E will be underbid for expensive Diablo Canyon power, leaving them with an economic albatross. This might make the buyout proposal look mighty good to the utility.

Other Energy News
Good news on three different fronts comes from the Clinton Administration. First, Ward Valley, near Needles, California, was recently designated as critical habitat for the Desert Tortoise. For quite some time activists have been trying to obtain this designation to help fight the imminent Ward Valley nuclear waste dump. In addition to trying to help the environment of Ward Valley, folks have been worried that a new dump would add credence to the nuclear industry's perspective that it's okay to go ahead and produce more waste since there was going to be some place to bury it. Assuming that the critical habitat designation holds, this is yet another nail in the coffin of the nuclear industry, and still another ray of light for a safe and clean energy future.

FY95 Energy Budget Announcements
In other action with a similar nail-in-the-coffin result, Secretary of Energy Hazel O'Leary has promised to fight future funding for plutonium burning breeder reactors. The administration has decided to terminate the funding as of the end of the 1994 fiscal year (FY94). According to a *Washington Post* article, R&D money put into the breeder reactor program totalled $8.7 billion to date. The Bush administration had been pouring money into the project as a favor to the Japanese government which is building a string of breeder reactors and a reprocessing plant for fuel containing plutonium.

O'Leary also announced that the FY95 DOE budget request will decrease by $0.5 billion to $18.5 billion. The energy efficiency and renewable energy budget request increased by 25% from FY94. Up by 47%, in a mixed blessing, is funding for natural gas programs. Nuclear R&D programs took the major hit, allowing the above modest increases while still achieving an overall budget decrease over FY94 figures.

Redwood Alliance, Safe Energy Communications Council, and Nuclear Information & Resource Service are three of a growing coalition of organizations supporting the Sustainable Energy Budget. We will continue to urge the Administration in more appropriate directions. This suggested budget cuts $1.2 billion from nuclear and fossil fuels energy, redirecting $0.8 billion for sustainable energy with the rest going to reduce the budget deficit. The Sustainable Energy Budget is available for downloading from the Home Power BBS.

DOE Announces "Breakthrough in Solar Technology"
You may have heard about it already, it seems to be spreading through the energy community like wildfire. DOE announced in late January that a three-year government and industry collaboration has produced a new thin-film photovoltaic (PV) technology. The new panels will be manufactured by United Solar Systems Corporation at a new plant to be built in Virginia.

According to the DOE, current costs for PV electricity run from 25 to 50 cents/kW-h. This new technology will significantly reduce manufacturing costs to provide PV electricity at 16 cents/kW-h, and eventually down to 12 cents/kW-h. It is the intention of United Solar to incorporate the new technology into roofing shingles and to replace glass panels used for exterior walls in commercial building construction. Is this the elusive photovoltaic roofing product we have been waiting for?

Politically, this is a very interesting announcement. DOE is touting it as "an early example ... of what the Clinton Climate Change Plan can do." As you may recall, the Power Politics column in *HP*#38 blasted what was then called the Global Warming Action Plan as really being an inaction plan... in other words, let's ask industry to please be nice to the environment instead of legislating them into helping halt global warming.

Now, the DOE claims to be putting forth a good example of what can be done under the Clinton plan. But hold on, here. This project was really started under another administration. Clinton's administration is only reaping the benefits, not sowing the seeds as their announcement would have us believe. We could give them the benefit of the doubt and agree that this truly is an example of a good thing that can come out of a government/industry collaboration, but it certainly is a stretch and more than a little misleading for them to make us think that this new technology resulted from Clinton's inaction plan.

Access

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Singin' Solar!

Therese Peffer

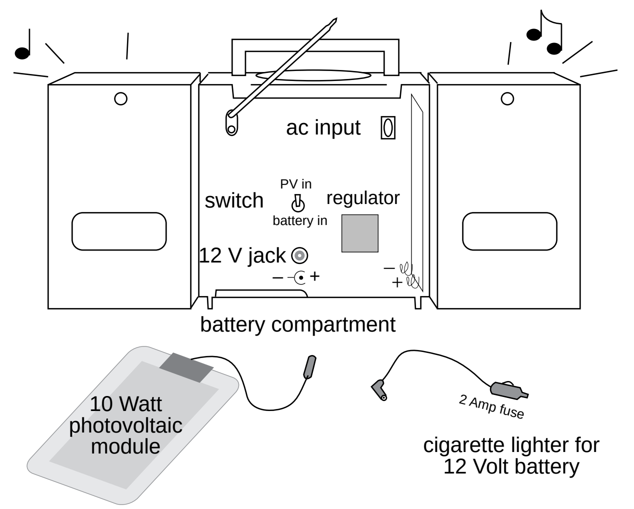
Over a year ago, my old boom box died. It had provided radio and taped tunes for me faithfully since high school graduation — eight years of service! When I searched for a replacement, I looked for one with a 12 Volt DC jack, like my old one. Why? Well, I wanted to use it in my 12 Volt solar electric system. And I discovered from talking to a few people (and looking inside my old box) that the ac power was just converted to DC anyway inside the stereo. Seems like a waste to convert DC to ac back to DC again especially when I've got DC solar power to begin with.

What a search! I did not find a boom box with a 12 VDC jack. But portable stereos take batteries, usually D cells, which provide DC electricity. So all I needed was a boom box that takes eight D cells. Why eight? Because each cell provides 1.5 Volt DC. When lined up head to toe in series, this adds up to (8 cells x 1.5 V) 12 Volts!

I finally settled on a portable stereo with AM/FM radio, dual cassette decks, and a compact disc (CD) player — a Sony CDF-40 rated at 21 watts. And I got cold feet. Yes, I got a little nervous about sawing holes in my brand new, $200 boom box. So I ran it in the office and made sure everything functioned properly for several months while I got involved with other projects (and the warranty expired). One snowy day recently, I decided to take the plunge.

Drilling Away

First, I unscrewed the five screws that held the the box together from the back. I ignored the warnings that said I could be shocked if I did this. Last year when I replaced the bands in my old boom box (hoping to bring it back to life), I asked about the warning. I was told that the only danger would be the capacitors, which store electric charge. I eased the two parts of the box apart (and was wary of small cylindrical knobs) The unit had not been used for several days, so I wasn't too worried about shock, as capacitors lose their charge over time.



My boom box can now play music using power from ac, a 12 Volt DC battery, or a 10 Watt PV module.

The boom box does not weigh much for its size, and I found out why. Much of the box contained empty space! I have a cigarette lighter plug with a set of interchangeable coaxial plugs — the common cylindrical ones with the inner pin. I originally thought that I could just add a coaxial jack to the box and plug it in. My boom box's circuitry is protected from too much current by an internal two Amp fuse in the cigarette lighter plug. But I had forgotten about voltage.

I know the boom box can take 12 Volts DC or less — the eight D cells will drop down to 8 Volts when they are depleted. But what about voltages higher than 12 Volts? My 12 Volt lead acid battery can reach over 14 Volts when charged by my 60 Watt PV module. What if I used my boom box on a 12 Volt alkaline battery that can reach over 16 Volts under charge? Voltage higher than the circuitry is designed for can damage components. I certainly didn't want to ruin my new boom box.

I had an electronics wiz, Richard, help me. Richard suggested measuring the DC voltage fed to the circuitry by the ac supply. So when I had the box apart, we traced the ac power supply as it was transformed, rectified, and filtered to DC power to feed the stereo. I carefully plugged it in, turned on the various functions, and we measured 13 to 16 Volts. This voltage range allows me to just plug right into my 12 Volt battery. If the voltage had been less than 16 V, I would have had to use a voltage regulator to protect the circuitry (see sidebar next page).

Richard also suggested getting the service manual for my boom box, which shows the full wiring schematic and would have helped our search. I called Sony's Publications Department, plunked down $13.50, and received the 50 page manual three weeks later.

You can do this

I bought a coaxial DC power jack from Radio Shack (#274-1576), took a deep breath, and drilled a hole in the back of my boom box. The black plastic was surprisingly soft — I was afraid it would be brittle and crack. I found where the positive and negative terminals from the battery section of the boom box joined the circuit board that contained all the power elements. I soldered wires from the jack to this board, careful to get the polarity right, positive to positive, negative to negative. The center pin of my jack is positive, which I labeled on the outside of the box.

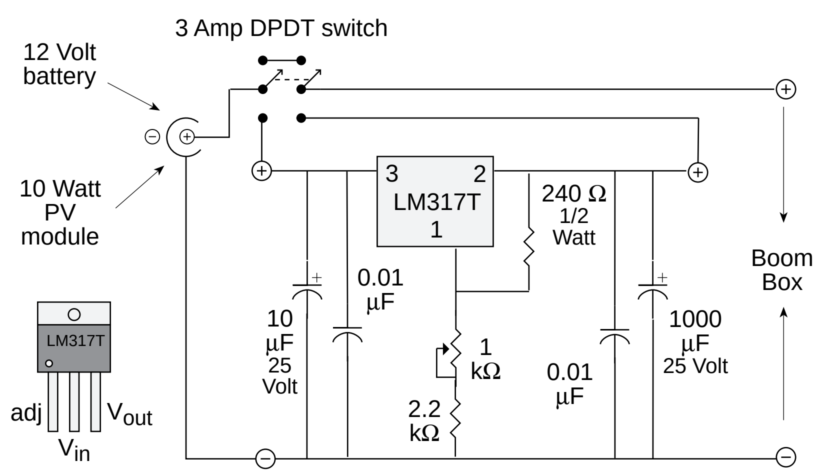
Did I need to drill a hole in the box? If the battery terminals had been accessible from the battery compartment, I might have been tempted to solder directly to the terminals. But they were not and a jack looks neat and tidy. And I can still use the battery compartment. I hauled the boom box down to my trailer, plugged it in, and listened to some solar-powered REM.

Why not just use a small inverter? Right now, I just have a few 12 Volt lights. I don't really need an inverter just for the stereo. Using an inverter would be less efficient. After I inserted the 12 Volt jack, I took some measurements just for kicks. I played the radio, tape, and CD player at regular volume, and at full blast. My boom box drew almost 10 Watts maximum from a 12 Volt battery. Then I ran it off a small inverter — over 16 Watts maximum drawn from the battery! In some

You too can build this regulator!

I had built a regulator before, and made a lot of mistakes. So this time I decided to do it right! Having a friend that has electronic know-how is helpful.

First, I made a list of the components: four capacitors (two electrolytic), two resistors, one potentiometer, one LM317T voltage regulator, and some perforated board. If you can scrounge parts, great. If not, all of these components (except for the 240 Ω resistor) are available from Radio Shack for under $10 (less from DigiKey, 800-344-4539). I used Richard's 12 Volt, 25 Watt soldering iron.



My approach to "homebrewing" previously had been similar to cooking with a cookbook, but without tasting until the food is on the table. I learned that it can be risky to get the components together and solder the circuit without testing it first. So this time I bought a "breadboard" from Radio Shack (about $12), hooked the circuit up and tested it first.

