HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #78

August / September 2000

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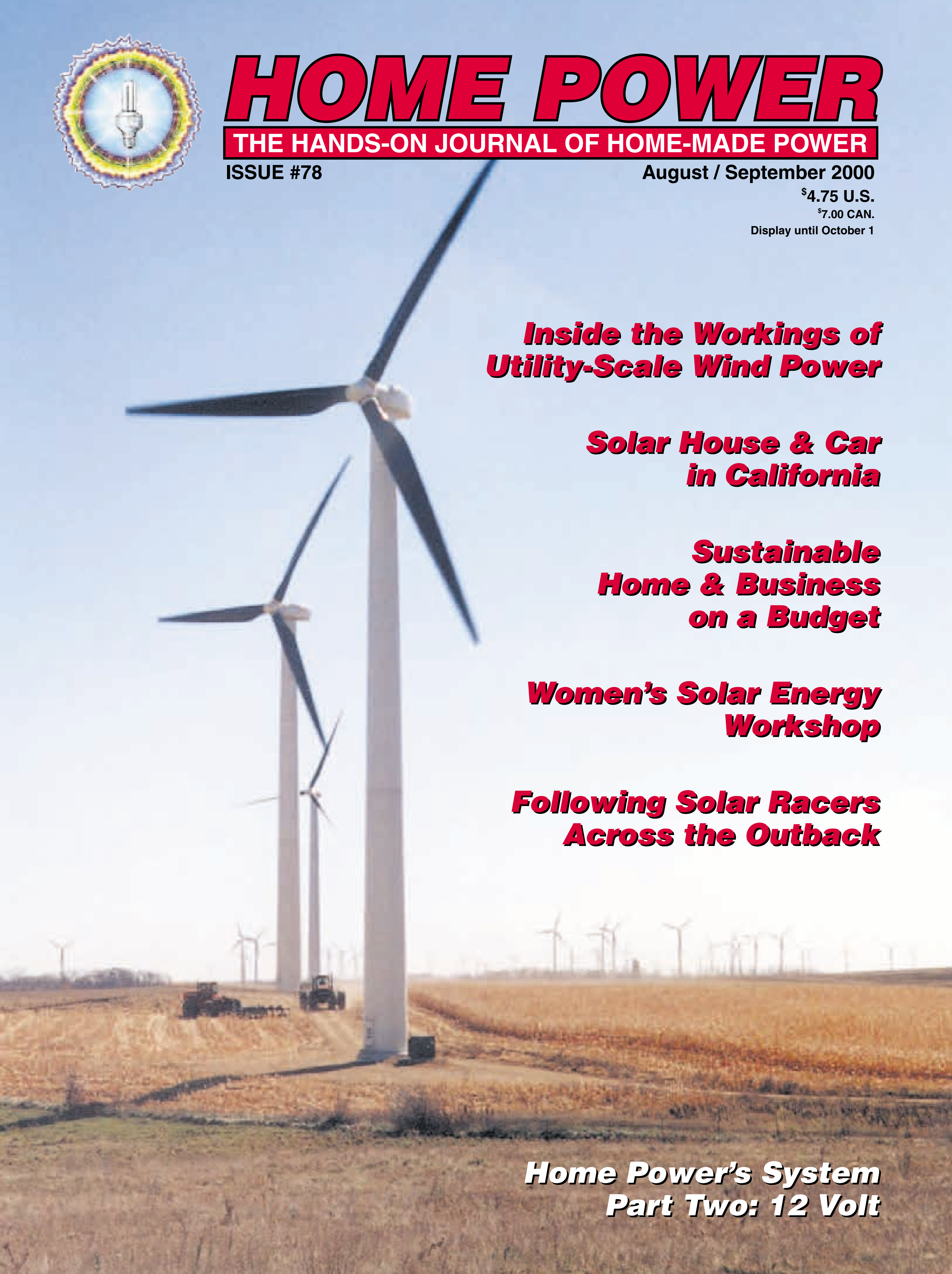

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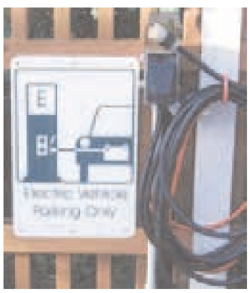

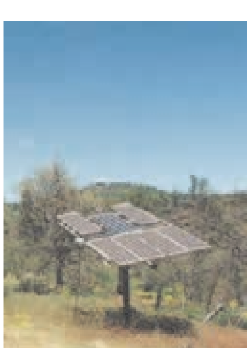

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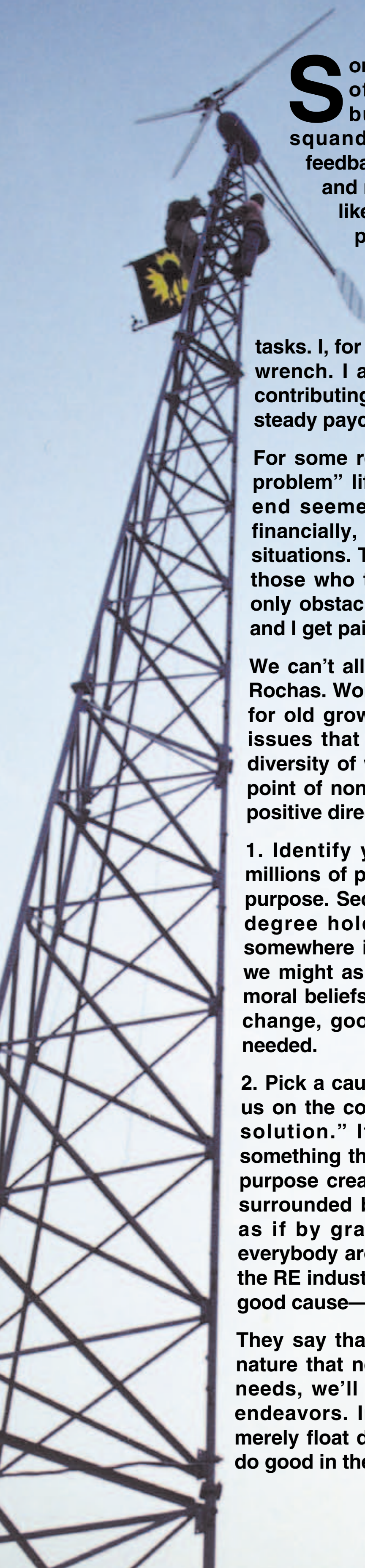


Sometimes we get burned out on the daunting task of producing a magazine—especially one that bucks the entrenched traditions of an energy squandering, money oriented society. Then we get feedback from some reader that reinforces our reasons, and rejuvenates our spirits, for action. It makes us feel like part of the solution again, rather than part of the problem.

That's easy for us to say—we work in a field that is, by definition, part of the solution. But within that field is a diversity of people, skills, and tasks. I, for example, am neither an energy activist, nor an RE wrench. I am a graphic artist who could just as easily be contributing to the sale of some McProduct in my quest for a steady paycheck.

For some reason, the decision to abandon my "part of the problem" lifestyle and apply my skills toward a meaningful end seemed tough at the time. It is easy for us to feel financially, socially, and emotionally trapped in our current situations. The status quo, like crabs in a bucket, holds on to those who try to climb out. Now I realize that fear was the only obstacle—my work is interesting, meaningful, inspiring, and I get paid too—sounds easy, doesn't it?

We can't all be Julia Butterflys, Ralph Naders, or Zack de la Rochas. Working for *Home Power* leaves me little time to fight for old growth forests, indigenous peoples' rights, or other issues that I consider important. In fact, the vastness and diversity of worthy causes can overwhelm us idealists to the point of nonaction. How do we direct our life, and work, in a positive direction?

1. Identify your skill. I'm just a graphic artist. There are millions of people like me with skills independent of any final purpose. Secretaries and ditch diggers, blue collar and white, degree holders and just smiling faces are all valuable somewhere in the scheme. If we have to go to work anyway, we might as well perform our daily tasks in the name of our moral beliefs. In fact, within the "movements" toward positive change, good help is in demand. Whatever you do, you're needed.

2. Pick a cause. Choosing one good purpose to work for puts us on the contributing side of social change—as "part of the solution." It doesn't have to be our final purpose, just something that is important to us now. Our investment in that purpose creates momentum. Suddenly, we are proactive, and surrounded by other proactive people. Momentum increases as if by gravity—we fall into positive change. It's as if everybody around us wants to help us succeed. The growth of the RE industry is a good example. It becomes more than just a good cause—it becomes a good investment, a good career.

They say that nature fills a vacuum. Well, there are holes in nature that need filling. If we open our talents to fill nature's needs, we'll find that we are practically sucked into noble endeavors. Instead of fighting our way to the top, we can merely float downstream to exactly where we want to be—and do good in the process.

–Ben Root, worker bee / activist
for the *Home Power* crew

People

Joy Anderson
Corey Babcock
Will Beckett
Mike Brown
Sam Coleman
Richard Engel
Eric Hansen
Kathleen Jarschke-Schultze
Stan Krute
Don Kulha
Don Loweburg
Ray Ogden
Tony Pereira
Karen Perez
Richard Perez
Shari Prange
Benjamin Root
Connie Said
Dennis Scanlin
Joe Schwartz
Laurie Stone
Gary Thomas
Bill von Brethorst
Kathleen von Brethorst
Michael Welch
John Wiles
Dave Wilmeth
Myna Wilson
Ian Woofenden
Rue Wright
Solar Guerrillas 0001

"Think about it…"

I am I plus my surroundings, and if I do not preserve the latter, I do not preserve myself.
-Jose Ortega Y Gasset

Solar Trailblazer

PV Charges EV in Palo Alto, California

Will Beckett

The Beckett home and car—integrating solar power throughout.

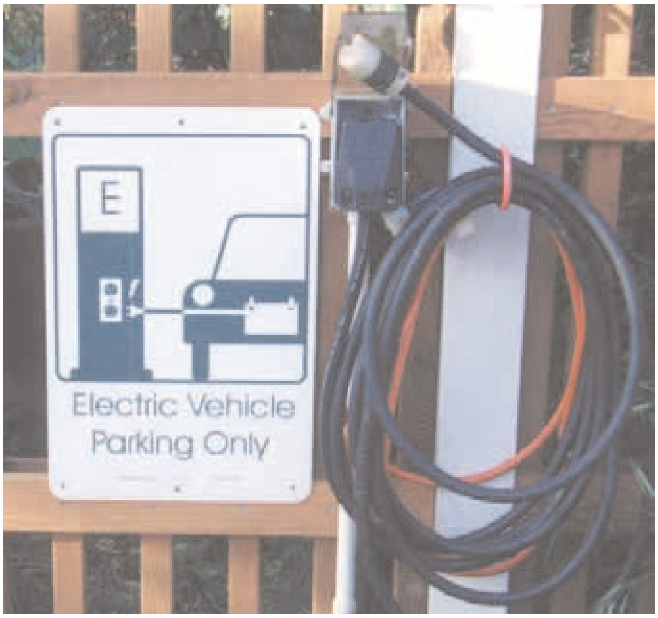
Renewable energy is something that is not understood by most people. If you want to buck the trend, you either have to be willing to take the plunge blindly or educate yourself enough to feel secure in what you are doing.

Tinkering Genes

I was very fortunate to grow up in a family that was very forward thinking. My father was an electrical engineer, and liked to use his engineering skills at home, too. My grandfather was also a tinkerer, and enjoyed being the first with new technology. I enjoyed watching their excitement and joy, which was generated by these passions.

My first experience with electric vehicles was a ridable train on our property in Marin County, north of San Francisco Bay. The project was a community effort, but started with a vision my father had and developed. He did it right, with all the appropriate fanfare, including recognition of our train by the Northwestern Pacific Railroad Company and the Texas and New Orleans Railroads. The train went around our very large lawn, with three creek crossings and lots of twists and turns. There was a ridable engine, and three flat cars. Each flat car was designed to hold either two people sitting or one lying down.

Will's EV charging station.



But what made this early experience even more interesting, as I look back on it now, was that this train was battery powered. There were small motors on each of four drive wheels on the engine. I learned as a boy how to top off a flooded battery, which I am doing again now with my electric car. I am also reminded of the times my mother was upset with me because of the holes in my pants caused by the acid I rubbed on them. Some things never change—I still have work pants with battery acid holes in them…

The southeast sub-array peeks through the trees.

This was my first introduction to an electric vehicle, and to the notoriety of being the first to use new technology. What a rush! At just six, to be the hit of the neighborhood was a major deal. Keep in mind, this was in 1954. Even the early adopters didn't get into electric vehicles until the gas crunch in the 1970s. In the '50s, if you had a ridable train, it was gasoline powered, and most likely 2-cycle with an oil mix (a big polluter). Later, we moved to Palo Alto and left the train behind, but my knowledge of what was possible had been changed forever.

Electric Vehicle

Almost forty years later, the opportunity to purchase an electric vehicle came up. Since I'd had this great upbringing, and always knew that I wanted to drive an electric car, there was very little holding me back. In between my childhood experience and my present EV, I had a variety of contacts with electric vehicles. I test drove Electric Auto Association members' cars, including EV evangelist Bruce Parmenter's Blazer. I decided that my next car would be electric, but it had to be able to get me roundtrip to both the San Francisco and San Jose airports. This was the longest trip my second car would ever need to do.

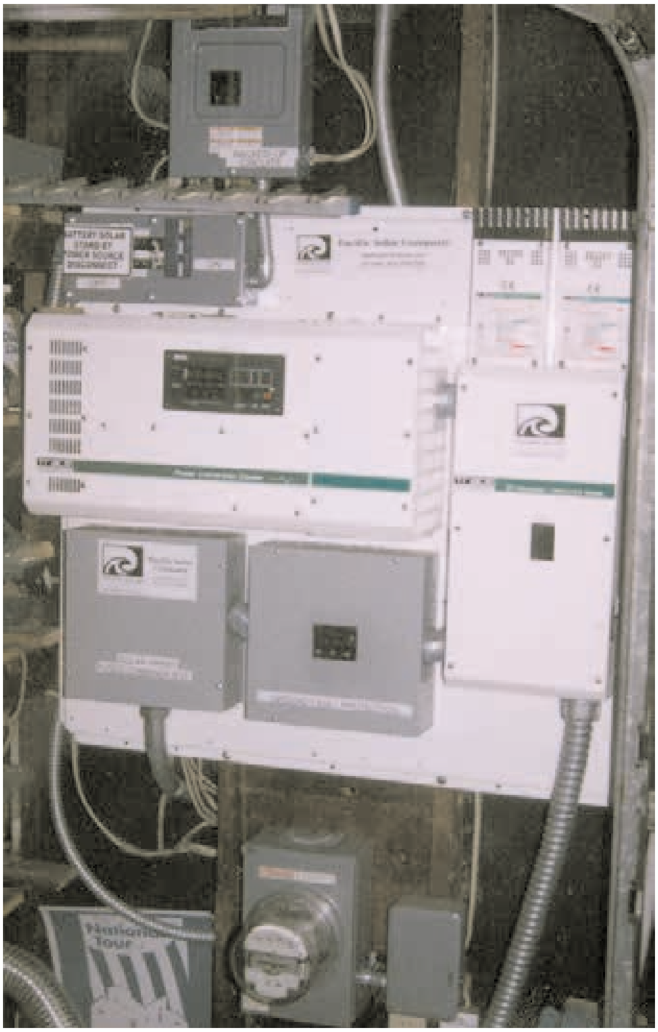
I saw a posting from Bruce about about six vehicles that were being sold off by U.S. Electricar in Sebastopol. I asked them about the 1992 S-10 Blazer they had listed. They said, "Well, this was converted for Robin Williams' wife. We have had it around here for two years, since she traded it in for a smaller car." It had 7,000 (all electric) miles on it, and was two years old. They only wanted US$15,000, and I had heard from others that this vehicle was in very good condition.

My wife and I scheduled a driving trip to see the car. It was great looking! We both took it out for a spin and it seemed to drive well, although the steering was not easy. It had a manual steering box, and the car is 4,700 pounds (2,100 kg), so it was a little hard to manage. But we had spent a number of years driving a 1958 220S Mercedes, which was 3,500 pounds (1,600 kg) and had manual steering, so this really didn't bother us much.

I wrote the check for the car, and a week later it was delivered to my house. It has twenty T-145 Trojan batteries configured for 120 VDC, an Auburn C600 controller, and a 9.25 inch, 28 hp Advanced D.C. motor. Since we bought it, I have added a new controller, put in a DC to DC converter for the 12 V system, and added power steering. Top speed is 65 mph (105 kph), and it will go from 0 to 60 mph (0-97 kph) in less than a minute. I get a 35 to 60 mile (55-100 km) range, and over the last 5+ years, we've driven the car 40,000 miles (64,000 km).

Since we got the Blazer, I have been working to promote the use of electric cars. I'm currently the president of the Silicon Valley chapter of the Electric Auto Association. My political connections with the city of Palo Alto have given me a lot of press locally on the car, and on EVs in general. I am usually contacted if anyone needs electric cars for events.

Under the hood of the electric Chevy Blazer.



The Trace PP-SW4048/S Power Panel.

The Big Step to Renewable Energy

My next big step was to exercise my environmental interest, and charge my car—as well as power my house—with a renewable energy source. Environmentally speaking, this was not a difficult next step. But with electricity prices at 6.5 cents a kilowatt-hour, it was one that was very hard to justify financially.

The city of Palo Alto has had its own utility department since the early 1900s, and prices are half that of other cities in the San Francisco Bay area. It was very difficult to consider buying a system that could not possibly pay for itself for more than fifty years. But beginning this year, Palo Alto began to offer a PV Partners program, which covers about half the cost of a complete PV system. The subsidy is US$4 per watt, or $6 for demonstration systems. Although I applied to be a demonstration site, mine was not one of the five sites that were picked. Still, I did move forward with my installation as I was approved for PV Partners' US$4 per watt subsidy.

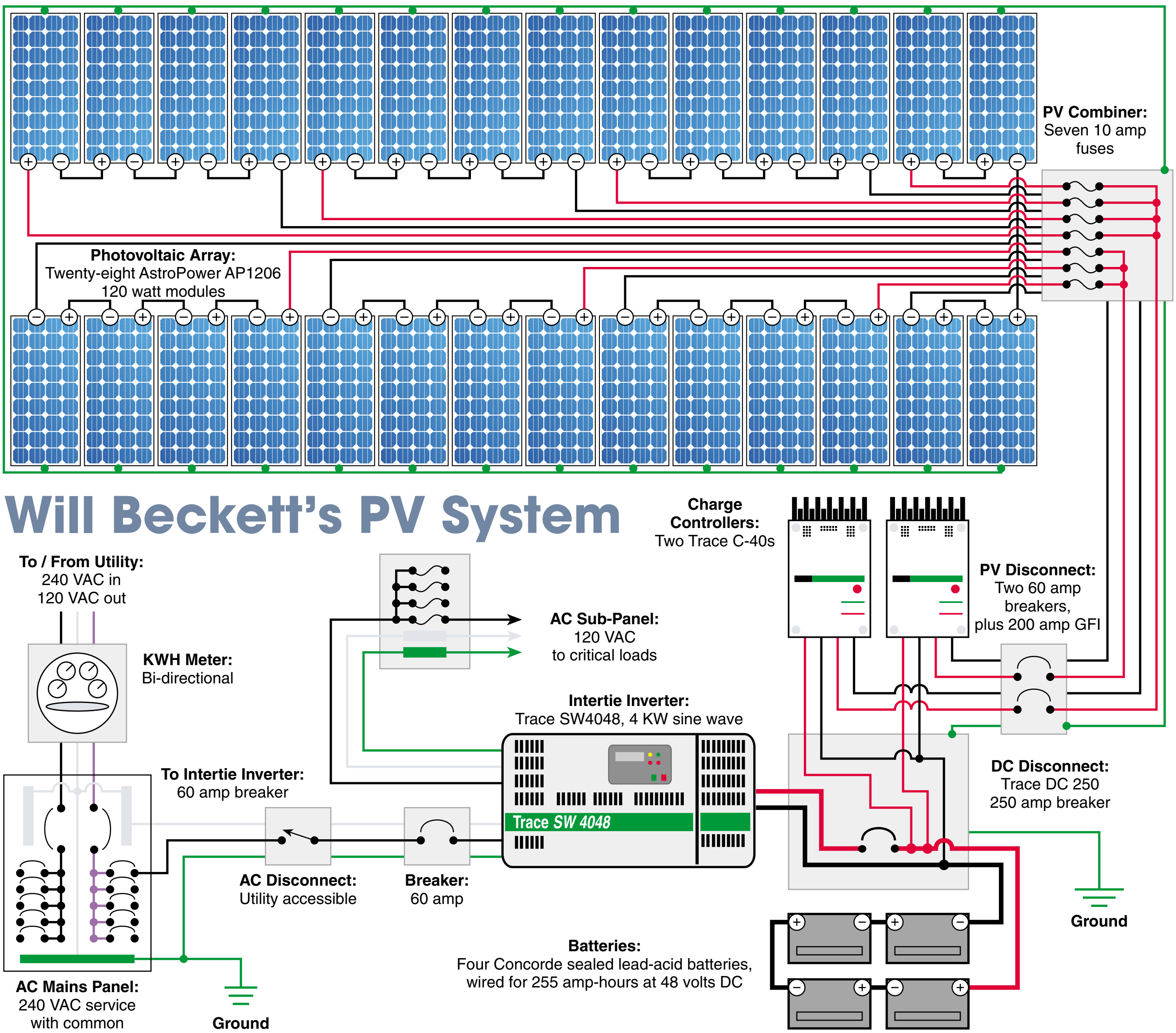
My contractor was Marianne Walpert of Pacific Solar in Redwood City, who I have known for years because of our mutual interest in electric cars. She came out and measured the space, and developed a proposal based on the maximum roof area available. I expanded this a bit by asking her to allow the corners of the panels to protrude over the ridges of my roof. The final system includes 3,360 rated watts of PV.

Most homes in Palo Alto face at an angle to the north, so they have a southeast and southwest exposure to the sun. I have panels on both roof faces, with most of them on the southeast. There are lots of trees in Palo Alto, but these have little effect at the beginning and end of the day during the summer. They are more of a problem during November and December.

Power Use

My average usage is about 32 KWH per day. Charging the electric car uses about 10 KWH per day, and the remaining 22 is used by my household loads. The

Outside—the utility KWH meter and lockout.



system also includes a Trace 4048 inverter with a battery backup system. I used sealed batteries so I don't need to worry about the holes in my pants from the acid. We have four Concorde batteries, rated at 255 amp-hours each.

This system is tied to circuits that are most needed during a power outage (which happens very infrequently). These include kitchen lights and plugs, and my computer, of course. I wired the house so that one of the circuits carried at least one light in each room. It is either a closet light or the main ceiling light. The computer room and the family room (with TV and VCR) are on one circuit. The other backup circuits are in the kitchen, plus the freezer in the garage.

I replaced all my light bulbs years ago with energy-saving fluorescents. Still there are many power-hungry appliances in my home, including a pool pump, forced air heater (gas) with a fan motor, refrigerator, freezer, electric range, microwave, computer, fax/printer, shop/garden tools, and of course the electric vehicle. I also have an electric rototiller, which I use in the spring on weekends. I built it myself from an engineless front-end tiller over twenty years ago.

To make this tiller, I mounted a 1.5 hp, 220 VAC motor to a salvaged tiller, and played with the pulley until I had it going at the right speed. People who have watched me use it are really surprised that all they hear is the noise of the tiller action and not the motor. Since I am a

Installer Perspective

When we went to do the site survey at the Beckett home, we saw that it was not an ideal site. We were concerned, since they have a wood shake roof with many different planes, a solar hot water system, and some shading from trees. We gave Will the options on the layout, and he decided to put as many panels on his roof as possible. This worked out to be 28 of the AstroPower 120 W modules.

These AstroPower modules have a 120 W manufacturer's rating, but the California Energy Commission rating is only 107 watts—a more real-world rating. Also, the system output is not DC, but rather AC, so the inverter inefficiency must be included to get a realistic rating on the system. The Trace SW4048 inverter has a peak efficiency of 95 percent. The rating for the Beckett system is 2,846 watts, or 2.8 KW AC (28 modules x 107 watts DC x 95% = 2,846 watts AC). These calculations were necessary to figure out the subsidy from the city of Palo Alto.

But people care about how much overall energy their system will produce more than the peak power output. We estimate the energy output using an annual average output of 5 KWH per day for each AC KW of a system. Thus we would expect the annual average energy produced per day on Will's system to be 14 KWH per day (2.8 KW x 5 hours). This represents slightly less than half of their average use.

The other thing we always spend time explaining is the battery backup option. This is one of the selling points for many people, since it really is nice to know that you can still provide power to your home when grid power is down. The inverter has two separate outputs. One connects to the grid, while the other connects to a separate circuit breaker panel for the backup circuits.

We usually recommend that people select four to six circuits to back up. These might include some house lighting, the refrigerator, computers, heater fan, or whatever seems important to the homeowner. We make it clear to customers that the backup system is limited by the size of their battery bank and the amount of sun there is during a power outage.

While the backup power feature is nice, we find that most of our customers are purchasing solar electric systems because they care about the environment. And with a twenty year warranty on the solar panels, it's likely that a system will eventually pay for itself. Distributed generation helps everyone by minimizing the energy wasted in sending power hundreds of miles through wires to get to the end user. Owning your own solar-electric generation capacity is the cleanest, greenest option for electricity supply.

-Marianne Walpert, Pacific Solar Company

morning person, it is great to be able to work early in the day and not disturb the neighbors.

The Work Begins

I expected the PV system to be installed while I was on a two-week vacation in August, but permission from the city was a long time coming. This was the first system to be approved under the new PV Partners program, and very few people in the building department understood the components. When I returned from vacation, I found that no work had been done. But shortly after I returned, the permit was issued and work began.

The electrician spent a lot of time working on my electrical box—he wanted to make it just right. I already had a Trace modified sine wave inverter for backup power, so we had the emergency circuits broken out. My whole setup was outside the garage on the wall, and we moved the emergency breaker box inside and above the Trace panel. The Trace panel fit perfectly on the garage wall after I trimmed back my overhanging shelves.

The conduit up to the PV panels on the roof goes through the garage wall and then up the roof. We felt better about running it through the eave than over all the electrical boxes in the garage. This was also much easier to do. The conduit then runs over the garage roof to my second story wall, and up the wall and through the eave again to the second story roof, where the southeast panels are.

The panels were the last thing to be done. A very big crane was used to raise the four panel units from the street straight up and over the power and telephone wires to the two workers on the roof. They locked the units in place, and the lift was completed in about an hour. The workers spent the rest of the afternoon connecting things up and completing the fuse connections below.

At the same time, the electrician cleaned up some of my electric vehicle wiring by running the conduit to the meter inside the garage. This is for the plug (220 VAC NEMA 14-50) that I have out on the street on my fence. He also put in a NEMA 6-20 220 VAC plug for when I use my tiller in the front yard.

The work was completed quickly, and soon it was time for our first inspection. A building inspector came over and started to review the items he would need to inspect, and determined that utilities needed to be there first. So after another week, we were able to arrange to have a meeting of utility and city inspectors at the site to review the process and complete the inspection. This went well, and no changes were required.

Beckett System Costs

Description	*US$*
28 AstroPower AP 1206 modules, 120 W	$14,000
Installation labor	5,000
Trace PP-SW4048/S Power Panel	3,535
Sales tax	1,700
4 Concorde 255 AH sealed batteries	1,596
Misc. hardware, conduit, wire, fittings, etc.	1,500
Supports & roof attachments for modules	1,000
Delivery & freight	1,000
2 Trace C-40 controllers w/ temp. sensors	330
Lockable, visible disconnect	330
200 A ground fault protection, 2 array pole	300
Battery cables & hardware	200
Pacific Solar fuse box	150
Boxes & breakers for C-40s	120
Total	$30,761

Watching the Meter Going Backwards
As soon as we connected the array, I unplugged the refrigerator so we could immediately watch the meter go backwards. These days, I see it going backwards starting at about 9:30 AM each day, and until the pool pump comes on at 1 PM. We get very little fog in Palo Alto. On cloudy days, some energy will still be generated unless it is raining. There is still a lot of light with cloud cover, so we will always get a few amps. In December, the peak was about 11 amps, but now I have seen it as high as 18 amps when it is really bright.

We did some testing of the battery backup system and checked to make sure that the required cut-off switch worked correctly, and then the final inspection was signed off. When utility power goes down due to storms or overuse in the summer, we often don't notice it. The fact that only some circuits are on the backup system gives me a clue, but this can also be confusing. My wife once called me at work to ask why the lights wouldn't work in one of the rooms. She was in the kitchen when the power went out and didn't know it. The clock on the microwave doesn't skip a beat—it's great!

I spent the first few months recording the electrical use, separating the electric vehicle charging from the power use of the house. I have a separate meter to indicate the power used by my car. The total grid use during the winter was about 20 KWH per day, which indicated to me that the new system was covering at least the car charging.

I had a pleasant surprise recently when all but one member of the family were away on vacation. I took a reading before leaving and just after we returned, and found that there was a net gain of 32 KWH after five days. Now that the angle of the sun is higher and the days are longer, I can see how much more energy is being generated. My average house-only use from the grid has been about 14 KWH per day this spring.

Solar DHW Too
About fifteen years ago, the city of Palo Alto had a program to help purchase solar hot water systems. All these systems are starting to fail now, and one half of my system had to be disconnected this year. I originally had two 32 gallon (120 l) tanks in the peak of my attic. The panels are near the eave and the pipe runs "uphill" to the tanks. It wasn't plumbed correctly the first time, and the water wouldn't move. They came back and replumbed, and it finally did start to work correctly.

The two storage tanks feed a 60 gallon (230 l) gas water heater on the first floor of the house. On most sunny days, the temperature going into the water heater is about 120°F (49°C) or higher. Even now with only half a system, I still get the 120°+. But we don't have as much solar hot water, since it's now only 32 gallons (120 l).

I will soon be replacing this with a system that has the storage in the panel. This new system will have one 55 gallon (210 l) panel to replace my current two panels, and will also be passive. It is also an all-copper system, so it should last a lot longer. The city of Palo Alto will be offering a new incentive program soon, and I hope my current panel lasts long enough so that I can take advantage of the program.

An RE Example
Our house was quickly added to the local RE tour circuit, starting with the National Solar Homes tour in November of 1999. Lots of people came by the house to get a firsthand look. Since the tour, I continue to receive requests for tours, and I am always happy to

Will's electric tiller—another use for solar in the garden.

oblige. Seeing the electric car out front along with the solar water and PV system gives a broad view of renewable options in one location. Some of the folks who have toured our house have installed their own systems after seeing our setup. The system is doing all that I hoped it would.

All in all, it has been a very interesting experience, and I know it will continue to be a source of pleasure showing off the system. I hope it will continue to influence people to add RE systems to their homes. As prices continue to drop, and RE education escalates, more and more people will make the move to cleaner energy.

Access

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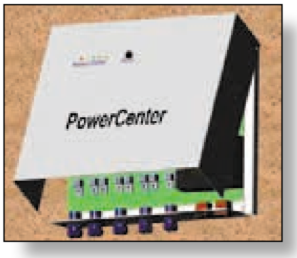

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1–Air is a registered trademark of Southwest Windpower, Inc.
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A Sustainable Home & Business on a Budget

Bill & Kathleen von Brethorst

We are owners of an alternative energy systems company located in Ennis, Montana. Over the past six years, we have sold or installed over 400 sustainable projects. As owners of this company, we sincerely believe in a lifestyle that reduces consumption of both energy and natural resources. We strive to practice what we preach.

The shop and power shed with PV arrays and wind generators visible.

While living in Jackson Hole, Wyoming in the mid '90s, we began looking for a permanent home site, since we had been leasing properties. But like many growing western resort areas, rental and property prices in Jackson Hole were high, and not within our budget. We started to look in other areas near the Tetons and Yellowstone. We eventually found the Ennis, Montana area, which seemed to offer both affordability and abundant sun and wind for our energy systems.

Natural House?

After finding a 6 acre property, we had to decide what type of building to construct. We compared the costs of straw bale, standard construction, and a wood/stone mix. All of these alternatives had some drawbacks, given the nature of the area and our proposed time frame for having the project completed. With some reservations, we began checking into modular or pre-manufactured homes.

After some searching, we found an 1,800 square foot (167 m^2) pre-manufactured home. The more we learned about pre-manufactured construction, the more this option appealed to us. First, though construction is similar to a conventional stick-built home, there is about 40 percent less waste in materials because of the factory building methods. Second, we would need no permits because it would come already wired as we liked and per code, and because we were not connecting to the utility grid.

Finally, we could add on to it at any time due to the simplicity of construction, and it was within our budget. The land and home deal closed in September of 1998, and the move to Ennis took place in mid-December. Along with the home, a 1,000 square foot (93 m^2) warehouse/shop with dual access doors was built, and driveways were constructed for business traffic.

As with most construction projects, the unexpected obstacles we ran into only served to add to our wealth of experience. In other words—live and learn. For instance, the entire property has an abundance of rock, with only about 1 to 2 feet (0.3–0.6 m) of topsoil on a nearly 190 foot (58 m) cap of basalt, a fact we discovered while drilling the well. All piping could only be buried a couple of feet deep, with topsoil added to bring up the grade.

The water lines and well pipe needed to be freeze-proof. We solved this problem by laying a large PVC pipe just below the surface, and burying it with additional soil. The water lines were then insulated and sleeved through the larger pipes from both the well to the power shed, and from the pressure system to the house. Since making this adjustment, nothing has

A 10 by 12 foot greenhouse extends the growing season luxuriously.

frozen, even in -20°F (-29°C) temperatures. The buried water lines are still only about 2 to 3 feet (0.6–1 m) below the surface.

Water System

As well as the main PV systems, the power shed houses water storage tanks and pressure systems for both irrigation and supplying water to the main house and offices. By housing the electrical and water systems in the power shed, we were able to install these systems before the house was set up.

The water system consists of a Solarjack SDS-D-228 pump located at 190 feet (58 m) in a 267 foot (81 m) well. It fills three 165 gallon (625 l) poly storage tanks on a 24 hour a day basis. Even though the well will produce 15 gallons (57 l) per minute (gpm) with very good water, we chose to operate the well at 3/4 gpm to illustrate how little water is necessary for a home that is properly designed. Water conservation was a central part of our plan, with 1.6 gallons-per-flush toilets and low-flow showers in the home to help save water.

Two SHURflo 2088 pumps and a 33 gallon pressure tank provide 7 gpm at 45 psi.

We explored the composting toilet option, but since the county sanitation department was going to require a septic field anyway, standard plumbing seemed more reasonable. For pressure, SHURflo model 2088 pumps are used in tandem, producing 7 gpm at 45 psi with a 33 gallon (125 l) pressure tank. The water system has performed well, and there haven't been any problems when operating the washer, dishwasher, or other appliances.

Power System

The main power system has two sets of modules for PV input. A Trace SW4024 inverter supplies AC power for the home and business. A Zomeworks four-module tracker, model UTR-040, holds AstroPower model 1200, 120 watt panels. Another Zomeworks tracker holds four AstroPower 110 watt modules, two of which were formerly on the power shed roof.

A Trace model C40 controller handles all the PV input for the 24 volt system. It has recorded over 39,442 amp-hours between November, 1999 and the end of March, 2000. The main battery system in the power shed consists of twelve IBE industrial 2 V battery cells. They are rated at 738 amp-hours at a 20-hour rate in a 24 VDC configuration. All of these components are packaged as a power system in a self-contained, portable enclosure including batteries, inverter, controller, and fans. This same self-contained system was originally a grid-connected system in Jackson Hole, and is the prototype of the power package we manufacture and sell.

Shop System

A small portable system is located in the shop/warehouse. It contains a Trace SW2512 inverter, a Trace C30-A controller, and eight Surrette/Rolls 350 amp-hour 6 V batteries. This system powers the shop, our Buderus boiler, and an auxiliary Vestfrost refrigerator, in addition to lights, tools, and temperature sensors and controls for the heating system. This shop system includes three fixed-mounted 110 watt AstroPower panels and an Air 403 wind generator, all operating at 12 VDC. This is one of the few 12 VDC systems we have installed. We normally do not recommend 12 VDC systems, mostly because they don't allow as much room for expansion. We also feel that 12 VDC systems are not efficient enough for a large home. Since many of our systems are 2.5 KW and larger, we do not often recommend using 12 VDC.

The backup charging source for both systems is a Kohler LP generator rated for 7.6 KW at our altitude of 5,200 feet (1,585 m). It provides two 120 VAC charging circuits, with one of the Trace inverters on each leg of the output. Since there are two battery banks, absorption time is critical to keep the generator

Four AstroPower 110 watt PV modules on a Zomeworks tracker contribute to the main 24 volt system.

charging on both systems at the same rate. If one inverter were to go to float before the other, the generator load would be unbalanced, which is not good for any generator.

My main concern for this part of our system is generator life. By gauging the absorption time on each unit, I can keep both legs loaded to about 60 percent until I am through charging. The 12 VDC system actually has the same watt-hour capacity of the 24 VDC system. It normally takes just about as long to charge the 12 VDC system as it does the 24 VDC system, even though the 12 VDC system has over 1,400 amp-hours of storage.

The 12 VDC system charges slowly due to the lower charging capacity of the Trace SW2512. But the main house 24 VDC system has a heavier demand, so it sees lower cell voltage before charging. It generally requires the same amount of charging time with the relatively higher charge capacity of the SW4024 inverter. When setting up systems, the overall charge time becomes an issue, and requires some real thought. This generator has had about 690 hours of service from December, 1998 through April, 2000.

Wind Systems

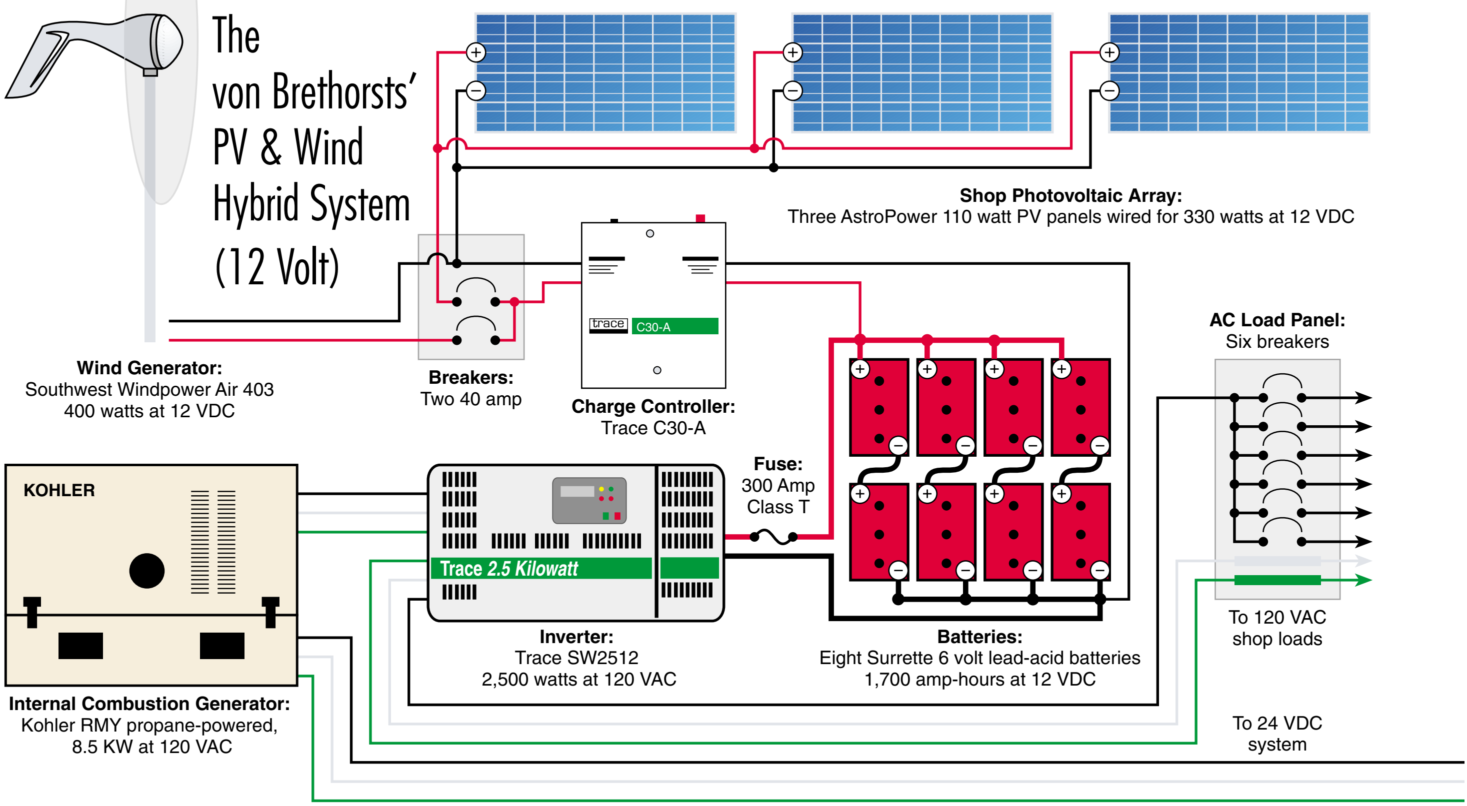
Our wind systems have changed over time. We started out with a Southwest Windpower Air 303. It had to be replaced because of the high winds here, which left us with ruined bearings and no wind power. We then installed a Windseeker 503 and have had this unit running since last July. It is mounted on a 26 foot (8 m) tilt-up tower, with guy wires as well as a bracket to the back of the power shed. The tower is made of 2 inch schedule 40 steel pipe, and has a hinged base for tilting down.

