Some of Life's Easy Choices:

There are enough tough ones. We'd like you to make a couple of simple — but necessary — choices for your energy system. Ready?

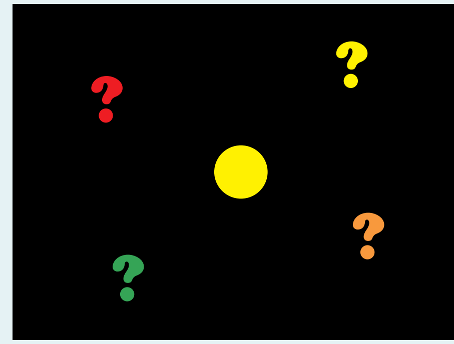
Choice #1

There's a reason why they're called *idiot* lights. They will only tell you one thing for sure about a battery: Whether there is enough voltage to turn the idiot light on. No light means either the battery is dead *or* a wire is broken *or* the idiot light is burned out *or* ....

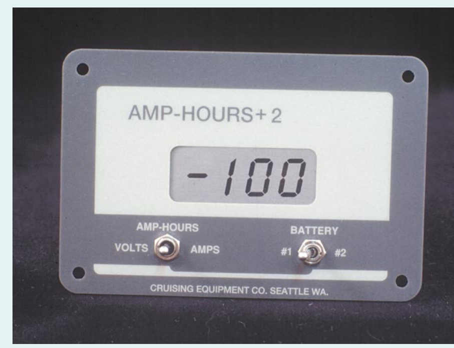
On the other hand, a precision scientific instrument, like Cruising Equipment's **Amp-Hours+** series of meters reports how many Amp-Hours have been consumed, precise battery voltage and battery current. Not to mention enough computer horse power to learn your battery's efficiency, drive the Ideal Regulator and much more...

Amp-Hours+ or Heart Interface **Link 2000** meters tell you the whole story. A light doesn't.

☐ **Idiot Light**



☐ **Precision Scientific Instrument**



Choice #2

In many parts of the world, people turn on a light switch and nothing happens. The power is off, the voltage is low, power lines are down or not available, and repairs could be hours or months away.

Fortunately, there is an alternative: Clean, reliable, AC power from Heart Interface. Powered by a bank of batteries, charged from the grid when available and by wind, solar, and even low head hydro when it's not.

Whether you need silent reliable AC power from your inverter in Indonesia, the mountains of Malaysia, aboard your motor home in the mountains of Montana, or to run a blender on a boat in the Bay of Biscayne, Heart Interface has competitively priced solutions in stock and available for immediate shipment.

☐ **Blackouts, Brownouts, Darkness**

☐ **Silent, Reliable AC Power**

Think of us as your partners in the power business.

Inverters by heart interface 21440 68th Ave. So. Kent, WA 98032 (206) 872-7225

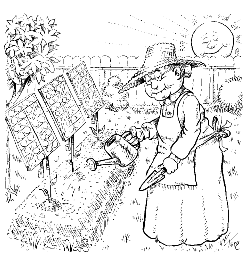
Instruments by Cruising Equipment Co. 6315 Seaview Ave. NW Seattle, WA 98107 (206) 782-8100

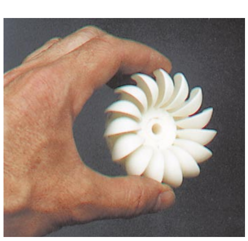
HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #44 December 1994 / January 1995

Features





GoPower

Fundamentals

Cover: Solar energy powers this beautiful stone home on Mt. Ashland, Oregon. Story on page 6.

Things that Work!

Homebrew

Columns

Regulars

Access and Info

Access Data

Home Power Magazine
POB 520, Ashland, OR 97520
USA
Editorial and Advertising:
916-475-3179 voice and FAX
Subscriptions and Back Issues:
916-475-0830 VISA / MC
Computer BBS: 707-822-8640

Paper and Ink Data

Cover paper is 50% recycled (10% postconsumer and 40% preconsumer) Recovery Gloss from S.D. Warren Paper Company.