Chris Greacen's article (*HP*#32) explains how this circuit works. Basically, the LM317T can handle 1.5 Amps of current up to 37 Volts. The output voltage is adjustable. Since the LM317T takes 2 Volts, you can adjust the output up to 2 Volts less than the input. I asked for help on the choice of capacitors. The small 0.01 µF capacitors filter high frequency noise, and the large ones store up charge for a boost when those bass notes hit and extra power is needed.

Richard and Chris used different resistors for the regulator's output. By experimenting, I discovered that this decides the output voltage. I tried several combinations: A 2 kΩ potentiometer (variable resistor) with 1 kΩ resistor allows a range from 6.42 V to 15.73 V. A 1 kΩ potentiometer with a 2.2 kΩ resistor allowed the range 12.51 V to 15.69 V. This was perfect for my boom box — I adjusted the potentiometer until the output voltage was 13.5 Volts. I used a small light bulb as a load to set the output voltage. I tested the circuit after soldering and after I installed it on stand-offs in the boom box.

The switch allows me to use the same jack for battery input and PV input. I can send the power right to the boom box or through the regulator first. I must be very careful though — if I plug in the PV module without switching on the regulator, I would damage the boom box!

cases, almost 7 Watts was wasted power. I also found that the boom box is a phantom load in certain settings. That is, when it is switched to CD, but not playing, it draws 3 Watts. When switched to tape, but not playing, the boom box does not draw any power.

Not Done Yet

While I listened to the music, I thought of other modifications to make it more portable. I could buy D cells. I could buy the new rechargeable alkalines ($23 for the cells, $28 for the charger) which would last 13 hours or so at a time for 25 cycles. Or I could buy rechargeable nickel cadmium cells ($56 or more for 6 or so hours at a time for hundreds of cycles). Or I could buy a small photovoltaic module (10 Watts for $129), which would last 10 years or more. And I could use the module for other things.

I decided to buy another solar module — yes, it's an addiction. I bought a 10 Watt Solarex MSX-10 Lite PV module. I don't need to worry about overcurrent protection with this small panel. The short circuit current is only 0.6 Amps. The open circuit voltage, however, is 21 Volts — more than I want to send to my new boom box. Now I needed a regulator to ensure that the boom box never sees more than 16 Volts.

Fortunately, this work was already done for me. Chris Greacen wrote an article on building an array-direct regulator (see *HP*#32, page 46) and Richard wrote about a regulator for his solar-powered PowerBook (see *HP*#38, page 33). The circuits are fairly similar and pretty simple. I learned a lot trying to adapt these regulator to my application. See sidebar previous page.

After I built the regulator, I had to decide where to put it. Should I build it in a box that plugs into the boom box? That way I could use the regulator for the PV module in other applications. Or should I put it inside the boom box? I decided to put it inside. Instead of using two jacks (one for battery input and one for PV input which leads to the regulator), I decided to just use one jack and a switch. I bought a 3 Amp double pole double throw (DPDT) switch (Radio Shack #274-614) that allows me to swtich the regulator on and off.

Singin' in the Sunshine

I sat with my boom box outside in the sun the other day and admired the crocuses that announce the beginning of spring. I can't turn up the CD player full blast with the photovoltaic module — the deep bass notes disappear. But music on full blast stretches the sound limits of my music box anyway. Another solar project completed, but the sun's work is never done....

Access

Therese Peffer, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

IPPP Update

Don Loweburg & Bob-O Schultze

This last month has been active and productive for IPPP. In California we have 21 trade members. Outside California interest is beginning to grow. We will coordinate contacts and keep a record of names and addresses as they come in to us. At that point, the ball passes to you, the new members and your state chapters. This organization needs to operate in a decentralized manner (just like PV). Our mission: to promote the independent (utility free) development of off-grid photovoltaic power systems.

We've already received significant input that we should broaden our perspective and include solar thermal, solar hot water, and on-grid (roof top utility-tied) PV. These suggestions have strong merit, however we suggest that we stay focused for the moment on off-grid PV. The immediate struggle is already in this area. If other utilities follow current proposals, they will likely try to extend their monopoly to off-grid PV systems first. Under IPPP's decentralized model, other chapters of IPPP may broaden their mission statement to reflect member consensus as they wish. Different areas have different needs. Eventually we'd like to give all small renewable energy providers and producers the opportunity to come together under the IPPP banner if they wish. With unity comes strength.

Some background on utility activity. PVUG (PhotoVoltaics for Utilities Group) is a national organization of mainly utilities that has been working on programs to commercialize PV. Many states have affiliate groups, generally termed State Collaborative Working Groups working in coordination with PVUG. One of the main tasks of the working groups is to deal with regulatory "concerns". In many states, such as California, explicit regulatory language prohibits utility control of solar technology. The IPPP in your state needs to participate strongly in any PVUG attempt to adversely address or gloss over regulatory protection of existing PV providers and the end-user.

In California, Southern California Edison has filed with the state Public Utilities Commission a proposal to provide off-grid PV to customers. IPPP and others have filed official protests to the Commission. At this time, no decision has been made.

Utility filings in other states will soon follow. IPPP folks need to begin forming a strategy to present their position. We've found here in California that early input into the planning stages of these ventures by organized in-state groups will save lots of time and energy for all concerned. Learn how your Commission functions. Call or write us for information on your State Collaborative Working Group. Get involved. It's easier and better to be part of the process than risk being steamrolled later on. You may not change the Group position, but you can present your concerns before your PUC or PSA. We need to articulate the many reasons why utilities should not control the PV industry. At some point these issues may go to court. Legal expertise will be needed. If you use PV, are a PV professional, or just a person who thinks that utilities should stay out of the off-grid market, put your efforts behind IPPP. Join now.

We need some specific information. If you have obtained any kind of financing for PV systems, please call or write. If you have or know anyone who has financed PV system purchases, we want to know about it. This is important information. The utilities have perceived financing as an industry weakness and an excuse for them to offer this "service". We think that financing represents an opportunity for the existing service providers, not an invitation for new utility intrusion. We'd also like to hear about your experiences with utilities who ARE encouraging renewable intertie with net billing and other progressive policies. We can throw flowers as well as darts.

For those of you planning to attend SEER '94 in July, plans are afoot to have an IPPP booth. This will be a great opportunity for independents, manufacturers, utilities, and all concerned to exchange views and news in an informal, non-confrontational setting. Plans also include a presentation and workshop for IPPP folks on Friday. We'll keep you posted as things develop.

Access

California: Don Loweburg, Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643 • 209-877-7080

National: Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 916-475-3401

New IPPP Regional contacts:

Colorado: John Adams, Current Solutions, PO Box 653, Silt, CO 81652 • 303-876-2113

Florida: Tom Lane, ECS, 4110 S.W. 34th Street, Suite 15, Gainesville, FL 32608 • 904-377-8866

Missouri: Julie Courtney, Ozark Renewables, Rt.3, Box 4305, Reeds Spring, MO 65737 • 417-338-8688

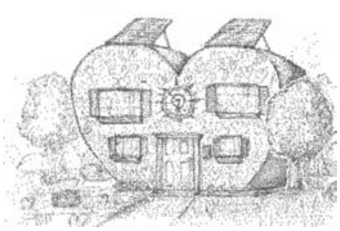
Arkansas: Jimis Damet, Rocky Grove Sun Co, HCR 65, Box 280, Kingston, AR 72742 • 501-677-2871

Wisconsin: Christopher LaForge, Great Northern Solar, Rt 1, Box 71, Port Wing, WI 54865 • 715-774-3374

Oregon: Bob Maynard, Energy Outfitters, PO Box 1888, Cave Junction, OR 97523 • 503-592-6903

Indiana: Mark Downing, Hurshtown Alternative Power, 14701 Hurshtown Road, Grabill, IN 46741 • 219-627-6397

Home & Heart



Kathleen Jarschke-Schultze

During that "ask me no questions and I'll tell you no lies" stretch of time before Christmas, Bob-O approached me. He asked casually (as if we discuss appliances every day), "If you were going to put a new appliance in the kitchen, what color would you want, black, white, or almond?"

"Black," I replied, "I like bold colors."

Surprise

I got it into my head that he was going to buy me an automatic dishwasher. Was I surprised when my new black appliance turned out to be a Peerless-Premier gas stove! I certainly needed one. My old Wedgewood, from the fifties, had only two temperatures for the oven, 325°F and 650°F. This resulted in a certain amount of smoke whenever I baked anything. I had been cruising the used appliance stores, but nothing had attracted me.

Criteria

First of all, there are not very many used stoves with a griddle in the middle. I really use that feature. Stoves that are set up for propane are rare. Then, of course, I did not want a gas stove that required electricity to work. Finally, I had bought a large pizza pan that fit into my oven when cold, but got stuck when it expanded with heat.

Peerless-Premier

My new range turned out to be Model SLA 849. It is 36 inches wide, 46 inches tall, and 26 inches deep. There are four main burners with a center griddle. The griddle comes off and a fitted piece of enameled steel fits into its place with a cast iron burner grill. This fifth burner is very useful with the wok or the big canning pot. I love it.

This model does use electricity to run the timer and clock; it also has an electronic ignition system. It uses less than two watts when it is on. I have it plugged into the same fused plug strip that we use for the microwave. That way I can turn it on to use the oven light and timer while I cook, but I don't have a phantom load when I'm not using the range.

The Oven

I really like the oven. It is 25 inches wide, 15 inches high, and 18 inches deep. I can use my large pizza pan. There is an oven light, so I don't have to open the oven and lose any heat to check on my cooking. The bottom comes out for easier cleaning. Probably the most important feature is that, unlike most other electronic ignition gas ranges, I can light the oven or the top burners with a match if there is no electricity. Even with power it only takes two watts to light the oven. There is a pilot light that comes on when the oven is in use and turns off when it is not.

I did a test using Bob-O's Fluke 87 multimeter. I wired a heat sensor to the oven shelf directly below a Pyrex® casserole dish. First I preheated the oven for eight minutes. I placed the shelf and the casserole into the oven at the same time. Although I had set the temperature at 350°F according to the oven dial, the meter registered a rapid rise to 210°F, then began a slow gradual rise to 340°F. Whenever I heard the oven burner cycle back on, the temperature would rise another three or four degrees. It took one hour for the meter to register 340°F and by then the casserole was done.

The Griddle

The griddle on the old stove had an oblong burner beneath it. The Peerless has a single round burner in the center. The new griddle is covered with a Silverstone® non-stick finish. It is so easy to clean I find myself making pancakes and grilled cheese more often. When I want to use my wok I convert the griddle to the fifth burner set up. When not in use the fifth burner accessory fits into the side storage compartment. It is so sturdy that I can really toss that stir fry around while I'm cooking.