The tower location is the highest point on the property. We regularly have winds from 26 to 40+ mph (11–18 m/s), and have recorded gusts of over 60 mph (27 m/s) many times. A few times this last winter, we recorded gusts of 80+ mph (36 m/s), with sustained winds of 60 mph (27 m/s). The Windseeker 503 has worked very well, with an average estimated output of about 100 amp-hours per day. This machine is just a demo. We will probably sell it later and try something else. The next unit will most likely be a Bergey 1500 24 VDC unit. We also now have an Air 403 tied through a simple 30 amp disconnect to the shop system.

Loads

The main house AC loads were selected for load efficiency. They include lighting, a vacuum cleaner, Frigidaire Gallery washer and dryer, Maytag dishwasher, microwave, toaster oven, coffee maker, TV,

The power package includes Trace inverter, charge controller, fusing, and battery box all in one.



stereo, and satellite dish. Office loads include phones, fax, computers, a scanner, inkjet printer, and copier, among other things.

The DC well pump, which draws 2.8 amps 24 hours a day, is included in the house 24 VDC system. So are the two pressure pumps, which draw 6.8 amps total when running. We have found this DC pumping system to be both energy efficient and trouble-free. The DC Solarjack well pump has been operating steadily for 14 months, 24 hours a day.

The normal daily load for this system as read on our Trace meter is 101 to 121 amp-hours, or about 2.4 kilowatt-hours daily. A typical renewable energy home should use 2 to 4 kilowatt-hours or less per day. This reduces the cost of the PV/wind system or AC generator to support the daily loads placed on the storage batteries. Reducing the load reduces the overall system costs dramatically.

Hot Water

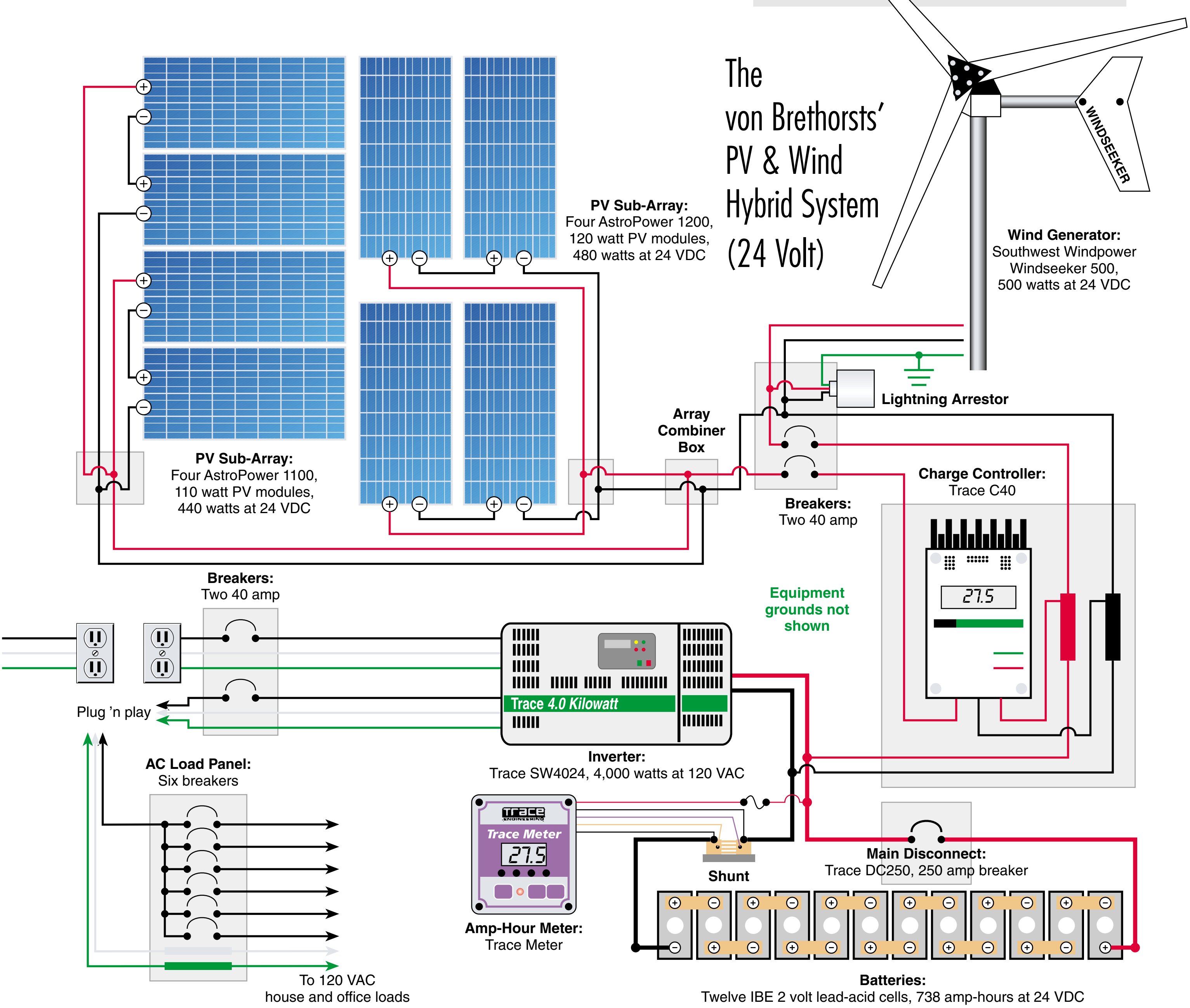
Our home is heated with hot water using a propane-fired Buderus boiler. It is rated at 74,000 BTU input, and burns 0.7 gallons (2.6 l) of propane per hour when operating. It heats a mixture of water and antifreeze. This heating medium is distributed by a small Grundfos 1/25 hp AC pump. A grid of 180 feet (55 m) of 3/4 inch PEX pipe under the floor in the crawl space distributes the heat throughout the house.

Each radiator is tapped off this main trunk line using what is called the "reverse-return" method. One pipe carrying heated supply water is routed in one direction around the perimeter, while the return line is routed in the opposite direction. This system of piping allows for equal flow through any of the Buderus radiators mounted throughout the home.

Each radiator has its own thermostatically controlled valve that varies the amount of heat radiated, thus each room is self-zoned. This zoning makes the system easy to use and comfortable, without much in the way of electronics. We have recently installed a LongBurn cordwood-fired tank water heater to supplement our heating. This product is a small woodburning hot water tank, which we have connected to the feedwater return line from our radiator loop. It pre-heats the return water before it enters the boiler. This has saved us about 25 hours per week of boiler run time.

We estimate that this unit will pay for itself in about a year. We do have to devote some time to stoking it, but it will burn for up to four hours giving about 120 to 150°F (49–66°C) water during this time. We sell and install Buderus radiant heating systems as well as these wood boilers, which are made by Hot Products in Eureka, California.

Our domestic hot water is presently heated by a 40 gallon (150 l) propane-fired tank heater, which came



with the home. We plan to replace this with a Takagi instantaneous heater when this tank heater quits doing the job, or if propane prices rise.

Sustainability

Most of the appliances and devices required for a renewable energy home are in use in our house. In an effort to make sure these appliances are both safe and reliable, we are using them ourselves before including them in our product line. These products include low energy refrigeration, low energy ceiling fans to distribute heat, low energy compact fluorescent and halogen lighting, double-pane low-E windows, and insulated doors, among others.

We have also grown a portion of our own food in a 10 by 12 foot (3 x 3.7 m) greenhouse that we purchased from Gardener's Supply. The greenhouse has been in use for just under a year. It was only heated in the early spring and late fall, producing a crop of herbs, peppers, and more tomatoes than we knew what to do with. It requires very little extra heat input due to the type of glazing used. It is frequently 40°F (22°C) warmer than the outside temperature during the night after the sun heats it during the day. We heat it with an auxiliary catalytic propane heater when needed.

The greenhouse foundation is made of 7 by 7 inch (18 x 18 cm) timbers treated with an environmentally benign water-resistant solution. Then 1 inch (25 mm) thick

An individual thermostat controls each Buderus radiator.

insulation was placed in the interior floor area. Eight inches (20 cm) of sand with brick pavers tops the insulation. This tends to soak up heat during the day and release it at night. The greenhouse kit comes with solar-thermal operated vents. There are also two 55 gallon (210 l) water tanks painted black at the rear to soak up more heat during the day. These can also be shielded to provide some cooling during the summer.

We made another innovation in our water system. This is a dry climate, and both we and the local wildlife need water. The overflow from the well is piped to a set of ponds, which in the winter simply collect water. In the summer, they supply water for irrigation and wildlife.

Lessons on a Budget

The main thing we should have done differently is to spend more time on site overseeing the construction. It is important to be available on site for questions that inevitably arise during projects. Lack of communication with contractors is responsible for most mix-ups or problems in any construction project.

We completed the deck, shop interior, walkways, and most trim and landscaping ourselves, taking about eight months to do so. Our budget was a major factor in the decisions we made about the home location and projects. We had hoped to create a home that was low cost and low impact, using as few non-renewable resources as possible. It may not be possible to recreate this exact scenario everywhere. But experience has shown us that these systems can be implemented nearly anywhere, subject to local codes, land use restrictions, and such.

If you are considering purchasing a pre-manufactured or modular home, be sure to work as closely with the seller as possible. Make sure that all details are covered as to the interior and appliances you want, the actual setup of the home, and the final checklist and completion details. This will save you some headaches later.

One of the best things to come from this experience is our commitment to reduce greenhouse gases, provide green space combined with water conservation, and set an example for others. We live very normal lives with a very extraordinary combination of renewable energy and low impact lifestyle. Anyone can do this.

A Buderus boiler (right) provides hot water for space heating.
A Hot Products wood-fired boiler (left) preheats the water.

The von Brethorst System Costs

Main house power package system	*Cost (US$)*
Trace SW4024 inverter, 12 IBE batteries, Trace C40 controller, AC & DC disconnects	$5,780
4 AstroPower 120 watt modules	2,396
2 Zomeworks UTR-040 trackers	1,198
Windseeker 503 wind generator	998
4 AstroPower 110 watt modules	1,900
2 array combiner boxes	190
Miscellaneous hardware, conduit, & wire	105
Tower & tower hardware (mostly scavenged)	13
Total for main system	$12,580
Shop power package system	
Trace SW2512 inverter, 8 Surrette CH-375 batteries, Trace C30 controller, AC & DC disconnects	$3,600
3 AstroPower 110 watt modules	1,425
Air 403 wind generator	499
Miscellaneous hardware, conduit, & wire	55
Tower & tower hardware (mostly scavenged)	13
Total for shop system	$5,592
Total for both systems	$18,172

We estimate, based on carbon offset data and using a formula to convert BTU and KWH to energy produced by coal, that we have prevented about 0.4 tons of coal-burning by our local utility. What's good for Mother Earth is good for us. All in all, we have been exceedingly pleased with the performance of the home and systems. We would do some things differently if given the chance, but every project is a learning experience, and we love to learn.

Access

Bill & Kathleen von Brethorst, Planetary Systems, PO Box 340, Ennis, MT 59729
406-682-5646 • brethors@3rivers.net

Buderus Hydronic Systems,16 Industrial Way, Salem, NH 03079 • 800-283-3787 or 603-898-0505
Fax: 603-898-1055 • buderus@ix.netcom.com
www.buderus.net • Boiler

Gardner's Supply, 128 Intervale Rd., Burlington, VT 05401 • 800-863-1700 or 802-863-1700
Fax: 800-551-6712 or 802-660-4600
www.gardeners.com • Greenhouse

Hot Products, Inc., 300 Broadway, Eureka, CA 95501
800-757-3177 or 707-444-1311
Fax: 707-444-1380 • mail@hotpro.com
www.hotpro.com • LongBurn cordwood-fired tank water heater

Industrial Battery Engineering, Inc., 9121 Degarmo Ave., Sun Valley, CA 91352
800-653-8889 or 818-767-7067
Fax: 818-767-7173 • info@ibe-inc.com
www.ibe-inc.com • Batteries

Southwest Windpower, 2131 North First St., Flagstaff, AZ 86004 • 520-779-9463
Fax: 520-779-1485 • www.windenergy.com
info@windenergy.com • Wind generators

Trace Engineering, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826
Fax: 360-435-2229
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www.traceengineering.com • Inverters and charge controller

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In just one year, these Solarex Millennia modules will have generated an amount of electricity equal to the energy used in their production. Note: Actual photograph of Millennia modules with patented Integra™ frame.

Thinking about an environmentally friendly solar electric system for your home?

Consider this—Solarex's new Millennia™ modules generate enough electricity in their first year of operation to offset the energy used to produce them.

While Millennia is generous in delivering electricity, it's a miser when using scarce resources. In fact, Millennia needs less than 1% of the silicon required to make equal-output crystalline modules. Also, Millennia modules don't contain potentially toxic or scarce materials.

Millennia by Solarex, the leader in solar electric technology for more than 25 years, offers an attractive appearance, greater efficiency, better stability than previous generations of thin film, as well as a choice of framing options for easy installation.

Millennia delivers all of this at a lower cost to the environment, and what's even better, a lower cost to you.

Millennia: *Proving you can get more for less.*

Contact Solarex today for more information.

It could take five to ten years for comparably rated monocrystalline modules to generate the electricity equal to that used in their production. Note: Computer simulation showing comparably rated monocrystalline system and its frame.

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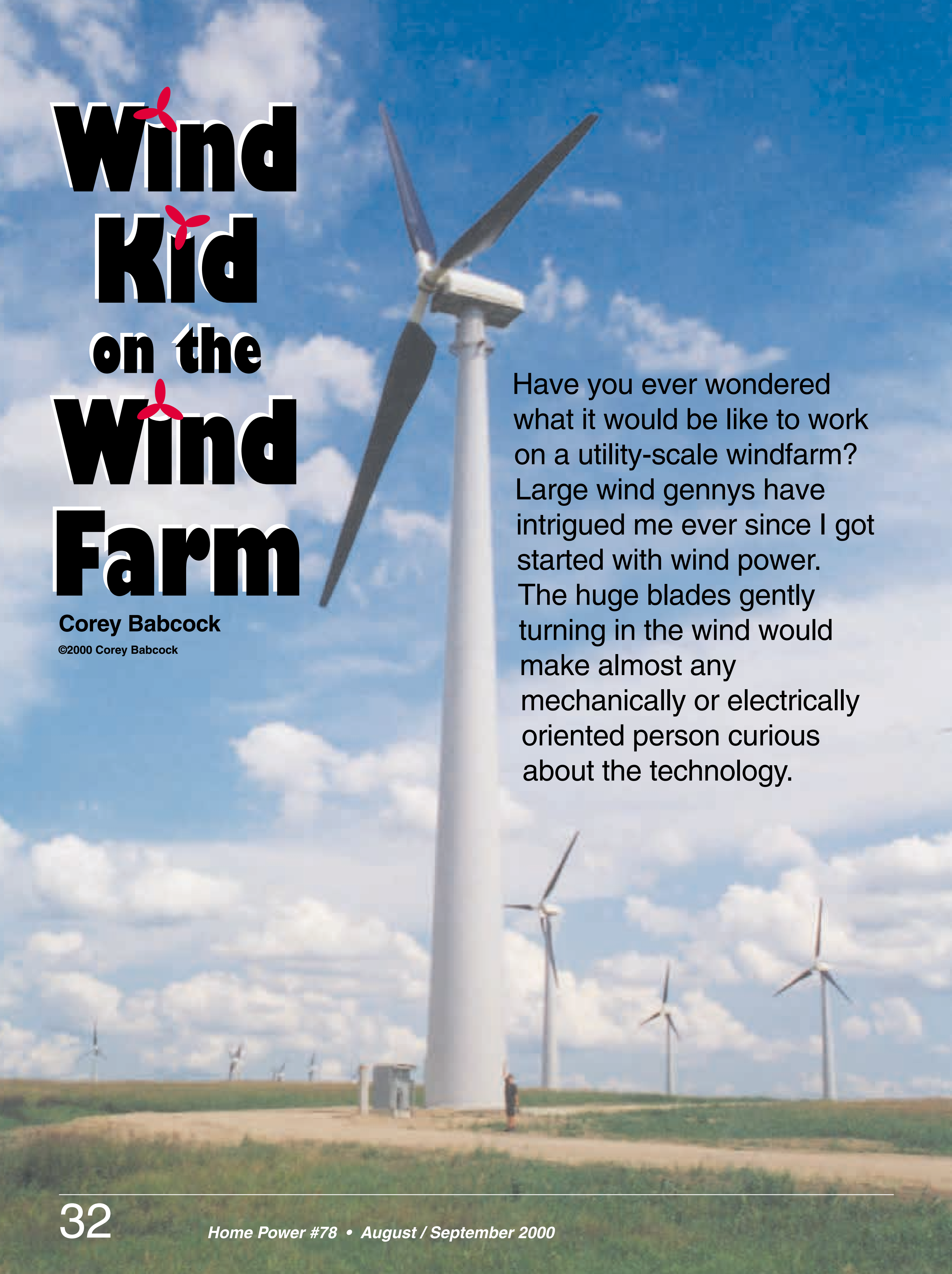
Wind Kid on the Wind Farm

Corey Babcock



Have you ever wondered what it would be like to work on a utility-scale windfarm? Large wind gennys have intrigued me ever since I got started with wind power. The huge blades gently turning in the wind would make almost any mechanically or electrically oriented person curious about the technology.

My interest in wind power started out in my early teenage years (see *HP56,* page 32). I was frequently in the garage trying to build a new wind genny to put up in the backyard. Some of them worked, and some didn't. I started playing around with pre-REA machines too. The idea of a 75 year old wind generator struck me as something special.

My next big step was to install a whirly bird that was intertied with the utility grid. A donated Enertech did the job quite nicely (see *HP69,* page 14). Now I'm spending my days working on turbines with blades as long as my Enertech's tower is tall.

Power in the Air
If you live near a windfarm, you've more than likely had the chance to get up close to these monsters and take a look for yourself. Today's utility-scale wind turbines are getting bigger and bigger every year. When most RE maniacs think of a windfarm, we picture thousands of 100 kilowatt turbines spinning away in one of California's mountain passes. Most of those 100 KW machines are being replaced with bigger and more powerful turbines that are much more reliable and efficient.

All new utility-scale windfarms are also using the latest technology to their benefit. The Northern States Power (NSP) windfarm in southwest Minnesota is using these powerful advancements to harvest the wind. This windfarm currently stretches for about 60 miles (100 km), and has over 400 wind machines.

Put to Work at Vestas
I started working with Vestas—American Wind Technology, Inc. in November of 1999. Taking this job required me to move about 250 miles (400 km) west of my hometown in southeast Minnesota. This was a hard thing to do. I was moving away from my family and friends, which are important parts of my life. But after spending years working with small-scale wind machines as a hobby, working on a utility-scale windfarm was looking pretty cool, so I took the position.

After getting the job, there were several trips from my hometown in southeastern Minnesota to the Lake Benton area in southwestern Minnesota to search for a place to live. In about a three week period, I went from milking cows part time and playing with small wind machines, to working full time on 220 foot (67 m) tall electronic wind turbines.

The job includes maintenance, troubleshooting, traveling, construction, and of course plenty of muscle-strengthening climbing. For me, the best part is just the fact that I spend my days in the middle of a windfarm. A wind power nut couldn't ask for anything more.

The author atop a 600 KW Vestas V-44 in Minnesota.

The Job
The Vestas Minnesota crew consists of nine employees. Seven of us are service techs, and are usually out in the field. Our supervisor and a secretary complete the crew. The day starts off by "calling up the turbines." We go to a computer and connect to the various sites via telephone, not unlike connecting to the internet.

After the site is called up, we note whether any turbines have gone down overnight. If all is well, we head out to the site in groups of two or three, and begin scheduled maintenance or other work that is needed. If we find a problem with a turbine when we are calling them up, we either contact the person in charge of the site and help get the turbine back online, or we send a couple of techs out to resolve the problem.

Maintenance
The maintenance end of the job is simply that. You go out to the turbine at the scheduled time and service it. Bearings get greased, bolts get torqued, and equipment is checked. If something is not operating correctly, it is either fixed or replaced. Maintenance can get to be

Looking out past the nose of a Vestas.

fairly routine. Some people dread a job that gets to be routine, and I'm one of them. The nice part about it is that you know exactly what you need to do. But I'd rather do different things to break up the day.

When we start our maintenance procedure, we have about an hour of tests to perform on the ground. These tests are mostly to insure that the turbine is operating properly. In one test, we overspeed the rotor to check the controller's ability to shut the machine down at a certain RPM. Another is a test of the pitching of the blades. Up top, there are tests of the hydraulic system. At certain pressures, certain valves are supposed to open or close, and if they don't do it within the specified pressures, the component at fault either needs to be replaced or fixed. There are usually no problems with the components.

I feel that maintenance is one area where small wind machines suffer. Sure, the saying goes, "If it ain't broke, don't fix it," but maintenance usually will prevent something from ending up broken. If you don't grease the bearings when they're supposed to be greased, they aren't going to last as long as they should. If you don't check your blade bolts to make sure that they're tight, there's a better chance that your machine will throw a blade. My opinion is that the small wind industry needs to follow the example that the wind farms have set when it comes to maintenance. There is no such thing as a maintenance-free wind turbine.

The Turbines

The Buffalo Ridge windfarm in southwestern Minnesota, where I have spent most of my time with Vestas, has four different makes of wind machines. The first to be installed were seventy-three Kenetech 33M-VS, 400 kilowatt turbines. Next were one hundred forty-three Zond Z-750, 750 kilowatt machines, then another one hundred forty-three Zond Z-750s. After that, seventeen Vestas V-44, 600 kilowatt machines were installed, followed by eighteen Vestas V-47, 660 kilowatt turbines.

Finally, fifteen 750 kilowatt NEG Micon turbines were erected, bringing the Buffalo Ridge windfarm to its current capacity of 425 MW. The state government mandated this 425 MW of wind power in exchange for allowing Northern States Power (NSP) to build additional storage of nuclear waste from one of their nuke plants. And because wind power is in the public interest, there has been a further mandate to install an additional 400 MW of wind power in the future.

These babies are all sitting on tubular towers starting at 120 feet (37 m) tall, and stretching as high as 220 feet (67 m). The Vestas machines are on the tallest towers—they must have known I need the exercise.

Watch that first step...220 feet!

Climbing a couple of these 22-story structures is quite the workout. I'm usually out of breath by the time I get up there, especially on Mondays!

At the top, the view is magnificent. You can see for miles, and the ground has never seemed farther away. If you're afraid of heights, you might not want this job. I didn't know quite what to think on my first climb. Before working for Vestas, the tallest tower I'd climbed was 80 feet (24 m). After a 220 foot (67 m) climb, the 80 foot tower back home looks like a stepladder to me.

Even the Vestas V-44s are dwarfed by a 4 megawatt USBR.

Big Generators

The generators are basically just big induction generators with close electronic surveillance. The blades pitch to keep the rotor at the optimum running speed according to signals received from various sensors, like the anemometer or the high-speed shaft sensor. But instead of using springs and centrifugal force to control blade pitch, as some small wind gennys do, a hydraulic and electronic system is used.

A variable speed machine is a lot easier on the components of the turbine. It allows the rotor speed and power to rise and fall with wind speed. The same happens with a constant speed machine, but a lot more stress is put on the mechanical components during high winds. To get a variable speed machine, one brand of turbine on Buffalo Ridge uses a variable speed alternator/generator. The AC from the alternator is rectified to DC to be sent down the tower and fed through a synchronous inverter to produce grid-quality power.

This is not too much different than some small home-scale machines intertied with the grid, but of course more electronics are involved here. The upside of this machine is the variable speed, which means slightly more power. The downside is inverter malfunctions, and a more complex machine.

Most small wind gennys have a set of sliprings to transfer the energy from the yawing generator head to the stationary tower. The big gennys don't. The cables simply hang down the center of the tower, and are allowed to twist up as the generator yaws. There is a counter that counts the number of times that the machine yaws completely around in one direction. When the controls see that the turbine has yawed around two or three more times in one direction than the other, it will untwist the cables. This all happens automatically, at a time when the winds are low. The turbine shuts itself down, yaws around to untwist the cables, and then points itself back into the wind before it starts up again.

Troubleshooting & Traveling

Troubleshooting can be tricky. You have to remember that we're not working with a simplistic old Jacobs. The electronics involved are the heart and soul of these machines. If something is out of spec, the turbine will automatically shut down, or "fault." When this happens, someone needs to go out to the machine, find the problem, and if need be, climb the tower to fix it. Some faults are fairly simple to troubleshoot, and others can take days.

To me, troubleshooting is tough at times. It's kind of like a new riddle that someone tells you, and it may take you a while to search around to get the answer. Once you've solved the problem, you're almost guaranteed to have learned something new about the turbines.

We recently had a problem with one turbine going down on "feedback-brake." The turbine was shutting down because of a controller-to-component communication fault. The controller was not receiving a signal saying that the brakes were released. When we got to the machine, we immediately started singling out components with an electrical schematic of that particular system. It turned out to be a loose wire connection in the controller.

Traveling is one of the cool things about the job. I get paid to travel around the country. Some may think "whooptee doo," but for a 19 year old, it's pretty awesome. The bad part about it is that there may not be a whole lot of notice. I can be sent across the country for a few weeks at the snap of my supervisor's fingers.

So far, I've been to the mountains of Wyoming, the plains of Iowa, the small rolling hills of Nebraska, the deserts of Texas, and everywhere in between. I got to see antelope and mule deer for my first time in person on trips to Wyoming. Texas brought roadrunners, snakes, and a tour of Bergey Windpower on the way home. Iowa and Nebraska always bring back just a taste of home—minus the trees!

Having What It Takes

A good understanding of mechanical and electrical components is very useful in this job. When your supervisor tells you to go out and Fluke a component, you know that he wants you to ohm through the part (checking for proper resistance) to see if it's good or bad, or to see if the connections are live. And when your partner asks you to check the torque on a bolt on the connecting rod inside the hub, you know what he's talking about.

I've learned a lot since I started working on these machines. When I started working at Vestas, I had the basics of small wind machines down pat. I have an even better understanding of some of the components in a small wind turbine after getting into the electronics and mechanics on these huge turbines. For example, I now realize that an SCR is basically a diode with an extra lead to dissipate voltage spikes. I have a better understanding of how capacitors energize an induction generator. And I realize how just a couple of degrees change in blade pitch can create extraordinary increases in power.

Some of the stuff that I learned from working on small gennys also applies to these monsters. First off, be prepared to get a workout. The climb definitely strengthens muscles. Always be on your guard when someone is above you, and use common sense when someone is below you.

Safety

Safety is vital when working around wind turbines. Once on site, hardhats are inspected and put on before even getting out of the vehicle. The last thing you need is to get hit in the head by a piece of ice thrown from a blade, or something that someone dropped down the tower when you weren't wearing your hardhat.

Before each climb, we each inspect our safety harness, lanyard, and Lad-Saf® for normal wear and tear. A Lad-Saf (we say "lad-safe") is a slider that is attached to a cable that runs all the way to the top of the tower. It allows you to climb the ladder, and if you slip while climbing, it locks onto the cable and prevents a fall.

Each week, a safety meeting is held at the office. Everything from electrical safety to emergency situations is covered. At this or any time, anyone can address anything that they feel is a safety hazard, or something to watch out for that could cause an injury.

Big or Small?

I've been asked numerous times whether I like working on the big machines or the smaller home-scale turbines. I'd have to say that I like the small machines better, simply because that's what I started out on. Even the most complex home-scale wind generator is very basic compared to the monstrous utility-scale turbines.

The same principles are incorporated into both, but with the large-scale machines, there is much closer surveillance of the various components by the controllers. Many variables play a part in how the machine is functioning, including wind speed; wind direction; ambient, nacelle, generator, gearbox, bearing, and hydraulic temperatures; and high and low speed shaft RPM.

The large-scale machines are really cool pieces of machinery, and I enjoy working on them. But the small home-sized gennys are definitely my passion. The fact that I started out with small-scale wind power, the simplicity of the systems, and the people that I have made friends with all keep me yearning to spend more time working with small wind machines. This job is a great education and experience, but I don't think I'll be able to stay very far away from the little machines for too long.

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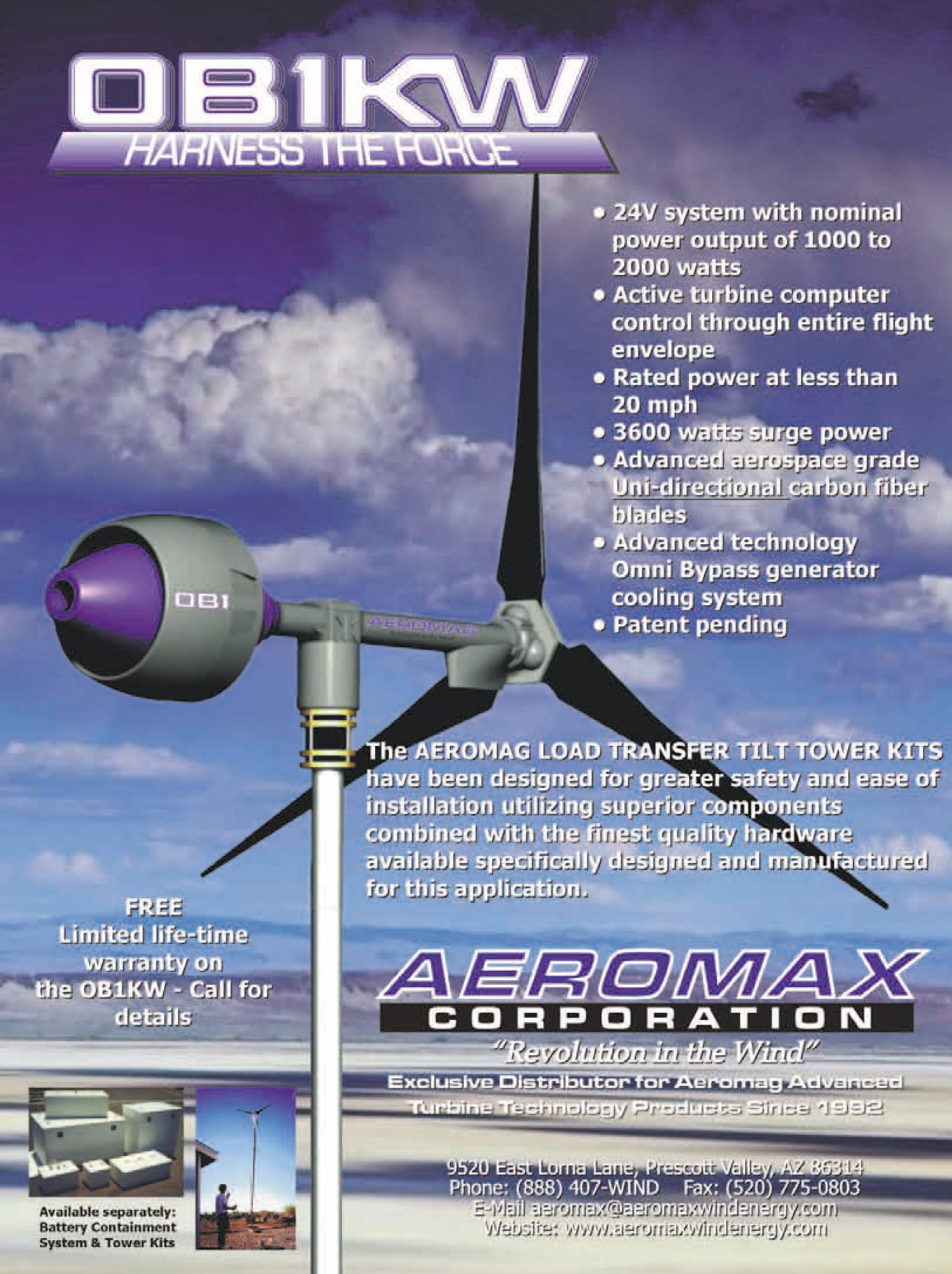
Northern States Power (NSP), 414 Nicollet Mall, Minneapolis, MN 55401 • 800-895-4999 or
507-825-5422 • inquire@nspco.com • www.nspco.com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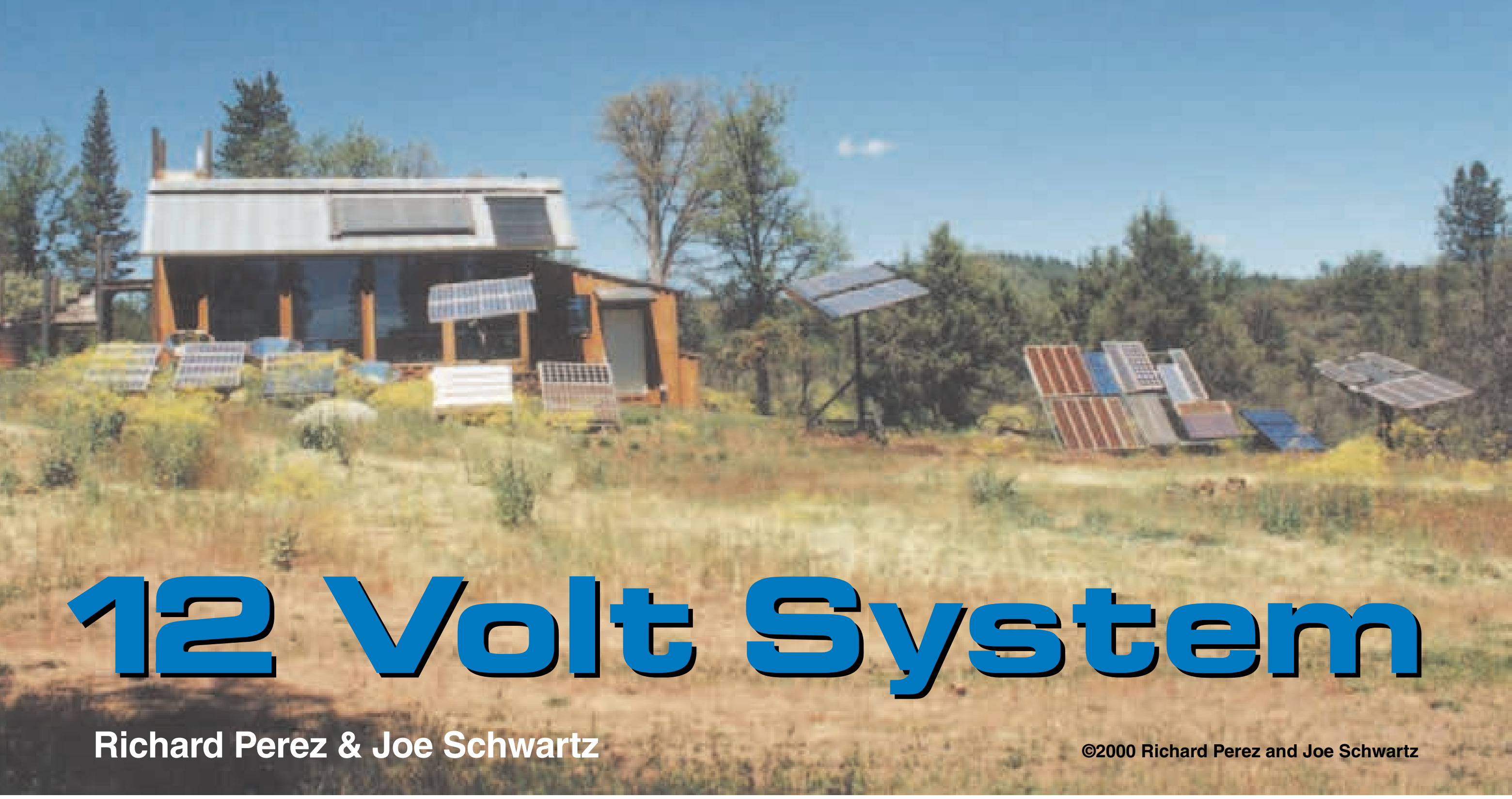
Home Power's 12 Volt System



Richard Perez & Joe Schwartz

HP's **bathhouse and power room, with all of the 12 volt PV arrays (and some of the 24 volt arrays).**

In the last issue of *Home Power,* we reported on our new 24 volt system. This issue's report is about rebuilding our 12 volt system. This system has many of the same design details as the 24 volt system. Perhaps the most novel feature of this new 12 volt system is the use of a "booster battery" to solve the problem of voltage loss in a long 12 volt power line.

Re-Using the Leftovers

After we had finished pillaging our old 12 volt system to build the 24 volt system, we assembled a new 12 volt system with the remaining hardware. It became sort of a patchwork job, making do with the leftovers. Fortunately, there were plenty of leftovers.

Revamping our systems here at *Home Power* gave us a renewed appreciation of the modular nature of RE equipment. We were able to break down our original huge 12 volt system, and use the components to make two systems—one 24 VDC and the other 12 VDC. Though we needed to purchase new inverters and batteries for the 24 VDC system, all the major 12 VDC components were reused. Nothing was wasted.

While our 24 volt system currently cycles about 8 KWH per day, the 12 volt system cycles only about half this amount, 4.7 KWH per day. We mostly use the 12 volt system for water pumping and garden irrigation, and to energize our 12 volt appliances.

Photovoltaics

The PVs in the 12 volt system are a motley assortment of modules. We used most of the modules that had identical mates for the 24 volt system, and what remained were mostly our older modules.

The 12 volt PVs are divided into three sub-arrays. 12 VDC sub-array #1 consists of eight Kyocera J-51 modules mounted on a dual-axis Wattsun tracker. In addition, a BP-275, an Arco Super Tri-lam, and a Mariposa concentrator are ground-mounted and paralleled into the tracked PVs. The combined output of 12 VDC sub-array #1 is 545 watts.

Home Power's democracy rack makes up 12 VDC sub-array #2. This ground-mounted array is made up of eleven modules from nine different PV manufacturers. Three ground-mounted Solarex MSX-53s are also paralleled into this array, for a total output of 580 watts.

12 VDC sub-array #3 consists of a dual-axis Wattsun tracker with six high-voltage, 44-cell Kyocera J-61 modules. A single Solavolt SV8000 is paralleled into this array. Total output of 12 VDC sub-array #3 is 310 watts.

All in all, there are about 1,400 watts of photovoltaic modules in the 12 volt system. Most of these modules are static mounted, so the output is significantly less than a largely tracked system like our 24 volt system. We routinely see around 90 amperes from this system when the sun is shining, and total energy production is around 5 KWH per day.

12 volt PV sub-array #2: The democracy rack and more, 580 rated watts.