Interior paper is recycled (30% postconsumer) Pentair PC-30 Gloss Chlorine Free from Niagara of Wisconsin Paper Corp.

Printed using low VOC vegetable based inks.

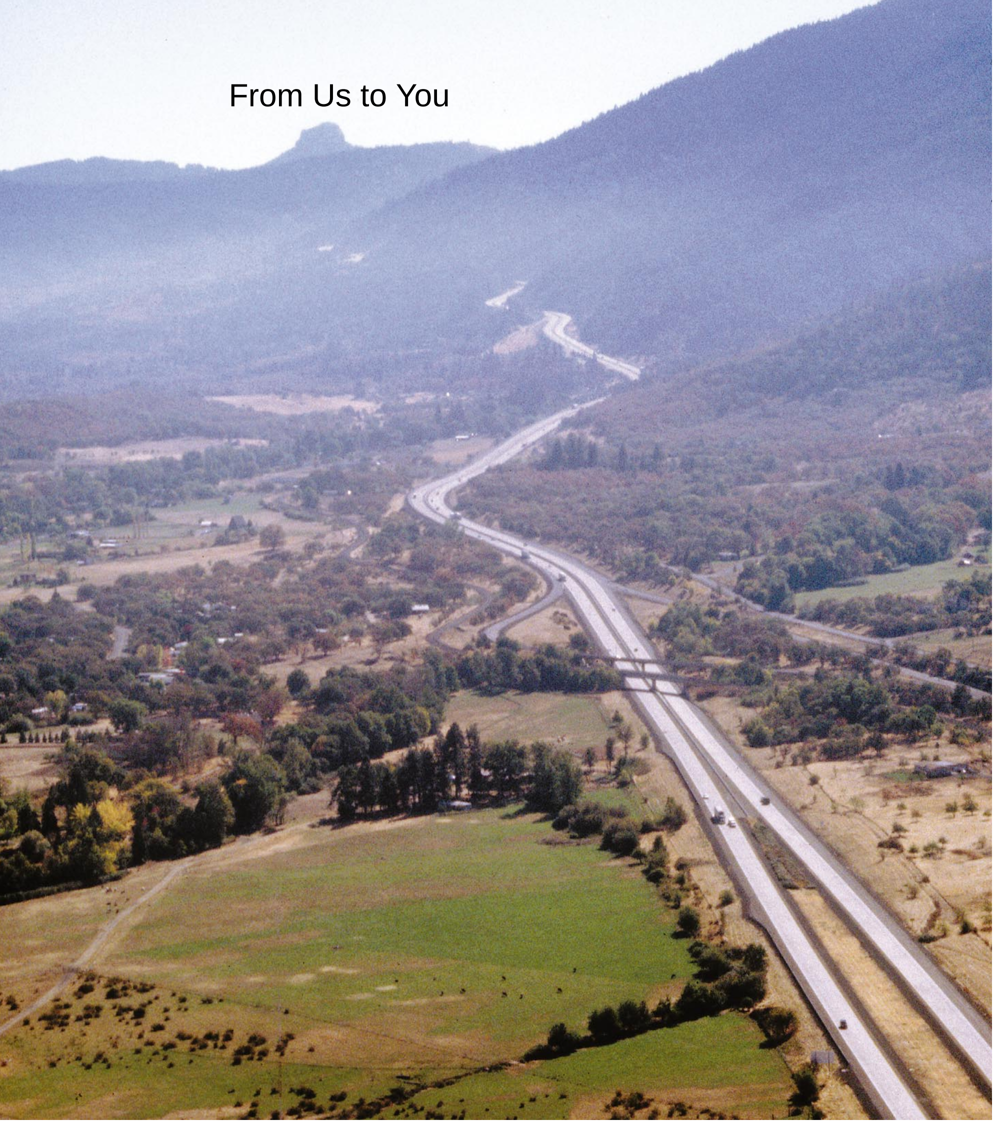
Printed by

St. Croix Press, Inc.,
New Richmond, Wisconsin

Legal

Home Power (ISSN 1050-2416) is published bi-monthly for $15 per year at P.O. Box 520, Ashland, OR 97520. International surface subscription for $20 U.S. Second class postage paid at Ashland, OR and at additional mailing offices. POSTMASTER send address corrections to Home Power, P.O. Box 520, Ashland, OR 97520.