Burners

The burners have one ring of orifices as opposed to the Wedgewood's two. However the heat is more finely controlled and appears to be hotter. A range using natural gas will attain 9,000 BTUs, while one using propane will only reach 8,000 BTUs. Apparently the old stove wasn't even getting the full 8,000 because the Peerless really does get hotter. There were four removable chrome heat reflector trays for the burners included. They make clean up easier.

Packaging

We bought the range from Energy Outfitters. It arrived in a large cardboard box. It was reinforced so there were no dings or dents in it. The sides were covered with a thin layer of clear plastic that had to be removed. That meant no scratches on the enameled surface. Nice touch. Bob-O had to attach the backguard and

Above: Kathleen woks up dinner on her new range.

hook up the propane. The unit comes ready to use natural gas, but is easily adjusted for propane. For propane use instead of natural gas, all you have to do is tighten a jet orifice, then adjust the burner flames.

We got Stan, our neighbor, to help us lug the old beast out to the porch (that's when I found the bullet holes in the wall behind, see Muddy Roads, HP #21) and slide the new stove in place. Bob-O thought the Peerless wasn't very heavy duty. True, the old Wedgewood was built like a Buick with fenders and fins — the only things missing were the chrome portholes. The Peerless stands up well against the contemporary ranges available in appliance stores today, with a notable lack of a heavy cast iron infrastructure. Since I have been using it, I haven't had any problem with its sturdiness.

What I Don't Like

The cover that goes over the grill when not in use is a non-shiny metal that shows scratches if you use a scrubbie on it. I would have liked it a lot better if it had been black enamel like the rest of the stove.

Conclusion

The Peerless-Premier is a swell range and I'm glad I have one. The cost of my Model SLA 849 is $509 plus truck freight. There are twenty-five different models that range in price from $359 plus freight up to my model's cost. You can call either Peerless or Energy Outfitters for a free color brochure showing all the models available.

Solar Food Drying

I got a nice letter from Larisa Walk the other day. She has had time to use and prove the modifications on her Humid Climate Solar Dryer. She has written up the instructions on building and using it. If you send her a dollar and an SASE she'll send you the plans. She will again be teaching her workshop at the Midwest Renewable Energy Fair this year.

Access

Author: Kathleen Jarschke-Schultze can take the heat and can't stay out of her kitchen in northern-most California c/o Home Power Magazine, P.O. Box 520, Ashland, OR 97520

Peerless-Premier Appliance Co., P.O. Box 387, Belleville, IL 62222 • 800-858-5844 FAX 618-235-1771

Energy Outfitters, P.O. Box 1888, Cave Junction, OR 97523 • 800-GO-SOLAR

Larisa Walk, RR3 Box 163-A, Winona, MN 55987

HAPPENINGS

INTERNATIONAL
COSTA RICA
2nd Annual World Conference Solar Cooking Use and Technology, July 12–15 1994, Universidad Nacional, San Jose, Costa Rica. Contact Solar Cookers International, 1724 11th St, Sacramento, CA 95814, 916-444-6616, fax 916-447-8689.

FRANCE
The European Conference on Energy Performance and Indoor Climate in Buildings will be held Nov. 24–26 1994 in Lyons, France. Its aims are to discuss the results from research and development in solar energy applications and the rational energy use in buildings, to confront the views and needs of industry and professionals, to inform the European building community on the latest developments in the research and application of new building products and evaluation of tools and to discuss the possibilities for standardization of assessment methods and energy performance requirements on a European-wide level. The oral sessions will be in English and French. For more information contact, Ecole Nationale des Travaux Publics de L'Etat, Rue Maurice Audin, 69518 Vaulx en Cedex, phone 33-72047070, fax 33-72046254, telex ENTPE 370511F

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

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

World Unity Festival, August 22–28, 1994, Flagstaff, AZ. The Festival celebrates global oneness, generates environmental awareness, shares cultural wisdom and honors the Earth's diversity. Contact: Quetzalcoatl Productions, 4 San Francisco St #438, Flagstaff, AZ 86001 • 602-773-9669

ARKANSAS
Meadowcreek offers a seminar in basic photovoltaics on July 16, 1994 from 10 AM to 4 PM. The sessions provide information on designing and installing your own solar electric system. The cost is $10 and includes a detailed design manual. If you would like to become more energy independent or are simply interested in solar energy, contact Meadowcreek, PO Box 100, Fox, AR 72051, 501-363-4500 for more information.

CALIFORNIA
Arcata, California will host Humboldt County's Third Annual Renewable Energy Fair, at Arcata High School on April 23, 1994. This Fair will display renewable energy and energy efficiency: small-scale hydro power, solar power (solar electric, solar cooking, water heating, and active and passive home heating), energy efficient lighting and refrigeration, alcohol and hydrogen fuels, electric vehicles, and more. Many workshops will be held on a variety of topics related to renewable energy. Music and guest speakers will be interspersed throughout the day using a solar powered sound system. Richard Perez will be a keynote speaker, along with Dennis Weaver (invited). Our fair is will be a family event and will include Earth Games and other organized activities for kids. For information contact Renewable Energy Fair, PO Box 4179, Arcata, CA 95521 • 707-822-3481.

The 4th Solar Energy Expo & Rally (SEER), July 15–17, 1994 at the Redwood Empire Fairgrounds, 1055 N State St, Ukiah, CA. For information: Janet Orth, 733 S Main St #234, Willits, CA 95490 • 707-459-1256

Siemens Solar Industries is offering its 1994 five day Photovoltaic Technology and System Design Training Course. Learning begins by purchasing the two volume set of Training Manual and Technical Appendix for $175. The fee includes the 30 minute videotape "The World of Solar Electricity". Step two is a five day training class. Classes will be held April 18–22, July 18–22 & September 19–23 at the Siemens Solar Training Center, Camarillo, CA. The training class, including the two set manual & video is $1500 (food and lodging not included). The course offers experimentation with inverters, controllers, batteries, modules, trackers and loads. The "final exam" is a full system design. Contact the Training Department of Siemens Solar Industries for a Course Information Package and application form. Call Cindy Vernon • 805-388-6568 • fax 805-388-6395.

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

Solar 94: Golden Opportunities for Solar Prosperity, June 25–30, 1994, San Jose, CA features the 23rd American Solar Energy Society Annual Conference and the 19th National Passive Solar Conference. For more information contact American Solar Energy Society, 2400 Central Ave. G-1, Boulder, CO 80301 • 303-443-3130 • fax 303-443-3212.

SMUDs Brown Bag Solar Series VI, every other Thursday, 12–1 PM, SMUD Energy Services, Conference Rooms 1 & 2, 6507 4th Ave Ste 500, Sacramento, CA. Bring lunch and enjoy the free presentations. Dates and topics: April 7—1993 World Solar Challenge; April 21—Sustainable Cities; May 5—Solar Driven Architecture; May 19—Passive Solar Concrete Homes; June 2—The SMUD Solar Water Heating Test Facility; June 16 The Graetzl Cell: electricity production with artificial Photosynthesis.

COLORADO
Solar Energy International (SEI) is offering workshops on the practical use of solar, wind, and water power. The 1994 Renewable Energy Education Program (REEP) features one and two week workshops beginning April 11: Solar Home Design Principles, Alternative Building Technologies & Passive Solar, Women's Basic Carpentry, Solar Water Pumping, PV Design & Installation, Advanced PV, Solar Cooking, Drying & Water Distilling, micro-hydroelectric systems, alternative transportation/EV Conversions, Hydrogen Energy. Guest speakers and professional instructors will teach the design of state-of-the-art solar homes that are self-reliant, energy efficient, healthy to live in, and earth-friendly. Participants will learn the knowledge and skills to build energy independent homes with solar, wind, and water power. The series is for owner-builders, industry technicians, business owners, career seekers, and those working in developing countries. The workshops may be taken individually or as part of a program. The cost is $400 per week. Scholarships and work/study programs are available on a limited basis. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623-0715 or call 303-963-8855.

The Crestone Energy Fair will be September 10–11, 1994. The usual fun — great solar-powered music, delicious solar baked food, and the gathering of the solar tribe for council. Contact Kenny Dessain, Turtle Island Peace Camp, PO Box 222, Crestone, CO 81131.

The 3rd Annual Boulder "New Renaissance" Festival will be held Sept. 3–5, 1994 in Boulder, Colorado. A future oriented community event whose focus is on creativity, art, education , health and wellness, and a strong emphasis on the environment and appropriate technology. This year's festival will spotlight technology for building a sustainable society with expanded emphasis on renewable energy. TIMEWEAVE, the educational non-profit group producing the festival, is working with Citizens for Clean Energy to design the Solar Electric Carnival, an interactive educational exposition of renewable energy technology. After the 1994 Festival this display will become a mobile educational exhibit, available for schools and other public events. Planned events also include media and policy maker's days for EVs, an electrathon race, a 10K WalkAbout and a hybrid electric/HPV challenge. The Festival is seeking participation from individuals, groups and industry. To participate or exhibit, contact Steve Clark, TIMEWEAVE/BNRF '94, PO Box 348, Boulder, CO 80306-0348 • 303-939-8463

"Solar Systems Made Simple" (April 23 in Pueblo, CO & June 25, Canon City, CO) are one day classes designed for those living in a home powered by solar electricity, or those who plan to have their own system. The class covers all of the basics starting with basic electric terms and covering system design and sizing, and what appliances to use in an off-grid home.The day ends reviewing how to maintain and troubleshoot your system. The class takes a "Whole Home Approach", from space heating to water pumping and designing a system that will fit your life! Also available is a class on "Whole Home Approach to Earth Friendly Homes", May 7, Florence, CO. Cost is $30 ($10 pre-registration deposit required), $45 for two people from same family. Classes run from 9 AM to 4 AM.

FLORIDA
Hydrogen '94, June 20–24 1994. 10th World Hydrogen Energy Conference & Exhibition, Cocoa Beach, FL. Contact Florida Solar Energy Center, 300 State Rd 401, Cape Canaveral, FL 32920-4099 • 407-783-0300, fax 407-783-2571.

IOWA
The Third Annual Iowa Renewable Energy Expo & Alternative Fuel Vehicle Showcase will be held September 10–11, 1994 at Hawkeye Downs, Cedar Rapids, IA. The Expo will feature: Entertainment, Speakers, Kids Activities, Demonstrations, Workshops & Displays of small-scale & utility wind systems; active solar heating; PV systems & water pumping; energy & sustainable agriculture; conservation; energy efficient architecture; hydrogen, soy diesel, natural gas, solar powered & conversion vehicles; basic electric, batteries, inverters; utility issues and more. For more information contact Iowa Renewable Energy Assn., 611 Second St SE, Dyersville IA 52040 • 319-875-8772 or Stan Eilers, 319-365-7314 or Tom Deves, 319-556-4765.