Each of the three 12 VDC PV arrays has a separate #1/0 (53 mm²) copper home run into the power room. The longest run is 60 feet (18 m) from array to battery. We are starting to build a new addition onto *Home Power's* cabin/office. Afternoon shading from this addition will require the ground mounted PVs in 12 VDC sub-array #1 to be moved. When these modules are relocated, separate home runs will be provided for testing small 12 volt charge controllers.

12 volt PV sub-array #1: 545 rated watts.

Controls & Instrumentation

The various PV arrays are regulated by a single Heliotrope CC-120 PV controller. See *HP48,* page 36 for a *Things that Work!* review of this controller. In the past, we seasonally adjusted the regulation voltage of this controller to reflect changes in battery temperature. We would set the controller at 14.9 VDC for winter operation and 14.7 VDC for summer operation. Now that the 12 volt system battery is housed in the hydronically heated battery box, we'll just leave the Heliotrope CC-120 set at 14.7 VDC.

Instrumentation for the 12 volt system is provided by two battery ampere-hour meters. A Cruising Equipment Amp-hours +2 meter is located in the Ananda power center in the new power room. This two channel amp-hour meter measures both net battery current and voltage, and total PV current and voltage. A Cruising Equipment E-Meter is located on the wall in the office.

Even though we check the instrumentation in the power room several times a day, it's convenient to be able to check on system operation without leaving the office. Battery ampere-hour meters are essential items for off-grid PV systems—without them you are flying blind. This is especially true in our case, since we are operating two different systems. We need to know which system is energy rich, so we can use its energy first.

12 volt PV sub-array #3: 310 rated watts.

Inverters
The 12 volt system is currently equipped with three inverters. The main inverter is a Statpower PROsine 2.5 KW, with surge capability to 4 KW, a peak efficiency of 88 percent, and a maximum total harmonic distortion (THD) of 5 percent. See *HP69,* page 60 for a *Things that Work!* review of this unit.

The PROsine 2.5 KW inverter is primarily used for pumping water from our well with a 1/3 hp submersible pump. It also occasionally powers a 1/2 hp centrifugal irrigation pump that pressurizes four Rainbird sprinklers in the vegetable garden. These two tasks use a considerable amount of energy—about 0.7 KWH per day in the winter, and over 5 KWH per day during the summer months when the garden is green and growing.

There are two other inverters in the 12 volt system, a Statpower PROsine 1000 and an Exeltech XP1100. Since we are currently testing the PROsine 1000, it is the active smaller inverter, and operates 24 hours a day. The PROsine 1000 has a surge rating of 1,500 watts, a peak efficiency of 89 percent, and a maximum THD of 3 percent. The Exeltech XP1100 has a surge rating of 2,200 watts, a peak efficiency of 87 percent, and a maximum THD of 2 percent. See *HP75,* page 76 for a *Things that Work!* review of this inverter. The Exeltech is currently off-line during testing of the Statpower 1000.

We're using these particular inverters because they produce high quality power. Because the output is a true sine wave, THD never rises above 3 to 5 percent and is typically below 1 percent. Needless to say, all of our appliances love this clean power. Big motor loads such as the well pump and irrigation pump run cooler and more efficiently when powered by the true sine wave output of these inverters.

The main loads currently connected to the PROsine 1000 are two solar hot water circulating pumps. Each of these pumps consumes about 65 watts, which at first glance might not seem like much power. But these pumps run all day, every sunny day, and between them they can consume over 1.5 KWH per day. The circulation pumps are the third largest daily electrical load at *Home Power* Central.

The solar thermal systems could be much more efficiently driven by smaller, magnetically-coupled DC pumps, and this upgrade is on the project list. Also connected to the PROsine 1000 are the compact fluorescent lighting in the greenhouse/bathhouse, and the Staber washing machine, neither of which are big energy consumers.

Battery
We store energy in four Surrette 6-CS-25PS batteries, each 820 ampere-hours at 6 volts. See *HP75,* page 84, for a *Things that Work!* review of these batteries. We used #4/0 (107 mm^2) copper welding cable (labeled "CU") to series/parallel the Surrettes. Total battery capacity is 1,640 ampere-hours at 12 VDC. These four Surrettes are housed in the solar-hydronically heated battery box described in *HP77,* page 41.

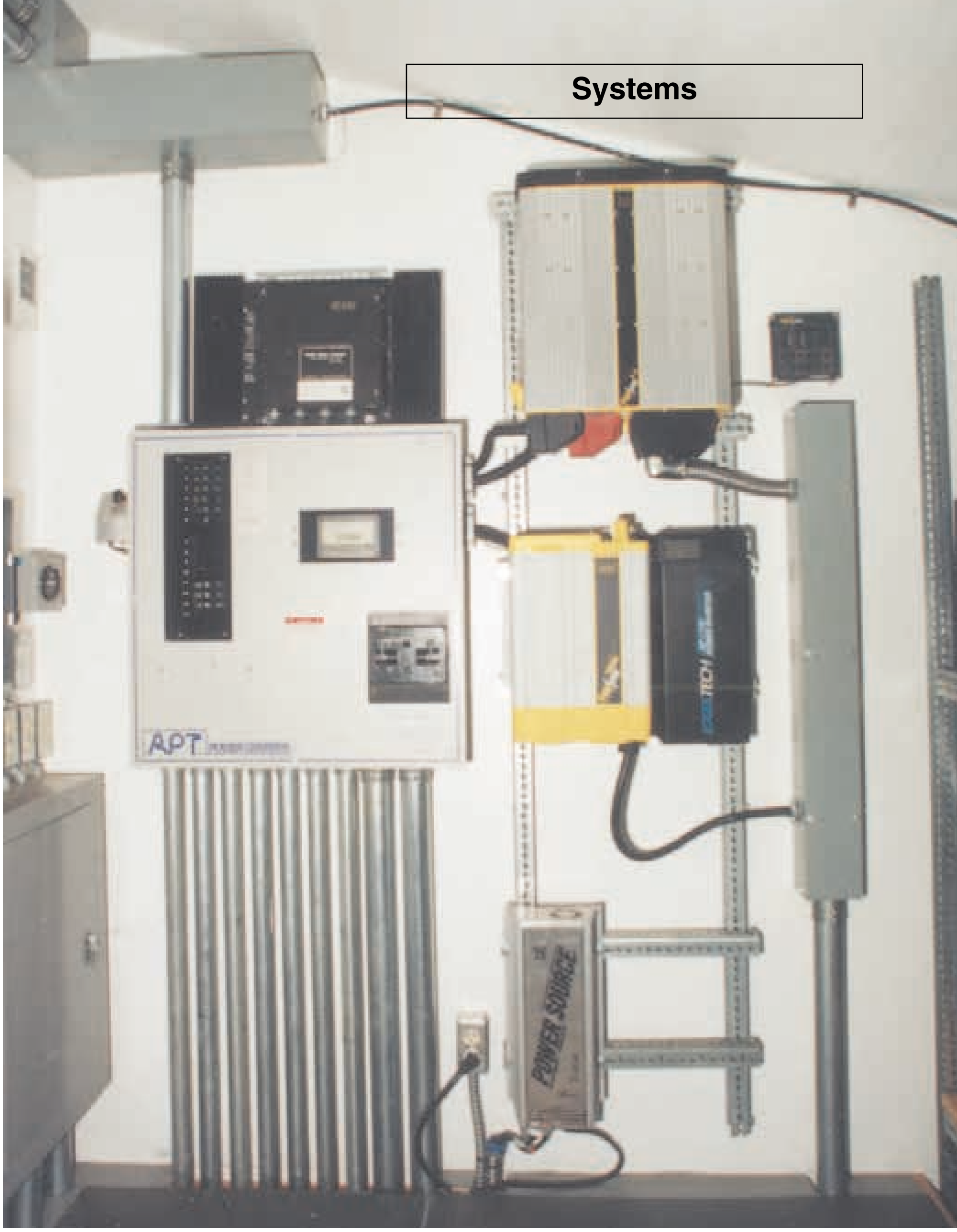
System Connections
RE products we receive for testing are rotated through the system on a regular basis. Because of this, we wanted to keep the system as modular as possible. We followed the same basic design parameters for the 12 VDC system as we did for the 24 VDC system detailed in *HP77.* All hardware is mounted on racks for ease of installation and additional cooling. Conduit and raceways are oversized to simplify modifications or additions to the system.

The hot inputs from the three 12 VDC PV sub-arrays are wired to separate 60 amp, DC-rated breakers in the Ananda. The positive PV input is combined on the battery side of the breakers, routed through a Heliotrope CC-120 charge controller, and terminated at the positive bus in the power center.

The negative leads from the PV arrays each pass through a dedicated 100 mV/100 A shunt for metering of the individual arrays. The PV negatives are then combined and run through a 50 mV/500 A shunt used to measure total PV input. The PV negative leg then goes to the charge controller, and finally terminates at the negative bus in the Ananda.

The batteries are wired to the Ananda with two pairs of #4/0 (107 mm^2) CU welding cable. All lugs are crimped, soldered, and sealed with heat shrink tubing. DC input to the inverters is routed through Class-T fuses in the Ananda. AC output from the inverters runs through an easily accessed raceway and then to the AC distribution mains.

When the Sun Doesn't Shine
We use a Honda ES6500 120 VAC generator to supply backup energy for both the 12 volt and 24 volt systems. In the 12 volt system, we use a dedicated hot leg of the generator to power the onboard charger in the Statpower PROsine 2.5 KW inverter. This leg also provides AC for a 70 ampere Todd battery charger.



The 12 volt system including power center, inverters, controller, and charger.

We're totally impressed by the quality of the charger built into the Statpower inverter. It puts over its rated 100 amps (we've measured 117 A) into the battery at 12 VDC. The charger presents a near-unity power factor (0.99 to 1.0) to the generator. This results in less generator run time, fuel consumption, noise, and pollution. The Statpower's AC charger is so effective that we rarely have to use the Todd charger.

The Surrette 6-CS25-PS batteries provide 1,640 AH of storage at 12 VDC.


A GennyDeeCee 12 volt engine generator manufactured by Feather River Solar Electric is a second backup charging source. It uses a Honda overhead valve engine to drive a 12 VDC alternator. Our unit has a maximum output of 100 amps at 12 VDC. The big advantage of the GennyDeeCee is that it uses about half the gas per amp-hour into the batteries as a conventional AC generator. Burning fossil fuels is definitely an instance where less is better!

Inside the Ananda Power Center.

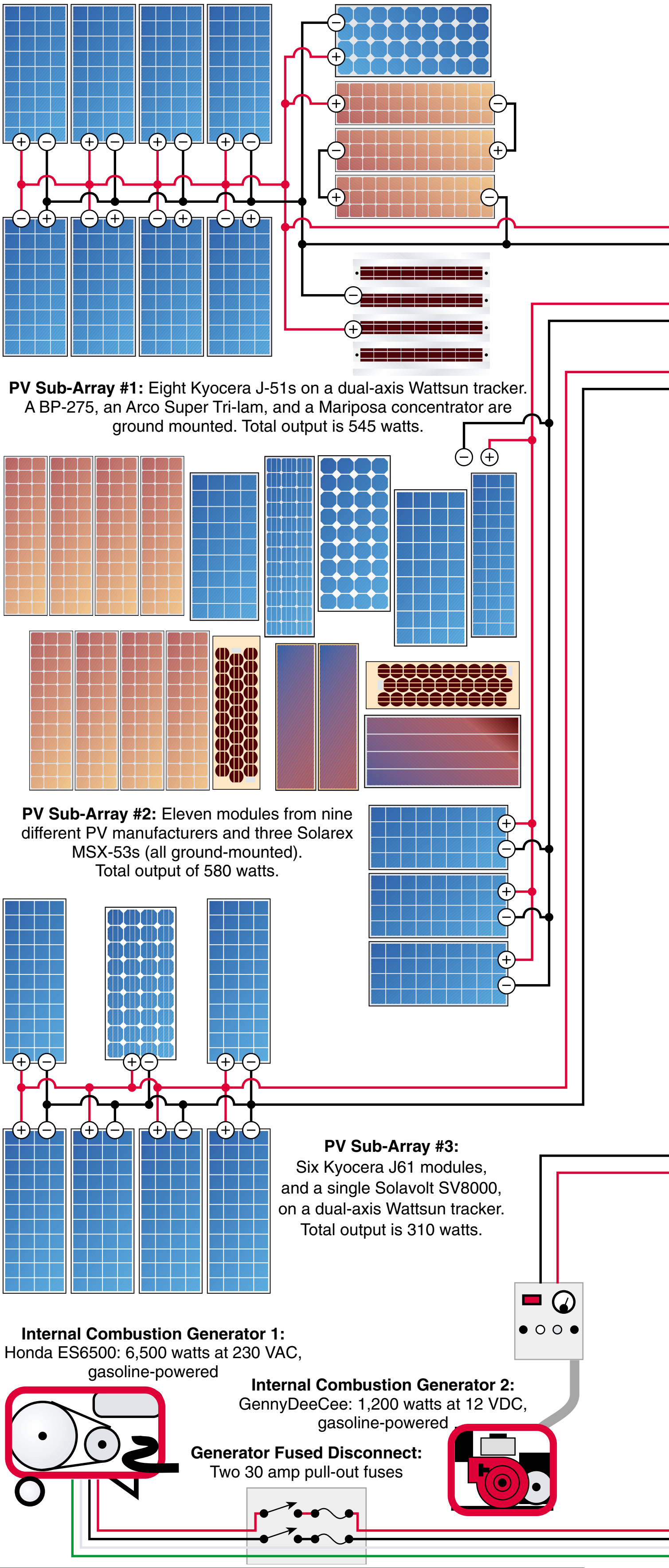
12 Volt DC Loads

Our AC loads are covered in the inverter section. AC loads are about 61 percent of our total load for this system, while DC loads are about 39 percent. One of the reasons we opted to keep a 12 volt system was our 12 VDC loads, which, while few in number, are still significant energy users. The largest consumer is our Sun Frost RF-19 refrigerator, which uses an average of 960 watt-hours per day. Smaller consumers include our ham radios (242 watt-hours per day) and our radiotelephone (264 watt-hours per day).

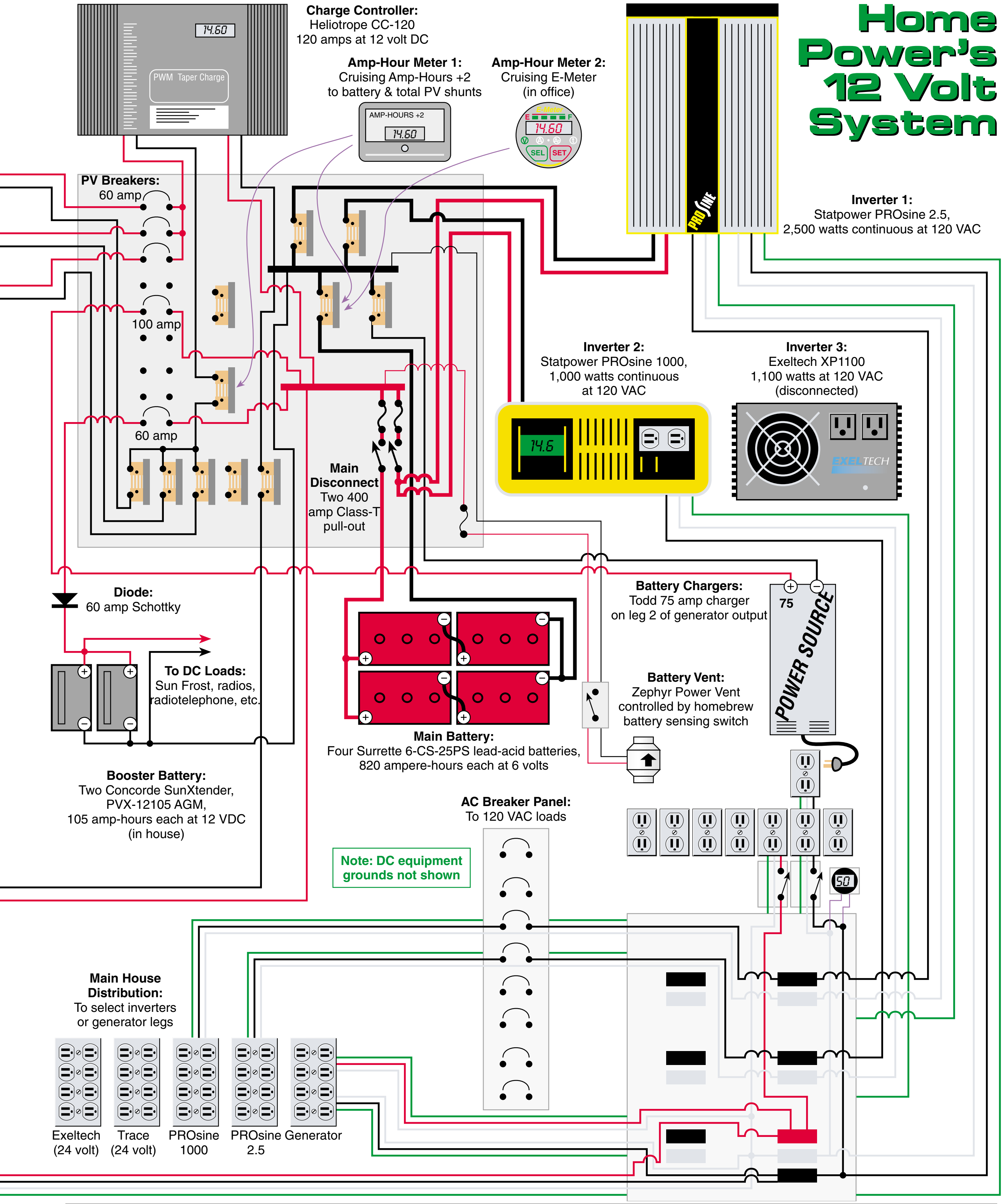
These loads consume a total of about 1.5 KWH per day. They are all located in the house, which is about 100 feet (30 m) from the 12 volt battery housed in the power room. The best way to move 12 volt power this distance without excessive voltage drop was the topic of much discussion.

While the average current consumption of a single motor/compressor in the Sun Frost is about 5 amperes, the peak or surge consumption is around 15 amperes. And the Sun Frost has two motor/compressors, one for the refrigerator and one for the freezer. We were concerned about supplying the peak demands of these compressors without undue voltage loss in that long, low-voltage power line.

We installed 110 feet (34 m) of #1/0 (53 mm^2) aluminum (AL) cable between the battery in the power room and the house. With a single Sun Frost compressor operating, voltage loss in this power line averaged 0.5 VDC. With both compressors operating, the peak voltage loss in the 12 VDC power line was over 1.5 VDC—far too high.



Home Power's 12 Volt System



The Missing Wind Generator

Home Power's 1,000 watt Whisper wind generator, manufactured by World Power Technologies, doesn't really have a proper home in either the 24 or 12 volt system articles. When we wrote the 24 volt system article, the wind genny was charging the 12 volt system. Now it is has been switched over to the 24 VDC system. We made this switch because the 24 VDC system is loaded more heavily than the 12 VDC system.

The Whisper 1000 is mounted on a 64 foot (20 m) tilt-up tower located 600 feet (180 m) from the new power room. The generator is wired for 48 VDC to minimize losses in the long wire run. Its output is run through #1/0 (53 mm^2) AL USE wire and stepped down to 24 VDC in the power room using an 80 amp Bobier Electronics LCB. The shift from the 12 V system to the 24 V system means that the LCB runs more efficiently because there isn't as much of a down conversion.

At high output, the LCB is only about 85 percent efficient. But it allows us to transmit maximum wind generator output over a long distance with an acceptable 9 percent voltage drop. The other nice feature of the LCB is that the wind generator's maximum power point can be manually adjusted. During high winds, we dial up the LCB's input voltage, resulting in a higher operating voltage at the wind generator and increased current into the battery.

During nighttime operation when the batteries were not under charge, the compressors in the Sun Frost were getting browned out. They were forced to start and run while supplied with lower than specified supply voltage. (12.0 VDC minimum). This will shorten their life and reduce their efficiency. We were also concerned about feeding too low a voltage to the ham radios, and most especially the radiotelephone (R/T). After a few days of this condition, we opted for plan B. We decided to solve this problem by using a "booster battery" installed in the house, near the Sun Frost.

Booster Battery

We probably didn't invent the concept of a booster battery. We're sure that someone, somewhere, must have tried this before, but we've never heard of it. Here's the basic idea: A small 12 volt battery is located as near as possible to the 12 volt loads. In our case, this small battery is two Concorde AGM batteries, each rated at 105 ampere-hours at 12 VDC. These are wired in parallel with the main 12 volt battery bank.

During the day, the 12 VDC system recharges the booster battery, and also powers the loads connected to it. At night, the booster battery supplies the surge current needed to operate appliances without undue voltage depression. Should the booster battery's voltage ever drop to lower than the main battery's voltage by 0.4 VDC or greater, then the main battery will supply the loads.

We chose the Concorde AGMs for this job because they are sealed, and could easily be housed in a kitchen cabinet. We wired them in parallel for a total of 210 ampere-hours at 12 VDC. This booster battery is connected to the main 12 volt battery, which is over 100 feet (30 m) away.

There is a Schottky diode inserted in series in the positive leg between the main battery and the booster battery. This diode prevents the booster battery from discharging into the main battery, but allows the main battery (and its power sources) to recharge the booster battery. The main idea here is that the booster battery will deliver the surge current required to run the Sun Frost compressors, and thus keep the DC voltage higher in the house.

So far, this booster battery concept is working well. We installed a TriMetric battery ampere-hour meter on the booster battery so we could measure its performance. At night, we discharge the booster battery about 40 ampere-hours, and each day it is refilled by the main 12 volt system. The main 12 volt system regulates at 14.7 VDC. The 60 ampere Schottky diode we used has a forward voltage drop of 0.4 VDC. This limits the charge voltage to the booster battery to 14.3 VDC, which is

***Home Power's* 12 VDC System Loads**

Appliance	AC or DC	WH per day	%
2 Solar DHW circulating pumps	AC	1,200	27.3%
Well pump, 1/3 hp	AC	1,200	27.3%
Sun Frost RF-19 fridge/freezer	DC	960	21.8%
Inverter in standby mode	DC	360	8.2%
2 Ham radio receivers	DC	192	4.4%
Staber washing machine	AC	165	3.8%
Radiotelephone receiver	DC	144	3.3%
Radiotelephone transmitter	DC	120	2.7%
Ham radio transmitter	DC	50	1.1%
Soldering iron	DC	3	0.1%
	Total	4,394	

perfect for the sealed Concorde AGMs. When the batteries receive equalization charges, we will disconnect the booster battery from the main battery system to avoid overcharging the sealed batteries. A 30 ampere Square D QO breaker provides overcurrent protection and a disconnect to the booster battery circuit.

The booster battery picks up the surge current required by the Sun Frost compressors, and keeps the voltage high at night for the ham radios and radiotelephone. While the booster battery is a somewhat roundabout approach to solving voltage loss in long 12 VDC lines, it works. Most systems will not need this approach. It's best to site your battery bank as close as possible to major DC loads, or run only 120 VAC appliances only if this is not possible. But in special cases, it's good to know that a custom approach like this can work.

Other Options

We considered other options to the booster battery. We could have achieved an acceptable voltage drop by running #4/0 (107 mm^2) copper cable from the main battery up to the house. The expense involved didn't make this a very attractive option. A second option was to run 24 VDC to the house and convert it down to 12 VDC using a power supply. The problem with this was noise from the DC to DC converter.

Switching power supplies tend to produce electrical noise, which is in turn transmitted to the various 12 volt appliances, and particularly communications devices. That includes TVs, two-way radios, cell phones, R/Ts, AM radios, FM radios, cordless phones, satellite dishes, etc. Communication is essential, entertaining, and very much a part of our media-drenched lives. Anything that interferes with it must be eliminated!

Our radiotelephone and ham radios are by no means noise tolerant. Even a small amount of DC noise or ripple on the 12 volt line gives us a buzz on the radios. On the ham radios this is merely annoying. On the radiotelephone, this noise can shut down modem communication entirely. A battery has inherent capacitance, which stores charge and can reduce voltage ripple on DC lines. With the added capacitance filtration of the booster battery, we have no noise or DC ripple, so all the radios are happy, and operate without interference.

System Cost

Since almost all of the gear in our new 12 volt system was scavenged from our old system, the cost to us was merely wire, cable, conduit, and such like. That and all of three days of Joe, Eric, and Jason's labor wiring everything up in the new configurations. If anyone were to duplicate this 12 volt system using all new gear, it would cost about US$15,000, and would provide about

Fossil-fuel backup: A Honda ES6500, 6,500 watts at 230 VAC (left), and a Feather River Solar GennyDeeCee, 1,200 watts at 12 VDC (right).

5 KWH per day. That's enough to run an energy efficient home of four people in a deluxe fashion.

Flexibility

One of the main reasons we retained a 12 volt system here was to have the flexibility of two discrete systems. We can draw from whichever system has the most energy at the time. We can also continue to test 12 volt equipment, which is essential for reports to our readers. Overall, we're very happy with two systems. To be sure, it has been some additional expense and lots and lots of additional work (thanks, Joe!), but for us, it's worth it.

The flexibility of our two systems shines in the new plug-and-play center in what used to be our old power closet. We can waltz in there and choose which system and inverter we want to use to power a load or group of loads. This flexibility is greatly reducing our generator operating time, and saving fossil fuel.

Access

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Bogart Engineering, 19020 Two Bar Rd., Boulder Creek, CA 95006 • 831-338-0616
bogart@bogartengineering.com
www.bogartengineering.com • TriMetric AH meter

BP/Solarex Solar, Inc., 2300 N. Watney Way, Fairfield, CA 94533 • 888-274-7652 or 707-428-7800
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solar@sunselector.com • www.sunselector.com
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conbat@earthlink.net • www.concordebattery.com
Batteries

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800-886-4683 or 817-595-4969 • Fax: 817-595-1290
info@exeltech.com • www.exeltech.com • Inverter

Feather River Solar Electric, 5575 Genessee Rd., Taylorsville, CA 95983 • 530-284-7849
Fax: 530-284-6544 • frenergy@psln.com
www.psln.com/frenergy
GennyDeeCee 12 volt generator

Heliotrope PV, PO Box 1053, Fall Creek, OR 97438
541-937-9812 • Fax: 541-937-9813
rvsolar@continet.com • PV controller

Kyocera Solar Inc., 7812 East Acoma Dr., Scottsdale, AZ 85260 • 800-544-6466 or 480-948-8003
Fax: 480-4831-6431 • info@kyocerasolar.com
www.kyocerasolar.com • PV modules

Pulse Energy Systems (formerly Ananda Power Technologies), 870-E Gold Flat Rd., Nevada City, CA 95959 • 530-265-9771 • Fax: 530-265-9756
info@pulseenergy.com • www.pulseenergy.com
Power center

Surrette Battery Company Limited, PO Box 2020, Springhill, NS B0M 1X0 Canada • 800-681-9914 or 902-597-3767 • Fax: 902-597-8447
sales@surrette.com • www.surrette.com • Batteries

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Refrigerator/freezer

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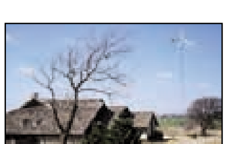

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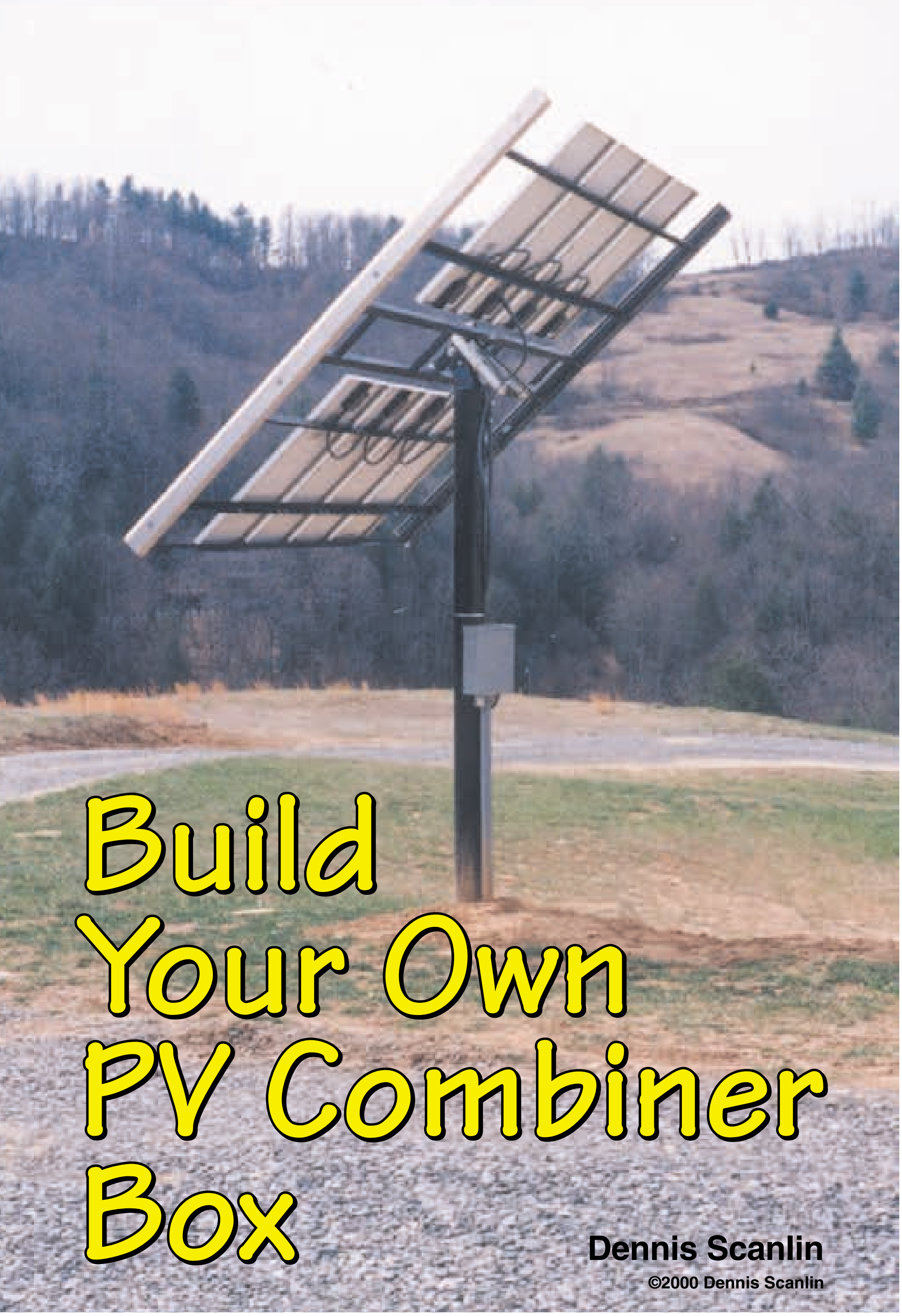


Build Your Own PV Combiner Box

Dennis Scanlin

A typical tracked PV array with pole-mounted combiner box.

Look at a recent PV system schematic, and you'll see a component between the PV array and the charge controller—it's called a combiner box. It provides a place to join the array conductors to the conductors that feed the electricity to the batteries. It also often contains other components. This article describes the design and construction of a combiner box that attempts to address all *National Electric Code (NEC)* requirements.

A combiner box is an important component of a code-compliant system, and I am aware of only one commercial model available now. The combiner box I describe here is easy and enjoyable to build. The components are readily available, and for smaller systems, significant savings can be realized by building your own.

Combiner Box Functions

A combiner box is similar to a junction box (J-box). The #12 or #10 (3 or 5 mm^2) conductors used to wire the PV array come into this box. There they are connected via a power distribution block to the larger conductors that run to the charge controller and batteries. The goal is to carry the electrical energy from the PVs to the batteries with a minimum of voltage drop.

A combiner box also permits the combining of multiple photovoltaic source circuits (subarrays, panels, or series strings), and provides a method of removing a module or subarray/panel from the array without interrupting the rest of the array. Sections 690-4(c), 690-14(b), and 690-18 of the *NEC* address this situation and make the combiner box an essential component of a code-compliant system.

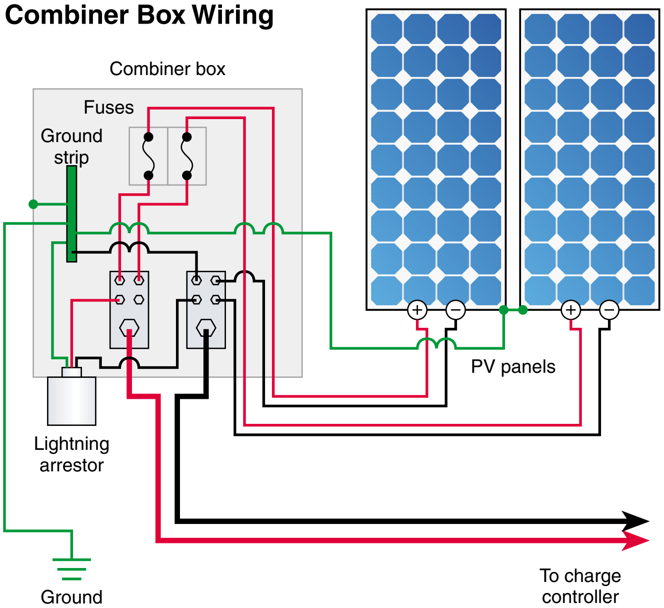
This requires a different approach to wiring the array than has been used in the past. Figures 690-19(a), 690.7, and 690.8 in the 1999 *NEC Handbook* clearly depict PV arrays formed not by the more typical daisy chain connections, but by creating sub-arrays of series strings (panels) each having the nominal system voltage. Each of these series strings is then directly connected to the combiner box. So in a 12 volt system, every module is considered a subarray or series string, and will be directly connected to the combiner box. In a 24 volt system, every two modules are connected together in series, and then each pair or series string is directly connected to the combiner box.

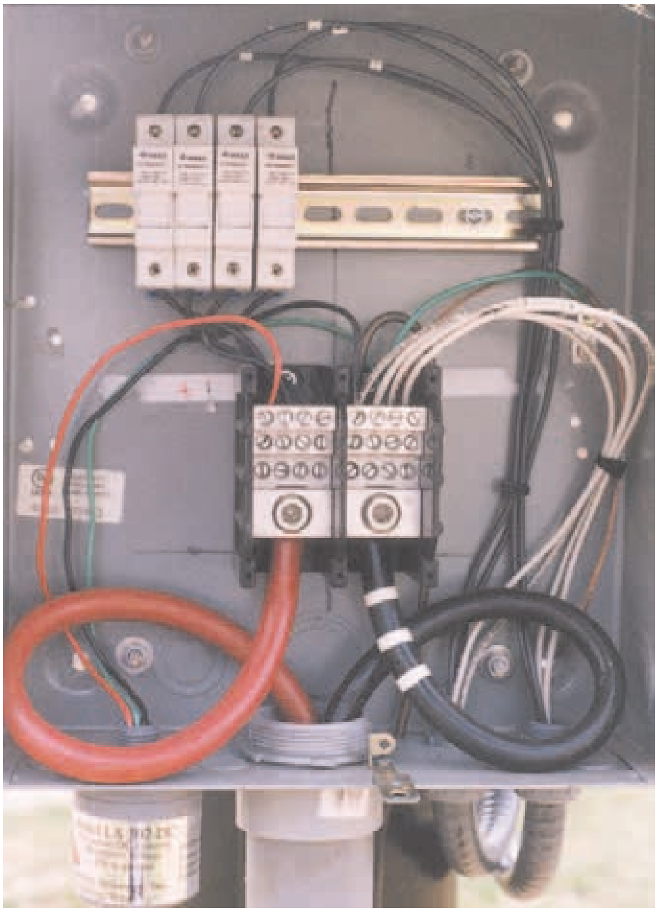
In addition to providing a place to join multiple PV source circuits, combiner boxes also often house disconnect mechanisms, fuses, equipment grounds, a grounding terminal strip, grounding electrode conductor, and lightning arrestor. The combiner box is normally mounted near the array, and often mounted to the pole or rack supporting the modules. A roof-mounted system could have the combiner box mounted on the roof near the modules or inside the attic.

Weatherproof Box
If these combiner boxes are outside, they need to be rainproof junction boxes. These should be UL-listed boxes that have specially fitted or gasketed doors to prevent the infiltration of moisture. The NEMA TYPE 3R, available from Grainger, satisfies these criteria and is commonly used for this purpose. These boxes come in a variety of sizes with side hinged doors, or in a less expensive version with a screw-on cover. Both are lockable. In an outdoor environment, wire access to the box should only be through the bottom to minimize the entry of water. A good size for the box would be 12 by 15 by 4 inches (30 x 38 x 10 cm).

Conduit and/or strain reliefs listed for outdoor use can be easily attached to the box through the knockouts. Conduit should be used with 90°C rated conductors that are not sunlight resistant, such as the commonly available single conductor stranded THWN-2. The strain reliefs listed for outdoor use should be used when conductors having sunlight resistance (such as USE-2 or TC) are used and not run in conduit. Some of the other components, such as a two-pole power distribution block, DIN rail, and grounding terminal strip should be securely attached to this box with stainless steel fasteners.

Combiner Box Wiring





A combiner box for an array with four series strings, designed and constructed by Shawn Fitzpatrick.

Power Distribution Blocks
A power distribution block brings the conductors together in a combiner box. Power distribution blocks come in a large variety of sizes and configurations. They can be single, double, or triple pole. They have a large barrel-type connection on one side, and normally four or six smaller barrel connections on the other side, although quite a range of other options exist.

The primary or large terminal block for the outgoing cables needs to be large enough for the size of cable selected. You also need to be sure that there will be enough spaces on the secondary side of the block for the incoming array wires. Depending on how the array is wired, this could mean four spaces for an eight module, 24 volt array—one for each series string.

Grounding Terminal Strips or Blocks
The power distribution block for the grounded or negative current-carrying conductors often requires additional connections for the grounding system. An additional grounding terminal strip is desirable for a variety of reasons. It should be attached to the box electrically to meet the equipment-grounding provisions of the code for the combiner box.

Four-Circuit Combiner Box Costs

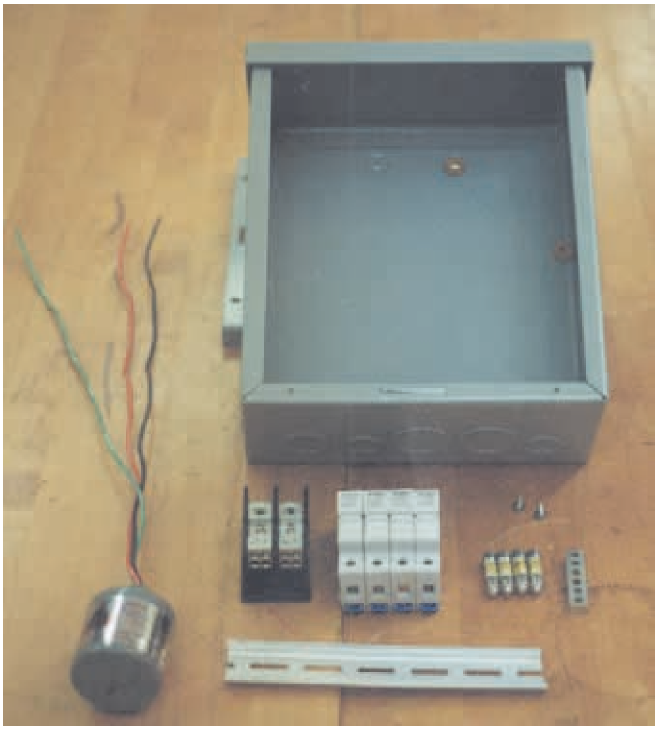
*Component**	*Supplier & Part Number**	*Cost (US$)*	*Total*	*%*
Delta LA302 DCMB lightning arrestor	Hutton #LA 302DCMB	$30.00	$30.00	21.6%
Wiegmann RSC10124 NEMA 3R box	Grainger #6C726	27.45	27.45	19.8%
4 Ferraz Shawmut Ultrasafe fuse holders	Fuses Unlimited #USCC1	6.64	26.56	19.2%
4 Cooper Industries low-peak LP-CC fuses	Grainger #ICX61**	6.48	25.92	18.7%
Ferraz Shawmut 63132 power distribution block	Grainger #5A671	19.02	19.02	13.7%
Omron PFP-100N DIN mounting track	Grainger #6X295	6.63	6.63	4.8%
Grounding terminal strip	Any electrical supplier	3.00	3.00	2.2%
		Total	$138.58	

** Similar parts are available from other suppliers and manufacturers.*
*** Fuse sizing requirements are dependent on module amperage and interconnect methods.*

Use heavy star washers rather than lock washers, and remove the paint where the grounding block meets the box. Then repaint any bare metal after mounting the block, to prevent rusting. Some boxes have a specific threaded hole for the connection of the grounding block.