Recycled Paper   Recyclable Paper



Above: a view from 4,000 feet over Ashland, Oregon, looking south on I5.

A view down the road

Our use of renewable energy is changing, slowly, but it is indeed changing. For example, look at the two systems featured in this issue.

One system (see page 16) was installed in 1985 and reflects the minimalist philosophy of its creators. It uses no inverter and four PV modules supply all the necessary power.

The second system (see page 6) was installed this year. This system uses 36 PV modules, two inverters, and even has the local utility grid on-site. This system provides power for a large home with all the electrical conveniences.

While the systems differ in size and technical sophistication, they share the same user motivations. Both families want to use natural, clean, and independent renewable energy sources.

What was once the domain of a handful of energy conscious back-to-the-landers is now the province of all. Technology has made it possible for individual homes to produce energy. We can all become energy farmers. Read the article on page 20. It tells how the Germans and the Swiss are becoming independent energy farmers right now. Using renewable energy sources is not a matter of technology or money. It is a matter of intent.

Richard Perez for the Home Power Crew

People

Barbara Atkinson
Andrew Bean
Clare Bell
Sam Coleman
Paul Cunningham
Michael Hackleman
Kathleen Jarschke-Schultze
Tom Jensen
Bob Johnson
Stan Krute
Dan Lepinski
Don Loweburg
Harry Martin
Andy McDonald
Greg Pio
Karen Perez
Richard Perez
Shari Prange
Byron Stafford
Mark Schimmoeller
Bob-O Schultze
Marc Schwartz
Terry Torgerson
Michael Welch
John Wiles

"Think about it…"

An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: it rarely happens that Saul becomes Paul. What does happen is that its opponents gradually die out and that the growing generation is familarized with the idea from the beginning.

Max Planck
The Philosophy of Physics 1936

SOLAR DEPOT

camera ready
on film
four color

7.6 wide
9.8 high

this is page 5

Above: Bill and Sara Epstein's solar-powered home located on the southest side of Mt. Ashland, near Ashland, Oregon.

Sunshine Superpeople

Richard Perez and Bob-O Schultze

Sunshine can power anything from two hippies in a tepee to the grandest mansion perched on a mountainside. At the heart of every solar power system is intent. Intent to live lighter on this planet. Intent to do things better and to pass it on to our children. This is a story of one family's intent.

Meeting friends and influencing people through logging accidents?

We first met Dr. Bill Epstein when Karen was involved in a wood cutting accident in 1985. Karen was removing a small branch from a round of dry oak firewood by banging it against another larger round. The branch shattered and a piece flew up hitting Karen in the face. This small, high-velocity bit of wood smashed Karen's sunglasses and drove glass into her right eye. I freaked out, we were over an hour from town and my sweetheart was bleeding and maybe even blinded!

I bundled Karen into the dune buggy and we raced to town. I had used our only means of communication, a 2 meter ham radio, to contact a friend of mine in the nearest town, Yreka, California. I asked him to call the hospital and let them know we were coming. My friend said he knew a crackerjack eye surgeon. We drove right to Dr. Bill Epstein's office and he spent the next two hours removing glass from Karen's eye. He saved Karen's sight and we made a new friend.