MASSACHUSETTS
11th Annual Quality Building Conference '94 — Making Sustainable Building Standard Practice: November 11–12 1994 in Springfield, MA. Expert builders will present practical, cost effective applications of the latest advances in energy efficient, sustainable design and construction, indoor air quality and building science. QBC'94 will take a comprehensive look at the people, economics and practices which are changing the way we think about and construct buildings. Workshops, technical presentations, demonstrations and a design competition will underscore the close connections between energy efficiency, sound business growth and environmental responsibility. In depth workshops will feature the Energy Crafted Home, Waste Reduction and Recycling and other topics. For more information contact NESEA, 23 Ames St, Greenfield, MA 01301 • 413-774-6051 • fax 413-774-6053

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

NEW YORK
Any New Yorker who lives off-the-grid in a primary residence may be eligible for New York's grant money for 50% of a renewable energy system. Call 800-432-7283 for information and an application.

June 11–12, 1994, Here Comes the Sun! The Northeast's Alternative Energy Fair, to be held at the Rochester Institute of Technology in Rochester, NY. Brought to you by the Center for Environmental Information, the Fair is designed to introduce the public to a wide range of contemporary alternative energy technologies. Featured at the Fair will be workshops, exhibits, vendors booths, speakers, tours and the regional Jr Solar Sprint model race car competition. For more information, please call 716-262-2870.

The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516.

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

OHIO
Solar electric classes taught at a rural solar and wind powered home with utility backup. Maximum of 12 students. Must advance register. $30 fee per person and lunch is provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will build a system. Dates: April 16, May 21, June 18, July 23, August 20, September 17. All classes held from 10 am to 2 pm on Saturday. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perryville, OH 44864-9537.

OREGON
IN-POWER 94: Oregon's Conservation, Renewable Energy and Solar Technology Fair. July 23, 1994 at Westmoreland Park, SE McLoughlin Blvd, Portland, Oregon 10 AM – 6 PM. Contact: The Oregon Conservancy at 503-232-3575 or 503-637-6130, Fax 503-637-3549 or write 19140 SE Bakers Ferry Rd, Boring, Oregon 97009

Planning for the Oregon SunWorks '94 is underway. The tentative date is August 19–21. We encourage suggestions as to what should be included or dropped from the whole conference agenda. If you know a business that would like to increase it's product/service awareness in the renewable energy arena contact us at 503-224-7867

RHODE ISLAND
The Sustainable Transportation and Solar and Electric Vehicle (S/EV94), October 3–5, 1994, will be held at the Rhode Island Convention Center in Providence, RI. The show provides transportation planners, auto, bus and train industry personnel, business people, fleet owners and operators, students and concerned citizens a forum to exchange information on EV technology, policy, and business, as well as transportation planning strategies to create a non-polluting, equitable and efficient multi-model transportation system. For more info contact: NESEA, 413-774-6051.

VERMONT
"Photovoltaic Home Electric Systems: Seminar and Workshop" is a one day program, held at Sunnyside Solar in Guilford, VT. The 1994 dates are May 14, July 30, and September 24. Each program runs from 9 am to 4:30 pm with lunch included. This introduction to independent solar electric systems includes the hands-on assembly of a four module system. The fee is $135 with a companion registration available for $95. A $45 advance deposit is required, balance due the day of the seminar. Each session is limited to the first ten deposits. Included in the fee is a full packet of information & related articles, Joel Davidson's *The New Solar Electric Home* and Steven Strong's *The Solar Electric House*. Sunnyside Solar offers this seminar and workshop to those interested in photovoltaic technology and it's use, particularly in residential application. For information & registration contact, Carol Levin, Sunnyside Solar, RD4 Box 808, Brattleboro, VT 05301.

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

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

Model Home Electrical Systems Workshop. Help install the PV and wind system that powers the Model Home at the Midwest Renewable Energy Fair. Instructors are Jim Kerbal of Photovoltaic Systems Co. and Chris LaForge of Great Northern Solar. Course length: June 9–19 Cost: $100 (payable to Midwest Renewable Energy Association). Class size limited to 12, so sign up early. For more information call Jim Kerbal at 715-824-2069.

Wind/PV Hybrid Design & Installation Workshop. Participants learn how to use wind and PV to produce electricity. Topics include system sizing, site analysis, hardware specification and component selection. Activities include hands-on exercises with PV modules, wind generators, batteries, controls, inverters and wiring. Participants will get practical experience installing the Wind/PV system that will power the 5th Annual MREF. This workshop is for homeowners, dealers, and installers, as well as those planning careers in renewable energy. Instructors are Mick Sagrillo of Lake Michigan Wind & Sun and Johnny Weiss of SEI. The Workshop runs from May 31–June 9. For information, call SEI at 303-963-8855.

The 1994 Environmental Fair, "An Understanding of Responsibility", is scheduled for April 29, 1994. The mission is to create increased communication and understanding between business and environmental concerns. There will commercial and non-commercial displays and demonstrations. For more information contact Woody Bundick, Superior/Douglas County Chamber of Commerce, 305 Harbor View Pkwy,Superior, WI 54880 • 715-392-2773 or 715-394-7716 Fax 715-394-3810.

the Wizard speaks…

The Solar Hydrogen Economy

The necessity of switching to a world economy based on solar power and hydrogen fuel is becoming clearer every day. Fossil fuels pollute the air and water, produce acid rain, and accelerate the greenhouse effect.

Solar power is non-polluting, easy to install, easy to maintain, and easily replaced or added to. The potential pollution problems in the manufacturing process can be controlled by rigid enforcement of tough environmental standards.

Hydrogen is a clean burning fuel producing only water as a by-product. The potential for nitrogen oxide production can be controlled by catalytic agents, the use of fuel cells, and other technical means.

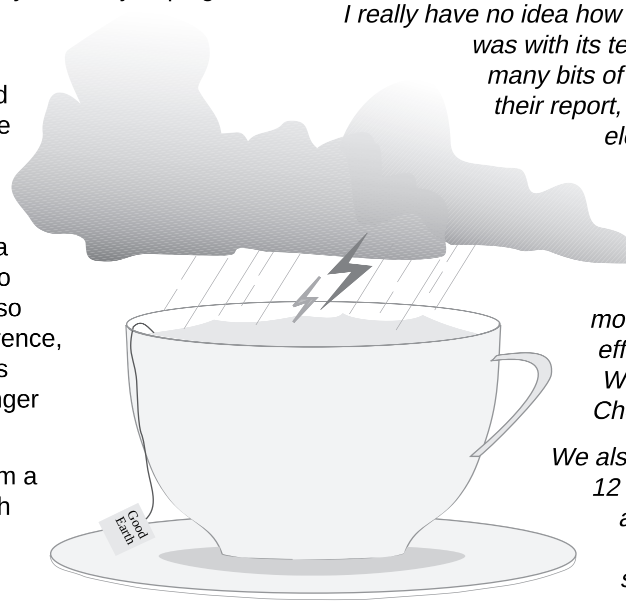
We cannot continue to burn fossil fuels in any great quantity. The evidence for their negative effect on the environment grows yearly. Throughout the world, frogs and coral reefs are dying. Air and ocean temperatures are rising. Ocean levels are rising. Lakes and forests are dying from acid rain. Drought and wind-related storms seem to be increasing. Even the great Mississippi and Missouri river floods of 1993 can be attributed to the effects of global warming.

The simplest solution to these problems is to implement the solar-hydrogen economy. This will take some time to phase in. However, we must begin immediately if we are to avert a major catastrophe in the earth's eco-system.

Sun Frosts
You probably have seen the *Consumer Reports* (February '94) article about Sun Frost refrigerators. We feel their "study" was very biased with preconceived ideas. Their main interest seemed to be the cost of operation of the Sun Frost over other refrigerators, without consideration to alternate power users who need all the kilowatt savings they can get. Also, they tested only the 19 cubic foot model, which has an enormous freezer, and comparably small refrigerator, instead of the more standard 16 cubic foot we have. Of course, the one with the huge freezer will use more energy. The people who tested this obviously have no idea what life is like when you can't just plug in anything that you feel like.

There were other flaws in their comparisons as well. It was tested sitting on the floor, which would be inconvenient, and more or less said you had to buy the $295 pedestal from Sun Frost, which is nonsense. Also, I like not having a bunch of built-in compartments, so I can arrange things as I like. It also fails to mention the humidity difference, and that you can leave vegetables uncovered, and store them for longer periods of time.

We felt you might like to write them a letter of rebuttal, maybe along with Sun Frost. Waldi and Mike Rook, Scott Valley Real Estate, PO Box 1017, Fort Jones, CA 96032



Richard and Karen Perez test their Sun Frost
Hello, Waldi and MIke. You bet we saw the Consumer Reports *review of the Sun Frost. We received no less than ten letters from readers (and most of them Sun Frost owners) who saw the article and disputed its data and conclusions. This is really a tempest in a tea cup. Upon receiving these letters, we immediately began taking data on every Sun Frost frig/freezer in the neighborhood and beyond. Our findings were very different from those printed in* Consumer Reports*.*

We tested our two year old 12 Volt Sun Frost RF-19 and found this out. We could easily get the freezer below -3°F. (setting on the thermostat was 0°F) and at this setting the warmest location in the freezer (next to the bottom of the door) was an average of 9.5°F. We measured freezer temperature and ambient room temperature with an accurate recording thermometer. At this setting, ice cream placed on the freezer's top shelf was hard enough to bend the average K-Mart spoon. Our Sun Frost i an unfortunate and unavoidable location — our hot kitchen. Our Sun Frost is less than five feet from our woodstove (major heat all winter) and four feet from our gas range. Average room temperature during our nine day test period was over 76.9°F, with a low of 69.3°F and a high of 86.2°F. This is a hot location! During this test our Sun Frost consumed an average of 88.6 Ampere-hours per day (1,124 Watt-hours per day or 410.3 kW-h per year). This is 42.2% less power consumption than reported by Consumer Reports *AND our freezer averages less than 1°F in an 76.9°F average temperature room. All electric power measurements were made with an SPM 2000 wired directly to the RF-19. We tested the accuracy of the SPM 2000 against two Fluke 87 DMMs before taking this data. In an effort to be fair with this test we didn't even defrost the freezer and used it as always!*

I really have no idea how thorough Consumer Reports *was with its testing of their RF-19. There were many bits of essential data missing from their report, such as test duration, method of electric power measurement, and appliance usage. I suspect that* Consumer Reports *took their data over a short period of time — less than 48 hours. Sun Frost's have a small motor/compressor. Their forte is efficiency, not fast cool down. World's most efficient, yes. Cheapest, no.*

We also have tested Sun Frost's RF-12 (see Home Power #5) and it averaged 277 Watt-hours per day. Less than Sun Frost's specifications.