For roof-mounted systems or systems with an equipment-grounding conductor traveling back to the charge controller/inverter location with the current carrying conductors, the UL standards and the 2002 *NEC* will require the equipment-grounding conductor to be as large as the current carrying conductors. This could require a larger grounding block or strip. For pole or rack mounted systems with a grounding electrode at the array location and no equipment-ground traveling back to the charge controller/inverter location, the strip shown in the photos should be adequate.

The necessary components, including lightning arrestor.



Fuses

Fuses in the combiner box are desirable for several reasons. Article 690-9 of the *NEC,* Overcurrent Protection, states that "circuits connected to more than one electrical source shall have overcurrent devices located so as to provide overcurrent protection from all sources."

Blocking diodes located in the charge controller or the modules normally prevent electricity from moving from the batteries to the modules. But they may lose their blocking ability and allow backfeeding of electrical current, which could damage the PV modules. Properly sized fuses will protect PV modules should this condition arise.

Section 690-4(c) of the 1999 *NEC* requires that the connections to a module or panel shall be arranged so that removal of a module or panel from a PV source circuit does not interrupt a grounded conductor to another PV source circuit. By fusing each module or string, it is possible to easily remove one without interrupting the other modules or strings in the array.

The code (690-18) also states that it must be possible to disable an array or portions of an array for installation and servicing. Covering the modules with an opaque material is a common and code compliant way to achieve this requirement. However, another acceptable method is to divide the array into nonhazardous segments using switches or connectors. Fuses and fuse holders make this possible.

The fuses should be DC rated (690-9(d)), UL listed, and "have the appropriate voltage, current, and interrupt ratings." The desired fuse characteristics should be identified on the modules by their manufacturer, and should be at least 1.56 times larger than the short circuit current of the module. Trace Engineering has a fuse selection guide for many commonly available PV modules on their Web site.

Combiner box with midget fuses, fuse blocks, and safety pullers.

Fuse Holders

The fuses need some kind of holder. There are a couple of options. The nicest ones are the Ferraz Shawmut Ultra safe fuse holders, which mount on DIN rail and snap on and off very easily. The positive conductor of each series string attaches to the top side of a holder in a pressure plate terminal. Another positive conductor is attached to the bottom of the holder and then to the secondary side of the positive or ungrounded distribution block. They can accept wire size ranges from #6 to #14 (13-2 mm^2). The holders have a little door that opens for inserting or removing a fuse. The holders protect the operator from live parts, or are "finger safe" (NEC 690-17). They provide a way to disable the array, or portions of the array, for servicing (NEC 690-18).

A second option is to use a fuse block with a safety puller, cover puller, or dead-front fuse cover. Different blocks are available for both the midget and class CC fuses. The blocks come in 1, 2, or 3 pole configurations with a choice of box, screw, or pressure-plate connectors. They cover exposed live clips and terminals, and reduce accidental contact by personnel. The safety pullers also allow you to easily remove a fuse without the use of standard fuse pullers.

Combine and Conquer

The combiner box I've described can easily and inexpensively be constructed for smaller arrays. It uses UL listed or recognized components. However, it is not considered a UL-listed device. So the person who builds, installs, or uses the device could be open to liability or insurance claim problems if it fails or causes an accident.

Trace Engineering distributes the TCB10 combiner box which is UL listed and is available for US$229. For larger arrays with up to ten series strings, this unit would probably be a better choice from both an economic and *NEC* perspective.

A combiner box lets you combine multiple photovoltaic source circuits (sub-arrays, panels, or series strings), and provides a safe method of removing a module or sub-array/panel from the array without interrupting the rest of the array. It also provides fuse protection to protect modules from current that could backfeed from the batteries, provides a convenient bond for equipment and, if appropriate, a system ground, and a convenient location for a lightning arrestor.

A two-string combiner box used as an educational tool.

Access

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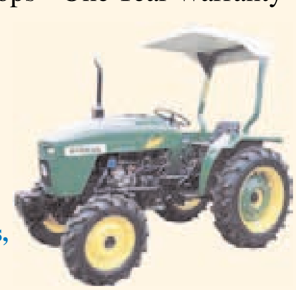
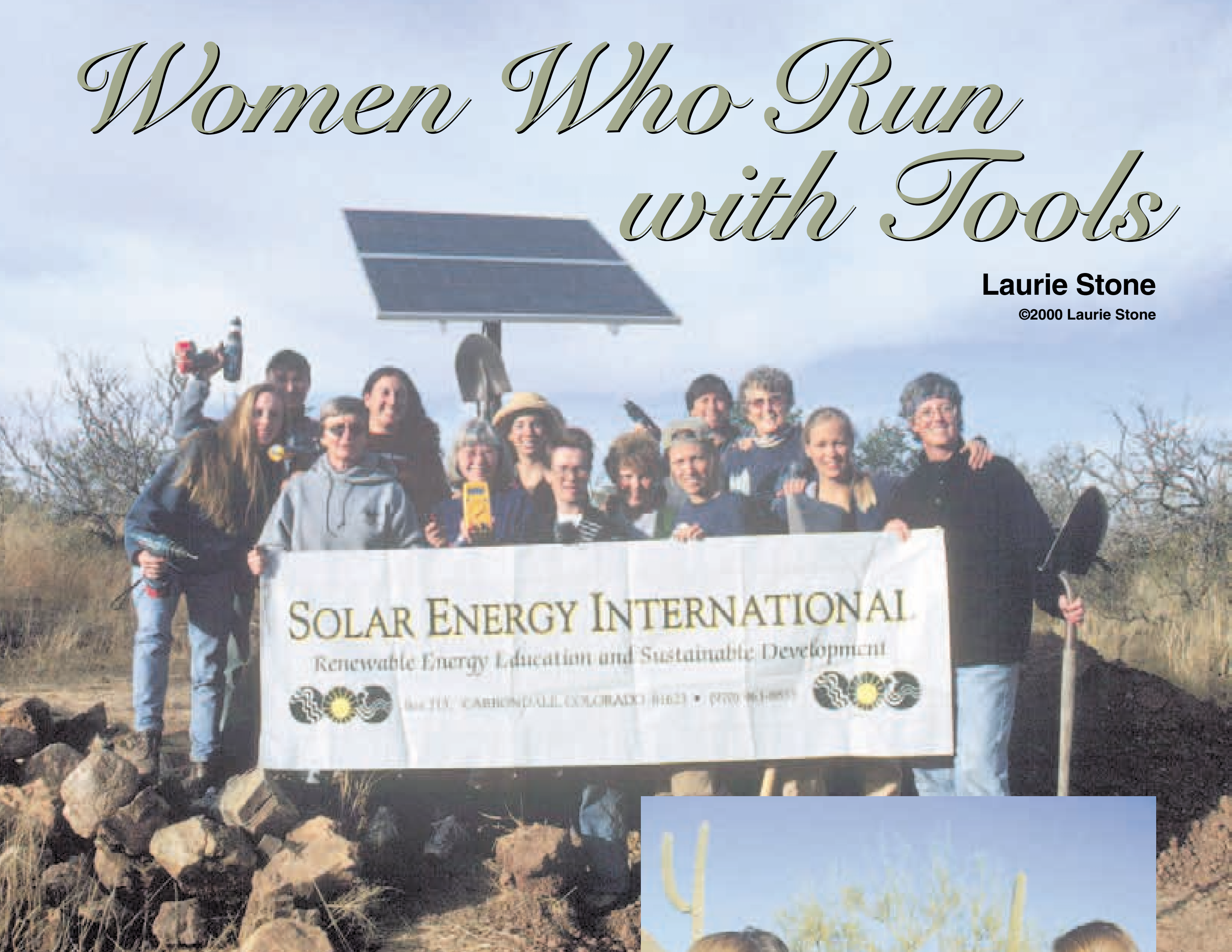


Women Who Run with Tools



Laurie Stone

Above: Solar sisters. Right: Testing short circuit current and open circuit voltage on a PV module.

Last February, a group of dedicated and enthusiastic women descended on Tucson, Arizona to learn how to incorporate solar energy into their lives. Though it hasn't always been this way, women wielding power tools and installing solar electric equipment is becoming more common.

For the past three years, Solar Energy International (SEI), an educational non-profit based in Carbondale, Colorado, has offered photovoltaic workshops for women. Fifty-five women have attended four workshops–three in Tucson, Arizona, and one in Portland, Maine. Twelve year old girls, NASA engineers, ranchers, housewives, and a wide variety of other women have attended the workshops. They've taken steps toward their goals of bringing renewable energy into their lives. Whether they came to learn about installing a home system, start an RE business, or simply to increase their knowledge of renewables, the women brought an enthusiasm to these classes seldom seen in a coed course.

Arizona PV Workshop

The fourth Women's Photovoltaic Design & Installation workshop was held in Tucson, Arizona in February. The women participants learned about photovoltaics, met other women in the PV field, and learned technical skills not often taught to women. They also installed a system for a former SEI student—a single mom living in rural Arizona.

Women came to the workshop in Arizona from as far away as Canada and New York to learn about solar-electric technology. The diverse group of women included a rancher, a schoolteacher, a nurse, and a grandmother touring the country in her RV, among others. The workshop was taught by five women who have been working in the PV industry as technicians, electricians, educators, and researchers. The instructors included Justine Sanchez and Laurie Stone from Solar Energy International, Carol Weis of Eco Electric (a PV installer in Basalt, Colorado), Marlene Brown of Sandia National Labs, and Melinda Zytaruk, an SEI intern who volunteered to help out.

Katharine Kent talks about being a woman, business owner, and solar pioneer.

The classroom part of the workshop was held at the Cooper Environmental Science Campus (Camp Cooper), in the foothills just west of Tucson. Camp Cooper is part of the Tucson Unified School District. Elementary school children from all over Tucson spend one to two days at Camp Cooper learning about desert ecology, wildlife, and solar energy.

For the first four days of the workshop, the women learned the basics of electricity, PV system components, solar site analysis, and how to size a residential system. Through laboratory exercises, they learned how to estimate insolation, using a Solar Pathfinder. They used digital multimeters to test battery voltage as well as array current and voltage. And they learned how to wire a switch, receptacle, and light fixture.

System Tours

Previous SEI women's workshops had already installed stand-alone PV systems on a ramada and three cabins at the camp. One of SEI's coed workshops had installed a grid-tied system on the office. So there was plenty to see at the camp itself. We toured the previously installed PV systems, using them to learn how to draw schematics. We also took two tours to meet with other women in the field, and to see more PV applications.

Photovoltaic systems at the Cooper Environmental Sciences Campus, where the classroom part of the workshop took place.

Students mount the two Uni-Solar 64 watt PV panels at Darlene's remote desert home.

On the first tour we met with Katharine Kent, who runs the Solar Store, a PV dealership and installation company in Tucson. She enlightened us about the advantages of a woman-run business, but also about the trials and tribulations of being a woman engineer in a male-dominated field. She felt that she was not taken seriously by many of her male colleagues when she first started out. It took her longer to gain respect as an engineer than it would have taken a man.

On our second tour, we met with Judy Knox of Out on Bale fame. Judy showed us the PV-powered straw bale home that she and her husband Matts Myrhman built for Matts' mom, right in the heart of Tucson. Judy also talked about how women are the heart of straw bale construction—it is their interest and passion that usually drags their husbands to straw bale workshops.

Remote Desert Installation

After the women in the workshop had their fill of classroom sessions, laboratory exercises, and tours, we headed for the remote desert of southern Arizona to install a system on Darlene Dobroslavic's house. Darlene had attended the Women's PV workshop the year before, and had been gathering equipment to eventually bring electricity to her remote home. For over two years, Darlene and her nine year old daughter, Brittany, had been living with kerosene lamps, and spending a lot of money on small throw-away batteries for their radio. Needless to say, even a small amount of energy was going to make a big difference in their lives.

Dobroslavic System Loads

Item	*Volts*	*Watts*	*Hrs/day*	*WH/day*
CD player	120	32.0	4	128.0
Television	120	60.0	2	120.0
2 lights	120	40.0	3	120.0
Compost toilet fan	12	1.4	24	33.6
Cell phone charger	12	24.0	1	24.0
			Total	425.6

The participants split up into three groups: one to work on the PV array; one to work on the controller, inverter, and batteries; and one to work on the DC and AC loads. The two 64 watt Uni-Solar modules were mounted on a pole about 40 feet (12 m) from Darlene's house. The 600 watt Trace inverter and the Prostar 30 amp controller were mounted inside a box on the north side of the house. Because of the inverter hum, Darlene decided that her 400 square foot (37m^2) house was too small for her, her daughter, and the inverter, so one of them had to go outside.

SEI students get hands-on experience.

Darlene's exterior-mounted inverter enclosure keeps the hum outside.

The two 220 amp-hour Exide batteries were put in a vented picnic cooler, which will act as the battery box until Darlene builds a custom adobe box for them. Darlene's loads consist of two AC lights, a CD player, cell phone charger, composting toilet fan, and 12 volt DC television. She also hopes to add two more modules to her system someday, which is why she chose an oversized controller and oversized wire.

Comfort Zone

Teaching women-only workshops for photovoltaic technology is important on many levels. Women feel more comfortable asking questions and participating. They are not as apprehensive about using unfamiliar tools, and they meet other women who are working in or trying to get involved in a male-dominated field. The following comments we received from past participants are typical of the feelings women express after attending our women's PV program.

Dobroslavic PV System Costs

Qty	Description	US$	%
2	Uni-Solar modules, 64 watt	$696	32%
1	Trace UX612 inverter, 600 watt	550	25%
	Misc. wire, conduit, & hardware	253	12%
1	Uni-Solar top of pole mount	212	10%
1	Prostar 30 amp controller	175	8%
2	Exide E3600 batteries, 220 AH	116	5%
1	Square D breaker box, 70 amp	65	3%
1	Square D fused disconnect	48	2%
1	Delta lightning arrestor	46	2%
	Total	$2,161	

"I felt very comfortable having longer discussions in a group of all women. I would have felt hurried or bothered by the same discussions in a group with mostly men. Removing the men made the class focus on our individual needs in comfort, and allowed us to ask questions that we may have been intimidated to ask in the presence of men, especially men who have more experience with power tools, wiring, etc."

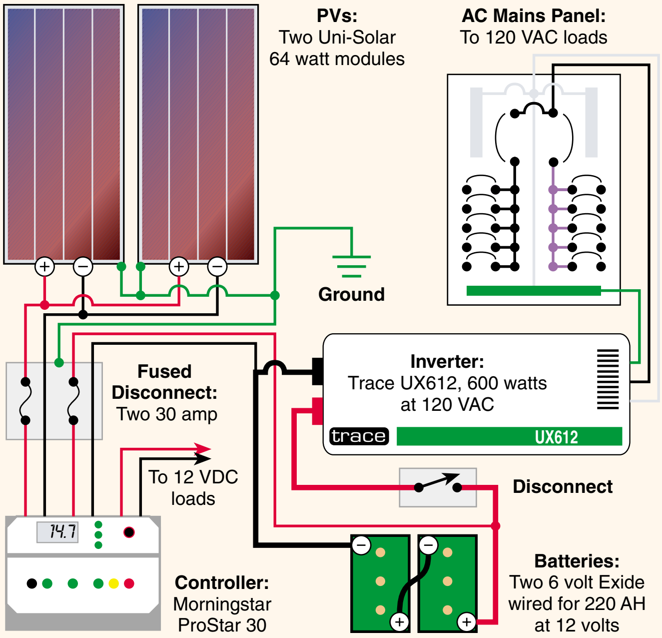
"Women learn differently than men, and work together differently than men. We were able to learn in our own way without the criticism that you sometimes get when dealing in mixed classes."

"Being taught by women in the field inspires confidence in women trying to break into a male-dominated field."

Gaining Conveniences & Confidence

Now that Darlene is powering her small home with the sun, she will be saving money that would have been spent on kerosene and dry-cell batteries. She is gaining conveniences that she had to do without before, and feeling good about using a clean reliable source of energy. And Brittany is excited about some of the new appliances they will have in their lives.

There will also be more women entering the PV field and putting systems on their own homes. These workshops show that women can and will make an important contribution to the renewable energy industry.



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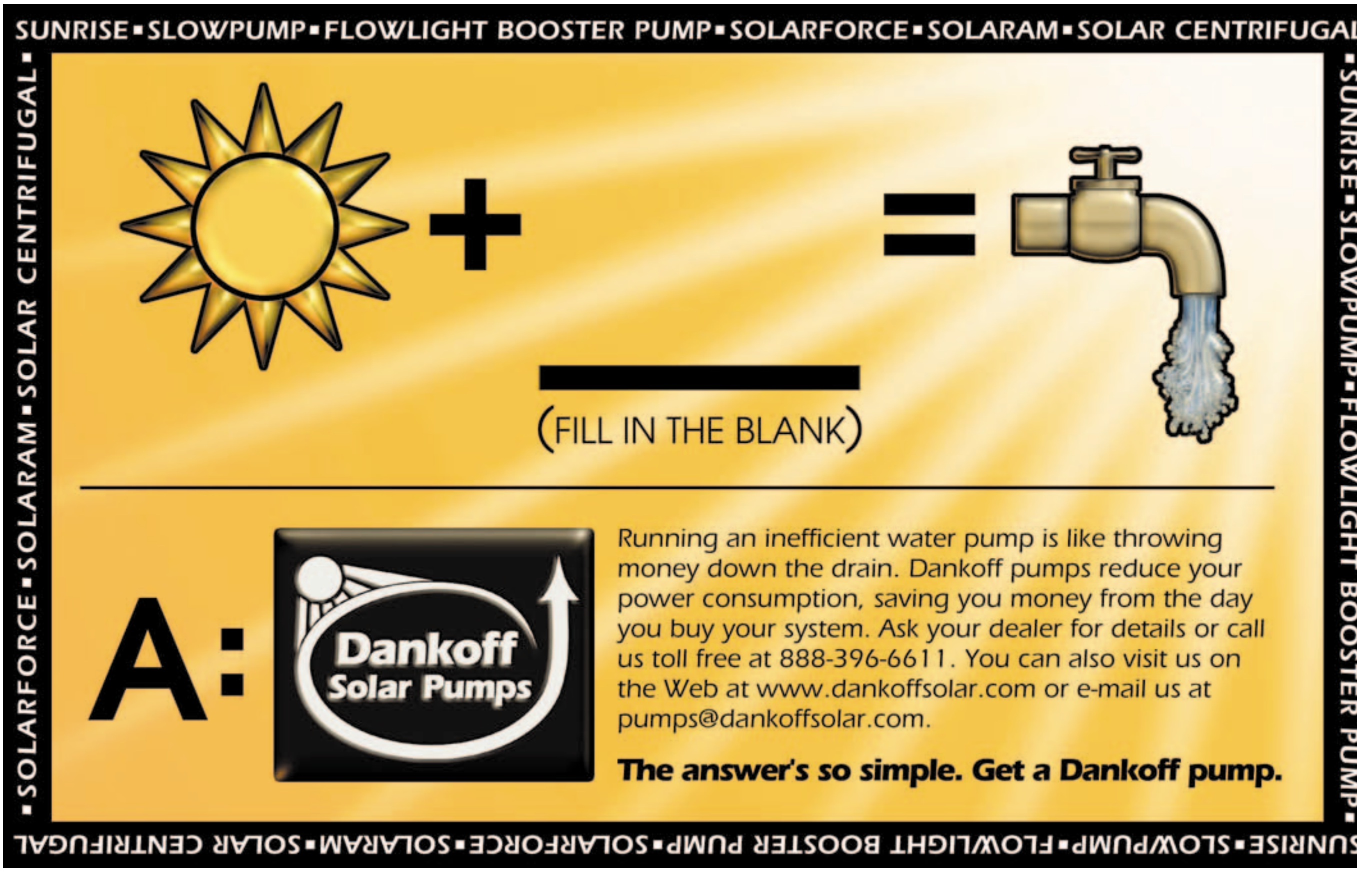
www.greenbuilder.com/dawn

SEI will offer two women's photovoltaic workshops in the spring and summer of 2001. Contact SEI for dates, or keep your eyes on the SEI ads in *Home Power.*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G'Day, Sun!
Solar Car Race in Australia

Tony Pereira

Mushashi Tech ready to go at 8 AM. Notice the "highway"—no shoulders for 1,870 miles.

The World Solar Challenge is the world's most grueling solar race. It is held about every two years, and runs through the heart of Australia, from Darwin to Adelaide. The entire 1,870 mile (3,010 km) course is traveled using only the power of sunlight!

Race Official

As a race official for the 1999 event, my functions included starting and stopping the solar cars along the course, logging the event, setting time and battery penalties, keeping the official race time, and race safety. Each race official was assigned one car at a time. This usually lasted one day, or until the next control stop was reached. Then officials had time to take showers, fill water bottles, buy food and supplies, get the logbook from the previous team observer, and move to another solar car team.

Each car had its own official logbook with all the technical details, pictures of the car, weight, type and number of batteries and solar panels, names of all drivers, etc. I logged all times and events, penalties, and penalty times for each team that I officiated for. By the end of the race, I had observed and logged four different teams.

My job included not letting the solar car I was assigned to out of my sight. This meant driving right behind the solar car for the entire course, and sleeping alongside it at night. I did this for ten days and nights, from the beginning of the race in Darwin to the end of the race in Adelaide. This is roughly the same as driving from Los Angeles to Chicago, or from Costa Rica to Los Angeles.

Shoulder to Shoulder

The race course is divided into six segments, each with a control stop, usually around a significant town or city. These are about 300 or 400 miles (480–640 km) apart. The "track," as it is affectionately called, is a two-way country road with no shoulders, and no middle divider, but it is called a highway anyway. Shoulders are gravel, and so are all the parking and rest areas along the way.

There were forty entries from eleven countries in the race, including France, Denmark, Germany, England, Italy, Malaysia, Canada, Australia, Japan, and the U.S. The U.S. was represented by several universities, including the Massachusetts Institute of Technology (MIT), the University of Wisconsin, the University of Missouri at Rolla, and the University of Minnesota. Two

American high schools—one from Texas and another from New Jersey—also had entries. Solar Motions, the only car from California, won the Private Class (an entry made in the name of an individual or group of individuals). The team made a great attempt to win the race after a disastrous crash destroyed their front wheel right at the start.

Rules

The rules for the solar race are straightforward, but the engineering puzzle it presents is less than simple: Put up to 8 square meters (86 square feet) of solar panels on wheels. Build the fastest and lightest car you possibly can. Drive to the finish line almost two thousand miles away, observing all street signs and speed limits. Travel is only allowed from 8 AM to 5 PM, and all battery charging must be solar only.

All the solar cars must survive two days of inspection at the beginning of the race for compliance with the race rules, engineering, construction, and safety. Then they are issued a temporary street license permit and license plate by the Northern Territories DMV.

Engineering

Most solar cars of this type are built using a carbon fiber monocoque chassis, which is very light and strong. Other alternatives are welded tubing chassis of either cromolly, aluminum, or titanium tubing with a fiberglass shell. Conventional flooded or gel cell lead-acid batteries were used on half of the solar cars, with the rest using nickel metal hydride or lithium-ion batteries.

Most cars had 30 to 40 amp-hours of storage at voltages from 80 to 144 VDC. The PVs in the solar cars were of various types, but mostly pure silicon, with efficiencies from 8 to 27 percent, the latter being claimed by a manufacturer from Germany.

Motors used were from 1 to 4.5 KW, roughly equivalent to 1–5 horsepower nominal power rating. Most of them were built by UNIQ Mobility, and New Generation Motors (NGM) in the U.S. This last motor was the favorite, and it was developed, designed, wound, milled, built, and licensed to NGM by the Northern Territories University in Darwin. Many of the solar cars were using maximum power point tracking (MPPT) units, built either in Australia or Japan.

A Variety of Teams

There were several phenomenal entries in the race. An entire solar race family—Team Kirenjaku—came from Hokkaido, Japan. The team included a couple who built the car, and spent US$40,000 of their own money on the car, travel, and race expenses. Their son drove the car most of the time—sometimes for eight hours straight—and their teenage daughter also drove at times.

One of the teams was from the Musashi Institute of Technology in Japan. It included six engineering graduates and five students. The graduates picked up the whole US$40,000 tab by themselves with no sponsors, and paid for the students' expenses.

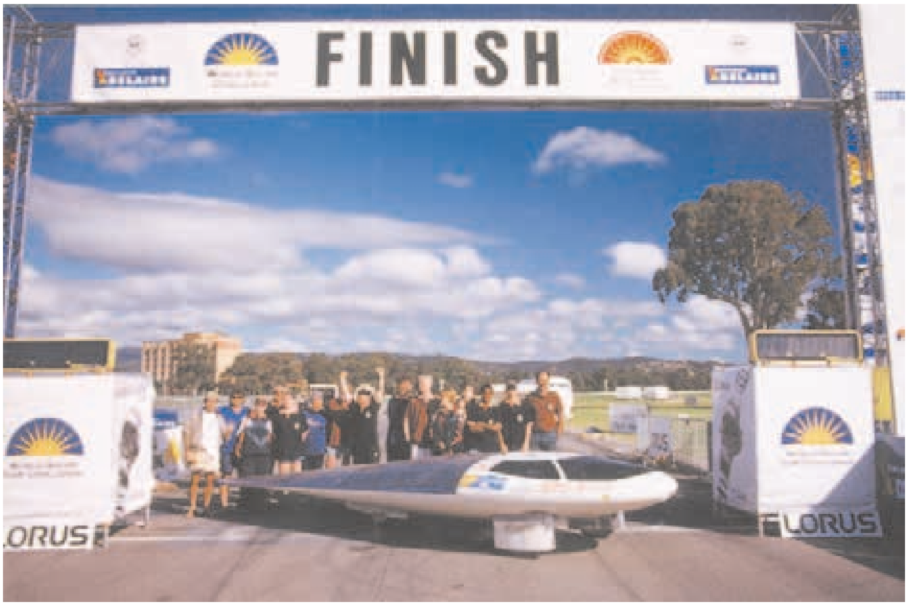
Another team was from Kormilda College (a college is a high school in Australia) in the Northern Territories. They raised the entire budget of about US$40,000 by selling lemon pie and chocolate cake at fund raisers. Wow! These teenagers were brand new drivers, and they finished the race.

Another team of about fifteen totally average, inexperienced youngsters from Japan—Team Junkyard—built a phenomenally small car with off-the-shelf parts, and finished seventh. They won the Australian Greenhouse Office efficiency prize over all cars in the race, which is based on a complex formula for efficiency, weight, energy consumption, and speed, among other criteria.

Winners

The winning team, Aurora, was a group headed by an ex-Ford Australia engineer, with an impeccably built car. They finished the 1,870 miles (3,010 km) in five days (41 hours 6 minutes, to be exact), with an average

At the finish line in Adelaide, after 1,870 miles on solar power alone. The author (left) is in the race official's white shirt.



Australian-made Aurora, the winner in the general race. Notice the impeccable craftsmanship.

The "solar family" shipped the truck in the background from Japan, with their solar car inside.

speed of 45 mph (73 kph). They did this driving only from 8 AM to 5 PM. Can you beat that in your gas car? They did have the highest budget—approximately US$200,000—mostly from Ford Australia.

Second place was taken by Queens University in Canada; third by the University of Queensland, Australia; and fourth by the Northern Territories University, also from Australia. These three teams finished within minutes of each other. The U.S. MIT team finished eighth overall, and won their category—vehicles that only use terrestrial-grade cells.

The race was sponsored primarily by the Greenhouse Office and Transportation Department of the Australian government. With a total administrative budget of about US$600,000, it took about US$15,000 per car for administration alone. Several high officials were present during the race, including the Australian transportation minister and the Australian energy secretary. I was very impressed by the level of commitment to renewable and sustainable technologies by these elected officials, as well as their knowledge of the issues.

Issues

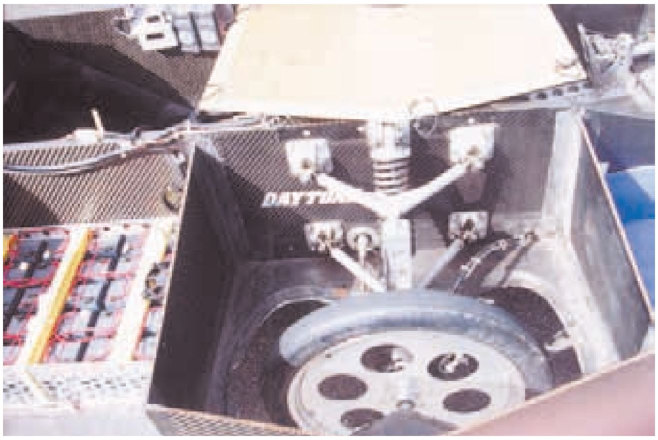
The media has hyped the concept of solar cars so that some people might be saying, "Who's afraid of no oil, the greenhouse effect, or air pollution?" But we aren't there yet. These are custom-made specialty cars, not available to the average person. Although it is encouraging to see them, it may be years before the technology comes to the masses.

There's a huge energy investment to make this "solar" race happen. To get to this race, I jumped on a 747 that burned some 70,000 gallons of jet fuel. After a couple of additional short flights, the total was about 100,000 gallons. Each solar car must have a support team of one safety car in front and a follow-up car behind. Most teams had four conventional gas cars, including one with the trailer for the journey home. All of this uses huge amounts of non-renewable fuel.

These cars are not completely ready for real-world conditions either. One team I rode with forgot to test the car for rain. And none of the solar cars had windshield wipers. Other than brake lights and blinkers, the cars

A welded cromolly chassis with a fiberglass shell. One of the heaviest entries, at over 660 pounds (300 kg).

Front suspension, double wish bone, and Dunlop Super Solar tire.



The Kormilda College Lemon Pie Budget Solar Car—
not a lemon.

University of Queensland's Sunshark,
third-place winner in the general race.

are not equipped with driving lights, even if most can easily drive a couple hundred miles on fully charged batteries alone and no sun.

The tires, most of which are made by Michelin and Dunlop, are 14 by 2.5 inches and cost US$300 each. They do not last more than about 300 miles (480 km), so trying to keep one of these cars in tires would wreck my allowance. Most teams used more than ten sets each, and were changing tires every night, as soon as I gave them the stop signal to get off the road.

Stop-and-go city traffic was another hazard. One solar car toasted their US$1,200 electric motor because of rush hour traffic in Adelaide, one mile from the finish line. It's commendable that most of these cars survived this race, but that doesn't mean they are ready to replace the average American car. These are generally bare bones vehicles, without many common automotive amenities.

Safety is another concern. Solar cars are capable of sustaining speeds of 80 mph (130 kph) and higher. Even with the mandatory three-point safety belt harness and rollbar, I wouldn't want to be in a crash at those speeds in such a small and light car. The Australian road trains (long-haul trucks with three to five trailers) are an awesome sight. I counted 62 wheels on the average road train, and 82 on the largest. Just one of those wheels on top of a solar car would destroy it.

Looking Forward

At best, the race is a proving ground for new solar technologies. It is not the place where your next solar car model is going to be introduced, to be picked up at the solar car dealership the following year. Maybe we could travel this way every day, with a few engineering and safety changes, together with a decent, safe, and well planned infrastructure. Infrastructure is the key word here—it's what we don't have for these solar cars.

The next World Solar Challenge will be in 2001. The race will leave Darwin on November 18th, and will end in Adelaide to coincide with the International Solar Energy Society World Congress being held there. In the U.S., the American Solar Challenge is slated to run

The electronic boards are MPPT;
the fire extinguisher is optional equipment.

Pilot seating, with minimal comfort, typical of all
solar cars. All black panels are carbon fiber.

from Chicago to Los Angeles in July of 2001, with segments ending in Missouri and Nevada.

Maybe we could also organize a solar race that is truly sustainable, without the use of gas, with organic food, going from one sustainable community to another. Such a race would need a different set of rules based on efficiency, sustainability, and cost, not just the first to cross the finish line—how superficial and unimaginative! It's something to think about. Let's talk.

Access

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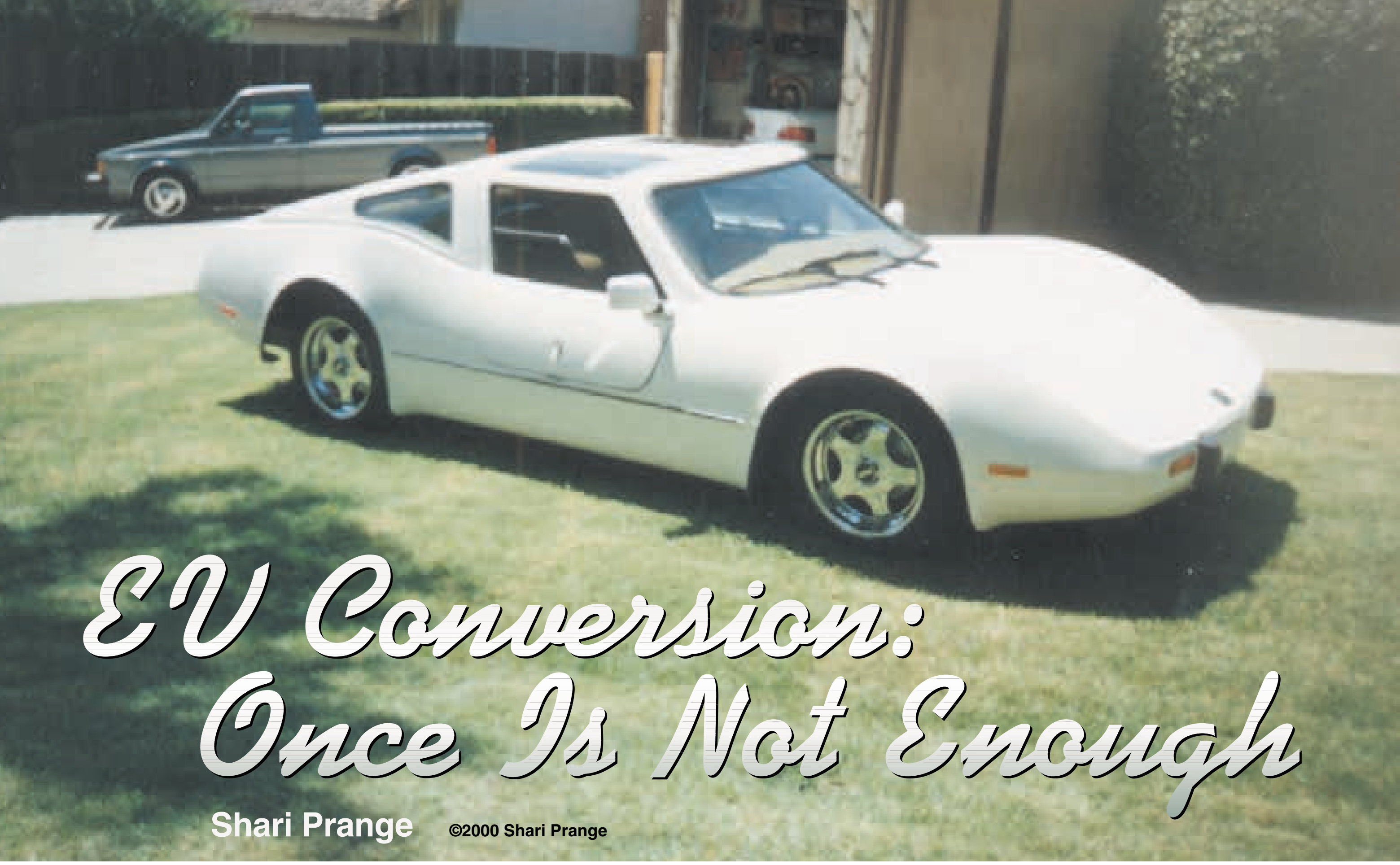

EV Conversion: Once Is Not Enough

Shari Prange

Bill's electric Bradley kit car.

Bill Nalbandian just can't help himself. He started building one electric conversion, then another, and then another. He's now working on his fourth. But he isn't looking for a chapter of Electric Cars Anonymous to cure him—he's very happy with his addiction.

How It Began

Bill got his first taste of electric mobility at an early age. When he was five years old, he lived in Ethiopia, and his father was a mechanic who had his own auto repair business. World War II came, and gasoline became scarce. Bill's father attacked the problem from an auto mechanic's perspective, and created a solution.

He took the starter motor from a heavy-duty Renault truck, and installed it in a British "Baby Ford," along with a set of batteries. At that time, gas cars used 6 volt batteries as starting batteries, so these were what Bill's father used to power the drive motor. Bill was too little to remember how many batteries there were, or any details of the engineering. But he does remember that his family could drive during the war, when no one else except the military had gasoline.

He never forgot that car. Almost fifty years later and a hemisphere away, he renewed his interest in EVs when he saw a beautiful electric conversion of a VW Karmann Ghia at the county fairgrounds. The owner, Scott Cornell, told him how he converted the car himself, and about the reliable performance he got from it. Bill was hooked. Scott told him to call Mike Brown at Electro Automotive for parts, and his journey into the EV world began.

Honda Civic

His first conversion was a Honda Civic. He bought the donor car in 1991, from a neighbor just a few blocks away. The engine was dead, but the body was in good condition. Bill stripped out the internal combustion components, and started the conversion process.

He installed a Prestolite motor with an adaptor to mate it to the original Honda transmission. This Prestolite is a brushed series DC motor that was used by Jet Industries when they were building production electric conversions. By the time Bill built his car, the motor was no longer in production, but there were still many new ones available from various sources, and they were the most popular motors among hobbyist converters.

His speed controller was a solid-state Curtis/PMC 1221, which could handle up to a 400 amp draw. The controller limits current to 400 amps, to protect itself and the rest of the system. The Curtis/PMC controllers were also the overwhelming favorite among conversions, but at that time the 1221 was a brand new model, an improvement on the earlier model 21.

For batteries, he used U.S. Battery model 2200s. They were 6 volt batteries, but not the standard starting batteries his father had used. These batteries were designed specifically for the repeated deep discharges and high amp draws of an electric vehicle, so they would have a longer cycle life than a starting battery. His pack consisted of sixteen batteries in series, for a total of 96 volts for the system.

The batteries were contained in plywood boxes. This was essential because they were in the passenger compartment. Any batteries inside the car must be completely contained and ventilated during charging, for safety reasons. Bill used the book *Convert It,* which came with his kit, as a guidebook in building his boxes.

The boxes were put together with construction glue and sheetrock screws, with caulking at the seams. The material for the box was actually a three-layer sandwich: plywood, insulating foam, and more plywood. This design keeps the batteries warm, which produces more consistent performance, even in cooler weather.

The finished boxes were primed and painted with an enamel paint, and the seal between the lid and box was fitted with weatherstripping. The entire box is supported in a steel frame, and is vented and equipped with a fan. Once painted, the box made a secure and attractive battery container that would stand up to moisture and acid for years.

Bill still has the Honda. The only thing he has modified is the battery pack. He added two more batteries, for a total of 108 volts. The car now has 12,000 miles (19,300 km) on it as an electric. Bill's wife uses it primarily for errands around town. "She loves it," Bill said. "Sometimes I talk about selling it, but she won't let me."

Rabbit Pickup

Bill liked the Honda, but felt he could improve on it if he did a second conversion. For one thing, the battery box in the back seat area prevents the seat from moving back as far as it might. Since Bill is 6 foot 3 inches tall, this was important. His commute to work took about half an hour on the freeway. Sitting for that long in the Civic was just too cramped and uncomfortable for him. In 1994, he decided to do another conversion. His next choice was a VW Rabbit pickup truck. This was

Electric Honda Civic conversion.

more comfortable for him to drive, and had more room to carry things.