On a non-technical note, my editorial nose detected a pronounced bias against the Sun Frost in Consumer Reports' *article. Add bias to inaccuracy and you have the perfect ingredients for a superb tempest in a teacup. — Richard Perez*

Tom Flynn tests his Sun Frost
Tom Flynn of Washington State tested his RF-19 and sent us the data. At an average room temperature of 67°F and an average freezer temperature of 7°F, his 24 VDC RF-19 consumed an average of 591.4 Watt-hours daily. This is 64.1% less power consumption than reported by Consumer Reports*. This is better than Sun Frost's specifications.*

Bob-O Schultze and Kathleen Jarschke-Schultze test their Sun Frost

After the incredibly negative Consumer Reports *article on the Sun Frost RF-19 ac, I decided to test or, in some cases, retest some of Sun Frost's other models. The RF-16 is Sun Frost's best seller and the model in their product line which most closely resembles a conventional refrigerator. The proportion of refrigerator to freezer space is approximately 4 to 1. Actual measured capacities were 3.8 cu.ft. freezer and 10.3 cu.ft. in the refrigerator. The RF-19, on the other hand, is half freezer and half refrigerator. It's a good choice for an off-grid family who puts by a lot of their own home-grown food and need to avoid the extra power consumption of a separate freezer in addition to a refrigerator/ freezer. It's probably a poor choice for a "downtown" home where the supermarket isn't miles and miles of muddy roads away and food shopping happens once a week or sooner.*

Kathleen and I tested our 12 VDC RF-16 (try getting Amana or GE to build you one of those!) which has been in service for 2 1/2 years. Data was taken over an 18 day period of normal household usage by two adults and a teenage boy. The test was carried out during a winter period where the indoor ambient temperature averaged 65°F . Random measurements were taken during different times of day and in different parts of the refrigerator and freezer compartments.

We used an SPM 2000 System Power Monitor to accumulate Watt-hours during testing. Several checks with a Fluke 87 during testing confirmed that the SPM 2000 was performing within its 2% ± 1 LSD accuracy specification. Temperature measurements were taken by the Fluke 87 thru a Beckman TC-253 Temperature / Voltage Converter and Wavetek TP 255 and TP 254 Bead and Immersion Probes. Accuracy is rated at ±1°C.

The bottom line is that the freezer averaged 1.1°F and ranged between +3° and -0.2°F. The refrigerator averaged +37.5°F and ranged between 40.5° and 35.5°F. The RF-16 has separate freezer and refrigerator temperature controls and either one could have easily been adjusted to a lower temperature.

The RF-16 used 8312 Watt-hours total during the 18 day test. That works out to 462 Watt-hours daily or 169 kW-hours per year. This beats Sun Frost's specification. Using CR's national average figure of $0.083 kW-hour, that's a whopping $14 per year in on-grid power costs. — Bob-O Schultze and Kathleen Jarschke-Schultze

Bill Battagin test his Sun Frost
I tested my eight year old 12 VDC RF-16 refrigerator/freezer for four days. Average freezer temperature was 18.2°F and the Sun Frost consumed an average of 645.7 W-hours per day. Average ambient temperature was 65.4°F. — Bill Battagin, 5575 Genesee, Taylorsville, CA 95983

RE in Northern Ireland
I obtained a copy of *Home Power* while on a visit to the Alternative Technology Center in Wales. The magazine had been passed around to some of my friends, who have similar interests. We did not realize that such a rich store of wind turbines and electrical inverters were so readily available. In North Ireland we have a small group of people with interests in wind power. As these machines are not readily available we have manufactured our own, ranging from 750 watts–20 kW. *Home Power Magazine* opens the door to a wide range of turbines and equipment not normally available to us. Personally speaking I find the type of people who buy farms and small holdings, as described in *Home Power*, using renewable energy for their homes, as people who have dropped out of the rat race and really started to live for a change. I am sure that *Home Power Magazine* is both a comfort and a useful tool for such people. Fred Crossett, 165 Ballyutoag Rd, Nutts Corner Crumlin Co Antrim BT29WN, North Ireland

Thanks for the flowers, Fred. We do our level best to make the info in Home Power *accurate, useful, and understandable. It's satisfying to know that folks in Ireland are also into using renewable energy. — Richard Perez*

In Ethiopia
We have worked in development (forestry, veterinary, water, crops, library, and missionary work) in Ethiopia for eleven years. The last seven years have been "out in the bush" with semi-nomadic pastoralists. Grass huts, sun, water under sandy river beds! *Home Power* has helped us learn about solar, more than any other single source. So far: solar electricity, solar oven, solar food dehydration, solar water distiller water for batteries and for veterinary clinic, solar water heater, solar water pump, solar electric veterinary laboratory, solar vitamin D, solar clothes dryer. We thank God for sunshine — and appreciate rainfall, when it comes, like never before! Keep up the good work! Please hold your good balance — don't go the way of *Mother Earth News*. Drs. Fred and Vicki Gorkum, c/o SIM, PO Box 127, Addis Ababa, Ethiopia

Well, Fred and Vicki, it's impossible to write or even edit accurate articles about renewable energy (RE) from a grid-powered apartment in the city. Witness the latest round of RE misinformation published by mass-media magazines. Well, we aren't moving and we aren't changing. Look forward to more of the same from us, only better! It's folks like you actually using RE and sharing your experiences that make it all work. — Richard Perez

Volunteer
Just another piece of fan mail. I discovered your magazine about a year and a half ago and have since become an avid fan. I eagerly anticipate the appearance of each new issue (bi-monthly is far too little) which I read cover to cover. I particularly enjoy the articles about RE projects in the developing world and related articles about solar stills and ovens.

Between 1991–92 I spent a year traveling in the South Pacific and Southeast Asia. I saw first hand villages in Fiji and Thailand where Peace Corp volunteers had installed PV systems. More importantly, what I saw was the improved quality of life things as simple as light and refrigeration provide. In two years I hope to graduate from the University of Washington with a degree in mechanical engineering, and plan on joining the Peace Corp.

The articles in *Home Power* are a constant source of inspiration giving me a clear vision of the kind of work I would like to do in the Peace Corp. Keep them coming.

I certainly don't need to tell the *Home Power* staff and readership that alternative energy is an Rx the world desperately needs. Alternative energy developments are the kind of low and middle tech solutions that the developing world needs, as opposed to the World Bank type fiascos that focus on massive projects funded by huge loans that poor countries cannot afford. These do little to benefit the common men and women of these countries.

I would like to get some practical experience in developing alternative energy systems and maybe get some actual field work done, so that I will have some experience before I enter the Peace Corp. If you know of any projects planned for the near future (especially in summer) where they would appreciate the help of another volunteer, it would be a great help. Luke Jennings, 1424 N Garden #1, Bellingham, WA 98225

AW Reet, Luke! Your address and desires are printed here. How about it readers? Anyone need a volunteer? — Richard Perez

In Small Steps

This is a thank you letter. Two items written by you have changed my priorities. Item 1: "Come off the grid one circuit at a time". Two years ago I ordered a Solarex MSX-60 from Backwoods Solar and converted my basement lights to 12 V fluorescent. Item 2: The following year I read "Become an RE Dealer". So I did! I ordered more PV and went to ham fests, flea markets, gun shows and best of all the GLREA show in Traverse City, Michigan last August. The small shows do not turn a profit but where else can I do interactive advertising for $1.75 per hour? I broke even at the Traverse City show.

Today I installed one of Dan Alway's four cubic feet refrigerators. Solar cooled beer is now the norm in my house. One half the lights in the house have now been converted to solar and the Consumers Power bill keeps dropping. But the electric bill change is really inconsequential. Richard, your articles struck the one ultra sensitive nerve in me. Become independent! Now I'm advertising my own home-brew charge controller in your micro ads. Now I'm working to become a full time RE dealer and hang up my electronics-teacher hat. Now I have a useful hobby. Thanks for sharing your philosophy with one who took it seriously. Don Sheets, Freedom Energy Co., 15902 Turner Rd, Lansing MI 48906

Welcome, Don. A circuit at a time, works really just fine, when starting to deal, expect beans for a meal. — the HP Crew (the Wiz got the rhyme).

Radical

Hello from the other side of the world. I have been a subscriber to *HP* for several years now and really look forward to its arrival at my home. Having come from a traditional right thinking conservative background in which every single member of my entire immediate and extended family fervently upholds every single Republican value and belief, I introduced a compact fluorescent light bulb. Oh boy. I convinced Grandpop to try one, and every day at 5:00 PM his TV remote would stop working. It took two months to figure out that the bulb I had replaced was on a timer, that the timer switched on at five o'clock, that the compact bulb manufacturer told us it put out the same IR frequency as the remote, and Grandmom wanted to know if it would radiate her every day at 5:05 PM. I told her it would, just kidding, Ma. Undaunted, I began to replace every light bulb in my two story colonial house with compact fluorescent bulbs. It took several months and LOTS of the following at family gatherings:

"You bent the harp!"
"Oh my god Rita, he put 'em in the laundry room."
"They're too dim."
"They're too bright."
"Lorrie, look in the bathroom. Up there, what's that?"
"It takes a minute to warm up? *Sheesh*."
"How much carbon dioxide?"
"Do you use disposable diapers?"
"I can't believe you bent the harp?"

I switched over to a Time of Use meter from the electric company, remote cycled my air conditioner, installed a whole house fan, and ceiling fans. Family members would get real quiet when I walked into the room. Lunatic liberal on the loose. Then I showed them *the bill*. My electric bill plummeted. Compact bulbs started to appear in conservative households across the family landscape, very slowly.

My point is this: who cares what the reason is behind anyone's decision to conserve or use renewable energy, as long as they do it and use it. When I read *Home Power* I see rugged individuals that want more control over their lives, a real sense of independence, and a lack of interference from Big Business and Government. I don't see anyone delusional enough to think that what they are doing alone will save the Earth from ourselves.

Let's not forget the shift to the political right that the USA is currently suffering through. Please allow me the role of devils advocate. In the old days, the bad guy was *communism* and all that it meant. Now the terms liberal and environmentalist are labels for the bad guys. The conservative view of Environmentalism: It's the new Socialism, a way to reclaim land and property (factories etc.) for the state, a hidden agenda dressed in "Earth Day" T shirts. Since citizens as property owners show irresponsibility for the health of their land, then we as environmentalists will pass law after law, to limit use of land to the point of uselessness, thereby rendering ownership of land and property pointless. In states like my own New Jersey, over-regulation, and an overzealous environmental department have helped the economy to be the worst since the depression. Hell bent on increasing fees and accumulating operating capital through fines, the regulations had little impact on the environment.

The conservative notion that the environmental movement is actually a socialist movement runs counter to the nation's concept of property ownership, whose roots were planted in our nation's culture since the colonial days. The majority of Americans sit squarely on the center of the political fence. A radical environmentalist approach ain't gonna sell nothin' to nobody. Any threat to accumulation of wealth is taken very seriously and has usually resulted in big trouble for the offending party.