Bill used a bigger motor this time, the Advanced D.C. 9 inch (23 cm) motor. This was also a brushed series DC motor, but was in current production. In fact, it was fairly new on the market, and had not been available when he built his previous car. The founders of Advanced D.C. Motors were former engineers from the Prestolite company. When their factory was phased out, they got together financing, and re-opened it under a new name. The 9 inch motor Bill used in the pickup was, in many ways, the direct descendant of the Prestolite he had used before. The engineers had made it more robust, with better internal cooling, and had generally refined the design to make it better suited for conversions.

Bill stayed with the Curtis/PMC 1221 controller. He also used batteries from U.S. Battery again, but he moved

Electric VW Rabbit pickup conversion.

Under the pickup's hood.

up to the 2300 model. This is the same physical size as the 2200, but has more capacity, which means more range. He also used twenty batteries this time, for a total system voltage of 120 volts. This gave him more range and a higher top speed.

The batteries were secured under the truck bed, this time in stainless steel boxes instead of plywood. Although enclosing the batteries wasn't as essential to safety as it was in the Honda, it was still a good idea. The boxes keep the batteries clean and protected from road splash.

The rear shocks on the truck came in pairs, one facing forward and one back. Bill had to rearrange them so that they both faced back to make room for his batteries. He also had to replace his spare tire with a "mini" spare. These changes left him enough room for one large stainless steel box containing fifteen batteries between the cab and the axle, and a small stainless steel box for two more batteries behind the axle. There are also three batteries under the hood.

The boxes under the bed are supported by four U-shaped welded steel cradles attached to the frame. For service access, Bill cut two openings into the floor of the truck bed and made them into hinged hatches. This gives him easy access to the batteries for maintenance, and still leaves the bed free for cargo. The hatches sit flush with the truck bed, and lock with keys for security.

Bill did all of the design, fabrication, and installation of both the Honda and pickup conversions himself. He figures each one took about 100 hours of his time. The only part he hired out was installing upgraded suspension parts on the pickup. The truck had McPherson struts, which can be very dangerous to take apart unless you have the proper equipment to contain the powerful springs when the tension on them is released.

The pickup is Bill's primary car. "Of all of my electrics, it's my favorite all-purpose vehicle," he said. He drives it 18 miles (29 km) to work on the freeway, where "the speed limit is 65 mph, and everybody drives 85 mph." But Bill just puts his foot to the pedal, and has no trouble keeping up. "I've had all three of my electrics over 90 mph," he said.

Since it was built in 1994, the pickup has accumulated 18,000 miles (29,000 km) as an electric. He did have one problem with a controller, which was repaired. That's the only problem he's had with any of his EVs. Both the Civic and the pickup are old enough to be on their second set of batteries. Bill finds that he gets about four years of use before he needs to replace a pack.

Bradley

So Bill and his wife each had an EV that they really enjoyed. Bill also had two gas cars, a gas motorcycle, and a Schwinn bicycle to which he had added an electric assist. You might think that by this time, the Nalbandian fleet was complete.

You would be wrong. Bill's fingers were starting to itch again. Then he learned about an older man who was

Batteries under the bed of the pickup.

selling a Bradley kit car. The Bradley was a popular fiberglass body kit that used a VW Bug chassis. The factory actually sold both gas and electric versions of the kit, and many of the gas ones were converted to electric by hobbyists.

This particular kit had been deteriorating in the owner's back yard for several years, and a lot of the parts were missing. He was asking US$4,000 for it. Bill liked the car, and liked the idea of building it. He knew it would be a challenge, but that was part of the attraction. Bill offered him $2,000, and his offer was accepted.

He was right about the challenge. He had to fabricate many of the missing parts himself. Also, this time he wasn't simply installing a new drive system in an existing car, he was building the whole car! The project took him 10 months.

For this car, he used the Advanced D.C. 8 inch (20 cm) motor. The inch size refers to the motor's diameter, and is the common way people identify which Advanced D.C. motor they are using. Advanced D.C. first entered the EV market with a 6.7 inch (17 cm) motor, which was roughly the equivalent of the old Prestolite, with a few improvements.

The 6.7 inch motor proved a little undersized for many applications, so the company introduced the 9 inch (23 cm) motor that Bill used in his pickup. This was a great EV motor, but was actually overdesigned for most compact cars. Next, they introduced the 8 inch (20 cm) motor, and this was the one Bill chose for his kit car.

Again, he stayed with the Curtis/PMC 1221 controller, although by now this was a newer version, the "C" model instead of the older "B" model. The newer model has some added protection for its circuits against damage caused by high current draws at very low speeds. Bill made a more drastic change in his batteries, and switched to Trojan 8 volt batteries. Fifteen of them gave the Bradley a 120 volt system. He had six batteries in front, and nine more in the rear.

The Bradley body rests on a VW Bug chassis, but requires a subframe for the batteries. Building this subframe was Bill's biggest challenge. The rather vague set of plans Bill acquired with the car indicated a flat subframe that ran straight from the front of the car to the rear. However, this would probably bottom out if the car had to drive up an abrupt rise, such as a driveway.

So Bill designed a much more complex two-part subframe, with the batteries in stainless steel boxes. In the very front of the car are two batteries, and behind them are four more, which sit about 2 inches (5 cm) higher than the front two. In the back of the car, nine batteries are divided up, with four on each side and one in the middle. The ones on the sides are staggered, with each battery sitting a little higher than the one behind it. By following the contour of the available space, he was able to allow better ground clearance overall and avoid bottoming out.

The 8 volt battery was introduced by battery manufacturers in response to golf courses that wanted to have 48 volt carts instead of the usual 36 volt versions. The 8 volt battery fit in the same physical case as the 6 volt batteries, but it squeezed in four cells instead of three. Since it was the same size as the 6 volt batteries, it could be swapped with no changes to the cart.

However, the laws of physics just don't allow cramming the same capacity into a smaller space. The 120 volt battery pack in Bill's pickup has 20 batteries in it, five more than the 120 volt pack in the Bradley. The system voltage is the same, but the battery pack weight and footprint is smaller in the Bradley. The range is significantly better in the pickup, because the larger pack of 6 volt batteries simply has more capacity.

Bill also notices a larger voltage drop, which affects acceleration. When the driver presses the throttle to accelerate an EV, the current draw rises sharply and peaks, and the pack voltage drops. As the car comes up to cruise level, the current draw drops off and stabilizes, and the pack voltage climbs again. Since pack voltage is directly related to motor speed, a smaller voltage drop means better acceleration.

A fully charged 120 volt pack will actually show more than the nominal 120 volts. This is related to the "surface charge" on the batteries just after charging. Bill noticed that when he first started out in his 120 volt pickup with the 6 volt batteries, the current on the ammeter would climb to 350 amps and the pack voltage would drop from 130 volts to 110 volts. In the Bradley, which had the same 120 volt system but used 8 volt batteries, the pack voltage fell off from 130 volts to 100 volts at the same 350 amp draw.

The Bradley is now three years old, and has about 2,500 miles (4,000 km) on it as an electric. It has a range of about 55 miles (90 km) on a charge. Although it's the flashiest of the three, Bill only drives it about once a week for pleasure, and takes it to shows. "I'm too worried about what I'd do if something happened to it," he said. "You can't get parts for these anymore. What if a rock hit the windshield?"

All three of Bill's EVs charge from normal 110 volt household current, and get a full recharge overnight. They use home-built chargers made by John Wasylina, one of the early engineering pioneers and geniuses of the hobbyist conversion movement. Each of Bill's cars also has a 12 volt battery to power the accessories, charged by a Wasylina-built DC-DC converter.

What's Next?

Is Bill finished building EVs now? Of course not! Always looking for a bigger challenge, he has set the bar much higher for himself. This time he is building a hybrid. The donor is a Daihatsu Charade. So far, the car is stripped, and Bill is deep into the design stage.

He is building his own motor, a high-rpm brushed DC motor, but he will probably still use a Curtis/PMC controller. In addition, the car will have a 6 hp Honda lawn mower engine, which will only run briefly to help the electric motor under acceleration and high power demand situations. The motor and engine will connect through a chain drive to a gearbox of Bill's own design, attached to the transaxle.

Bill recently saw an electric race car at a show, and the car used nickel metal hydride batteries. These are very expensive, but Bill is hoping he can get some sponsorship from the factory in the form of a good deal on a battery pack for his experimental car. He hopes to have the car finished within a year. Then he'll have to think of something harder to do…

Access

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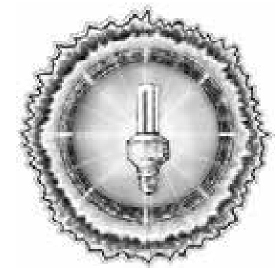

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TOP SECRET

GUERRILLA SOLAR: The unauthorized placement of renewable energy on a utility grid.

PROFILE: 0001 Update

BY MAKA RUKUS AND JENNY FREELY

Home Power asked us to update the guerrilla solar article we wrote for issue #67 (page 34). Our small guerrilla system is made up of an AC module--a Trace MicroSine inverter attached to a 108 watt PV panel. All we had to do was mount the module, run an AC line cord into the building, and plug it in to a standard AC receptacle.

Since we first fired up this system on April 10, 1998, we have put 208,827 watt-hours of solar-made electricity into the utility grid. At our utility rate, that means only about $20 towards paying for the system. So we can't justify this project based solely on economics. Larger systems can come a lot closer because larger installations are cheaper per watt. On the other hand, we fully expected the total output to be greater than 208 KWH.

Our MicroSine inverter has the optional computer interface, which monitors its real-time performance and cumulative watt-hours fed back into the grid. But this capability does no good if it isn't periodically hooked up to a computer. We have to confess that we hadn't monitored our little system in a year. We assumed it was happily working away up there on the roof. But it wasn't!

When we hooked it up to get the cumulative total for this update, we found that the inverter was not feeding power back to the grid, even though it was a bright, sunny day. AC amps and watts both showed zero. The inverter input was showing 40.1 VDC, which should be about open-circuit voltage for the 24 volt nominal module.

But here's the kicker: the MicroSine reported that the AC grid was at about 136 volts. Like any other intertie inverter, the MicroSine will shut down if the grid voltage or frequency is too far out of spec. Our inverter was not putting anything out because it thought the grid was at 136 volts. But the digital multimeter said that the utility line was at 123.9 volts, so obviously the MicroSine was misreading the voltage. Trace sent us a new MicroSine, and we are sending ours back so they can analyze the failure. Trace's tech support sure has improved in the last two years.

Could there be a lot of other intertie inverters out there that aren't working? Instrumentation is crucial, but MicroSines are usually sold without the optional computer interface. Since many owners would not notice a variation in their electrical billing from such a small solar output, they probably don't have a clue about whether or not the inverter is working.

One cheap, non-computer solution for checking MicroSines and other batteryless intertie inverters is to monitor DC voltage at the module. Put a low-cost meter in a convenient spot in the building where you can see it during the day. If the DC volts are within the module's operating range, you can probably conclude that the system is working. If you see open circuit voltage on the meter, the inverter is either off or disconnected from the module. Then you'll need to check the DC wiring. If it's OK, then something is wrong with the inverter. Seeing extremely low or zero volts would indicate a short circuit, most likely a fried inverter.

In spite of our recent technical problems, we are proud to be solar guerrillas. We did it because it is the right thing to do. We did it to show you that you can do it too. We wrote it up for Home Power to stir others to go guerrilla when their utilities give them a hard time.

EV Tech Talk

Mike Brown

I'm going to convert my car to electric. I want to use as many batteries as I can fit. Where do I put them, and how do I keep them in place?

Getting the answer to these questions involves dealing with some variables. You will face the reality of how much battery room is available in your conversion, and how much weight its chassis will support. The variables are:

- Battery pack voltage you need/want
- Type of battery
- Placement of batteries in the car
- Box and rack combination, or racks only
- Battery box material

The first two are major decisions, and beyond the scope of this article. For more details, see articles by Shari Prange in *HP72 & 74.* These decisions will determine how many batteries you need to use.

In general, the most common systems used in conversions have flooded lead-acid golf car batteries, and pack voltages up to 144 volts. For a steel-bodied conversion with freeway capability, we recommend a minimum battery pack voltage of 96 volts, and a maximum of 144 volts. At voltages above that, components such as motors, controllers, DC-DC converters, and chargers are more expensive and harder to find.

For the purposes of this article, let's assume that we have decided on a 120 volt pack made up of twenty 6 volt golf car batteries. Now we'll start trying to find a way to fit them into the car to be converted.

Where?

The ideal place for the batteries would be between the axles, and as close to the ground as possible. This keeps the center of gravity low and centered, which is critical for safety and good handling. However, this is usually the space occupied by passengers or cargo. In most car conversions, you are left with three places where batteries can go.

The first place is under the hood where the engine and radiator were. This area should be considered prime real estate for batteries. Many people make the mistake of mounting every electronic component in the conversion on one large mounting plate, and installing it in the middle of this area, destroying good battery space. It's fairly easy—and appropriate—to mount components ("peripherals") individually around the perimeter of the engine bay. It is nearly impossible to do so with individual batteries, so it is important to preserve any large open areas for groups of batteries.

The second place is under (or in place of) the back seat. The decision to use this space for batteries or keep it for passengers depends on what you need the car to do. If you want to use the space for both passengers and batteries, check to see if the floor under the seat has enough room for the batteries, battery box, and battery rack. If so, sinking the battery assembly into the floor and modifying the seat cushion as necessary is a viable option.

The trunk or hatchback is the third place for batteries. This area has the advantage of usually having a flat floor, where you can cut a hole to sink a battery box and rack assembly into the structure.

In the second and third options, the batteries share space with the passengers. In these cases, a sealed, ventilated battery box with proper hold-downs is required for passenger safety. This applies to cars with trunks also, since a piece of cardboard is often all that

A split-level battery pack makes the most of the available space.

separates the trunk from the back seat, and this is not enough protection.

In a light truck conversion, there is space for batteries under the hood, in a box in the bed, or under the bed between the frame rails on either side of the drive shaft. Even though batteries under the bed are not in contact with the passengers, it is best to put them in boxes to keep the batteries clean. A clean battery is a happy battery.

If you are doing a small van, there might be some room under the hood, but most of the batteries could go in the center of the van under the floor. Another option is putting them in a box on the floor, and upholstering the box to be used as a seat.

There are two important things to remember about battery placement. The first is to keep the mass of the batteries as low as possible to maintain the car's center of gravity for good handling. The second is to distribute the weight of the batteries as evenly as you can to maintain the car's front-to-rear weight distribution ratio. Too much weight in either the front or rear, or placed too high, will make for poor handling and an unsafe car.

How Many?

To determine how many batteries go where, you need to do some calculations and take some measurements. What you discover through these measurements may determine whether or not the batteries are enclosed in boxes, and what material is used to make the boxes.

Let's say we are doing a hatchback car, and start with the area under the hatch. We want to sink the batteries into the floor of the hatch area, for both weight distribution and safety reasons. This means we have to see how big a hole we can cut in the floor without interfering with frame members, brake lines and hoses, emergency brake cables, suspension parts, or the rear axle.

"Without interference" means "without touching." Anything that touches will rub when the car is in motion. Rubbing makes holes, and holes in important places make drivers into pedestrians—or casualties. Make the potential hole measurements both on top of the hatch floor and under the car, where the possible interferences mentioned above are located.

Once you have found the dimensions of a rectangle that clears every obstruction, it's time to see how many batteries you can fit in that space. This is done by dividing the width of the rectangle by the length of your chosen battery. Then try dividing the width of the rectangle by the width of the battery. Do the same calculations for the length of the rectangle (get the battery dimensions from the battery manufacturer, or from the table in one of the articles mentioned above).

This is a rough calculation to determine which way of orienting the batteries allows you to fit the most batteries in the space given. Do you line up your rows side by side, or end to end? This is a rough estimate, and the batteries should not take up all the space inside the rectangle, since we still need room for racks and boxes.

Sizing for Racks & Boxes

Now we do some precision calculations to include the thickness of the battery box walls and supporting racks. Boxes are essential here, since the batteries are in the passenger compartment of the car.

Start the calculations by adding 1/16 inch (1.5 mm) to the length and width of each battery. This is to compensate for the swelling that occurs as the batteries age. Without this extra space, when your batteries finally give up the ghost, you could find them hopelessly wedged into place. Multiply this new battery dimension by the number of batteries in a row across the width of the car. To this total, add another 1/16 inch for clearance between the last battery in the row and the battery box wall.

Next, take the thickness of the material you hope to use for the battery box and double it, since the box will have two opposite walls. If you are considering several different materials for battery boxes, go with the thickest at this point in the process, since space considerations might make your material decision for you. (The thickest material would probably be 5/8 (16 mm) inch plywood.) Add this to the total for the batteries and clearance space.

Now add 1/4 inch (6 mm) to the total to allow for the 1/8 inch (3 mm) radius on the inside of the angle stock used for the rack. This allowance makes it much easier to install the battery box in the rack and have the bottom of the box sit flat on the rack. If this rack is being sunk in the floor of the hatch area as I recommend, it will be bolted to the car's body with bolts through a flange on the top of the rack. We must add twice the width of the flange to the running total. If the rack is being attached to the car in some other manner, you only need to add twice the thickness of the rack material.

You now have the total width of the battery box/rack assembly. Do the same calculations for the length of the proposed battery pack, and you will have the true size of the space required for that battery pack. This dimension (minus allowance for the flanges) is also the size of the hole you need to cut in the floor of the car.

Now compare the rectangle you measured first with the one you just calculated. Does the rack with the mounting flange fit in your original rectangle of available clear space? Does the hole size fit within the clear space rectangle, with room for the mounting flange? Is there clear space under the flange for enough fasteners to hold the rack to the body? The answers to these questions might be easier to find if you cut pieces of cardboard to the size of the flange and hole dimensions and see how they fit in and under the car.

If there is interference with the body in some spot, and it isn't more than 1/4 inch (6 mm), a few clearancing blows with a hammer would not be out of order, as long as it's only sheet metal and not a structural support. As for the brake lines, hoses, or handbrake cables, a little careful repositioning might make a big difference. Go about this process slowly and carefully. Remember: measure twice, cut once.

If your space available is close, but not quite enough, you might want to think about using a different material for your battery box, something that is stronger, so it can be thinner. Box materials include plywood, fiberglass, polypropylene, and metal. We'll get into more specifics about each of these in my next column. This measurement and calculation process is the same for the remaining box and rack assemblies in the car, and will probably be a little easier each time you do it.

Under The Hood

Up front in the former engine compartment, there are some other factors to consider. (Yes, air-cooled VW fans, I know your engine was at the other end.) The battery rack/box dimension measurements should be made with the electric motor and transmission installed on the mounts you have designed for them, with all the shift linkage parts and torque rods in place. It's painful to find a battery sitting where a shift rod has to go when it's too late to change anything easily.

Since you are replacing a large, upright rectangular engine with a small, round electric motor, a fair amount of space is opened up. As I said earlier, this is prime real estate for batteries, but even a dream lot may have a few rocks or trees in the way.

In a front engine/rear wheel drive car or light truck, about all that protrudes into this space is the steering column, sometimes the steering box itself, a few inches of the adaptor and transmission, and the power brake booster/master brake cylinder assembly. This arrangement usually results in one box or rack holding six to eight batteries, and sitting a little offset toward the passenger side of the vehicle. Do your measurements and calculations, and see what fits.

The height of the battery box/rack assembly is an additional factor, since the hood has to close without interference. Sometimes this question is best answered with cardboard mockups. The hood issue is one that needs to be resolved very early in the design process—mistakes made here can be very hard to correct later. Pay special attention to the stiffening ribs on the underside of the hood. They stick down farther than you might think, and will cause trouble if given a chance.

On a front engine/front wheel drive car, you may have a little of the steering column and the power brake/master brake cylinder assembly taking up room. In addition, you also have the transmission and its linkage to work around. This usually leads to a split-level or two-piece front battery pack, with four or more batteries above the motor and toward the rear of the car, offset toward the passenger side. The remaining batteries end up along the front of the car in the space where the radiator usually goes. Don't worry about the different heights of the battery packs and the offset. Our Voltsrabbit's front battery pack is configured like this, and it handles very well.

If space is so tight that the additional thickness of a battery box is too much, the under-hood area is one place where a plain rack with adequate hold-downs is enough containment. The car manufacturers usually go to great lengths to isolate the engine compartment from the passenger compartment. Again, the use of cardboard mockups will be a big help in the design process.

I hope this journey through measurements, calculations, and mockups has helped you determine how many batteries you can use and where they will go. Next up is the actual design and fabrication of the boxes and racks, which I will get into in the next issue. If you are in the middle of the process and can't wait that long, call or email me and I'll see if I can help.

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Bikers Get Charged in Grants Pass, Oregon

Ray Ogden
& Gary Thomas

The authors with the Solar EV charging station and a zippy new generation of electric bikes.

Visitors to the Grants Pass downtown Grower's Market now have another reason to pause. Gary Thomas (The Solar Man) and Ray Ogden of Energy Outfitters recently completed the installation of their Electric Vehicle Solar Charging Station. The combination bike rack and solar charging station was donated to the city of Grants Pass by the two companies to encourage the use of alternative forms of transportation.

The new generation of electric-assisted bicycles are a wonderful solution for those short excursions to the market or post office. Ray says, "I can be across town before you ever get your car out of the garage." If we can get the general public to give more thought to the transportation options that are available, maybe we can get some folks to leave the gas burner at home when they run to town.

These new bikes are a far cry from the old gas-powered moped of yesteryear. The recent advancements in battery technology and sophisticated electronics provide a level of performance that is often surprising to new riders. "When people see me and my wife on these bikes, they call us cheaters," said Gary Thomas. "I say, 'Yeah we're cheaters alright—we're cheating the oil companies!'"

The bike rack was constructed from locally available materials by The Solar Man. The electrical equipment was supplied and assembled by Energy Outfitters. Power is supplied to the charging station by two Siemens SR-50 PV modules. Regulated 12 and 24 volt outlets are provided at the charging station to match the power requirements of the vehicle being charged. Two B.Z. Products 8 amp pulse width modulated (PWM) charge controllers regulate the voltage, one on each system.

This is only the beginning. We have plans to install a number of these racks around town, depending on sponsorship. If EVs become popular with the general public, free charging stations could be a great way for businesses to attract customers. And with gas prices approaching US$3 per gallon in some parts of the country, it is only a matter of time.

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Word Power
Renewable Energy Terms

Ohm's Law—Basic Electrical Equation

Ian Woofenden

Derivation: Named for Georg Simon Ohm, 19th century German physicist and mathematician. Ohm made key discoveries about the nature of electricity.

In previous columns, I've covered volts, amps, and ohms. Now it's time to talk about all three together, and their relationship to each other. Voltage is electrical "pressure"—it's the push that makes electrons move. Amperage is the *rate* of electron flow—the number of electrons per second passing a point. An ohm is the unit of electrical resistance—the "drag" on electron flow.

Or as a friend in Texas says about her grandson, "Volts are Matthew's determination, amps are how quickly he can get to where he is trying to go, and ohms are his denim pants and the carpet, which slow down his crawling considerably."

There is a direct relationship between volts, amps, and ohms that is fundamental to electrical theory. It is described in what we call *Ohm's Law.* Written as an equation, it's generally shown as **E = I x R.**

E in the equation stands for "electromotive force"—voltage. **I** stands for electrical "intensity"—amperage. And **R** stands for resistance—ohms (Ω). So the equation could be written **V = A x Ω,** or volts equals amps times ohms.

If it's true that **E = I x R,** it's also true that **I = E ÷ R,** and **R = E ÷ I.** Take a look at the diagram below. Cover any one of the three elements of the equation with your finger—this is the element you are trying to solve for. The remaining two elements give you the rest of the equation. If one element is above the other, divide the top one by the bottom one. If the remaining two elements are beside each other, multiply them.

So if you cover the **I,** you are left with **E** over **R.** This means that **I = E ÷ R,** or in other words, that amperage equals voltage divided by resistance.

Play around with the equation and the diagram, and try to get your brain around the concepts. It should improve your understanding of basic electrical principles. It takes time to grasp what this equation is saying, and there's no substitute for thinking it through repeatedly.

Practically speaking, Ohm's Law tells us that higher voltage gives us more push, and that we can move more electrons with this higher pressure, given the same resistance. It also tells us that lowering resistance is key, since the electron flow at a given voltage is directly proportional to the resistance in the conductors.

If Matthew's determination increases, his grandma better not leave the breakables within reach for very long. And he may soon figure out that if he gets rid of those pants that are dragging him down, he'll outrun his grandma more often. Ohm's Law does have some technical exceptions, as does Grandma's. But I'll leave bending these laws to serious electrical nerds, and to Matthew.

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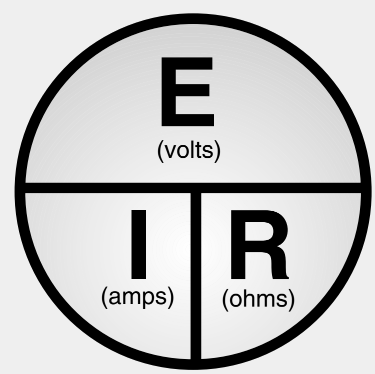
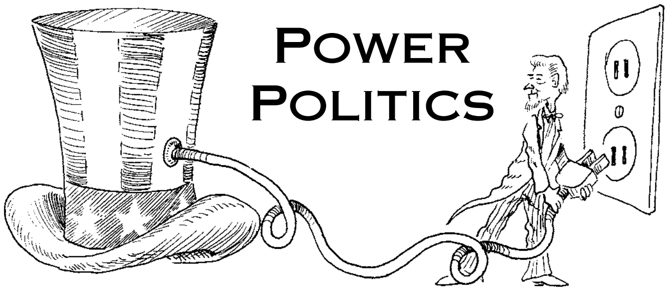


Ohm's Law



Support Renewable Energy Education

Michael Welch

The past year has been good to the renewable energy (RE) industry. Manufacturers, distributors, and dealers are doing well. Meanwhile, governments and utilities have gone about as far as they can go with RE education. I think RE non-profits are the real hope for the future of renewable energy, and these groups should be supported by RE companies and users. It's time to turn some of the industry's good fortune into RE education and advocacy to continue growing the industry.

Good Times for RE

More systems have been installed and more solar modules sold in the last year than in any previous year. Sure, Y2K fears had an effect on the record sales, but I am hearing that many dealers continue to do well. I attribute this to PV prices steadily dropping over the last several years, and to end users with larger disposable incomes. More of you have been willing to invest in RE projects for your home than ever before.

The RE industry and its consumers make up a very unique portion of our society. Both of these segments are interested in RE for similar reasons, the most important of which is concern for our environment. RE businesspeople started their companies because they wanted to make their living in an industry that they believe in—one that helps our environmental future. Customers are buying from them for the same reason.

Citizens, environmental groups, and activists are discovering the connection between energy and the environment. They are realizing that RE is not the energy of the future, but is available now, and is becoming affordable. We are on the verge of the cost breakthroughs that we have been wanting for years. Now the larger public needs to become ready to use RE.

Education is the Key

It is time to shift educational efforts into high gear, so the public will be knowledgeable enough and ready to buy into home-scale RE when the price is right. If we wait to educate until the price has come down enough to create more demand, we will be stuck with a significant lagtime as people slowly learn about RE via the market.

The more the industry and activists get out there and spread the word, the more end users will receive it. As businesses begin to see the financial benefits of RE education, they will be in an even better position to support still more educational projects. And as a growing number of RE equipment buyers begin to see price breaks within the RE industry, they too will be more willing and able to support RE education.

We will eventually see exponential growth for RE, on the home scale as well as on the utility scale. I am looking for ways to accelerate this growth. *Home Power* magazine has been working for RE expansion for over thirteen years. But not that many folks are exposed to our rag, so we alone cannot make that exponential growth happen. We need to hit the mainstream.

Community Takes Over

For too long we've relied on the government and the utility industry to take the lead in bringing the public into our fold. But government is too slow to move, and suffers from too much special-interest influence to get the job done right. And the utilities are extremely fickle about their support for RE. We still need to get governments and utilities on board, but there are other important baskets to put our eggs into.

Some government programs as well as recent media coverage about the international carbon dioxide crisis have helped the larger non-profit environmental and social justice groups to understand how important RE is. As the big non-profits slowly come on board, they encourage others. Individual activists get re-inspired, and more support goes to the smaller, local groups.

Put Your Money Where Your Mouth Is
The time is right for both the sellers and the users in our industry to start supporting non-profits and projects that can accelerate our renewable energy future. The RE industry is doing better than in years past, and consumers have more disposable income. So let's divert some of our money and "invest" it with the organizations that can do the most to promote RE.

We'll see a double return from this type of investment. First and most important, the environment will do better from the increased energy awareness and change in energy production. Second, as increased demand results in new and more efficient manufacturing, we will see a corresponding decrease in the prices of PVs and RE equipment.

If every *Home Power* reader gave $200 per year to help educate the public about RE, more newbies would begin to buy RE products. This would result in increased production and production efficiency, which means lower prices to the end user. You may find that you save more on your next PV purchase than the $200 you invested. What a deal!

Support Local Efforts First
So how can we make our investments best serve the RE future our world so desperately needs? I've come up with a three-pronged strategy. First, support your local grassroots organizations that are working on energy-related issues. If you are not sure who they are, call a local or regional RE installing dealer for a referral. If that doesn't help, drop me a line and I will try to find groups in your area.

Find out what projects are being worked on by your local groups, and encourage them in their efforts to educate and energize the public about RE. Some particularly effective projects are energy fairs, community workshops, and mobile RE systems set up to power events. People really get excited about solar-powered sound stages and events, though they are not easy or cheap to organize.

Much of the public has been brainwashed to think that solar doesn't work. When someone shows up with a PV system on a trailer to power an entire concert in the park, there is almost always a stream of curious and interested people. Redwood Alliance built a small garden cart with batteries, an inverter, and a couple of PV modules. It drew so much interest at a recent craft fair that by the end of the day, I was hoarse.

Another idea is to work with a local granting agency. Most urban and semi-rural areas, and many rural areas, have community foundations set up to help match donors with local non-profits. You might set up an RE-focused fund within that foundation that would attract other donors, thereby increasing the potency of your own investment. I do realize that many of us are not in a position to help financially. But remember that the same local groups that could use your funds will also value your donated time and energy.

Big RE Groups
The second most important facet of my three-pronged strategy is support for the national and international groups that recognize the importance of an RE future. See below for a partial list of larger groups that are doing good work. If you decide to invest in their efforts, be sure to let them know how important you believe RE is to our world's future.

Another sub-strategy would target those groups that should be working on RE issues but are not, or are barely scratching the surface. Let them know that you are a new supporter, and that if they want to keep that support, they should start working on important energy issues.

Keep Fighting the Bad
Finally, we need to do everything we can to overturn the chokehold that non-renewable industries have on us. That means not only supporting the groups that are pro-renewable, but also supporting those with "anti" missions focused on eliminating dirty energy technologies. These groups are keeping the reasons *for* renewable energy crystal clear, and at the same time making sure that environmental degradation is kept to a minimum until RE gains its foothold.

Some of My Favorites
Over the years I've developed a liking for several organizations that do excellent work. There are many other groups out there that work on energy-related issues, and you may prefer to support them over my own favorites. I decided that energy was the area for me to concentrate my activism and monetary contributions, but I also help out groups local to me that work on other important environmental and social justice issues. Here are a few of my favorite national and international groups. Please support them and let them know how important their work for a safe energy future really is.

The Committee For Nuclear Responsibility: This non-profit, educational group provides independent analyses of the health effects and sources of ionizing radiation. John Gofman, founder and director, is a well-known physicist and physician who has done much to publicize the effects of ionizing radiation.

Public Citizen's Critical Mass Energy and Environment Program: Ralph Nader founded this subgroup of Public Citizen. The organization has been a powerful voice for protecting natural resources by promoting renewable and energy efficiency technologies, watch-dogging nuclear safety issues, stopping the reckless disposal of radioactive waste, and ensuring that environmental and consumer interests are protected.

Union of Concerned Scientists: This non-profit augments rigorous scientific analysis with innovative policy development and tenacious citizen advocacy to make positive, tangible improvements in people's lives, mostly in the realms of energy policy and nuclear weapons issues.

Safe Energy Communication Council: This organization educates the public and the media about energy efficiency and renewable energy's potential to produce a larger share of our nation's energy, as well as the economic and environmental liabilities of nuclear power. They provide local, state, and national organizations with technical assistance through media skills training and outreach strategies.

The Greens: This political party works mostly on the grassroots level with decentralized groups of activists throughout the world. They have a very strong platform for RE, and are running Ralph Nader for President of the United States.

Nuclear Information and Resource Service: This fine organization is the premier information and networking center for citizens and environmental organizations concerned about nuclear power, radioactive waste, radiation, and sustainable energy issues.

I hope you will consider my suggestions in this column. We are often deluged by non-profits looking for our support, but RE education is critical to the growth of the industry and the resulting benefits. It is just as important as any other cause you can think of.

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Don Loweburg

PVUSA— End of an Era?

Photovoltaics for Utility Scale Applications (PVUSA) has a two megawatt PV test facility located in Davis, California. Now over twelve years old, the US$40 million facility is about to be closed.

Initially funded by the Department of Energy and utility ratepayers, the site has been under the stewardship of the California Energy Commission for the last three years. This May, the commission announced the imminent closure of the site unless a new sponsoring agency could be found quickly. Ideas for saving the site include municipalization by the city of Davis or purchase by a green energy provider. So far, no strong option is apparent, and some in the PV industry fear that the site will be scrapped.

During the last three years, the site's mission has shifted from its original purpose, utility-scale PV research and demonstration, to small-scale residential and commercial PV systems. New activities at the site include testing rooftop PV systems and small to mid-sized inverters. In addition, workshops for PV installers and building inspectors have been offered. Unfortunately, in the absence of outside grants or governmental funding, these activities generate insufficient revenue to cover operating expenses.

Carrizo Repeat?

Two hundred miles south in California's Central Valley, not far from Fresno, another PVUSA site languishes. The 500 KW Kerman PV plant, also funded by taxpayers and ratepayers, is operated by Pacific Gas and Electric (PG&E). It has been out of operation for about a year. This project, completed in mid-1993, was intended to demonstrate the value of utility-scale distributed generation (DG). Repeated failures of the two 275 KW inverters used at the site and their high cost of repair or replacement fuels speculation that the utility does not intend to put the plant back in service. One source indicated that PG&E was trying to sell the facility.

At first glance, it seems that selling Kerman and PVUSA could be a viable proposition. Since power generation is now deregulated in California, a "green" power marketer could purchase these sites and offer PV power in their energy mix. There are two big hurdles that may keep this from happening. First, these sites are damaged goods. Neither is fully functional and each will incur significant repair expenses before it can be functional. But a far greater obstacle to marketing the PV power from these plants is the fact that any new owner will be held hostage by the utility distribution company (UDC)—PG&E in this case.

Every KWH of PV power that departs these plants will have a monkey on its back in the form of a 4 cent per KWH surcharge called the competitive transition charge (CTC). The CTC must be paid to the UDC, and raises the price of already expensive green PV power. The CTC is a part of California's deregulation legislation intended to recover the utilities' "stranded" assets. The CTC is, by design, a willful monkey wrench favoring the utilities' "brown" power in the deregulated market.

Predating the troubles at PVUSA is the failure of the Carrizo Plains PV project near San Luis Obispo, California. This 6 megawatt utility-connected PV power plant was installed by Arco Solar in the early 1980s. It also received public subsidy in the form of a 40 percent federal tax credit. Due to the use of reflectors, the PV modules turned brown, resulting in a significant loss of power. Low power output and the miserable "avoided cost" contract with PG&E made operation of the plant uneconomic.

The plant was sold as salvage shortly after Siemens, the German industrial giant, bought Arco Solar. Many of us in the PV business can recall the disruption in the market for PV modules as the heat-damaged, low output "lams" flooded the market. I wince at the thought of a repeat of that.

What Went Wrong?
Is utility-scale PV a total failure? I think so. But some good things that are applicable to small-scale and commercial-scale PV came out of the tests. Some bright engineers were employed and some good work was done. The basic PV module architecture we see today was proven in these projects. The encapsulant-yellowing problem was eliminated. The understanding that reflectors would void module warranties was established. The importance of a good weathertight junction box was demonstrated.

However, these results do not justify the millions of dollars squandered and the scale of these utility projects. The failure is not really that of the utilities, though. It should be no surprise that they will eagerly feed from any taxpayer or ratepayer-funded trough.

The failure is one of vision. Specifically, the vision that utilities are the natural market for PV power. A primary perpetrator of this failed vision has been the Department of Energy, its planners, and the politicians who control its funding. This is the same bunch that pushed nuclear energy and the nuclear utilities on the American public a decade earlier.

How ironic that we must now bail out the nuclear utilities, and in so doing create market barriers for renewables in the form of CTC charges. (As I write, the Diablo Canyon nuclear power plant near San Luis Obispo, California enters it fourth day of "hot shutdown" after emitting a cloud of "slightly" radioactive steam.)

What Does It Take to Get It Right?
How do we avoid repeating the mistakes of the past? Certainly a first element must be the correct overall vision or model. That model for renewables, and especially for PV, is distributed generation. A recent article in the June 2, 2000 issue of the *San Francisco Chronicle* indicates that the DOE may now be getting it right. The headline is "Energy Secretary Says Utilities Hinder Use of Small Generators."

The article begins: "U.S. Energy Secretary Bill Richardson said utilities are hindering the use of small generators such as fuel cells, small gas turbines, and solar cells, which allow consumers to produce their own electricity." Richardson noted that blackouts and the associated economic losses "could be avoided if the barriers to distributed generation were removed."

Distributed generation represents both a structural and technical transformation. When the source of generation is located at the load, the maximum value is delivered to the owner. With DG, we now refer to the customer-generator, a new entity that didn't exist in the old consumption based central-generation model.

Customer-generators own the generation resource and benefit directly from its wise use. So they have incentives to exercise options that are neither attractive nor available to others. For example, in an electricity market that is based on real time-of-use pricing, customer-generators could choose to shed load at critical times and improve building and appliance efficiency. This would allow them to develop saleable electric capacity during periods of peak pricing.

Political Will
An important second element in a transformation to renewable energy is a political will and consciousness on the part of citizens. But this is difficult to develop. First, many Americans don't think energy is or should be political. And second, when presented with a political choice regarding energy matters, many vote against their own self-interest.

For example, last year Californians voted overwhelmingly to retain the bailout surcharge tacked onto their utility bills (the CTC). California utilities spent over US$40 million essentially bullying voters with the message that if the CTC were rescinded, utilities would pull the plug on California. Consumer advocates spent about US$100,000 advocating the abolition of the bailout.

Energy is profoundly political. Though we seldom see energy issues on the ballot, behind the scenes lobbying by the petroleum, gas, and utility industries is incessant, and amounts to hundreds of millions of dollars each year. And as the example above demonstrates, politicizing energy issues and getting them on the ballot is no guarantee of a successful outcome. So besides political will, we must have the right political consciousness.

As an example of the difference that political consciousness can make, look at the successful PV programs in Japan and Europe. In both regions, the government has incentives for the use of rooftop and building integrated PV (BIPV). These programs deliver benefits to the end user, and the result is that now the United States lags behind both places in PV utilization.

A PV colleague recently returned from a trip to the Netherlands. He reported that 20,000 PV systems were installed there last year, in a country with about the same population as the San Francisco Bay area in California. Could the fact that about 25 percent of the voters in the Netherlands are Greens have anything to do with this situation?

The Third Leg
A third major element in the transformation to renewables is unfettered access to the electric distribution system. The distribution system (wires) is

now owned and operated by local utilities. Deregulation has changed nothing here. Since the local utility may still generate power, it will be competing with independent generators, including self-generators. Additionally, a utility distribution company that has no generation still gains revenue based on the amount of electricity transmitted. Again, self-generation at the customer's site would reduce utility revenue.