Taking these ideas into consideration, the American public probably won't accept changing lifestyles until we all choke to death on crud, and we folks who know better might say "See I told you so" (from heaven). But do we really want to see people destroyed just to be so selfishly satisfied? In my opinion, hauling out the old "Sky is falling" environmental sell job for renewable energy won't work. I think a new, capitalist marketing approach is needed. Renewable energy will only have an impact if it is used *big.* Everybody has got to get into it, from downtown apartment buildings to uptown nightclubs, from remote dwellings high up in the Ozarks to boats, trains, and automobiles. What I'm talking about is marketing. Getting everyone to *use* Renewable Energy is the goal, *nothing else is important*. All the benefits will occur as naturally as rain on a hot summer night. Of course the environmental gains are tremendous if we as a nation move to renewable energy. But if demand is low then let's face it, prices for renewable energy will continue to be ridiculously high. You can't increase demand for a product on intellectual arguments and altruism.

Now I don't think we have to pop a monkey into a solar powered electric jeep full of bikini clad girls and send them hurtling down a beach, but we could emphasize individualism, freedom, self-reliance, cost savings, and of course fun. So what if we as crazed solar babes are the only ones who know the real advantage.

Hey, it works for soap. Larry DiBona, 15 Snowfield Dr, Glassboro, NJ 08028

You are dead on target, Larry. If you take a look at editorials I have written in Home Power, you'll see that I agree. — Richard Perez

RE Friends in Atlanta?

In a conversation I had with Richard Perez, he advised me to put my name on a contact list. Since your subscription list is confidential, perhaps others from the Atlanta, Georgia area could contact me. Please use my name and city/state and telephone number only — not the street address. Thank You. Linda Tava, Doraville, GA, 404-816-0605 wk

A Request

I'm glad to see EV info has expanded as this is my primary interest right now, with alternative energy second.

I'd like to request that your readers whether EV advocates or not, write to CARB (California Air Resources Board) in support of the ZEV (zero emissions vehicles) mandate that requires 2% of vehicles sold in California starting in 1998 be ZEV. The US auto manufacturers are lobbying hard to get it removed or loosened and CARB needs to know we care. They should also write Governor Wilson and their own legislature leaders about their support. This affects other states than just California, so all should write in. Thanks. T. Cygan, 1749 9th ave, Sacramento, CA 95818

A Go Power Fan

It took 36 issues, but finally, at page four, an answer to EV followers and leaders. Go Power needed to expand to cover what appears to be an inevitable drive into the transportation future. Including transport, *Home Power* has once again turned on the lights. The road ahead now has *HP* as a welcome cartographer and *ATN* can continue its agenda. Allan Adamson, PO Box, 222, Gardner, CO 81040

I share the passion with you, Allan. After being off-the-grid for 24 years, my next job is the gas guzzler in the front yard. We are very pleased to work with Michael Hackleman and bring you cutting-edge and useful EV information. — Richard Perez

Ditto

I'm currently trying to learn and understand alternative energy sources. I'm planning on converting my Ford Festiva to an all electric vehicle this spring so EVs are of interest too. Soon I hope to build and live in a self-sufficient home. My plans are to become efficient enough to live in a small solar home completely paid for and earn enough money to just get by with taxes and peace of mind for emergencies. I use *HP* magazine for info on the latest info available and how to find the answers to my alternative energy questions. I really like the contest coverage. Being an ex-racer I know competition breeds new and advanced ideas. Ralph W Huey Jr, 110 Pfarr Ln, Loveland, CO 45140

Hi, Ralph, check out the Electrathon info in this issue! I have wanted to campaign an Electrathon racer, but Karen reminds me that I'm years behind on my battery book revision…. — Richard Perez

Service Counts
Since our oldest son first gave us a copy of your magazine in 1990 we have discussed using solar power for our second home which is north of Oakland, Oregon.

The more we thought about it the more confused and apprehensive we became. We read every issue of HP from cover to cover and it seemed easy enough but was the unknown.

After looking into the cost of bringing power (and the outside world) into our hideaway we decided to talk to someone about it. The people we attempted to get information from in Roseburg, Portland, and several Northern Californian firms left us believing we probably knew more about the subject than they. One "dealer" boringly slid a worksheet across the counter at us and said, "Fill this out, figure out what you need, send in the order. We ship UPS". End of conversation!

One day in 1992 I called your office and asked if you ever recommended solar equipment dealers to your subscribers. The lady I spoke with asked where we lived, then said, "Call Bob Maynard at Energy Outfitters in Cave Junction. He is very knowledgeable and easy to talk to". We did.

On a cold, information-only call, Bob spent at least 30 minutes with me answering questions, giving approximate prices, making recommendations and making me feel very secure.

I mentioned that we were planning a trip south and would it be convenient to stop by to discuss things further. He made us feel so welcome and spent a long time asking and reasking about our lifestyle and expectations for our solar system. By the time the interview was over he had mapped out a solar/generator/propane power system for us that was well within our budget and included everything we thought we wanted plus some things we hadn't even thought of — and he offered to come to our place (at least a two hour drive one way) to look over our site and point out the best place to put our equipment.

He arrived, he marked, we ordered, we drove to Cave Junction to not only pick up our equipment but to spend the morning with Bob explaining and drawing diagrams to show us exactly how this all went together. By the time we finished, even I, who have trouble changing a light bulb, thought I could put it together.

We had rainy weather during much of 1993 so getting out to work on our system became a real problem. We have soil with a lot of clay in it and when it's wet it's difficult to even stand up! Therefore, we put off starting the project until very late in the year which gave us lots of time to fuss and worry and forget everything Bob had told us.

Eventually we put up the rack, built a battery/control shed, installed the panels, wired the panels to the battery, then the battery to the controls, always knowing that Bob was there at the other end of an "800" phone number if we needed advice. Everything went as smooth as clockwork and when we finally attached the last wires (in a driving rain storm) and turned the bedroom light on (without the roar of the generator) it was a red letter day for us.

I realize this is rather long and probably boring but my point is — solar power systems *do not* require rocket scientists to set up and use. If we could clone Bob and Golda Maynard and send them all over the country to help people get over their fear of the unknown we would have many more solar systems in operation. Thank You Energy Outfitters (800-467-6527) for helping us get started on energy independence.

PS. Our main point is that the unknown is not half as scary when you have a good guide! Thank you for your contribution! George and Sharon Findling, 2230 SE 152nd, Portland, OR 97233

Well, George and Sharon, your experiences are shared by many readers who write us. There is no really good reason to settle for RE system #6 out of a catalog, when there are experienced people who can custom design one for your family. Bob and Golda Maynard are among the best! Renewable energy systems are fast outpacing the expertise of the average home installer. It now takes the experience of a person who has recently installed many systems to design the most effective system for a given situation. You don't get this kind of experience by selling lots, you get it by installing lots. The few extra bucks spent with an real installing dealer are well worth it. See my article "Mail Order Shoes" in this issue (page 72). — Richard Perez

Competition
Home Power is very informative, I have learned a lot from the articles. I use your magazines as a reference at times, like an encyclopedia. As a home owner and solar electric user it is very good. As a dealer in solar and other renewable energy equipment and energy efficient equipment, I do not recommend it or even mention it to people who don't know about it because of the large outfits that advertise at prices I cannot compete with. I offer the high quality and complete service that is in demand but my market volume seldom justifies below retail prices. I share my knowledge freely with anyone but hesitate to give away my livelihood. Scot Schaffer, PO Box 1308, Kaunakakai, HI 96748

Well, Scot, when I was an installing dealer (and I did it for fourteen years) the first thing I would show a potential customer was a copy of my cut-rate competitor's mail order catalog. I'd tell the customer what I would do what the mail-order house wouldn't — starting with standing with him on his site and talking to him. If the long list of services that I provided wasn't enough to justify the additional ten or so percent of cost, then I'd hand the customer the mail-order catalog and wish them good luck. Oh, by the way, I didn't install what I didn't sell.

Renewable energy systems are a lifetime investment. Anyone who thinks that saving a few bucks on hardware is worth leaving out the help of a competent system designer/installer, is a fool and will eventually pay much more for the supposed really good deal. See the letter above. — Richard Perez

Water and Wind Generators

I'm a medical Corp soldier stationed in Korea. Sometimes rereading *Home Power* is the best morale raiser here away from home. Anyway, a letter from *Home Power* #34, page 100 talked about the "submersible prop generator tale." Well, it's true, check out Jack Rabbit Marine, 425 Fairfield Ave, Stamford, CT 06902, (203) 961-8133, fax (203) 358-9250, 1994 catalog, pages 5–6, for the Aquair 100 water & wind generator and the Aquair UW underwater prop turbine. Five amps at six knots water speed is pretty good, I'd say, for approximately $1000 US. Michael Rickman, 43rd MASH, Box 90, APO, AP 96271

Hi, Michael. Sailboat "drag-behind" hydros will work in the average creek or river if protected against debris. Thanks for the access. — Richard Perez

Alkaline Cells

In *Home Power* issue #34 (page 44), your article on "Alkaline Cell Operating Tips" was very useful. At the end of the article you said you would address the issue of how to recondition alkaline cells. I have not seen anything yet specifically on how to do this or where to buy chemicals. My nicad cells need to be reconditioned this spring due to low electrolyte levels.

Would you please go into specific detail on chemicals needed and how to mix them for this procedure.

We enjoy getting each issue of *Home Power* and appreciate all of the help you have bestowed on us. Randall Felder, PO Box 685, Joseph, Oregon 97846

Well, Randall, the article on reconditioning nicads (and nickel-iron) cells was done months ago, but for one thing. We have nowhere to send the spent electrolyte. Nicad electrolyte contains small amounts of cadmium. We cannot locate any place that will accept spent electrolyte for proper disposal. Karen has spent weeks on the phone with the EPA and disposal companies to no avail. Until there is an authorized disposal channel for the spent electrolyte, I will not publish info on nicad reconditioning. Give me a call at 916-475-3179 and we can discuss your particular problems. If anyone knows of a disposal channel that will accept spent electrolyte from Home Power readers, then please contact me immediately. — Richard Perez

Vacation in the Ozarks

We fall between the turn-key, dealer installed folks and the tech weinies, so keep the articles balanced. If you go for either extreme you will upset the purpose of *Home Power*. That said, I love the magazine. Also, Kathleen, we are very interested in the AE home trading information. We live in the beautiful Ozarks but would trade weeks with others in other places. PS. We would enjoy some solar oven recipes. Marie and Richard Cornelison, 119 Harlow Place, Hot Springs, AR 71901

PV Data

I like the style and contents of *Home Power* magazine. The articles are clear and convey lots of valuable information.

One complaint I have is the lack of information about PV modules in ads and articles. Wattage information is useful, but does not convey any meaningful data unless voltage or current specifications are known. Physical size, mounting considerations, and wiring data are also needed if a purchaser is to make intelligent purchases. I, for one, don't know one panel from another by model numbers. Please publish definitive PV spec's to use as references.

I would also like to see articles about how PV panels are manufactured and the physics involved. For instance, what does a single PV cell provide? Victor E Gray, 855 S Interstate Dr, Cedar City, UT 84720

Well, Victor, until recently PV manufacturers didn't advertise the techie specs on their modules because the ad department didn't think the public either cared about or understood the data. Write to the PV maker and they will send you the official specification sheets for their products. Home Power *routinely publishes performance tests on a wide variety of PV modules (see* HP*# 24 and #33). Complete physical specs and even junction box photos are in* HP *#33. — Richard Perez*

Pond Power?

I read every issue of *HP* cover-to-cover the day it arrives. My wife and I look forward to the day when we're both finished with school, and can move out of the city and put all our RE how-to to work. I'm wondering if anybody out there has experimented with small-scale pumped storage of water for hydro power generation. A pond seems like a much nicer storage medium for energy than a closet full of batteries. Ice could be a big problem in our climate. Our sunshine here is meager in the long winter, but the wind really blows at times. I'd like to see more info on combined sun/wind/hydro systems. Keep up the great work! Rick Aylsworth, 529 Sparksman Ave, Duluth, MN 55803

I know the idea of storing power in an elevated pond is very attractive, Rick. In fact PG&E stores power in this manner (using hydro electric power to pump water into a reservoir and then running the water back through a hydro). This is a long and devious path, full of inefficiencies. As a storage system I estimate it at less than 40% efficient. Batteries are between 85% and 95% efficient. I agree that we need some new form of long term energy storage. In the near future, I think that hydride storage of hydrogen is the answer. — Richard Perez

Environmentally Safe Buildings
We have been receiving your magazine for two years now and enjoy it very much. My husband and I live on a 45 foot sailboat and are completely self-handed. We are planning on moving to Washington in a few years and want to build our home in the mountains around snow line. The reason I am telling you this is we live in the Virgin Islands and don't have much access to magazines for home building environmentally sound ways. If you know of any magazines or books I would appreciate it if you could send me their names and address. I love your magazine and have saved them all. I can't wait to move to land so I can start doing & making your ideas! Thank You. Teresa Fisher, PO Box 308, Cruz Bay, Virgin Islands 00831

Hi Teresa, You're in luck! We just received a copy of a new magazine called Green Alternatives for Health and the Environment*, 38 Montgomery St, Rhinebeck, NY 12572, phone 914-876-6525. The pub is bi-monthly and the cost is $18.00 per year. Their stated purpose is to help individuals find alternatives to toxic or polluting substances, giving them tools for the practical application of environmental concerns. In their February/March 1994 issue they had an article called "Blueprint for Better Buildings" full of just the info you need. Send them an SASE for their list of sources. Here are just few places to get you started. "Healthy Buildings Resource Guide" by Dan Morris: How to select healthy materials for home construction; published by Healthy Buildings Associates, 7190 Fiske RD, Clinton, WA 98236; 206-579-2962; $19.95 plus shipping. The Healthy House Institute, 7471 N Shiloh Rd, Unionville, IN 47468; 812-332-5073: healthy building pioneer John Bower's center for resources and information; books, videos and other materials. "ReCraft 90 Handbook: The Construction of a Resource Efficient House" by Steve Loken, $12.50, available from the Center for Resourceful Building Technology, PO Box 3866, Missoula, MT 59806; 406-549-7678. ReCraft also carries "Guide to Resource Efficient Building Elements", a listing of sustainable alternative materials and practices in all phases of home construction.— Karen Perez*

Cheaper in the Long Run
After buying property off-the-grid, it didn't take long to figure out that kerosene lamps didn't suffice. We purchased a used generator which lasted two weeks before costing another $600 in repairs. After another two weeks it needed a complete overhaul. That is the point when I found I could put in a very nice photovoltaic system for less than I had in the generator and didn't have to feed it. Afterwards I found your magazine, which took almost all the mystery out of what I was doing and helped develop safety into the system. It also helped to find very hard to find items. Don Henley, PO Box 376, Big Oak Flat, CA 95305

Glad to be of service, Don. I continually urge folks to do their homework before moving off-grid. Using an engine/generator as a prime mover for the system is a nightmare. Again, see my Mail Order Shoes article in this issue (page 72). — Richard Perez

No Fair
I can't believe you keep getting better. I have all back issues (except #1) and in the last six years you are the true example of, "You have come a long way baby". What will the next seven years bring???

My only regret is that I live in the state which is the home of Southwest Windpower, Photocomm, Solarjack, and the Solar 500, and which has more sunny days than any other state and we do not have an Energy Fair. I guess everyone is too busy making money to put one together. (I'd be willing to help in any way I could .) It's too bad too, as the population of Arizona doubles from December to March with snowbirds coming from everywhere, it would be a great way of spreading the word. James Miller, 4920 E Holly Apt#1, Phoenix, AZ 85008

OK, Arizona, James has issued a challenge. Every Energy Fair now going on was the work of grass roots RE users. We had to drag businesses, kicking and screaming, to the first Fairs. They thought that it was a waste of money. Now, five years and dozens of Fairs later, businesses stand in line and pay big bucks to display at these Fairs. If you organize a Fair in Arizona, the businesses will come because, guess what, they sell a ton of stuff and make money. At Fairs like the Midwest Renewable Energy Fair in Wisconsin, or SEER in California it is very apparent that RE is alive and flourishing. As Therese says, "It could happen to you!" — Richard Perez

GFIs — A Phantom Load
An addition to the phantom loads you mentioned would be ground fault interrupt (GFI) sockets. Also (lately required) are hard wired smoke detectors. Our new house has five GFIs. It took some time and detective work to figure out what was activating the inverter. Since they are required by code, one must deal with them by turning the threshold of the inverter up. There are lots of little sneaky surprises when constructing a new house, in our high-tech world. Cayl Campbell, Winthrop, WA

GFIs are not only phantom loads, but also only marginally compatible with modified-sine wave inverters. My advice if you are using a mod-sine inverter is to use a GFI circuit breaker instead of the individual GFI sockets. It's cheaper and easier to replace when it eventually fails. No problems exist with GFI circuits on sine wave inverters, however they are still a phantom load. — Richard Perez

Amateur Solar
I notice you folk at *Home Power* often include your ham call signs with your articles. Could you tell me if there is a net or frequency on HF or VHF where renewable energy minded amateur radio operators hang out? I use homebrew HF gear from a small solar panel when on climbing or kayaking trips and would enjoy exchanging

ideas and experiences with other stations. Peter Talbot VE7CVJ or KB7TOK, Vancouver BC Canada

Hi, Peter. Currently there is no HF Home Power Net. We had one in the past on 40 meters, but everyone got too busy and it has lapsed. Is some one out there willing to take on the job of net anchor person? While the HP crew are all hams, we don't have a life, we have a magazine. Here's the roll call of HP full timers: Karen - KA7ETV, Therese - KB7WRP, Kathleen - KB6MPI, Bob-O - KG6MM, and Richard - N7BCR. We monitor 146.400 MHz Simplex FM as our "back fence" frequency. We usually hear any mobile on I-5 between Mt. Shasta and Ashland, Oregon. — Richard Perez

Phantom Load Exit Signs?

Most *Home Power* readers won't have any need for an exit sign in their homes but we do work or visit businesses, offices, schools, factories, and hospitals that contain thousands of these little life saving energy black holes. I'd like to share with HP readers news about the most energy efficient exit signs available called electroluminescents (EL) which use under 1/2 watt.

Millions of exit signs still use incandescent bulbs which can consume up to 100 watts per fixture (at $70 a year), generate heat which fades and melts the sign face, and require constant bulb replacement. Recently, many exit signs have been retrofitted with compact fluorescent lamps that consume less energy (9–20 watts at $13 per year) than incandescents and operate much longer (10,000 hours, 17–18 months). Unfortunately, compact fluorescent lamps have an environmental disposal cost because these contain mercury, require a ballast that wears out, are bulky and can be difficult to fit in many existing exit sign housings. Fortunately EL panels solve these problems.

EL panels are constructed by bonding a thin layer of electroluminescent material, in a dielectric medium, to a flat glass substrate containing transparent electrodes. When voltage is applied, 0.48 watts typically, the panel illuminates providing a uniform, solid-state lighting. A 90 minute flashing emergency mode can be arranged by adding an ac inverter and small battery kit. EL panels come in red (looks orange) and green although the green appears much brighter. Several adapters can be ordered such as bayonets, candelabra, intermediate or medium base. The retail cost of one panel is about $90, but quantity pricing can be arranged — and prices should fall as production tools up. Mike Mangan, Ecology Services & Products, PO Box 176, Delafield, WI 53018, 414-646-4664. Manufacturer of EL panels: Monopanel Technologies, Inc., 1535 S 101st St, West Allis, WI 53214, 414-256-5200, Fax 414-256-5252.

A Comfortable Retirement

Just saw this cartoon and thought you'd enjoy it. (Three cave people sitting around a fire, one of the cave people is holding a piece of paper and is saying "I just invented the power company. Here's my bill.") I immediately thought of the issue about the power companies "renting" the sun, leasing PV systems, etc. They would like nothing better than to charge us for warming ourselves at our own "fire". I just know you're laughing at this one!

My wife Dianne and I enjoy *Home Power* very much. It has a lot of everything in it. We own a 60 foot Sumerset houseboat (coastal cruiser) with rare power: twin Volvo 131 hp turbo-diesels with duoprop outdrives. Also a 12.5 kW Westerbeke genset, also diesel. We installed eight 51 Watt Kyocera panels on the front roof (room for more), twelve 6 V golf batteries, and a Trace 2512 inverter. This runs the whole works: refrigerator-freezer, 1350 watt microwave, coffee, two TVs, waffle maker, convection oven, and on and on. We take her to the Florida Keys, up St. John's River, and we plan to retire on it and take it up the Intracoastal Waterway to the Thousand Islands and the Chesapeake. What makes it so great is the solar power. All the comforts of home wherever we are. Also, this boat is aluminum, very little maintenance and very tough.

Keep up the great work — it is the wave of the future — and if you would be interested in a future article on the trials and tribulations of the "Scotch Bonnet" and solar power , we would be happy to do one, pictures, etc.

Thanks again for a super magazine. John and Dianne Hutchins, 335 Princeton Dr, Lake Worth, FL 33460

Hi John and Dianne, You're right the cartoon gave us a good chuckle. Your houseboat does sound very nice and we'd be interested in an article about her. Wouldn't it be loverly though not to have to listen to, smell, and hear that large diesel when cruising. — Karen Perez

Tubular

At the Botanic Gardens in Cheyenne they have clear plastic tubes filled with water instead of 55 gallon drums. The sign says they are a little less efficient than the drums. What is the difference? Do you know of any sources for the tubes. They are much more attractive than drums. Ms Carolyn Jackson, 3537 E 117th Dr, Denver, CO 80233

Well, Carolyn I can find no access for these water tubes. How about it readers? — Richard Perez

We Feel Good!