These are not abstract concerns. Utilities, reacting to self-generation and competitive generation efforts, are levying bypass charges, standby charges, and even "departing load" charges. Utilities are engaging in anti-competitive practices and abusing their utility franchise in order to harm competing technologies. Commercial PV projects located at customer sites in California are being economically hurt by these utility practices right now. These are not theoretical legal concerns, but rather economic realities that can make or break the viability of a PV project in the commercial sector.

You Can Make a Difference

In my last column, I included information about an ongoing California Public Utility Commission hearing in California addressing distributed generation. The Order Instituting Rulemaking (OIR) is designed to present facts like the above to the commissioners with the intention of curbing onerous utility practices.

IPP is working with a coalition of parties (Photovoltaic Distributed Generation Coalition) presenting testimony before the commission. We again ask for contributions to fund this effort. This project is very important to the future of PV, not just in California, since the outcome here will have ramifications in other states. Make checks out to IPP, with a memo "OIR."

Julia Butterfly Hill—
personal action equals personal responsibility.

30,000 passed under the banner in Concord, California.

Earth Day 2000

During the month of April, Earth Day celebrations were conducted throughout the country. This year is noteworthy because it was the thirtieth anniversary of the first Earth Day, and there was a significant emphasis on renewable energy at the many celebrations. In northern California, two major PV installations were commissioned during this anniversary year. One is a 32 KW system located at the Feltzer Winery in Hopland, California. The second, an initial 10 KW of a 100 KW system, was installed on the roof of the new Powerlight factory in San Pablo, California.

The Earth Day event in Concord, California (near San Francisco) featured a large "green power zone" sponsored by the California Energy Commission (CEC). Exhibitors included renewable energy marketers, renewable electricity generators, manufacturers, several IPP members, and an electric vehicle section.

The CEC also had a booth where they answered questions and passed out information on their Emerging Renewables rebate program. It's been a while since the California public has had the opportunity to see this much renewable energy hardware and information in one place. These efforts by the CEC that get information and benefits directly to the people represent a good example of how government can effectively support renewables.

Non-Violent Action

The Concord Earth Day also featured music, speakers, and food booths. The keynote speaker for the day was Julia Butterfly Hill. She had just come down from an old growth redwood tree in which she had lived for over two years.

Her personal action saved the tree named Luna from being killed, and helped raise national awareness about the damage done by old growth logging. In the course of her occupation, she withstood storms, personal discomfort, threats to her life, and harassment from loggers threatening to cut the tree down. Her message was simple. Personal non-violent action is the key to changing the world. Think about it, and act.

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Buydown Information: 800-555-7794, or for weekly funding update call 800-900-3594

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www.cpuc.ca.gov/dg-r9910025 • Order Instituting Rulemaking (OIR), making new rules for DG

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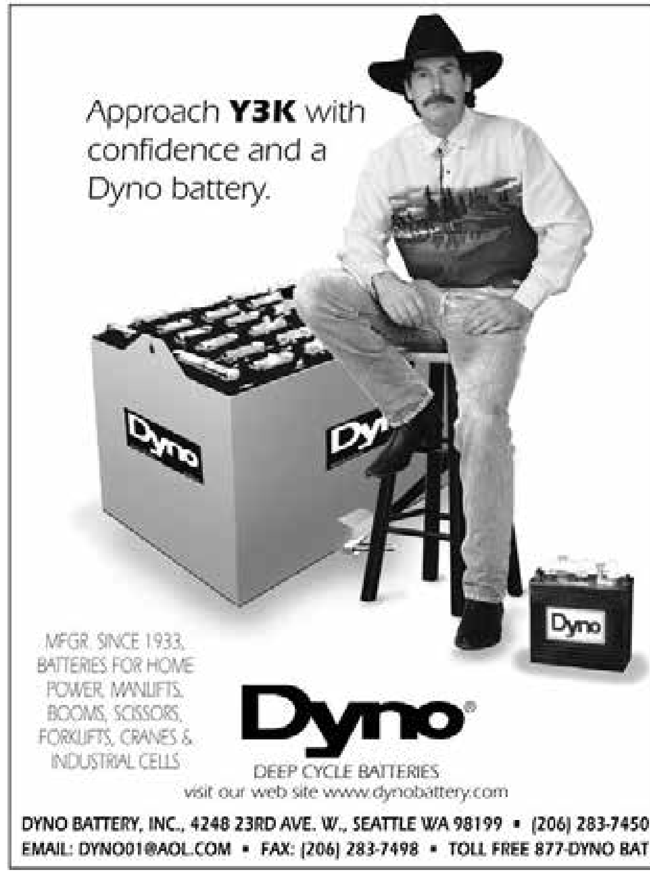

How Big?

John Wiles

Sponsored by the Photovoltaic Systems Assistance Center, Sandia National Laboratories

Power conductors in renewable energy systems range from #18 (0.8 mm^2) through #4/0 (107.2 mm^2), and up to the largest in the range of 300 kcmil (210 mm^2). The task of this column will be to discuss how the ampacity of conductors is determined in a particular installation or situation.

Conductor size in the United States is measured (with no insulation) in AWG, which stands for American Wire Gauge. The larger the AWG number, the smaller the conductor. A bare copper #18 (0.8 mm^2) conductor has a diameter of about 0.04 inches (1 mm) and an area in circular mils of about 1,620. (I didn't make this up. A mil is 1/1,000 of an inch, and a circular mil is an area calculated by the diameter in mils squared.)

Insulation on the conductor will make the overall conductor larger, and the exact size will depend on the type of insulation used. Conductors larger than #1 are numbered #1/0 through #4/0. (These are the same as 0 and 0000 and are pronounced "one aught" and "four aught".) Conductors larger than #4/0 are numbered by their area in thousands of circular mils (kcmil), starting with 250 kcmil (170 mm^2). Here is a table of the commonly used conductors, their diameters, and areas in square inches and circular mils.

Metric wire sizes use the cross-sectional area as their designator. Ideally, European conductor size equivalents should be made based on equivalent rated ampacity, not conductor sizes translated from inches to millimeters. If in doubt, use a metric size that is larger than the AWG equivalent. And make sure that the rated ampacity of the cable meets local codes for your intended application.

How Good Is That Cable?

The current-carrying capability (ampacity) of a conductor is related to how hot the cable insulation is allowed to get. The toughness of the insulation, its flexibility at cold temperatures, and its aging properties under various conditions (UV, oil, water, etc.) are also important parameters in establishing the quality of an insulated conductor.

The International Cable Engineers Association (ICEA) works with the cable manufacturers to develop standards for cable insulation. Their goal is for cables in normal installations to last more than twenty years when operated at the maximum temperature in specific environments that apply to that particular insulation. The ICEA Standards are then transferred to an independent party, Underwriters Laboratory (UL). They develop testing standards that enable independent testing agencies (UL, ETL, and only a few others) to test various cables to ensure that they meet the safety and durability standards.

The tests on a particular cable by a specific manufacturer must be repeated periodically (typically every three months) to ensure that the cable continues to meet the standards. This process of testing and retesting to a standard by an independent agency like UL is the process called "listing." It results in some sort of safety seal—such as the "UL in a circle" mark—being affixed to every product that meets the standard. Without this or a similar mark, there is no way of telling that the cable is safe to use in a particular application. Without continued testing, there is no way to ensure that the cable, as manufactured, continues to meet the standard.

Common Wire Sizes

*Size**	*Diameter in inches***	*Area in inches^2*	*Area in circ mils*	*Area in mm^2*
18	0.040	0.001	1,620	0.823
16	0.051	0.002	2,580	1.309
14	0.064	0.003	4,110	2.082
12	0.081	0.005	6,530	3.308
10	0.102	0.008	10,380	5.261
8	0.128	0.013	16,510	8.367
6	0.184	0.027	26,240	13.299
4	0.232	0.042	41,740	21.147
3	0.260	0.053	52,620	26.670
2	0.292	0.067	66,360	33.624
1	0.332	0.087	83,690	42.406
1/0	0.372	0.109	105,600	53.482
2/0	0.418	0.137	133,100	67.433
3/0	0.470	0.173	167,800	85.014
4/0	0.528	0.219	211,600	107.219
250*	0.575	0.260	250,000	170.000
300*	0.630	0.312	300,000	210.000

*All sizes are AWG, except for the last two, which are in kcmils.
** For copper only, no insulation, single conductor through #8 AWG, then stranded for larger conductors.

The use of untested, unmarked conductors or conductors marked for other applications is, at best, a violation of the requirements of the *NEC.* At worst, it can create safety hazards that may result in property damage or loss of life.

Conductor Temperature Ratings

Conductors that are commonly available for use in PV systems were discussed in this column in *HP76 & 77.* These conductors come with insulation temperature ratings of 60°C (140°F), 75°C (167°F), and 90°C (194°F). These ratings determine the maximum temperature that the conductor insulation is allowed to reach. Insulation is heated from the heating of the copper conductor by current flowing in it, and from the temperature of the surrounding media (air, conduit, earth, etc). The presence of other nearby conductors also affects the temperature of a particular conductor.

Ampacity

The basic ampacities of conductors are listed in numerous tables in the *NEC.* Conductors in free air are addressed by Table 310-17. Conductors in conduit are covered in Table 310-16. The basic ampacity tables present the current ratings as a function of conductor size and insulation temperature rating at an ambient temperature of 30°C (86°F). The basic ampacities (at 30°C (86°F) and unmodified by temperature or other considerations) require that there are no more than three current-carrying conductors grouped together or installed in a conduit.

From this starting point, there are a number of rules that must be applied to determine how this initial ampacity is modified to determine the ampacity of the conductor in a particular installation. I encourage you to obtain a copy of the *NEC* to ensure that all conditions are met for determining the ampacity of a specific conductor in a specific application. The many rules are too numerous and too detailed to cover here, but I'll mention a few of the more commonly used ones:

- Ambient temperatures above 30°C (86°F) decrease the basic ampacity; temperatures below 30°C increase the ampacity.
- More than three current-carrying conductors grouped together (bundled or in a multiconductor cable) or installed in a conduit reduce the ampacity.
- Conductors operating in more than one ambient temperature have special requirements.
- #14, 12, and 10 (2.1, 3.3, and 2.6 mm^2) conductors have additional restrictions on maximum ampacity.
- Some installation methods (such as aerial feeders or tray cable) require special calculations.
- The temperature ratings of terminals, fuses, and circuit breakers connected to conductors may reduce the ampacity.

An Example of Code Complexity

Here is an example of what might be involved in determining the ampacity of the PV array output conductors on a residential system. Exposed, single-conductor #10 (2.6 mm^2) USE-2/RHW-2 is run from the modules to a combiner box. The conductor then runs in conduit (four conductors in the conduit for two circuits) through an attic, and down through the house to a basement power center.

The combiner box (in an ambient temperature of 40°C; 104°F) has fuses in it, and the power center has a circuit breaker (both have terminals rated for 75°C; 167°F). The basement is always a cool 22°C (72°F), the attic reaches 50°C (122°F), and the module junction boxes and backs of the modules are at 70°C (158°F). The outside temperature is 40°C (104°F). More than 10 percent of the exposed single-conductor cable from the modules is routed along the backs of the PV modules.

The temperature rating of 75°C (167°F) for the fuse and circuit breaker terminals limits how hot the conductor can be at those connections (Section 110-14(c)). The insulation temperature cannot exceed 75°C from a combination of the current flowing in the conductor and the ambient temperature at the location of each terminal or device.

This might indicate that we could use a conductor with a 75°C insulation to save a few pennies. However, this same conductor must operate near the backs of the modules and in the module junction boxes where the ambient temperatures are 70°C (158°F). The 75°C conductor temperature limitations for ambient temperatures this high dictate that the 90°C (194°F) cable specified (USE-2/RHW-2) be used and that 75°C rated cables would be inappropriate.

If we start in the basement, the basic 30°C (86°F) ampacity of this cable (#10 (2.6 mm^2) USE-2/RHW-2) is 40 amps *(NEC* Table 310-16). It is then increased by a factor of 1.04 because of the 22°C (72°F) ambient temperature (Table 310-16), and is decreased by a factor of 0.8 because there are four conductors in the conduit (Section 310-15(b)(2)(a)). This gives a modified ampacity of 33 amps (40 x 1.04 x 0.8 = 33 A). However, there is a note to the ampacity tables (see Section 240-3) that states that #10 conductors may not be used with overcurrent devices at more than 30 amps, which further restricts the maximum current we can run through the conductor.

When the ambient temperature is 30°C (86°F), a #10 (2.6 mm^2) conductor with a 75°C (167°F) rated insulation can handle 35 amps and stay below 75°C (Table 310-16). This comparison allows us to evaluate the temperature of the USE-2/RHW-2 90°C (194°F) conductor as it is connected to the circuit breaker terminal that is rated for a maximum temperature of 75°C. The circuit breaker terminal temperature is not exceeded because we keep the current below 35 amps due to the 30 amp limit on #10 conductors mentioned above.

In the hot attic (50°C; 122°F), we derate the conductors for temperature by a factor of 0.82 (Table 310-16) and for four conductors in conduit by a factor of 0.8 (Section 310-15(b)(2)(a)). The derated ampacity becomes 26 amps (40 x 0.82 x 0.8 = 26 A).

For conduit outside the house (preferably shaded) where the ambient temperature is 40°C (104°F), the derating factors result in an ampacity of 29 amps (40 x 0.91 x 0.8 = 29 A).

The single-conductor, exposed cables from the combiner box to the modules operate in a temperature of 70°C (158°F) as they are routed along the backs of the PV modules and into the module junction boxes. Because they are exposed (in free air), the basic 30°C (86°F) ampacity is 55 amps and the temperature derating factor is 0.41, yielding an ampacity of 23 amps (55 x 0.41 = 23 A) (Table 310-17). However, if they were grouped together in a set of four after coming out of the junction box, an additional factor of 0.8 should be applied, reducing the ampacity to 18 amps (Section 310-15(b)(2)(a)).

The temperature in the combiner box (in the shade) will be 40°C (104°F), which is the same as the ambient temperature. Again we have to evaluate the 75°C (167°F) rated terminals on the fuse. In this case, the ambient temperature is above 30°C (86°F), and the higher temperature contributes to the heating of the terminal. If the circuit currents are kept below 31 amps (35 x 0.88 = 31 A), the terminals will stay below 75°C (167°F) (Table 310-16).

First we have to determine the minimum size of the conductors based on the *NEC* requirements for ampacity. Then we should look at voltage drop, which is not an *NEC* requirement, although it is mentioned in the *NEC* as a suggestion. Voltage drop is a subject all by itself, and there are many opinions on how the calculations should be done.

Summary

Confusing, isn't it? We made ampacity calculations on this run of #10 (2.6 mm^2) USE-2/RHW-2 that resulted in ampacities of 33 amps, 30 amps, 31 amps, 29 amps, 26 amps, 23 amps, and 18 amps. The *NEC* requires that the lowest figure be used. In this case, that would be 18 amps or 23 amps, depending on how the exposed conductors were routed. In installing PV systems, the difficulty of these calculations is not great. However, finding all of the applicable requirements takes time and familiarity with the code.

There are additional requirements that might apply to a particular PV installation. A team consisting of a PV-familiar person (PV vendor/designer) and a code-familiar individual (electrician) makes for safe, reliable, and durable PV installations. In the next *Code Corner,* we will work the ampacity problem from the other direction, and address the circuit currents and how they are determined.

Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems following the requirements of the *NEC,* feel free to call, fax, email, or write me at the location below. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work was supported by the United States Department of Energy under Contract DE-AC04-94AL8500. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

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The 1999 *NEC* and the *NEC Handbook* are available from the NFPA, 11 Tracy Dr., Avon, MA 02322
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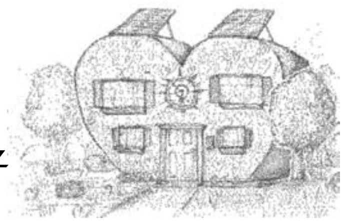
Home & Heart



Kathleen Jarschke-Schultze

As the Renewable Energy Appliance Queen, I am often asked just which brand and model of appliance is best. This includes (but is not limited to) clothes washers and dryers, dishwashers, vacuum cleaners, microwaves, irons, and toasters. Frankly, I don't know which ones are best. I only know what I have chosen for our off-grid home, and why.

Eye on The Prize

To decide on the right appliance for your RE home, you will need to consider the components of your RE system. What size of inverter do you have? Is the waveform square wave, modified sine wave, or full sine wave? How many amp-hours does your system produce in an average day in each season? How much of that do you already use? How often will you use this appliance, and for how long?

Some appliances will not work properly on square wave or modified sine wave inverters. This is actually a fairly common occurrence with appliances that have triacs or thyristers in their circuitry. One way to determine whether an appliance will operate on square or modified sine wave power is to call the service department of the manufacturer and run through the layers of repair technicians until you find someone who knows what an inverter is. It can be frustrating, enlightening, or both.

When troubleshooting an appliance and talking to a repair technician, remember that all situations you describe are hypothetical. The sad truth is that many warranties are void if the appliance is used on an RE system. It may not state that on the warranty, and I'm sure you could engage in a long drawn out grievance with the company and maybe get some satisfaction. But I have found it best not to mention RE when exercising a warranty. Grill the techs mercilessly before you buy any appliance. Don't let them tell you they don't have answers to your questions. They have the resources to find out.

Practically all appliances will run on a full sine wave inverter. Since we use a sine wave inverter, the Trace SW4024, I haven't had a problem with any appliance's electronic brain. The power coming from an inverter is often more stable than the power coming from the grid.

Research

For each and every appliance you buy, there are questions you have to answer first. If you have power or water restrictions, they must be identified. If the appliance will use water, what psi (pounds per square inch) does it require to function properly? For example, my dishwasher does not run enough water through our on-demand water heater to start the heater, so I have to temporarily turn on another faucet.

What do you expect and need the appliance to do for you? Is it worth the eventual cost? The monetary cost might include a bigger inverter, more batteries, and more panels. Maybe you will have to run your generator to power the appliance. This means fuel, maintenance, pollution, and noise.

Info Plaques

On every electricity-using appliance there is an info plaque that you will need to decipher. Bob-O trained me to find and read it before buying any appliance, large or small. The info plaque can be found on the edge of the open door or on the back or bottom of the appliance. It will tell you the model number, serial number, motor amps, heater amps (if any), and combined total amps. The volts and hertz (Hz) are also listed.

LISTED
8C71

Sunbeam-Oster Company, Inc.
Automatic Breadmaker
MODEL5811
5.25 A, 120 V, 60 Hz, AC Only
FOR HOUSEHOLD USE ONLY
Style # BM-100

Formula for Success

You need to multiply amps by volts (usually 120 V) to get watts (see *Back to Basics, HP29).* For example, if a motor draws 8.6 amps at 120 volts, the appliance will draw 1,032 watts (8.6 A x 120 V). You'll have to determine whether your system will support an appliance for the frequency and duration of intended use.

There is usually an installation manual and owner's manual stuffed between the machine and countertop on under-counter models, or in a plastic bag inside the machine itself. Take some time and leaf through both. This is a good place to find the manufacturer's repair or information access data.

Gas clothes dryers and cookstoves sometimes have a glow bar instead of a pilot light. Some stay on all the time, producing a phantom load in your system. Others come on when you start the appliance. If your cookstove has a glow bar for the oven ignition, you may not be able to use a match to light the oven if your system is down. Sure, RE systems are very reliable, but there are always natural causes such as lightning, floods, etc., that could shut down your power system.

Sales Support
Most salespeople are of two minds when you pre-shop. They may be interested enough in the fact that you live on renewables to try to find the information you need. Or they may write you off as a probable no-sale and leave you to hunt down your own information.

In shopping for a dishwasher, I learned that U.S. manufacturers have many models of each kind of appliance. These change and are discontinued regularly. I explained to one saleswoman that I lived on RE and was researching a purchase. I would not be buying a dishwasher for at least two months. She said that the models on display might not be available then. Two of the models on the floor had notices that they had been discontinued, and the floor models were the last of that line. That makes me wonder about parts availability.

All Things Considered
Here are some things to consider when shopping for an appliance:

- Quietness: amount of insulation, proximity to the living area, and sound level when running.
- Water: amount used per cycle, and psi needed to run properly.
- Propane: parts needed to change to the type of gas available.
- Glow bars: is there one, how much power does it draw, and is it on continuously?
- Dimensions: will it fit where you want it?
- Power use: inverter or generator, how much for each cycle, and estimated average usage.
- Cost vs. convenience: the convenience must equal or better the whole cost.
- Installation instructions: are they easy to read, with lots of pictures and diagrams (my favorite kind)?
- Materials: do the materials and manufacture of the appliance appear to be of good quality?
- Warranty: how long, for what, where is the repair center, and what is the process for obtaining warranty repairs?

Make a checklist of the features you want, and write down any concerns you have about the appliance you are shopping for. Take it with you to shop, and fill in the blanks. Gather all the data you can on many different models. Take your time—don't hurry into a purchase. I find it comforting to be able to compare things on paper away from the store and salespeople. Listen to the salespeople, and then get a second opinion.

Your local RE professional is an excellent source of information. They hear from their customers about what works and what doesn't. If they live on RE, they have the benefit of personal experience. A caveat though: dealers can get locked on certain brands. It's like Ford guys and Chevy guys. If a certain brand has worked for them with no problems, they swear by it, not at it. This is not surprising, since they have to stand behind the products they sell.

ACE^3
The American Council for an Energy-Efficient Economy (ACE^3) has a really great Web site, with lots of information. It includes sections on top rated appliances, and information on their *Consumer Guide to Home Energy Savings.*

This excellent Web site and the appliance guide are great tools in your search for the best appliance for your RE home. Add to that the expertise of your local RE dealer, and your research from local appliance stores. Do your homework, and you'll be able to find quality appliances that will work in your RE home for a long time.

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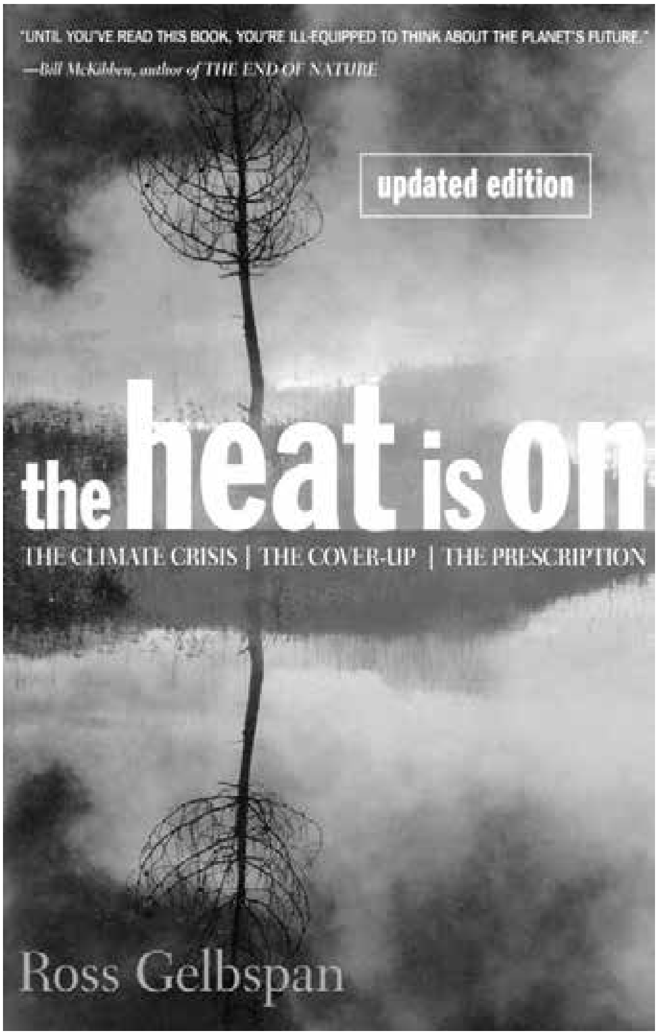
American Council for an Energy-Efficient Economy, 1001 Connecticut Ave. NW, Suite 801, Washington, DC 20036 • 202-429-0063 • Fax: 202-429-0193
ace3pubs@ix.netcom.com • www.aceee.org



By Ross Gelbspan

Reviewed by Richard Engel

We've all seen plenty of press on global warming these past few years. The link between global warming and the burning of fossil fuels has become common knowledge. But throughout the 1990s, as study after study demonstrated that, yes, humans are altering the world climate, the media and politicians stuck to portraying the whole issue as a raging controversy.

You couldn't help but get the idea that scientists were more or less equally divided on whether humans were causing global warming—or perhaps whether warming was happening at all. Even the most ardent environmentalists among us have had to wonder: Is it really happening? Might the doubting Thomas scientists be right in claiming that the greenhouse effect is just a lot of hot air?

With this book, Ross Gelbspan sets the record straight. Throughout *The Heat Is On,* he builds his case that, among credible scientists, the verdict is virtually unanimous: the biosphere is getting hotter.

The Case Against the Skeptics

Though it touches on many aspects of global warming, this book is primarily an exposé of the global warming skeptics. Gelbspan first points out that the cadre of skeptical scientists is minuscule. He claims that there are only about a half dozen "serious" scientists who persist in publishing papers dismissing global climate change as a non-event.

Second, he asserts, this handful of maverick scientists have poor credentials. Their studies are not peer-reviewed and do not get published in esteemed scientific journals. Third, and perhaps most important, their work is in most cases funded by the polluting industries that have a big stake in convincing policymakers and the public that global warming just isn't happening.

Not Just Eco-Freaks

The author points out some fascinating dramas that are being acted out as global warming becomes more obvious. For one, environmentalists are no longer the most formidable adversaries of the fossil fuel companies in this battle—insurance companies are. With each passing year, insurers are taking a bigger and bigger hit paying off clients devastated by floods, hurricanes, and wildfires.

Gelbspan rattles off a litany of statistics showing how both the number and the dollar costs of weather-related insurance payouts have soared since 1990. Insurance industry lobbyists are apparently beginning to out-shout the oil lobbyists in the halls of Congress, demanding policy changes and legislation to head off climate change.

Another sign that great changes are taking place on the stage of the global warming tragicomedy is the ongoing collapse of the Global Climate Coalition (GCC). This fossil fuels industry lobbying group has been the loudest heckler in the skeptics' peanut gallery for years, but lately their ranks have thinned dramatically. Even the fossil fuel mega-companies appear to be changing their position—or at least re-thinking their betting strategy—in the climate change debate. Shell, BP's U.S. division, and Ford Motor Company have all left the

GCC. Ford is even going so far as to publicly state that global warming may be for real.

Critique

Ross Gelbspan would have ended up with a perfect book if he'd let us get a better point-counterpoint look at what scientists on both sides are saying about each others' work. He does include an appendix in which several climate scientists critique the work of their skeptical colleagues. However, by only getting to read the critiques, we're left to guess exactly what these skeptics had to say in the first place. And honestly, the arguments confirming and denying global warming are quite slippery for a non-climate-scientist to make sense of. Each side accuses the other of selecting data that supports one point of view, and conveniently ignoring the rest.

All Is Not Lost

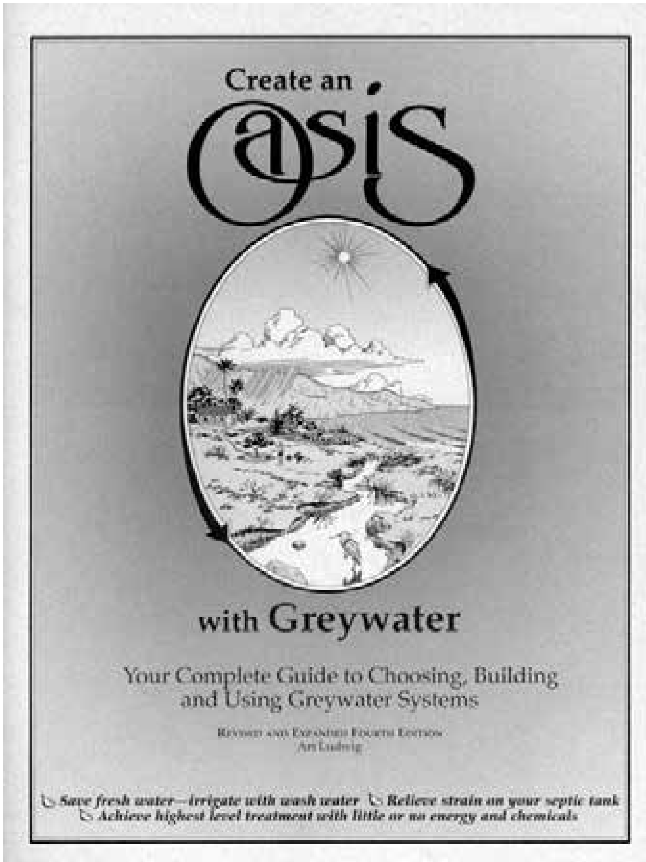
Fortunately, after making my way through all the bad news, I was rewarded with an action plan in the final chapter. Gelbspan proposes a three-point "Manhattan Project" for climate stabilization, a crash program he describes as our last hope for averting drastic and perhaps irreversible climate change. His proposals: One, shift all existing fossil fuel subsidies to renewables; two, phase in strict efficiency standards for all fossil-fuel technologies; and three, levy a worldwide tax on international currency transactions to fund a rapid transition to a sustainable, nonpolluting energy economy.

Gelbspan has done his homework very well. Now it's up to the rest of us to see to it that his climate stabilization program, or something like it, is implemented soon. If not, the only satisfaction we'll get is seeing the global warming naysayers proven dead wrong.

Access

The Heat Is On: The Climate Crisis, the Cover-Up, the Prescription, Ross Gelbspan, 1998, ISBN 0-7382-0025-5, 288 pages, paperback, US$14 from Perseus Books Group Customer Service Department, 5500 Central Ave., Boulder, CO 80301 • 800-386-5656 or 303-444-3541 • Fax: 303-449-3356
westview.orders@perseusbooks.com
www.perseusbooks.com

Richard Engel, Schatz Energy Research Center, Arcata, CA 95521 • 707-826-4345 • Fax: 707-826-4347
rae7001@humboldt.edu • www.humboldt.edu/~serc



By Art Ludwig
Reviewed by Joe Schwartz ©2000 Joe Schwartz

Conservation is the first step toward creating an efficient and affordable renewable energy system. Art Ludwig's book, *Create an Oasis with Greywater,* is a down-to-earth resource detailing the sanitary and efficient distribution of greywater to meet outdoor irrigation needs.

Greywater is defined as any wastewater produced by the home, with the exception of toilet water (blackwater). The reuse of household greywater is a seriously under-utilized conservation practice in America and many other "overly developed" countries.

Art's Santa Barbara, California based company, Oasis Design, specializes in ecological systems design. He has designed greywater irrigation systems in both North and Central America. *Create an Oasis with Greywater* addresses a range of topics that relate to greywater technology. It provides household water use figures and irrigation requirements. The quality of greywater produced by various household sources is examined. Examples of different filtering and distribution systems, along with design considerations for the different techniques, are described and illustrated in detail.

The book states straight out where and where not to use greywater. There's even a section entitled "Greywater Misinformation and Common Errors," which alerts greywater newcomers to failed greywater designs and potential maintenance headaches.

Many greywater system designs incorporate a pump. In a highly energy-conserving household, an inappropriately sized greywater system pump could be one of the top three power draws in the house. Art steers all small-scale greywater re-users away from pumps due to energy, maintenance, and cost issues. This is a welcome perspective for RE households. It differs sharply from that of regulators and most greywater system vendors, who typically specify systems that feature a pump.

Art's book isn't overly technical, but rather offers practical and field-tested advice related to the emerging field of greywater irrigation. The text is written in a laid back, often humorous style, and is a pleasurable—even relaxing—read. His hand-drawn line art of various greywater irrigation systems hints back to hippie-era classics like *Shelter* or Bill Mollison's early *Permaculture Design* manuals. Numerous photos also show both water and landscape designs.

Oasis has published two other books related to greywater. *Builders Greywater Guide* expands on system construction details, and explores code-related greywater issues. The just released *Branched Drain Greywater System Manual* explains Art's latest design for simple, inexpensive, and maintenance-free subsurface irrigation. You can order all three books on the Oasis Web site.

Water pumping is one of the largest energy demands on residential renewable energy systems. When part or all of a household's irrigation is supplied by greywater in a gravity-feed system, the water only needs to be pumped once. This can add up to big energy savings. And in areas with low annual rainfall, it means conservation of an often scarce resource.

Sound like a good idea? You bet! *Create an Oasis with Greywater* is an informative, enjoyable reminder to not overlook the obvious. Remember, our patterns of resource use determine what's "waste" and what isn't.

Access

Create an Oasis with Greywater: Your Complete Guide to Choosing, Building, and Using Greywater Systems, by Art Ludwig, 4th Edition, ISBN 0-9643433-0-4, 51 pages, US$14.95 from Oasis Design, 5 San Marcos Trout Club, Santa Barbara, CA 93105 • 805-967-9956 Fax: 805-967-3229 • odesign@sprynet.com www.oasisdesign.net

Joe Schwartz, *Home Power,* PO Box 520, Ashland, OR 97520 • 530-475-3179 • Fax: 530-475-0836 joe.schwartz@homepower.com • www.homepower.com

HAPPENINGS

INTERNATIONAL
Free instructions, photos, drawings, & specs to build solar cookers & water systems with local materials purchased with local currency. SUNSTOVE • www.sungravity.com

CANADA
Oct. 15–18 '00. International EV Symposium: exhibition & drive. Race an EV on a Formula One track. EVS-17 • 650-365-2802
Fax: 650-365-2687
ElectricEVent17@aol.com

Oct. 21–24, '00. Halifax, Nova Scotia. Rise and Shine 2000, Canada's 26th National Solar Energy Conference. Keith Robertson
902-422-1557
www.chebucto.ns.ca/Technology/RS2000

Alberta Sustainable House: open house 3rd & 4th Saturdays, 1–4 PM. Cold-climate features/products regarding health, environment, conservation, RE, recycling, low energy, self-sufficiency, appropriate technology, autonomous & sustainable housing. Free. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 Canada
403-239-1882 • Fax: 403-547-2671
jdo@ucalgary.ca • www.ucalgary.ca/~jdo

The Institute for Bioregional Studies demonstrates & teaches ecologically-oriented, scientific, social, & technological achievements. IBS, 393 University Ave., Charlottetown, PEI C1A 4N4 Canada
902-892-9578

Vancouver Electric Vehicle Association. Call for meeting info. PO Box 3456, 349 West Georgia, Vancouver, BC V6B 3Y4 Canada
604-878-9500 • info@veva.bc.ca
www.veva.bc.ca

CHINA
Nov. 23–26, '00. Beijing, China. Intl. Development & RE Conference. CERE 2000 Secretariat, Yong ZHANG, No. 1 Sandaokie, Jianguomenwai, Beijing 100022, P.R. China
86-10-65157760 • Fax: 86-10-65158442
cisc@midwest.com.cn
www.ciscexpo.orgcn.net

FRANCE
Sept. 7–9, '00. Aix-en-Provence, France. PV Hybrid Power Systems conference. Includes lectures, oral presentations, poster presentations. PVHPS-O.T. Bureau des Congres, 2 place du General de Gaulle BP 160, 13605 Aix en Provence Cedex 1, France • 33 (0) 442 161 173
Fax: 33 (0) 442 161 179
congres@aixenprovencetourism.com
www.aixenprovencetourism.com

MEXICO
Sept. 19–22, '00. Mexico City. ISES Millennium Solar Forum 2000—Mexico. Renewable energy and the environment. Simultaneous translation in English & Spanish available. Students & NGO's: 1,200 $MEX; General public: 1,800 $MEX. Conference location: Centro de Negocios y Comercio de la Ciudad de México, Morelos 67, Col. Juárez, México D.F. Information: Laura Kuri, Centro de Investigaciones en Energía, UNAM, A.P. 34, Temixco 62580, Morelos, Mexico
iseseco@mazatl.cie.unam.mx
www.anes.org/ecologia/pagina.html

NICARAGUA
Aug. 1–11, '00 & Jan. 2–12, '01. Short course on solar energy in Nicaragua. An opportunity to offer your hands, heart, & a unique gift—electricity! Introduction to PV for developing countries, course offers lectures, field experience, & tourism. In English, by Richard Komp & Susan Kinne. US$750, plus airfare. Barbara Atkinson • 215-942-0184
lightstream@igc.org

NATIONAL U.S.
Pollution Prevention Video Series. Appalachia Science in the Public Interest offers 42 in-depth videos, incl. Solar Dry Composting Toilets, Solar Hot Water Systems, PV, Solar Space Heating, Solar Powered Automobile, Quilted Insulated Window Shades, & more. Each US$25 + S&H, broadcast quality tapes available. Call or write for info or a brochure. ASPI Publications, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • Fax: 606-256-2779
aspi@kih.net • www.kih.net/aspi

American Wind Energy Association. Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

State financial & regulatory incentives for RE (reports). North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695
919-515-3480 • Fax: 919-515-5778
www.ncsc.ncsu.edu/dsire.htm

Energy Efficiency & Renewable Energy Clearinghouse (EREC): Insulation Basics (FS142), New Earth-Sheltered Houses (FS120), PV: Basic Design Principles & Components (FS231), Cooling Your Home Naturally (FS186), Automatic & Programmable Thermostats (FS215), & Small Wind Energy Systems for the Homeowner (FS135). EREC, PO Box 3048, Merrifield, VA 22116 • 800-363-3732
TTY: 800-273-2957 • energyinfo@delphi.com
www.eren.doe.gov

Energy Efficiency & Renewable Energy Network (EREN): links to government & private internet sites & offers "Ask an Energy Expert" online questions to specialists.
800-363-3732 • www.eren.doe.gov

Green Power Web site: deregulation, green electricity, technology, marketing, standards, environmental claims, & national & state policies. Global Environmental Options (GEO) & CREST • www.green-power.com

National Wind Technology Center. Assisting wind turbine designers & manufacturers with development & fine tuning. Golden, CO
303-384-6900 • Fax: 303-384-6901

Tesla Engine Builders Association: info & networking. Send SASE to TEBA, 5464 N Port Washington Rd. #293, Milwaukee, WI 53217 • teba@execpc.com
www.execpc.com/~teba

Sandia's Stand-Alone Photovoltaic Systems Web site: a handbook of recommended design practices, working safely with PV, balance-of-system technical briefs, & info on battery & inverter testing. www.sandia.gov/pv

Solar Energy & Systems. Fundamentals of Small RE: Internet college course. Weekly assignments reviewing texts, videos, WWW pages, & email Q&A. Mojave Community College • 800-678-3992
lizcaw@et.mohave.cc.az.us
www.solarnmc.mohave.cc.az.us

Federal Trade Commission (free pamphlets): Buying An Energy-Smart Appliance, Energy Guide to Major Home Appliances, & Energy Guide to Home Heating & Cooling. Energy Guide, FTC, Rm 130, 6th St. & Pennsylvania Ave. NW, Washington, DC 20580
202-326-2222 • TTY: 202-9326-2502
www.ftc.gov

Solar Curriculum For Upper Elementary & Intermediate Grades. Six week science curriculum or individual sessions—free! Over 30 classroom presentations & demos using free or low-cost materials. Susan Schleith, Florida Solar Energy Center • 321-638-1017
www.fsec.ucf.edu

ALABAMA
Centre, AL. The Self-Reliance Institute of NE Alabama seeks others interested in RE, earth-sheltered construction, & other self-reliant topics. SINA, 6585 Co Rd. 22, Centre, AL 35960 • cevans9@tds.com

ARIZONA
Glendale & Scottsdale, AZ. Living with the Sun: lecture series by AZ Solar Energy Association. Topic: How to save money & the environment. Includes history & current overview of concepts, design, applications, & technologies on solar heating/cooling, architecture, landscaping, PV, & cooking. 7–9 PM, first Wed. of every month at Glendale Foothills Branch Library & third Tuesday of every month at Scottsdale Redevelopment & Urban Design Studio. Jim Miller • 480-592-5416

Kyocera Solar Seminars. Aug. 15–17, '00: Advanced technical training by professionals & senior engineers. Sept. 19–21, '00. Solar Water Pumping: taught by a solar water delivery professional; includes overview, systems, products, & hands-on training. Kyocera Solar, Inc. Training Dept.