As an electronic technician, I appreciate *Home Power* keeping me informed about the latest technology of solar related products.

Your electronics articles are written so that the layman can understand. The more people that understand this technology, the more people become comfortable with it. The more comfortable people become with it, the more it will be embraced. Everybody wins! Thanks. Stephen Rosenbaum, 22588 Elam Rd, Sunman, IN 47041

Thanks for the flowers, Stephen. Homebrew is my first love and I love turning on other people to the invisible world of electronics. — Richard Perez

Wind Problems in Greece

I saw Graeme McIntosh's letter in *HP*#37 and was interested in his comments on U.S. manufactured wind machines not standing up to excessive wind in New Zealand. I have (or had) one which worked excellently for three months when the tail boom, together with the tail vibrated off in a Beaufort 8 wind. Even after this was fixed, I had constant trouble with loose connections inside due to the beating that the machine took in heavy winds.

The constant movement up and down on the springs that tilt the propeller in high winds seems to be the main problem especially when combined with the machine turning all the time to find the best wind, as happens when there is a real gale, with gusts and sudden high forces. Beaufort 8 is 17.2–20.7 m/sec (36–46 mph) and the survival speed of these wind generators is generally given as at least 50 m/sec. It is my opinion however, that these machines are really designed to work best in much lower winds and with more constant gentle forces. They do work very well and efficiently at high speed but this does take its toll on them. I suspect that for many people there is not a choice if they want a small turbine as there are not many models to choose from and most countries (including Greece) do not manufacture their own machines that would handle the local conditions satisfactorily. Roger Tarn, Alonnisos, 370 05, Greece

I am going to suggest to Mick Sagrillo an article about wind generator survivability in high winds. I do know that wind generators with very high survivability (like the NorthWind) are heavily built and cost about twice as much as the one you discussed. — Richard Perez

Home Power's 3rd Annual

Solar Cooker Contest

1st Prize: a Solarex MSX-60 PV Module

2nd Prize: a Solarex MSX-10 Lite PV Module

3rd Prize: a Solarex MSX-5 Lite PV Module

You can win a prize! It's simple.

Our planet needs solar cookers that fit all cultures and climates, that are easy and cheap to build, and fun to use.

So go to your backyard or attic or local dumpster. See that hatbox or old Weber barbeque, that piece of window that was replaced, that left-over aluminum flashing. And start designing!

For complete rules, see HP#39 pg. 82. For inspiration and judging criteria, see last year's contest, HP#37, pg. 22.

The Rules

1. Build a solar cooker from any materials, but simple, inexpensive, common, or recycled materials score high.
2. Your solar cooker must cook — it must reach at least 212°F.
3. The actual cooker must be sent to Home Power by 15 July 1994 or brought to the cookoff (let us know you're coming).

Solar cookoff and potluck will be held 6 August 1994 at Camp Creek Recreation Area, near Hornbrook, California. All are invited!

Send cookers to: Home Power, 19101 Camp Creek Rd., Hornbrook, CA 96044

Questions? Call 916-475-3179

Q&A

Answer to Trailer Grounding
I'm writing in response to Ed Watt's letter about grounding his fifth wheel trailer.

Ed, the National Electric Code requires, for very good reasons, your travel trailer to be grounded if it is connected to the electrical utility. The service neutral must be grounded at the disconnect outside your trailer, and the frame of the trailer must be bonded. The codes are somewhat obtuse, please check with a local electrician if you aren't 100% sure.

Think about it. Your fifth wheel goes down the road vibrating and bouncing with the bumps in the road. The electric wires in the travel trailer have weight and inertia. They bounce and rub around inside the trailer frames. In almost any trailer, after a sufficient number of miles and bumps, the electrical conductors are going to have some insulation rubbed off against the frame of the trailer.

You park your trailer in a mobile home park. You connect to the local electric power. If the park's wiring isn't right (which is not at all unusual, especially in older parks) *or* if your trailer isn't properly grounded, *and* if one of the hot wires in your trailer has had the insulation rubbed off and a hot wire is touching a frame or structural member, you now have a potentially lethal situation.

A neighbor's cute kid comes to visit, and standing in a puddle by your door, knocks on your door or grabs the doorknob. The current through that person's body will be limited only by the circuit breaker serving your trailer, the conductivity of the local soil, and the quality of the insulation of that person's boots.... Please ground your travel trailer properly. The life you save might be your own.

P.S. Lightning is attracted to earth by *static* electrical charges. The static charge on a tree is identical to the charge of the earth beneath it. Don't count on wood supports under your travel trailer. Ron Smith, POB 92373, Anchorage, AK 99509

Checking Old Wiring
I (we) have subscribed to Home Power since virtually day one (what percent of your readers can say that?) and pride ourselves on having nearly a linear foot of all issues.

Now a question When we built the addition (two-story) on to our cabin 15+ years ago we had an electrician from one of the local saw mills come up here and wire it for 110V, before we nailed up all the inside wall boards. He used #12-2 G Romex, non-metallic sheathed cable type NM-B 600 volt. He installed three simple circuits, one of which goes to our kitchen (original log cabin).

I'll spare you the details except to say that the above wiring job was never "completed". That is to say, the wall sockets were never wired and the wiring has never been tested as it has never been a functioning system. I may be able to do this one day soon but need some guidelines/advice, such as, can one of the circuits be 12 VDC, the others 110 ac? The latter would be inverter power. Our 12 gauge Romex has three wires including the ground wire. Could you provide me with a list of *Home Power* articles that focus on the above questions? Or perhaps you know of a better (or additional) source of info? My main concern is how one goes about adapting or modifying a place that has been wired for 110 ac, to accommodate a 12 Volt system.

My second question concerns lapsed time that our house wiring has sat unused for 15+ years. I am certain that various species of rodents (mice, chipmunks, golden manteled ground squirrels, even pack rats) have gained access, over the years, to areas where there is Romex wire. I am concerned about possibility of damage (short circuit). As I already mentioned, the system has never had power in it since installation. Is it possible to somehow test the security of the circuits (re: the rodent/short circuit concern) without having to dismantle the house? This problem may be addressed in some back issue of *HP*, but I don't recall ever reading it. I do remember reading a silly (non-lethal) pack rat story several years ago. Your advice would be very much appreciated. Frazier Nichol, HCR77 Box 2070, John Day, OR 97845

Well, Frazier, the following HP issues contain wiring information: #29, #7, #2, # 33, #14, #18, and #27. Since you didn't include the length of the NM cables, I cannot really say about using one of them to transfer 12 VDC. In general, I think that you could efficiently run at least 6 Amperes of current through the #12 NM cable. You would be far ahead to install a new pair of heavy wires (like #8 to #2 depending on current and distance) for the 12 VDC circuit. Rodent damage is a reality. You don't have to take the walls apart in order to test the wiring. Use an accurate ohm meter (like a Wavetek or Fluke) to measure the conductors for short circuits. There could be potential damage to the insulation that is not apparent with an ohm meter test, *but the damage will be apparent when a higher voltage (like 117 vac) is applied to the circuit. So look lively when the power is first applied to the circuit. You should see no current flow when the circuit is not being used, but powered up. Enlist the aid of a techie or an electrician in testing your wiring. It requires not only a good instrument, but some sharp-witted techie diagnostics.— Richard Perez*

Excess Wind Power
With a shunt type controller (Enermaxer) for our Whisper 1000 and four sets of Quadlams can I use standard water heater elements, 240 Volts, in tanks for excess power? The Whisper is an HV 24 Volt model transformed to 12 Volts. Can I run 12 Volt motors (fans?) at variable amperage from the Enermaxer? Thanks & keep it coming and growing. Dave Abbot, Faithwood Custom Builders, 601-650 Escalante Rd, Delta, CO 81416

Well, Dave, the standard 240 Volt heater element will consume 1/10 the current when fed 24 VDC. It will also dissipate 1/10 the power, making it a poor choice as a shunt load. If you use a 24 VDC water heater element (available from Kansas Wind Power and others) then you have the perfect shunt load for your Enermaxer. I would not recommend running motors as shunt loads. The first duty of the Enermaxer is system regulation, and the proper hot water element is a suitable load. Motorized appliances have different demands and can be damaged by intermittent or "browned-out" operation they experience as shunt loads. — Richard Perez

A Pressure Problem?
Can you shed some light on a Paloma gas water heater and a 12 Volt pump? I have a PH-12 and a SHURflo pump. I can't get the heater to work unless I turn on two faucets at the same time. If I turn on the cold then the hot water goes off. I have a 25 gallon bladder tank, the SHURflo pump (three gallons+/minute) set at 50 pounds pressure, 3/4 inch pipe input and output. Do I need more pressure, volume or what? Larry Beachy DDS, 1406 Elmherst Ct, Goshen, IN 46526

Hi, Larry. I think your problem is too small a water flow through the heater. I'll bet that you have an ultra low flow shower head. Replace the head with a higher flow model and the problem will go away. This is a common problem with demand type gas water heaters. — Richard Perez

Schools and Fan Feasibility
The magazine is great. I have recently become very interested in renewable energy, and was quite pleased to find something as current and accessible as your magazine. I have no contact with alternative energy, as I live in New York City, but I would like to learn about it, and I was wondering if you can direct me. I have been in contact with Jordan Energy Institute, after seeing their advertisement in your magazine. I wonder if you can tell me anything you've heard about their program, also if there are other options, perhaps shorter programs available with some sort of placement, or perhaps apprentice programs. I'm as green as can be, although I have mechanical skills and experience with wiring, as I used to install commercial and residential security systems. If you could direct me towards some help I'd greatly appreciate it.

The following question may be impractical, but during the summer I work out of a pickup truck, and I am interested in running a fan in the cab from a small solar panel placed on the cap of the truck. Is it feasible? Is there a particular fan motor, array direct setup or panel I could use? I'm merely interested in familiarizing myself somewhat with solar power, and as I don't have a home this is the simplest way to experiment. In any case, thank you for your time, and for your excellent magazine. Luke Stanyek, 86 Detroit Ave, Staten Island, NY 10312

Hi, Luke. Jordan has an excellent reputation and I'd be proud to hire any of the graduates. I just recently got a letter from Jordan grad, Terry Parker, who is now employed doing PV in the Marshall Islands. Jordan is a serious long term college. Try Solar Energy International for the short course. They offer effective hands-on training in one and two week courses.

Use any 12 VDC "muffin" fan (available from at least a dozen HP *advertisers) and a small (I recommend the Solarex MSX10 Lite) PV module. Anytime the sun shines, then the fan goes. This is a very simple and effective way to get started in PV. — Richard Perez*

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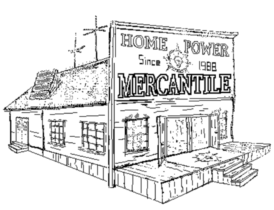

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