800-544-6466 ext. 7148 • Fax: 480-443-4562
seminars@kyocerasolar.com
www.kyocerasolar.com

Tax credits for solar in AZ. A technician certified by the AZ Department of Commerce must be on the job site. ARI SEIA 602-258-3422

ARKANSAS
Mt. Ida, AR. Sun Life Construction by Design: Seminars 3rd Sunday of each month on our passive solar earth-sheltered project near Lake Ouachita. Hands-on seminars incl. ferro-cement, building permanent dwellings for minimal materials expense. US$40 per day (includes construction manual). Loren Impson, 71 Holistic Hollow, Mt. Ida, AR 71957 • 870-867-4777
loren@ipa.net • www.Sun4Life.com

CALIFORNIA
Aug. 26–27, '00. Hopland, CA. SolFest 2000: Fifth Annual Real Goods SolFest. Speakers, entertainment, over 40 educational workshops, exhibitors, tours, children's activities, & more. PO Box 836, Hopland, CA 95449 • 707-744-2017 • isl@rgisl.org
www.solarliving.org

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State University. Ongoing workshops & presentations on alternative, renewable, & sustainable living. CCAT, HSU, Arcata, CA 95521
707-826-3551 • ccat@axe.humboldt.edu
www.humboldt.edu/~ccat

Asilomar, CA. Efficiency & Sustainability, ACEEE Summer Study: building technologies for professionals. ACEEE, PO Box 7588, Newark, DE 19714
302-292-3966 • Fax: 302-292-3965
rlunetta@erols.com

Energy Efficiency Building Standards for CA. CA Energy Commission • 800-772-3300
www.energy.ca.gov/title24

Hopland, CA. Workshops through Oct. on RE, straw bale, ecological design, & sustainable living. Real Goods, Hopland, CA. Institute for Solar Living, PO Box 836, Hopland, CA 95449 • 707-744-2017
isl@rgisl.org • www.solarliving.org

COLORADO
Aug. 5–6, '00. Carbondale, CO. Successful Solar Businesses. Richard & Karen Perez show how to make your RE business succeed, drawing upon their vast RE business experience. US$200, advance registration required, limited space. SEI, PO Box 715, Carbondale, CO 81623
970-963-8855 • Fax: 970-963-8866
sei@solarenergy.org • www.solarenergy.org

Sept. 2–4, '00. Crestone, CO, in the park. Crestone Energy Fair: 11th Annual. EV rally, RE workshops, solar stage, & RE tours. Box 222, Crestone, CO 81131 • 719-256-4838

Carbondale, CO. Solar Energy International: hands-on workshops. 1 & 2 week sessions include PV design & installation, advanced PV, wind power, microhydro, solar cooking, environmental building technologies, solar home design, & straw bale construction. Experienced instructors & industry reps. For owner-builders, industry technicians, business owners, career seekers, & international development workers. US$500/week. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855
Fax: 970-963-8866 • sei@solarenergy.org
www.solarenergy.org

ILLINOIS
Oct. 14, '00. Olson Conference Center, Western Illinois University, Macomb, IL. Alternative Resources For A Healthy Environment Expo 2000. Soy, cotton, kenaf, amaranth, & hemp products. Solar race cars, huge solar oven, bluegrass/folk music, & door prizes. 9–4 PM, US$2 per person. Sponsored by Save Our Land & Environment (S.O.L.E). Kathy • 309-837-3150 • Fax: 309-833-1176
http://homepages.go.com/~earthprotect

IOWA
Aug. 5, '00. Wartburg College, Waverly, IA. Iowa Renewable Energy Expo: 9th annual. Tours of Waverly Light & Power wind, hydro, & fossil fuel facilities. Vendor displays, Electrathon demo, workshops on active & passive solar, PV, & wind. Hands-on classes wiring & raising a wind generator tower & PV systems. IRENEW, PO Box 355, Muscatine, IA 52761 • 319-288-2552
irenew@irenew.org

IRENEW PV Solar Traveler Trailer. Trailer visits IRENEW Energy Expo, Wartburg College, Waverly, Iowa, Aug. 5, '00. Trailer powers sound stage at the Iowa State Fair, Des Moines, Iowa, mid-Aug. for 12 days. IRENEW, PO Box 355, Muscatine, IA 52761
319-288-2552 • irenew@irenew.org

Prariewoods & Cedar Rapids, IA. Iowa Renewable Energy Association (IREA): meets 2nd Sat. every month at 9 AM. All welcome. Call for schedule changes. IRENEW, PO Box 466, North Liberty, IA 52317 • 319-875-8772 • irenew@irenew.org
www.irenew.org

KENTUCKY
Oct. 21, '00. Mt Vernon, KY. Solar Tour Day: Appalachia—Science in the Public Interest. Solar cookers, dryers, fans, space heating, water heating, automobile, greenhouses, PV systems, & more. ASPI, 50 Lair St., Mt Vernon, KY 40456 • 606-256-0077
aspi@kih.net • www.kih.net/aspi

Livingston, KY. Appalachia—Science in the Public Interest. Projects & demos in gardening, solar, sustainable forestry, & more. ASPI, Rt 5 Box 423, Livingston, KY 40445 • Phone/Fax: 606-453-2105
aspi@kih.net • www.kih.net/aspi

MASSACHUSETTS
Greenfield, MA. Greenfield Energy Park needs help preserving Greenfield's historic past, using today's energy & ideas, creating a sustainable future. Greenfield Energy Park, NESEA, 50 Miles St., Greenfield, MA 01301
413-774-6051 • Fax: 413-774-6053

MICHIGAN
Aug. 4–6, '00. Lansing, MI. Sixth Annual Renewable Energy Fair: by Great Lakes Renewable Energy Assoc. Keynote: Peter Dreyfuss, head of the Million Solar Roofs Program. Renewable industry & teacher education seminars on Friday, AE & sustainable development workshops, displays, demonstrations, & children's area. Free. 616-887-0233 • glrea@aol.com
www.ermisweb.cis.state.mi.us/GLREA

Tillers International, classes in draft animal power, small farming, blacksmithing, woodworking. 5239 S 24th St., Kalamazoo, MI 49002 • 616-344-3233
Fax: 616-344-3238 • TillersOx@aol.com
www.wmich.edu/tillers

MONTANA
Whitehall, MT. Sage Mountain Center: seminars & workshops, one day, inexpensive sustainable home building, straw bale const., log furniture, cordwood const., solar electricity, & more. SMC, 79 Sage Mountain Trail, Whitehall, MT 59759
Phone/Fax: 406-494-9875
cborton@sagemountain.org

NEW MEXICO
Moriarty, NM. Profit From The Sun: workshops on RE, energy conservation, sustainable living, & energy independence. PFS • 505-281-1300 days • 505-832-1575 eves & weekends • proffit@flash.net
www.proffitfromthesun.com

NEW YORK
Oct. 15–19, '00. Bioenergy 2000—Moving Technology into the Marketplace: the 9th biennial Bioenergy Conference. NRBF
202-624-8464 • nrbp@sso.org

NORTH CAROLINA
Saxapahaw, NC. How to Get Your Solar-Powered Home: seminars 1st Sat. of each month. Solar Village Institute, PO Box 14, Saxapahaw, NC 27340 • 336-376-9530
Fax: 336-376-1809 • solarvil@netpath.net

OHIO
Perrysville, OH. RE Classes: 2nd Sat. of each month, 10–2 PM. Tech info, system design, *NEC* compliance, efficient appliances. Also hands-on straw bale post & beam building. US$70, or US$90 w/spouse, in advance. Solar Creations, 2189 SR 511 S., Perrysville, OH 44864 • 419-368-4252
www.bright.net/~solarcre

OREGON
Northwest Energy Education Institute classes: Eugene, OR. Aug. 9–11, '00: Passive Solar Building Design. Instructor: Roger Ebbage. US$225. Aug. 14–15, '00: Stand Alone Photovoltaic Systems. Instructor: Greg Holder. Final project will be powering an outdoor garden fountain.

US$425. 800-769-9687 • www.nweei.org
ebbager@lanecc.edu

Cottage Grove, OR. Aprovecho Research Center, non-profit edu. org: 10 week fall internships on appropriate tech, sustainable forestry, & organic gardening. Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198
apro@efn.org • www.efn.org/~apro

PENNSYLVANIA

Aug. 21–23, '00. Pittsburgh, PA. Energy 2000 Energy Efficiency Workshop & Exposition: energy managers conference. By DOE's FEMA Program, Dept. of Defense, & the General Services Admin. Florida Solar Energy Center, 1679 Clearlake Rd., Cocoa, FL 32922 • 800-395-8574
joann@fsec.ucf.edu

TENNESSEE

Summertown, TN. Kids to the Country: a nature study program for at-risk urban Tennessee children. Sponsorships & volunteers welcome. 51 The Farm, Summertown, TN 38483 • 931-964-4391
Fax: 931-964-4394 • ktcfarm@usit.net

TEXAS

Sept. 29–Oct. 1, '00. Fredericksburg, TX. Renewable Energy Roundup: RE exhibits, demonstrations, workshops, & tours. TX RE Industries Assoc. & Texas Solar Energy Society • 512-345-5446 • R1346@aol.com
www.renewableenergyroundup.com

El Paso Solar Energy Association bilingual Web page. Info in Spanish on energy & energy saving. www.epsea.org

El Paso, TX. El Paso Solar Energy Association: monthly meetings normally held 1st Thurs of every month at UT El Paso, Rm 205 of Classroom Bldg (next to Engineering Bldg). EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-solr • epsea@txses.org
www.epsea.org

Houston, TX. Houston Renewable Energy Group: monthly meetings last Sunday of odd-numbered months at the TSU Engineering Building, 2 PM. HREG, PO Box 580469, Houston, TX 77258
jferrill@ev1.net
www.txses.org/hreg/HREGhome.htm

WASHINGTON STATE

San Juan Islands, WA. SEI Workshops. Oct. 13–15, '00: Microhydro Power, US$250. Oct. 16–21, '00: Photovoltaic Design & Installation, US$500. Oct. 23–28, '00: Wind Power with Mick Sagrillo, US$500. Oct. 29, '00: Renewable Energy for the Northwest, US$75. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866
sei@solarenergy.org • www.solarenergy.org
Local contact:
ian.woofenden@homepower.com

WISCONSIN

Amherst, WI. Midwest Renewable Energy Association (MREA) Workshops. See ad. Call for cost, locations, instructors, & further workshop descriptions. MREA membership & participation: all welcome. Significant others half price. MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166 • Fax: 715-824-5399
mreainfo@wi-net.com

the Wizard speaks...

Thoughts On Magnetic Induction

Lately I've been considering a scheme to extract free energy using magnetic induction. Consider a long wire carrying a low power, high frequency alternating current. Imagine that wire surrounded by a series of toroidal coils. The wire runs through the center of the doughnut-shaped coils.

The current in the wire creates a changing magnetic field, which will induce a changing electric field in each coil. Although the induced current in each coil opposes the magnetic field from the wire, it does not necessarily affect the current in the wire. If it does not, then we may be able to get more power from the coils than is put into the wire. This would be done by increasing the number of coils in the device.

Preliminary calculations indicate that if this is possible, the frequency of the alternating current in the long wire must be at least ten million cycles per second. A lower frequency would require too many coils to be practical. A higher frequency would increase the output from each coil.

I do not know for sure if this analysis is correct. There may be some factors that I'm not taking into account. Some of these may be related to the operation of the device at such high frequencies. However, it is possible that this analysis is correct, and describes a potential free energy process.

Writing for Home Power Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small-scale renewable energy systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in *Home Power.*

Informational Content

Please include all the details! Be specific! We are more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough so that our readers can actually use the information.

Article Style and Length

Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible. We prefer simple declarative sentences which are short (less than fifteen words) and to the point. We like the generous use of subheadings to organize the information. We highly recommend writing from within an outline. Check out articles printed in *Home Power.* After you've studied a few, you will get the feeling of our style. System articles must contain a schematic drawing showing all wiring, a load table, and a cost table. Please send a double spaced, typewritten, or printed copy if possible. If not, please print.

Written Release

If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article. This will help us respect the privacy rights of individuals.

Editing

We reserve the right to edit all articles for accuracy, length, content, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get published first.

Photographs

We can work from any photographic print, slide, or negative. We prefer 4 by 6 inch color prints with no fingerprints or scratches. Do not write on the back of your photographs. Please provide a caption and photo credit for each photo.

Line Art

We can work from your camera-ready art, scan your art into our computers, or redraw your art in our computer. We often redraw art from the author's rough sketches. If you wish to submit a computer file of a schematic or other line art, please call or email us first.

Got a Computer?

Send us the text for your article on 3.5 inch computer floppy diskette, either Mac or IBM format. We can also read ZIP disks (either Mac or IBM), Magneto-Optical disks (128 MB, 230 MB, 1.2 GB, and 1.3 GB, all Mac only), and CD-ROMs. This saves time and reduces typos. Please also send a hard copy printout of your article. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use your "Save As Text" option from within your word processor. Please don't just rename the file as "text" because it will still include unreadable (at least to us) word processor formatting.

You can send your article via Internet to richard.perez@homepower.com as an attached ASCII TEXT file. If you are sending graphics, or articles with embedded graphics, then use this email address: ben.root@homepower.com

It is wise to telephone or email ahead of electronic file submission. This is particularly true concerning graphics files. There are many, many, many ducks and they all need to be in a row....

Got any questions? Give us a call Monday through Friday from 9–5 Pacific Time and ask. This saves everyone's time.

Access

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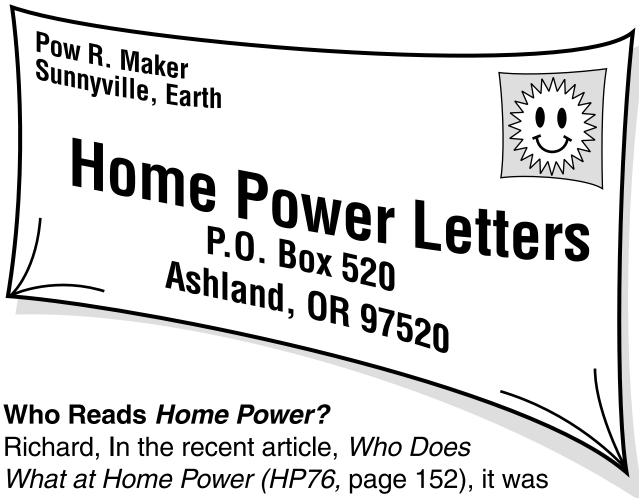


Who Reads *Home Power?*

Richard, In the recent article, *Who Does What at Home Power (HP76,* page 152), it was fun to meet the faces behind *Home Power.* I was interested in the diverse personal, technical, and professional backgrounds of the people who produce this fine RE resource. It also caused me to consider the diversity of the readership. What kind of folks read *Home Power?*

I came up with five main groups, which I call the five Gs:

GRIDLESS: These folks are here out of necessity. They find themselves living in off-grid locations. *HP* provides the number one source of answers to their problems.

GREENS: Out to save our planet, this group's main interest in *HP* is eco-friendly power. *HP* offers grassroots RE solutions that an individual can apply today.

GUERRILLAS: Motivated by an often-justified animosity toward utility monopolies, utility-bill independence is their goal. Political action is frequently their weapon of choice.

GUILD: RE professionals who make a living off the renewable energy industry. They do their homework by reading *HP,* and also find the perfect advertising audience here.

GEEKS: From electrical engineers to basement tinkerers armed with soldering irons, these guys and gals get their kicks inventing solutions to the challenges that RE creates.

I would suspect that most readers belong to more than one of these five groups. I find that the longer I read *Home Power,* the more I learn about and become drawn at some level into all five Gs. Diversity really is a great asset not only at *HP,* but also among its readers. Russ Barlow, Pittsburgh, Pennsylvania srbarlow@nauticom.net

Hello Russ. Thanks for the humorous but accurate portrayals—our chuckle for the day. Michael Welch

Hey Russ, I happen to fit into all five of your G categories. Since we began giving the current issue away on the Internet, we don't have as clear a picture of who reads Home Power *and why. Back in the old days, everyone filled out a sub form, and we had some idea of what they were doing with RE and why. These days, about two thirds of our over 75,000 circulation goes down on the Internet and is totally anonymous. Richard Perez*

Solar Water Pumping

Dear *HP,* Thanks to you and Windy Dankoff for showing a great water system *(HP76,* page 26). I am a big fan of using underground well pits for all the reasons Windy noted, and will no doubt use at least one in my future home site, but the picture of Windy Dankoff emerging from his water tank gave me cause for some concern.

My everyday occupation has exposed me to training regarding a little thing referred to as "confined space." A confined space is defined as a place with difficult access—one way in and out, and not suited for regular habitation by people (kinda like my teenage son's bedroom). Some common examples are underground tanks, vaults, water tanks, raised water towers, sewer lift stations, tank trucks, elevator shafts, and storm drains.

People go into these places to clean the tanks, do plumbing, wiring, and regular maintenance. When they enter these spaces, they can be exposed to many risks including falling, engulfment, electrocution, explosive atmospheres, low oxygen levels, and poisonous gases. The big problem is that when an unfortunate thing happens, it is often difficult to remove the person from the space without putting the rescuer in contact with the same risks. Like many drownings, these incidents often result in two deaths, the victim and a would-be rescuer.

Methane can enter the confined space from rotting vegetation in the soil, or from leaves and grass that end up in the bottom of tanks. It can reach explosive levels and can be ignited from sources such as pump switches or pilot lights. Rusting steel tanks that have little ventilation can have dangerously low oxygen concentrations because of the oxidation process. Hydrogen sulfide can be present in the soil. It has a rotten-egg smell, but quickly destroys your sense of smell and is extremely toxic. If you can smell it, you are in the wrong place.

The danger here is that once you climb down a ladder into one of these atmospheres, you will not be able to climb back out and will quickly become unconscious in an environment better suited for aliens than carbon-based life forms. People who work in these spaces must have continuous monitoring of the atmosphere through the use of four gas monitors.

Purely in the interest of science, I thought I might offer some annoying safety information to *HP* readers. Before entering these spaces, make sure that you have minimized the hazards. Do you need to have the power on when you go down there? Ventilate, ventilate, ventilate! Just like your battery box, it's important to provide for air exchange. Before we enter these spaces, we always ventilate with a big spark-proof fan, even if the monitors show no bad atmosphere. And it might not hurt to let someone know where you are going prior to entering the space. Well, this makes going down to the basement for a jar of grandma's canned peaches quite an ordeal, eh? My kids call me Mister Safety.

Water pumping has been on my mind lately as my wife and I are about to break ground on a small home and separate guest house (off the grid) here in Montana. Windy's system design addresses many of the issues with which we have been wrestling. Using heat from the ground to prevent freezing pipes and maintain battery temperature makes leaving a home unattended in the winter more feasible with less worry. The concept of burying pump houses is not a new idea, but one that can pose some interesting problems.

Friends of ours have a cabin (on the grid) that uses a cement vault (septic tank size) to house the AC pump controls, pressure tanks, and water filters. This tank was initially covered with a substantial amount of dirt, but erosion has left only about 3 inches of soil on top of the tank. This situation has caused some difficulties. The concrete lid has a very low insulating value. The tank also has a seam about halfway up the wall that was initially sealed with a mastic gasket material, but now allows seepage of groundwater into the tank. The tank was not coated with a foundation coating before being buried.

Whoever did the work installed a 12 inch electric baseboard heater on the wall near the ceiling. This heater came on at 45°F, and as you can imagine, never shut off except in the summer. Because of the lack of insulation on the ceiling, the heater would consistently melt the snow off the lid, exposing the top of the tank to winter's most extreme temperatures.

We set off to limit the use of the auxiliary heater to all but the coldest of winters in which there was a minimum of insulating snow cover. The owners were hesitant to haul in a bunch of fill to cover the tank to a proper insulating depth. We picked up some 2 inch blueboard insulation and covered the ceiling (from the inside) and top two feet of the side walls. The blue boards were cut to fit over and around electrical boxes and are held up with the assistance of expanding shower rods. Then we sealed the gaps with low expansion foam. Now we have to dig in the snow to find the insulated access lid. We disconnected the baseboard heater and installed a pump house heater plugged into a "Thermo cube" which allows the heater to work only if temperatures reach 34 degrees. (I don't think it has ever come on.) We wired in a 60 watt light bulb as a small heat source to assist with drying the room out.

Although we fixed the heat loss problem, the room remains so damp that all of the electrical equipment is corroding. Although warmer, there is condensation all over the ceiling and a damp floor. Yes, I am aware of the safety issues with electricity and standing water. I know that an exchange of air would help, and a non-leaking vessel would have been a valuable first step. We will continue to work on an air exchange system, but introducing cold outside air brings up issues of dew points, which is a subject that remains largely a mystery to me.

I don't want to repeat these mistakes when I dig up the ol' homestead. Our goals are to have a well pit from which we can control water supply to the main house and the future guest house. We would like to be able to drain the lines serving the buildings from the well pit. We would like to mimic the Dankoff system's ability to run excess water in the summer for irrigation and perhaps fill a small pond below the house.

Our current thought is to use a rectangular cement cistern as the basement for a small power shed. Available from the folks who cast concrete septic tanks for about US$560, the tank's inside dimensions are about 4.5 by 8 feet. The access for the "basement" would be from inside the power shed (nice in the winter). The secondary pump, pressure tanks, and plumbing would be below, with the majority of pump controls and electrical components above in the shed. We would coat the tank with foundation waterproofing, prior to placing it in the hole, and insulate the top with blueboard and dirt. The floor of the tank would contain a drain. A small foundation framed with treated lumber and treated plywood would transition from the top of the buried tank to grade for the shed to sit on.

Here is where I have some remaining questions. Should I bury an additional tank as a battery box, or superinsulate a box in the shed, above ground? Is it a better deal to have batteries at a constant 45 to 50°F underground year-round, or keep them in an insulated box above ground? Would the addition of an insulating box in the underground bunker keep them at a significantly higher temperature? I worry that above ground will keep them too cold in the winter, and require someone to open vents to cool them off in the summer. How do I ensure that ventilation happens in the winter, in the right direction, without cooling the pit too much below the dew point (or the frost point)? Do we bury a duct in the ground to supply fresh air at the bottom of the tank?

Thanks in advance for any insight you and other readers might provide, and thanks for showing *HP* readers a nicely engineered water system. Sincerely, Ed Brunsvold, Missoula, Montana • yasure@in-tch.com

Hi Ed, You make many good points in your letter. I feel perfectly safe working in my pits and tank, but readers should certainly heed Mr. Safety's warnings.

Regarding the problems of dampness, the design of a pit must be appropriate to the conditions of the site. It should be sufficiently researched and designed and/or based on successful experience in a similar environment. It should not be attempted if there is any doubt about its practicality. Excessive dampness has not been a problem in our pit because of our low humidity environment, and the high permeability of the gravel floor and the sandy soil beneath it. In fact, recently we had a pipe leak that released at least 1,000 gallons of water into the well pit. The water only rose a few inches off the gravel floor, and left no lasting damage. I kept the lid open for about two weeks of dry weather, and it dried out. I was happy that I had a separate pit for the power system components!

For your proposed battery box, I suggest that an underground shelter would be far better than anything above ground, to maintain a favorable environment for the batteries. Favorable means an approximate temperature range of 40–80° F (5–27° C), with even temperature distribution throughout the battery bank. An insulated enclosure above ground will serve only to keep the batteries at around the average outdoor temperature. It will temper the extremes of day and night, but it will not actually warm or cool the batteries.

You raise some interesting issues regarding ventilation and the control of heat, moisture, and battery gasses. Any form of electric heat is out of the question in an energy-conserving system. Excessive ventilation causes rapid heat loss. I hope we'll receive more suggestions from our readers. Windy Dankoff, Dankoff Solar Products, Inc.

Hello Ed. Thanks for the info on working underground. I'm sure that our readers will find it useful.

On the subject of batteries and temperature, lead-acid cells are happiest at around 78°F (25°C). At temperatures below 45°F (7°C) they become sluggish, manifesting an apparent capacity loss and depressed voltage. At temperatures above 100°F (38°C), battery efficiency decreases and self-discharge radically increases.

It's very difficult to keep an above ground battery enclosure warm in the winter without some source of heat. Consider direct solar gain, as in a window coupled with superinsulation. Vent the enclosure in the summer with an active fan system, and block off the solar window(s). While I've never done a below ground battery box, I suspect that it will require heating all during the year. It is a commonly held fallacy that the batteries will give off heat as they are recharged and keep themselves warm. While the batteries will give off some heat when recharged, it will not be enough to significantly warm them up if they are cold already.

If you have solar domestic hot water, consider building a hydronically heated battery containment like the one we have here. See HP77, *page 30 for details. This could be applied to either an above ground or a below ground battery containment. Richard Perez*

High-Stepping Inverters

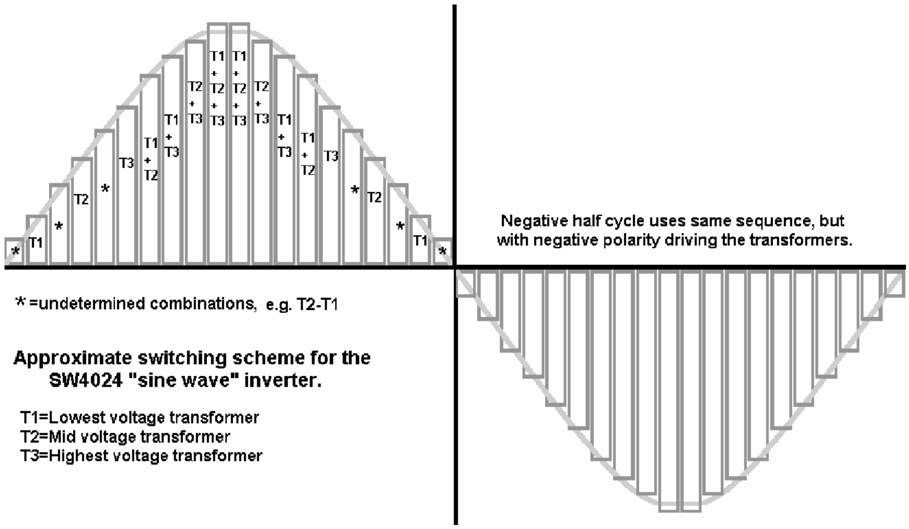
Dear *Home Power,* This is in response to the letter in *HP76* from Gerald Wright, concerning sine wave inverters. I recently had the need to open up a couple of Trace SW4024s for repairs, and was able to understand their method of sine wave generation.

First, I would like to point out that what has been called a "modified sine wave" inverter represents the height of marketing ingenuity. This is like calling a pup tent a modified mansion. This form of inverter would be better called an AC pulse width modulator.

When Trace uses the term "sine wave" to describe its SW4024, it is coming a lot closer to the truth, but it would be better to call it a "digitized sine wave." It is not actually a true sine wave. No inverter will have a perfect waveform, and some techniques will approach the ideal better than others. My guess is that Trace's technique was chosen for best efficiency rather than low noise.

The SW4024 has three power transformers, rather than the single transformer of the previous generation of "modified sine wave" inverters. Each of the three transformers has a different transformation ratio and power capacity. Each primary can be energized from the 24 volt DC source independently, or in any combination of two, or all three at once. The secondaries are connected in series with each other and the load. Since the secondary voltages, being in series, will add together, a range of different output voltages will be thus generated.

There are a variety of ways the transformers can be powered. If each transformer is powered by the same



polarity (called the "boost" configuration), then there are seven different combinations possible, giving seven different voltage steps. The figure above makes this a little more clear. Each transformer is labeled as T1, T2, or T3. Combinations shown as T1 + T2, for example, indicate that T1 and T2 are energized in the same polarity. Note that an unenergized transformer, with its primary shorted, will create a zero voltage at its secondary.

In addition to these steps, Trace adds some others (for a total of ten steps per quarter cycle), which are apparently generated by combinations of transformers powered by opposing polarities (called the "buck" configuration), which would cause their resultant secondary voltages to be subtracted rather than added. Thus intermediate voltages given by T2 - T1, for example, can be used to create a better approximation to the real sine wave than would be obtained from the boost configuration alone.

These widely variable combinations allow for a fine control of regulation over a range of battery voltages and loads. It is easy to hear the changing sound of the SW4024 as it switches in or out of the needed transformation ratios in response to changing load conditions. The sequence of control signals necessary to obtain this waveform is so complex that it necessitates the use of a computer chip. My hat is off to the Trace engineers, for this is a very clever circuit. It's definitely not something one would attempt as a homebrew project!

There are, of course, a number of other methods. A transformerless inverter could produce a digitized sine wave in a similar fashion. An array of ten independent, high frequency, DC to DC up-converters would step up the battery voltage in a series of increasing voltages, from close to zero on up to the 170 volt peak of the sine wave. Each voltage source would then be sequentially connected to the load, one at a time. The sequence of voltages would create the same sort of stepped waveform as the Trace. I don't know if this is the technique used by Statpower, but it is probably close. Again, this is a serious circuit that would take a long time to build and test. I hope this helps to dispel some of the sine wave mystery out there. Alastair Couper, kalepa@shaka.com

Advertisers: Take Heed

Dear Richard, I have a point that perhaps you could get across to your advertisers. We live in an area—on an island actually—that is not serviced by anything remotely connected with the Internet. We still have to rely on snail mail for any long distance communication. We do have a cell phone of course, but being right on the fringe of the service area, we never know whether or not we will be able to complete any call that we are actually lucky enough to begin.

I notice that many of your advertisers use a Web site address and have eliminated their mailing address. Surely, given the type of magazine that you are, many of your readers might find themselves in a position similar to ours, that is to say, they live in an area not served by the Internet. Would it be possible for you to suggest to them that it might be a great idea to continue to use their mailing addresses as well?

Let me give you some examples of what I mean. I wanted to drop a note to Trace—their ad lists their Web address only. Our island water committee wants information on a hand operated water pump, such as advertised by Alternative Energy Systems Co.—again, only their Web address is shown. There have been others. It would be a giant help if they could provide their mailing addresses.

Your article in *HP75* on how *Home Power* got started was absolutely great. God, I'm glad you did it. We'd be absolutely sunk if you hadn't. Our whole system has been put together mostly from advertisers in your magazine, and with information that we have gleaned from your pages. We still need to increase our system size substantially, and we will be buying from—guess who?—your advertisers. Bless 'em all. Keith Elliott, Ladysmith, BC, Canada

Hello Keith. We're pleased that Home Power's *advertisers have been of service to you. I totally agree with you regarding access data in advertising. If you check out* Home Power's *ads in this issue, you'll see that we list snail mail, Internet, and telephone access data. Richard Perez*

Failing in Business 101
Home Power crew, I enjoy the magazine for all the usual reasons: solar, wind, and hydro systems, homebrew, *The Wizard Speaks,* most of the articles, product reviews, and advertising. Yes, I enjoy the ads! The competition to sell quality energy equipment leading to lower pricing in your pages has made it possible for many, including me, to go from energy waster to assessment and conservation, and now to energy producer.

I don't think that the conventional power producers are concerned about the loss of our business as much as they worry about awakening our fiercely independent spirits. But enough about them.

My reason for writing is the failure of some of your advertisers and columnists to pass Business 101. As a plumber, when someone calls to have their quality fixtures installed, or to repair a mistake, I am delighted. There are a lot of plumbers in the phone book and a lot of alternative energy companies advertising in *Home Power.* From which should we buy goods and services, and why?

The point that price isn't everything has been made, and made, and made, and made. I like to give the perception that I've saved my customers money and got the job done right. I often refer them to the mega-store outlets with whom I cannot compete for best prices, saving them enough to pay my installation fees. Many people buy the self-help guides, visit trade shows, read magazine articles, attend training sessions, and listen to their Uncle Fred on how to cut corners, only to discover that their talents are in other areas. If this were not true, customers wouldn't need me, and they wouldn't need you.

My point is that we sell a service including expertise, and the parts as needed. Advice is free at my business, while site visits, labor, and parts pay the bills. Growth relies on return business and referrals. Charge a design fee if you must, and deduct it from the equipment purchase. Remember why you are in the business in the first place. I hope it's to spread the word, improve our environment, and make a living in an industry that you love.

To you know who: your arguments that paying substantially more for the same equipment guarantees a satisfactory owner installation (they would never deviate from your instructions), or that someone called you (given the great exposure in *Home Power)* after they bought equipment elsewhere (saved a bundle) for free advice read like "I missed out on a hefty pricing markup." Put away the crying towels. Enough already. Doug Jones N6KYX, Stockton, California

Dear Doug, I pretty much agree with your description of the realities of doing a service-type business these days. I gather that you have in large part given up on making money yourself on the equipment. That of course is one way of doing business. Focusing on a service-only business may be the direction that PV installers choose to go. It is understandable as the hardware becomes a commodity, as is certainly the case for plumbing supplies and equipment.

I have expressed the position that dealer-installers should make a fair markup on equipment they sell. I have not advocated that they charge a "bundle" or add on a "substantial" markup. It's great that we have choices, and that's how it stands now. Thanks for reading Home Power *and the* IPP *articles. Sincerely, You Know Who (aka Don Loweburg)*

RE Systems Financing
Dear *Home Power,* I have enjoyed reading your magazine for over a year now. I ran across it by accident while rummaging through the magazine section of a local bookstore. It is educational, entertaining, and inspiring. I have been interested in solar power for about ten years and have always wanted to become a part of the industry. I studied electrical engineering for a year and considered transferring to the semiconductor option of material engineering. Well, things didn't go as planned. I got married and just had a beautiful daughter. I started working for a mortgage company to make some extra money, and through networking, met several individuals who finance business projects.

One of these individuals suggested that I work for his company. It is a non-bank lender that works on SBA, USDA, leasing programs, and regular loans. I suggested that the company extend its products to the alternative energy industry. I think that this emerging industry is in need of alternative financing. It will increase industry sales and help customers afford the products they desire. I am limited to financing commercial and industrial projects, but hope to someday include residential.

The company is interested, and the owner suggested that I pursue the idea by talking to people who know the alternative energy market. Do you think that the market is in need of financing? If so, what is already available? What type of financial packaging is needed?

Another major concern is the collateral value of used PV systems and wind generators. If a customer defaults on a loan and the equipment is repossessed, is there a market for it? Can you give me some contacts that may be interested in buying repossessed equipment?

It is my goal to make solar power affordable for everyone! Any information you can provide will be greatly appreciated! Thanks, David Hershey, 348 Snyder Ave., Elizabethtown, PA 17022 • 717-361-8319 hersheydm@financier.com

Hello David, Yes, we think equipment financing would be helpful. I really don't know much about that market, but I do know there is a strong push for mortgages to accept RE houses and make them acceptable to secondary loan markets. See the article on GMAC Mortgage in HP70, *page 78, for one example.*

One person you can talk to is Keith Rutledge, Renewable Energy Development Institute, 383 S Main St., #234, Willits, CA 95490 • 707-459-1256 • Fax: 707-459-0366 • redi@saber.net • www.redinet.org. They got a grant from the DOE's Million Solar Roofs program to look into and help develop RE home financing. Keith knows a lot about solar financing and may be able to help you develop equipment financing.

The other suggestion I would have is to talk to some of the larger companies that sell and install RE equipment. They may have some ideas or may even be doing it already. Try Applied Power Corp. at 360-438-2110 and Kyocera Solar at 619-576-2600. You also might want to survey the installing dealers who advertise in Home Power *to see if and how they deal with system financing.*

Yes, collateral value could be a problem. Installed RE equipment keeps its value for the system owners because it is no simple matter to pull it out or replace it. One related serious problem would be the lender's expense of removal if people default on their equipment loans.

I believe the market for used equipment is underdeveloped. www.solaraccess.com has a used equipment section, and many folks selling used equipment rely on Home Power's *micro-ads. Sometimes retail dealers will buy used equipment if they can get it cheaply enough to turn a profit upon resale. But obviously, that seriously devalues the lender's value relative to the original purchase price and loan amount.*

PVs hold their value pretty well because they don't decay much. But when it comes right down to it, many users would rather buy new modules at US$5 to $6 per watt than used at, say, US$4.50 to $5.50.

Batteries are problematic because they need to be replaced every four to twelve years, depending on their level of use and abuse. But most financed systems will be utility intertied, and most of those systems are batteryless. Readers, if you have other ideas, please send your comments on to David. Michael Welch

Praise to Our Graphics Guru

Dear Mr. Root, I have been a subscriber to *Home Power* magazine for the past ten years. To me, your graphics and design has always been most impressive, if not astonishing. Being a former commercial photographer for advertising, I can perhaps appreciate your artistic work more than most subscribers can. I have yet to see any of your work that I didn't consider excellent.

I have written to Richard many times complimenting my most favorite magazine *(Home Power)* and expressing my admiration for the graphics and artwork. Only when they included my *Home Power* family in *HP76* did I know just who did what. Therefore I felt compelled to write you personally and express my admiration and thanks for going the extra step in making *Home Power* what it is today. Thanks! Patrick Swiney, Atmore, Alabama

Hello Patrick. Home Power *was produced for several years without the benefit of Ben Root. Back then, the magazine was graphically adequate for the semi-technical journal it is. But then came Ben. His class touches have taken the magazine from what it was to the beautiful and appealing journal it is today. Not only are we able to present the info as we always have, but now it looks great, too. Thanks, Ben! The* Home Power *crew*

Metal Hydride

Dear *Home Power,* In Shari Prange's article about automotive fuel cell technology *(Fuel Cell Cars, HP76,* page 104), there was no mention of metal hydride storage of hydrogen. I have read about systems that claim volume densities of hydride storage systems exceed that of liquid hydrogen without many of the issues presented in the article, such as problems with cryogenic storage. This approach may allow for simpler automotive systems without onboard reformers. Please refer to www.ovonic.com/hydrogen/smallFCapps.PDF for a presentation of such a storage system.

Thank you for publishing such an informative magazine. Andrew Tarnow, Troy, New York • tarnow@rpi.edu

There is some work being done on solid storage of hydrogen in a lattice framework (see HP59, *page 14). Although density is very good, the weight is also high, and there are some problems with releasing the hydrogen. There have also been many papers* *published about storing hydrogen in nano-tubules. However, no one has yet demonstrated success with this, particularly at a scale useful for fueling a car.*

It was not possible to cover all the issues surrounding hydrogen fuel cells in the space available, so I concentrated on the most central topics. At this time, solid hydrogen storage is not in the mainstream of fuel cell development. Shari Prange

Mission: Eco-Impossible
Hi Richard, I really enjoy and learn from your magazine. The coverage of biodiesel issues has been especially exciting.

My wife and I recently bought a new Plymouth mini-van, and I was tickled to find that it had a multi-fuel engine. It will burn standard unleaded as well as a fuel called E-85. From what I gathered in the owner's manual, E-85 is 85 percent ethanol and 15 percent unleaded gasoline. When we recently had the oil changed, I asked the mechanic if the synthetic oil was E-85 compatible. He called the oil company tech support line and found out that the oil is *not* compatible, and they could only get compatible lubricants by special order. The oil company then said that this is a non-issue, because only 42 service stations in the U.S. sold E-85.

The dealer where we purchased the van told me that about 80 percent of the mini-vans sold by his store had the E-85 compatible engines. This dealer moves a couple of hundred units a month. So in my area, there are a lot of E-85 capable vehicles on the road.

Yet, I can't buy E-85 anywhere in a three state area! I would have thought that this would be a no-brainer. Good for the environment, good for farmers (growing the raw materials for ethanol), and good for the oil companies (make a profit on each gallon). To me it seems like a win-win, at least until there are *true* zero emission vehicles (I don't count electrics as zero emission unless you've got a 12 KW PV array on your house to charge it).

I would think that in the near term, vehicles powered by biodiesel and E-85 would certainly help the environment, and would be an improvement on the way things are going now. Thanks again for the great 'zine, John Zaruba AA2BN, Franklinville, New Jersey jzaruba@snip.net

Hello John, That sure is a weird situation. It brings up lots of questions about big business and automotive politics. I was a bit surprised that synthetic oils won't work with E-85 fuels. I know that some fuel ends up in the lubrication of internal combustion engines, and ethanol and gasoline probably react somewhat differently with the synthetics. But I have this nagging suspicion that the synthetic oil company was in butt-covering mode rather than saying that it should be OK. How about it, readers, does anyone have the technical scoop on this?

And what kind of politics are going on with the lack of E-85 fuels in the U.S.? Do the automotive companies get some sort of EPA break on environmental regulations by supplying a "greener" vehicle in spite of the lack of fuel necessary to carry through on the prospect? Maybe the multi-fuel vehicles were mandated in the hopes that they would spur demand for E-85 to create a market? The cart seems to be ahead of the horse. Michael Welch

Empty Batteries for Backup
Hi Richard, After ten years of being off-grid with PV and wind, and having power hungry hobbies (wood and machine shops, lots of trees and garden), we have decided to bring in the grid. Since we are in a net metering state (Colorado), we plan to use the grid as a very expensive but high capacity battery bank.

Since the grid (with net metering) is a much more efficient battery than real batteries, I'd like to run our Trace 4024 with no batteries if possible. I plan to have a manual transfer switch to bring a small NiCd pack on line. The batteries would be flat from self discharging and would have to be initially charged by a generator. This would be our backup if the grid goes down (a rare occurrence here).

Does this sound reasonable, using the NiCds this way? I know we have lots of other issues with the 4024 firmware (120 from Trace vs. 240 from grid, our 24 VDC Sun Frosts, etc.).

Do you know anyone in northern Colorado who has experience doing a grid interconnect with Public Service Company (PSC) of Colorado? It was kind of a shock talking to PSC and realizing how they exercise their monopoly power. They won't even let us dig the trench to bring in power! Not negotiable! I was hoping that putting in our own trench would lower the US$7 per foot price tag. Thanks, Bob Gobeille, Fort Collins, Colorado • igs@verinet.com

Hello Bob, Your plans are technically sound. NiCds don't mind sitting around totally discharged. However, you are going to have a hell of a current surge when you first begin recharging them in the event of a power failure. While your PV and wind sources will aid in quickly refilling the NiCds, the bulk of the energy will have to be delivered by the generator. Make sure that the generator is up to the job, and that the Trace is programmed properly for this event.

Perhaps we have readers who are utility intertied with PSC. How about it, readers? The US$7 per foot that

PSC is charging you is below national average for power line extensions. I'd suggest adding enough PV or wind until your utility bill drops to zero. Richard Perez

4024 Modified Square Wave Inverters?
Richard, I just had an interesting experience with my original Trace 4024 that I thought I'd run by you.

The unit failed one day with a heatsink over-temp condition in the battery charger fairly early in the charging cycle (apparently the earlier units were not as well protected from over-temping as the current units) that corrected itself within 15 minutes. The unit seemed to be producing power OK afterward, but since it had failed during a charge cycle and gotten hot as hell in the process I sent it back in for a rebuild and upgrade. I was fortunate to have another unit in stock I could use in its place.

When the tech called to give me the price, he told me an interesting story about the failure. It seems all four high end FETs had failed (he said the board was "obviously burned"), and that had apparently contributed to the failure in the charger (though I'm not sure what the connection is there). When I asked him how that could happen, he said that high voltage on the charger side could cause it, and that generators could easily put out such high charges.

It seemed strange to me that if it were such a common occurrence they wouldn't have protected the system from it, but apparently the FETs are good to 200 volts. It turns out that when a generator runs out of gas (which is bound to happen sooner or later with all gas generators), the generator spikes the voltage to try to compensate. When that happens, unregulated voltages of 200+ are easily possible.

This was apparently when the FETs started to go, but according to the tech, it isn't a catastrophic failure but a cumulative one, and there is no indication from the unit that such a failure is occurring. When I asked him what that does to the unit, he said it basically causes the unit to cease being a sine wave and revert to modified square wave (I just can't bring myself to call it modified sine wave <grin>). It also reduces the surge capacity, but if no large loads were being run, the reduced capacity would never be noticed.

It strikes me as odd that the unit could undergo such a failure without any indication that it has happened. I wonder if there aren't a lot of "sine wave" 4024s out there that are now acting as modified square wave units. The only way we noticed it was when the battery charger failed.

I was wondering if you could do some checking on that, and if you might want to warn some folks of the dangers of letting generators run out of gas. I have never seen any indication in any of the literature that it was something to watch out for, and with such devastating results, you'd think someone would make mention of it.

Since I've said some very critical things about Trace and their tech support in this letters section in the past, I feel I need to comment on the changes that have obviously occurred since my earlier experiences. The Trace tech support, from the initial customer service call to the followup by their technical staff, was excellent. Unlike past experiences, all the folks I dealt with there were courteous, and interested in solving the problem. I never felt put off or talked down to by anyone I dealt with. Considering my previous experience, that is a definite change for the better.

You can be assured that I will be running this situation by as many other 4024 users as I can as well as all the wrenches I can find to see if anyone else has had similar problems. I will also follow up on this with the Trace folks at MREF in June. The possibility that a Trace sine wave unit could keep operating even though the sine wave output has been degraded or reduced to mod-square wave without any indication that this has happened is troubling. Maybe I misunderstood the technician, but I don't think so. I'll definitely be confirming that at MREF, and finding out if there is a way to notify the user through some kind of improved error checking if and when this happens. Tom Elliot, Guffey Energy Works • telliot@wagonmaker.com

Hello Tom. Thanks for the heads up with the Trace SW4024. Those of you with this inverter should check it out and make sure that all its FETs are firing. The best way to do this is with an oscilloscope. Richard Perez

Ethical Dilemmas of Clean Power
Like many others, I'm concerned with clean power generation because I don't want to contribute to global warming and environmental destruction. But the ethics of such choices are sometimes confusing, as the following parable illustrates.

Kay lived on the grid in a windy area with cold winters. She had a super-efficient gas furnace, but it still bothered her that every time she turned it on, she was contributing to global warming. So she decided to install a wind turbine to generate electricity that she could then use for heat. If she made extra power in the summer, she could sell it to the grid. But when the weather turned cold, she reasoned as follows: "If I use electric heat, I'll use up the power I'm feeding to the grid now. Then the power company will have to run their power plants. They'll burn more gas then I would burn if I used gas heat instead, because my super-efficient gas furnace is more efficient at heating than any power plant is at making electricity." So she sold her power to the grid, and heated her house with gas, but it bothered her every time she turned on her furnace, because she was still contributing to global warming.

There are various degrees of directness by which one can get clean power. The most direct is to generate it locally and use it locally. Then it's easy to see what your impact is. But unlike Kay, I don't have enough land to have my own wind turbine, so I'm reduced to trying to get my clean power through the grid.

The next most direct system is to pay some company by the kilowatt-hour to generate your power and ship it to you over the grid. But here in Massachusetts, we don't even have that available. All we have is a company called AllEnergy, which does business in an even stranger way.

When you deal with AllEnergy, you buy your power in the regular way from the standard offer on the grid. Then, separately, you pay AllEnergy US$6/month each for blocks of 0.25 KW (about 3.5 cents/KWH) of generating capacity. AllEnergy agrees to generate this much power using clean sources, and feed it to the grid. This power displaces the fossil-fuel-generated power that you would otherwise be purchasing through the standard offer.

Since it was the only game in town, I signed up with AllEnergy. I bought enough blocks to cover my electricity usage. Now I can say that, in a rather roundabout way, I'm not contributing to any environmental problems through my power use. However, it is still the case that, like Kay above, when I turn my lights on, I contribute to global warming. I've bought some fixed number of blocks from AllEnergy, and any incremental power I use requires an incremental increase in fossil-fuel-burning power generation.

Furthermore, I still heat my house with fossil fuels. I thought, when I signed up for this service, that maybe I'd buy more blocks and heat partially with electricity, but I think the parable shows that this doesn't make sense. The best I can do is to buy enough generation blocks to displace my own fossil fuel use, rather than just my use of electricity. At least this lets me say that I use, in net, no fossil fuels. But it is still the case that every time I turn on the heat or the lights, I contribute to the problem.

Is it better, then, to be off the grid, so you don't face this dilemma? Not really. If you can't generate all the power you need for electricity and heat, you will have to make it up with fossil fuels (propane, etc.). If you can generate all the power you need, at least some of the time you will have extra power generation capacity. You could be using it to displace fossil fuel use, if only you had a connection that would enable you to send it to the grid.

I don't want to discourage anyone from generating clean power or buying it from the grid. But I think one should think closely about the consequences of one's choices, and realize that the ethical calculation is not as simple as it might seem. Ken Olum, Sharon, Massachusetts • kdo@cosmos5.phy.tufts.edu

Dear Ken, I applaud your efforts to reduce your individual impact on global warming and the environment. You and Kay have both made good decisions toward reducing your environmental impacts. Still, it is possible to go too far. If you wanted to eliminate all *of your impact on global warming, you would have to terminate use of fossil fuel transport for yourself as well as all the goods you might consume. Incidentally, you would also need to stop breathing. Such a goal isn't all that desirable or practical.*

What should matter is that your net *impact on the environment is as low as possible. To this end; conserving, recycling, and cleaning up your local environment are probably the best methods. Sure, some greener methods are confusing and indirect, but planting a couple of trees might help balance your net impact a bit more. Eric Eggleston wattsworth@juno.com*

Eric's too modest to mention his fine article in HP71: It's Easy to Cut Your Utility Bills, Save Energy, and Help the Environment *(page 84). He gives many useful tips on how to lighten your load on the planet.*

I think it's much too easy to get focused on the generating technologies. PVs, wind generators, and hydro turbines capture our attention easily, as does buying "green power." But our first effort should be to look at our loads, conserve energy, and increase efficiency in our appliances. Compact fluorescents on the ceiling before PVs on the roof please! Then we have less to agonize over when we turn on the light switches and think about where the power is coming from. Ian Woofenden

Grant Info

I know for sure that grant money is available for RE power projects. Perhaps someone on your staff knows how to write grants and how to apply for them. Could you print a simple sample of what you think an RE grant proposal application should look like, and list a few Web addresses we could look at? Nothing much is going to happen with RE power unless we get help—we can't use our own money and wait for the payback. The power companies will own us to the end. Their latest thing is to charge a big bookkeeping fee if you try to sell them excess power. Thank you, Paul R. Jones

Hello Paul, Home Power *has not written any grants. We do not have that kind of expertise. But I think it would be a great idea to publish successful RE grant proposals so that others can be shown how to do it. But there are so many different grants out there, and they all differ so much that any one or two proposals we have room to publish would have limited applicability to the next person that comes along.*

And I believe there are other good reasons to install RE besides the financial payback. The most important are helping the environment and gaining self-sufficiency. Even though we may never pay for our on-grid systems with the savings on our power bills, we should still be investing our money in RE for our homes. The rewards are not all counted in dollars. Michael Welch

Hi Paul, Thousands of us have been using our own money to buy, build, install, and promote renewable energy systems for years. Without all that invested time, energy, and money, the RE industry wouldn't be where it is today, and you probably wouldn't have this magazine to read. Don't assume that it won't get done unless someone else or someone bigger does it. Do it! If you can't do it by yourself, pool your money, talents, and time with others.

Grants can be useful, but they can also skew the process and disguise the true intentions of those involved. When generous individuals or foundations want to support things they believe in, that's great. But I think grants should go to those people and groups who would do the work whether they had the grants or not. Much more has been accomplished in this industry (and world) by concerted private initiative by individuals and groups than by grant writing and waiting for others to do and pay.

It is true that the monopoly utilities have a chokehold on energy. We need to continue to work to break that hold, and to let people have true choices. Ian Woofenden

KWH Meter Sources

In *HP77 (Letters,* page 149), under "Component Sources," Jonny Klein gives some sources about kilowatt-hour (KWH) meters for 115 VAC. I would like to give one or two more sources.

We in the EV world have been greatly helped in our cause by KTA Services, ably owned and managed by Ken Koch. KTA is in Upland, CA (down near Los Angeles), at 909-949-7914.

I purchased a 115 VAC KWH meter from KTA several years ago for use in monitoring the electrical consumption of my EV and whatever else that piqued my curiosity. The unit was about US$50. I chose to mount it on a stand, and also upgraded its electrical cabling to withstand EV charger usage.

I also have another KWH meter that I might be willing to part with (the KTA one I definitely want to keep). This one I purchased from C&H Sales for $15. It has the lugs coming out the back, so it would have to be wired up and mounted (the lugs would normally go into a house meter wall mount). I've never used this one since I bought the KTA meter a month or two later. Both these meters are of the spinning-wheel type and have four dials. Chuck Hursch, Larkspur, CA • 415-927-1046 chursch@yahoo.com

Ozonal Notes

Muddy Roads in the Friendly Skies

Richard Perez

You will have to wait until next issue for our full-blown report on MREF 2000. There simply isn't time for us to process the photos and write the text before this issue goes to print. What you will get here is the saga of our personal trip to and from MREF 2000. It was a savage journey and without doubt the most difficult MREF trip we've ever had. Since there has been a running discussion regarding transporting the *HP* crew to energy fairs, I thought you might like to hear what happened when we chose the time and fuel-efficient mode of air travel. Read on for the gory details.

The Best Laid Plans

We'd been planning this trip to MREF 2000 for months. Karen had secured all of our airline reservations in January. Karen, Joe Schwartz, and I were flying out of Medford, Oregon. Don Kulha and Michael Welch were flying out of San Francisco. Ian Woofenden was catching a plane out of Seattle. We had it worked out with military precision. We would all arrive in Madison, Wisconsin on the same aircraft and with plenty of time to attend the MREF exhibitors' dinner on Thursday evening—or so we thought.

Hosed in Portland

Karen, Joe, and I arrived in Portland after a wonderfully sunny 6 AM flight out of Medford. I immediately checked the monitors. Our connecting flight to Denver was listed with a two hour delay. A quick glance at our tickets showed that we would miss our flight from Denver to Madison. We immediately went to the United customer service counter for rescheduling.

Just before this trip to MREF, Karen and I had flown to New Orleans to help her Mom relocate near us in Oregon. We were familiar with the procedures to follow when airlines strand you in the middle of a multiple-flight journey—go to customer service immediately, don't even stop to visit the john. On our way to New Orleans we were re-routed through Cincinnati due to a late flight and missed connections—about 1,500 wasted air miles and three hours of flight time out of our way. After customer service had re-routed us, we wound up in New Orleans seven hours late. And by the way, they lost our luggage….

We wasted no time getting into the queue at the United service counter in Portland. Karen and I were mindful of our recent problems getting to New Orleans. We waited there for about half an hour and watched the line rapidly grow behind us. The customer service rep verified what we already knew—there was no way we were going to get to Madison in time for the MREF exhibitors' dinner. United suggested that we spend the night in Portland and continue the next day. It was then 9 AM and we weren't about to waste 24 hours in Portland when we were supposed to be in Madison.

After significant flight juggling, the service rep arranged a scheme by which we would fly through Chicago instead of Denver, and eventually reach Madison at around 9 that evening. We went for it like starved piranhas. We've long ago given up hassling the poor folks who have to work these airline service counters. There is no point in going ballistic on them—they are doing the best they can to make everyone happy. But the fact is, they can't really correct for the massive overbookings and lackadaisical performance of the rest of the company. After an hour in line, we had new tickets and a four hour wait in Portland. The line behind us had grown to well over two dozen folks, and the crowd was getting ugly. We really felt sorry for the customer service reps—we wouldn't want their jobs.

To soften the blow, the United rep turned us on to some meal vouchers and suggested that we have breakfast on United. I replied that I'd rather be in Madison on time, but what the hell, we were hungry—so breakfast sounded pretty good. We took the service rep's recommendation and went to the Red Lion restaurant. We had a wonderful breakfast of fresh-squeezed orange juice, eggs benedict with smoked salmon, and espresso coffee. This consumed an hour, and left us in a far more forgiving mood.

Karen got on the cell phone and warned the rest of the crew that we would be late, and that they'd have to cover for us at the exhibitors' dinner. We settled down to waste a few hours reading, dozing, and people watching.

Hosed in Chicago
The flight from Portland to Chicago was uneventful. Once again, we immediately checked the monitors when we hit the ground. You guessed it, our flight to Madison was delayed for an hour. The Chicago airport was clogged with people, many no doubt waiting around because of all the flight delays. All the restaurants were jammed and had long lines of weary travelers waiting to get in. We managed to finally find some seats in an out of the way bar tucked into the corner of the United Express concourse. Here Karen caught up on her knitting, while I abused my liver and Joe had a nap. Eventually our flight got off the ground after even further delays, and we were finally on our way to Madison.

Hosed in Madison
We hit the ground in Madison shortly after 10 PM. We were supposed to be there seven hours earlier. The journey had consumed fifteen hours, but we only spent about six of those hours in the air. The remainder of the time we were stuck hanging out in airports.

Karen went to the rent-a-rig office to do the paperwork on our rented van. Joe and I combed the luggage carousel for our bags. Hosed again—our luggage wasn't there. We went to the United customer service desk and filled out forms for our lost luggage. By now it was well after 11 PM and we were thoroughly tired, jet-lagged, and grumpy.

Just as we were leaving the airport, we were paged. They had found our luggage! It had arrived hours ahead of us and was languishing about in a storeroom that United obviously hadn't checked when we filled out the lost luggage forms. The folks at United in Madison were very pleasant, and we resisted the urge to scream at them. We jumped into the rent-a-van, and drove through the quiet streets of Madison looking for our hotel.

Midnight Munchies in Madison
After we checked into our room at the hotel, we discovered that their restaurant and room service had shut down for the night, which was entirely reasonable because it was almost 1 AM. We were all hungry, having avoided what was being passed off as food during the flights. Karen checked the phone book, looking for food that could be delivered. No such luck—no one was delivering at that time of night. Joe and I decided to be daring, and hit the streets in search of food.

Neither of us knew our way around Madison. But hunger activated some primordial center within our brains, and within fifteen minutes we'd zoned in on a late night pizza place called "Toppers." Toppers makes great sandwiches. Karen says it was the best veggie sandwich she's ever eaten, but then she was half starved by the time we made it back to the hotel with the munchies. Fed, bone tired, and excited by the prospect of MREF the next morning, we crashed at about 2 AM.

MREF
MREF was in its eleventh year and it was fantastic as always. It was different this year because it was in the city and not in the country. You'll have to wait until next issue for our write-up of the fair itself. Suffice it to say that new products abounded, spirits were high, and we saw many new faces. This narrative has a far grimmer purpose. It is the story of the journey to and from MREF, a much darker saga that hadn't yet played itself out.

Sickness Strikes
I woke up Saturday morning with a rampant case of butt-kicking flu. Karen pulled the sodden bed clothes from my shivering, feverish body, touched my forehead, and grounded me. She returned to the hotel at about noon and dragged me out to a clinic where the doc told me what I already knew, "You have the flu." Back to bed I went, and I missed the entire Saturday at MREF and some great parties Saturday night, or so I hear. I want to thank Dave Katz, Ezra Auerbach, and Don Kulha for doing the workshops I had scheduled for Saturday.

I woke up Sunday morning feeling like death warmed over, but I was determined to make the fair. A quick shower and a quad shot of espresso produced a lifelike feeling, and off I went. The day was surreal. I couldn't tell if it was fever or the strong cough syrup that the doctor had prescribed, but MREF took on the aspects of a Fellini movie. I did two workshops of which I remember virtually nothing except that my voice stopped working. I talked with folks on the fair floor while trying not to drool on myself. I probably should have been in bed, but I was damned if I was going to come all this way, fighting the airlines and sickness, and not do MREF.

Hosed in Denver
After the fair, we went to the Madison airport and boarded a plane for Denver. Upon hitting the ground in Denver, guess what the monitors showed us? Our connecting flight was delayed and we would miss our connection from San Francisco to Medford. We

scrambled once again to the United customer service booth and, thanks to Karen's fast reflexes, arrived at the head of the rapidly growing line. We got rescheduled, and had three hours to kill in Denver. So Karen, Joe, Don, Michael, and I wound up in a bar, the only place in the Denver airport where smoking is allowed. The bar was packed. I gave serious consideration to investing in this bar—what a racket!

When it came time to board the aircraft for San Francisco, I was astounded. They were putting us aboard a Boeing 747-400. The 747 is just about the largest, long-range passenger aircraft there is. What were we doing flying this transoceanic monster on the short hop from Denver to San Francisco? The mystery deepened when I noticed that the aircraft was only half full. Something grievous and truly terrible must have been afoot at United Airlines for this to happen. I shudder to think of the cost picture of flying a half-filled 747 on the short hop from Denver to San Francisco. Obviously United had pulled out all the stops to cover for what must have been a weekend in hell.

Hosed in San Francisco
You guessed it—when we hit the ground in San Francisco, our flight to Medford was delayed by two hours due to aircraft mechanical problems. We had to wait for another aircraft to arrive from Los Angeles before we could make it home to Medford. Don and Michael split on airporters that carried them north to Santa Rosa and to their vehicles for the final drive home. Joe, Karen, and I went to the Crab Pot restaurant in the airport and drowned our sorrows in crab cakes and Anchor Steam Beer. Eventually, our aircraft was ready, and we made the short one hour hop back to Medford, Oregon, arriving six hours late. I was relieved to see our luggage spew out of the carousel. I couldn't have handled another pothole in this muddy road in the skies—I'd have gone postal.

Air Travel
I'm a seasoned air traveler. My first flight was from London to New York in 1948 on a four-engine Constellation. I've flown in commercial and military aircraft all over the world, from Texas to Tehran, from Chicago to Cali, from Dahran to Detroit. But I've never had a weekend like this one before. I actually like flying, but commercial air travel has become something painful.

I could see the disenchantment in the faces of our fellow travelers dozing in the chairs and on the floors at the boarding gates. I saw the tension and anger in the faces of stranded travelers screaming at the poor customer service reps. The system is breaking down. Air travel is no longer enjoyable and reliable. I reflected on missing the exhibitors' dinner at MREF. In eleven years of MREF, this was the first time we've missed that dinner. Thanks, United.

What really scares me is that we are booked into three more air junkets to energy fairs this summer. Who knows what further potholes lie in the friendly skies? I'm going to be prepared—fly early, expect delays, believe nothing, and carry a flask of strong drink. Prepared to sleep on benches and stand in lines. Prepared to be treated like dumb cargo.

Next year, we are traveling to all energy fairs via surface transport. I've had it with airlines.

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Q&A

Answers from Readers on Mod-Sine for UPS
In *Q&A, HP76,* Jerry Lilyard asks about a UPS system that will run on modified sine wave input. I suggest that you run the imperfect output of your inverter into a power line conditioner to clean it up. Then you can run your computers, UPS system, or whatever else you want to off the line conditioner. You lose a few percent of your energy output, but it works fine.

A power line conditioner accepts all sorts of nasty AC waveforms, and reconstructs them in better shape on its output side. I have used a 250 watt Acme Electric Electroguard True-Power PLC250 in this way to run my computers and electronic piano off modified sine wave inverters for many years. Other manufacturers and power ratings are available. I hope this helps. Joel Chinkes, Columbus, NM

More Answers
Dear Richard, Good afternoon! I saw in *HP76* that someone wanted to know about which UPS systems can run with modified sine wave. Recently I obtained a Centralion 250 VA (China made), which works 100 percent with my Trace 612SB and DR2412 now. And let me tell you, a few years ago we used a Tripplite 300 VA white case, and also did the job with an old Trace UX2424.

I have bad UPS experience with the following brands: Exide, APC, Liebert, Deltec, and a few more. One brand that works OK with any kind of wave form is Toshiba, but they are extremely expensive.

I would like to know your opinion about the Dryfit Prevailer gel batteries. I am thinking about using them for my office backup system. Looking forward to hearing from you soon, and I thank you in advance. Best regards to you, Karen, and all the crew. Pedro Mejias, Santo Domingo, Republica Dominicana, W.I. pedro.mejias@codetel.net.do

Hola, Pedro. Thanks for the info on computer UPSs which will operate on modified sine wave inverters. I've no experience with the Prevailer gel cell batteries, but we recently tested the Concorde AGM sealed batteries and they work very well. Let me know how the Prevailers do. Richard Perez

Half Right
Dear *Home Power,* In *Q&A, HP75,* Erik Frye asks what the *NEC* requires for battery interconnects. Your answer was half right.

All wires (interconnects and load) shall be #2/0 or larger if they are "inside a battery enclosure" *(NEC* 690-74) and all interconnects should be of the same gauge as load. (for example, if you need #4/0 from batteries to inverter, interconnects should be the same.)

I've been a reader for many years and last year I installed the basic system and am buying more solar this year. My inspector worked with me very well. Solar works here. Mike Lee, Renton, Washington

As with most code questions, the answers are not always simple. Joe Schwartz in HP75 *was on the right track. Section 690-74 of the* NEC *"permits" the use of flexible Article 400 cables in battery boxes if they are #2/0 or larger. The word "permits" in the* NEC *indicates an option and not a requirement. In this case the word "permits" refers to the use of flexible cable to minimize the possibility that stiff (#2/0 and larger) cable might distort soft lead battery terminals. Stiff cables smaller than #2/0 will not overstress battery terminals.*

Joe was correct in his answer that in a single string of batteries, the inter-cell or inter-battery connectors should be sized the same as the main battery bank input and output conductors. In parallel strings, we frequently assume that the current divides equally between the strings. Unfortunately, as the batteries age and fail, the currents do not divide equally. The code has no specific requirements in this area, so it is up to the installer. For two strings, I usually use interconnects the same size as the main cables. For three or more strings, I go down one or two AWG sizes on the string conductors.

The safest method would be to fuse each string at the ampacity of the string conductors. This is done in large commercial installations with battery strings operating over 48 volts nominal. In 48 volt and smaller battery banks, these internal string fuses are frequently not used, and we accept the fact that the string cables are not protected from faults within the battery bank.

As far as the ampacity requirements of the main conductors, stay tuned for the details in HP79. *John Wiles*

Really Small Wind Genny
Dear *Home Power,* I use a pair of 9.6 volt R/C car batteries to operate my LGB, 6 scale locomotive for my garden railway. I thought it would be cool to recharge these batteries with a homemade wind generator.

I have some very high quality Pitmon motors that when turned by hand, register on a meter. My question is, once the battery is full or partially full, how do you keep it from reversing into the generator/motor and running it like a fan? Could I use a diode network somehow to make it only charge the battery? Terry Allen Palmore, Meadow Vista, California

Hello Terry, You can simply use a single diode in one of the wires between the motor and the battery. We normally choose the positive (plus) wire. The marked end of the diode connects to battery positive and the other end of the diode connects to the positive motor terminal. The voltage (electromotive force or EMF) from the motor will depend on the speed. At low speed, the EMF is less than battery voltage. Without the diode it would take current from the battery. When the speed is higher, the motor will produce more voltage than the battery and the current will flow the other way. The diode ensures that the current can only flow one way—the right way. You will lose some voltage in the diode itself (almost 1 volt), but it's worth it.

Any motor can be used as a generator, but the problem is to run it fast enough. It has to run faster to generate than it runs as a motor. If it only runs slowly, there will not be enough EMF to overcome the battery voltage, and you will get no current. Cheers, Hugh Piggott, Scoraig Wind Electric, hugh.piggott@enterprise.net

Terry, The diode should be rated at least five times the working voltage of the generator and two times the current. Install it between the generator and battery bank. A volt meter and ammeter on the genny side of the diode will tell you what's happening (charging rate). Mick Sagrillo, Sagrillo Power & Light

500 Amp Recharging

Dear Sir, After reading your book about electric-powered vehicles, I am very interested in fast battery recharge. I read that you fast charged some batteries for a competition, applying 500 amps of current from another pack of batteries. Is fast charging bad for the batteries? Can battery life be reduced with such a method? Thank you, João Ferraz

Hello João, Fast charging like this is very hard on batteries, but this is a race situation. It will radically reduce battery life, but racers don't care about this. They just want to win. Richard Perez

Gel-Cell Battery Desulfator

Gentlemen: I read with great interest Alastair Couper's article *(HP77,* page 84) on making a lead-acid battery desulfator. Two questions came to mind relative to my own case.

1. Is a desulfator of any value for gel-cell lead-acid batteries? I was for many years in a testing organization where small sealed batteries were used and they seemed to last twenty years or more on their own. It was for that reason that I purchased used gel cells for my backup home lighting system.

2. Assuming the answer to question 1 is "yes," can the circuit described in the article be modified to handle a bank of gel-cell batteries? In my own case, I have a 12 volt system consisting of eight 80 amp-hour batteries in parallel. Thank you, John D. Betz, Rising Sun, MD

Hello John. The electronic desulfator is of immense value to sealed lead-acid cells. Since these cells are sealed, it is not possible to give them a standard equalizing charge because they would gas, vent, and dry out. The only way to keep sulfation at bay is with proper recharging and the electronic desulfator. We have successfully rejuvenated many sealed lead-acid batteries using electronic desulfators. They work just as well on sealed cells as they do on flooded cells.

The circuit published in HP77 *will work on your battery unmodified. No changes necessary. The desulfator circuit is not specific to sealed or vented cells, it will work on either. Richard Perez*

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1982 JACOBS 10-21 10KW Wind dynamo for sale with 100' Rohn SSV tower. In NH. 603-652-9559 eve, 603-868-2270 (W), scp@worldpath.net

EDTA RESTORES SULFATED Batteries. EDTA tetrasodium salt, info, catalog, $12/lb plus $3.50 ship & handle. Trailhead Supply 325 E. 1165 N. Orem, UT 84057, (801) 225-3931 or (801) 226-6630 email: trailheadsupply@webtv.net http://www.webspawner.com/users/trailheadsupply

WANTED: The Midwest Renewable Energy Association is in need of two wind generator towers. We'd like Rohn SSV towers, one at 90' to 100', and the other at 110' to 120'. Donations always accepted. Please call Mick at 920-837-7523 or Katy at 715-592-6595.

VERMONT PV DEALER. David Palumbo/Independent Power & Light has been installing off-grid systems, and helping do-it-yourselfers (who buy their equipment from him) with free professional design advice for over 10 yrs. Trojan and Surrette batteries. FREE with battery purchase IP&L deep cycle battery instructions. Trace, Solarex, Siemens, and BP at fair prices. Large supply of wire and cable. Beware of "fast buck artist," slick talking, "lowest price anywhere" mail order companies who don't take the time to find out what you really need and can't spend the time on personal support and service. Buy from an honest dealer who knows the products and cares about your success in using them. David's installations are innovative, simple to live with, and successful. And our long following of do-it-yourself customers always come back for more because they can rely on getting straight talk, no BS, and the best service possible. "David is one of the original RE pioneers... he knows how to really squeeze all the energy out of a KWH!" Richard Perez *(HP60).* I P & L, 462 Solar Way Drive, Hyde Park, Vermont 05655. Call David Palumbo 802-888-7194. Email: indeppower@aol.com. Web site: INDEPENDENT-POWER.COM. No catalog requests please. Please call for appointment before visiting.

COMPUTER NERD WANTED: Work/study trade opportunity, 6–12 months "Hands-On" workshop attendance in exchange for "net savvy" multi-media skills in IBM PC environment. Solar Energy International, 970-963-8855 sei@solarenergy.org (For SEI info see *HP* ad)

INTERNS WANTED at SOLAR ENERGY INTERNATIONAL! Work/study trade opportunities, 6–12 months "Hands-On" workshop attendance in exchange for multi-faceted office work, beginning ASAP. SEI, Carbondale, CO. sei@solarenergy.org • (970) 963-8855 (For SEI info see *HP* ad)

PROPERTY CARETAKERS/Housesitters enjoy rentfree living, worldwide 700+ opportunities available! The Caretakers Gazette (480) 488-1970. www.caretaker.org

AE DEALERS LIVING WITH systems they sell. Experienced design, supply & installation PV, Wind & Heating. SASK Solar Box 444 Air Ronge, S0J 3G0 Canada Ph/Fax 306-425-3930

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QUIRKS WIND GEN, 2kW, 3kW in 30mph, 110VDC 10'8" dia prop, complete, 10ft. tower, control pnl, inst.manual, drawings, as-new cond.,in orig. crates. Rugged heavy-duty unit good for heating and lights. $2500 David 801-768-8597,801-569-6630,801-599-2944.

NEW MEXICO HOMESTEAD SITES Private. Legal. Tillable farm soil. Pure abundant water 200ft. Quiet. Minimal restrictions. Prime Solar/Wind. Roads in. Deming 15 miles. Easy RV access. Build adobe, straw bale, papercrete etc. $600 & up. Believe it (505) 536-3813 dennis@gilanet.com

SOLAR ELECTRIC Business for sale Owner illness requires sale of non region specific solar electric business Could be run from anywhere Details Box 587 Roundup, MT 59072

$$$$$$$$$$$$$$$$$$$$$$$$$$$$$ Air 403 $455 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$ PC 500 $1299, C40 $143, PP-SW4024/S $3,299, PP-SW4024/D $5999, DC250 $229, www.NationalDiscountSolar.com 877-222-4990 (toll free)

TWO JACOB 17.5 KWH wind generators on 120' self standing towers, with inverters 12K each or both for 20K Call 715-682-9240

FOR SALE TRACE SW4024 inverter new in box never opened S/N w12044L + DC250 Disconnect box + SW conduit box all new $2500.00 + shipping call Ohio 419 289-3258

HOW TO SAVE HUNDREDS on your solar electric installation. Send $5.00 for info. Charles Lee, 425 Wells Av. N., Renton, WA 98055 425-204-8812

MINI-MICRO HYDRO ELECTRIC $599.00 12 or 24 volts, max. output 700 watts/da. As seen in *HP9,* Western Hydro, P.O. Box 728, Nevada City, CA 95959 Ph. 530-272-8485

55 KW GEN-SET Koher fast response continuous standby generator. Set on skids, 55 KW, 225 amp, 3 phase with automatic transfer switch. 303 hours was hospital standby generator. Excellent condition. ph: 719-836-0460

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ELECTRIC POWER YOUR BICYCLE. Henthorn Regenerative Electric Auto. Simple Homemade Hydrogen. Plans catalog $1. DWFrench, POB 2010(AEHP), Sparks, NV 89432

MIL. SPEC. POWER SUPPLY PP-110 AC/G New in box w/Dept. Army Tec. manual charger/regulator Mil. cost $4000. Sell $650. 760-471-4618, San Mateo, CA

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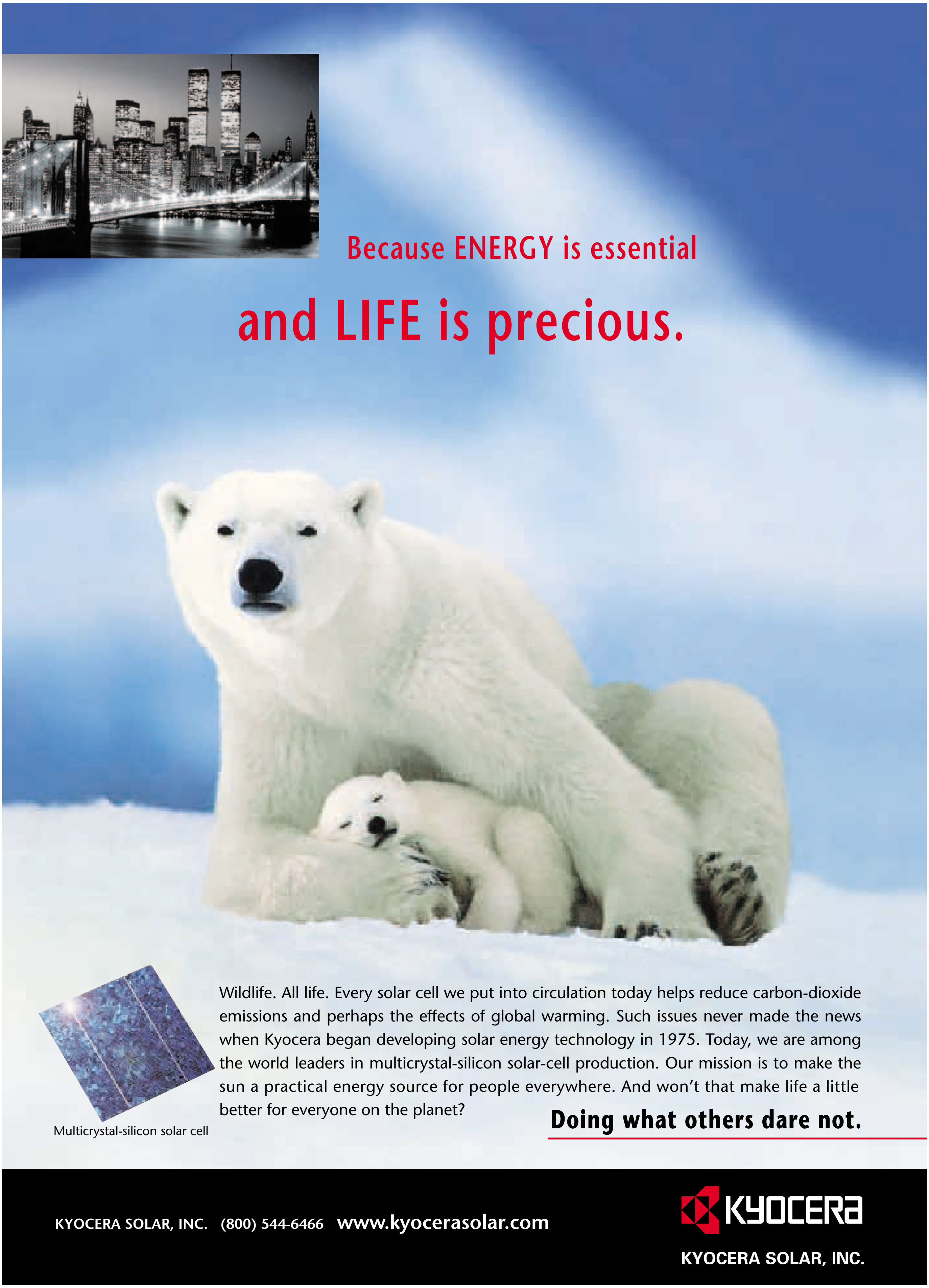

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The following information about your renewable energy usage helps us produce a magazine to better serve your interests. This information will be held confidential. We do not sell our mailing list. Completion of the rest of this form is not necessary to receive a subscription, but we would greatly appreciate your input.

NOW: I use renewable energy for (check ones that best describe your situation)

- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
- ☐ Recreational electricity (RVs, boats, camping)
- ☐ Vacation or second home electricity
- ☐ Transportation power (electric vehicles)
- ☐ Water heating
- ☐ Space heating
- ☐ Business electricity

In The FUTURE: I plan to use renewable energy for (check ones that best describe your situation)

- ☐ All electricity
- ☐ Most electricity
- ☐ Some electricity
- ☐ Backup electricity
- ☐ Recreational electricity (RVs, boats, camping)
- ☐ Vacation or second home electricity
- ☐ Transportation power (electric vehicles)
- ☐ Water heating
- ☐ Space heating
- ☐ Business electricity

RESOURCES: My site(s) have the following renewable energy resources (check all that apply)

- ☐ Solar power
- ☐ Wind power
- ☐ Hydro power
- ☐ Biomass
- ☐ Geothermal power
- ☐ Tidal power
- ☐ Other renewable energy resource (explain)

The GRID: (check all that apply)

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

____% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me _____¢ for electricity (cents per kilowatt-hour).

(continued on reverse)

I now use, or plan to use in the future, the following renewable energy equipment (check all that apply):

NOW	FUTURE		NOW	FUTURE	
❏	❏	Photovoltaic modules	❏	❏	Methane digester
❏	❏	Wind generator	❏	❏	Thermoelectric generator
❏	❏	Hydroelectric generator	❏	❏	Solar oven or cooker
❏	❏	Battery charger	❏	❏	Solar water heater
❏	❏	Instrumentation	❏	❏	Wood-fired water heater
❏	❏	Batteries	❏	❏	Solar space heating system
❏	❏	Inverter	❏	❏	Hydrogen cells (electrolyzers)
❏	❏	Controls	❏	❏	Fuel cells
❏	❏	PV tracker	❏	❏	RE-powered water pump
❏	❏	Engine/generator	❏	❏	Electric vehicle

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