Every time Karen and I visited Dr. Epstein for a checkup we'd talk about solar energy. Karen and I talk solar to anyone who will listen, but I got the feeling that

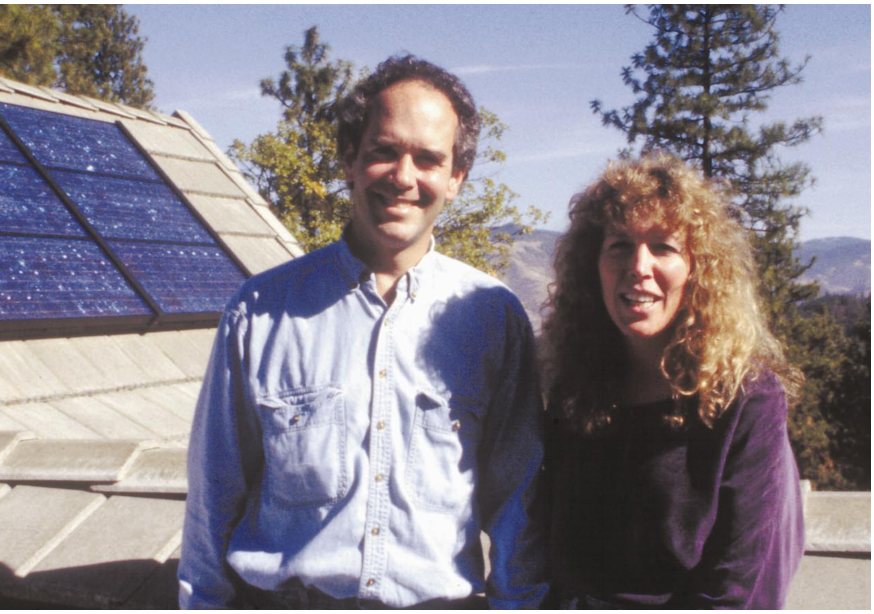
Above: Solar power was designed into this home from the very beginning. Bill and Sara use photovoltaics to make electricity and solar thermal collectors for domestic hot water and space heating.
Below: From the home's roof detail it is obvious that the architect planned to include PVs.

Bill Epstein was really paying attention. As the years rolled on, Dr. Epstein's practice and our business (at the time I sold and installed PV systems) grew. Dr. Epstein built a new, super energy efficient office in Ashland, Oregon that is a marvel of energy saving technologies. In 1987, Bill's office was awarded the State of Oregon Energy Edge Award. During that time we discussed making a solar-powered dream home for Bill, Sara, and their two children.

Eventually, I sold my PV installing business to Bob-O Schultze, one of the systems in progress that he inherited was Bill and Sara Epstein's. Six years after we first met Bill and Sara, they began construction of their solar-powered home on the side of Mt. Ashland. Bill and Sara Epstein knew from the very beginning that getting on-site grid power was cheaper than going solar. They went solar anyway, here's how and why.

Energy decisions that fit the situation…

Bill and Sara's home is located on the rugged southeastern side of 7,500 foot Mt. Ashland. Their 400 acre site is heavily wooded and extremely steep. Bill and Sara chose a



Top: A view of some of the 36 PV modules and the Thermomax solar thermal collectors powering Bill and Sara's home.

Bottom: Bill and Sara Epstein.

homesite on a point overlooking the city of Ashland. When we first started designing Bill and Sara's system, we planned to go totally solar with no connection to Pacific Power's utility grid.

Bill and Sara started, as any homesteader should, with their water supply. We were all very disappointed when the well came in at below 500 feet. This depth would require a very energy intensive-pump to move large amounts of water. One of the building requirements for homes on Mt. Ashland is a ready supply of water for fighting forest fires. The energy requirements of water pumping alone made installing utility power cost effective. In addition, the bank was growling about lending money for a home without utility power. Most folks would have stopped the RE system at this point, having already paid for the utility line extension. Most folks would not have continued seeking solar power, but Bill and Sara were determined.

A Solar Home

Bill and Sara's home was designed as a solar building from the beginning. Their architect, Dale Shostrom, is an experienced solar designer and contractor and he provided the home with a solid passive solar basis that requires little additional heat. In addition to the stone construction's tremendous solar mass, this home uses active hydronic heating and three wood-burning fireplaces/stoves. The solar electric system, designed by Electron Connection, was modified from the original stand-alone design to incorporate the grid rather than a generator as backup and keep open the possibility of a future utility intertie. Early negotiations with Pacific Power produced an unacceptable two-meter system with less than 2¢ per kWh buyback. But times change, and renewable energy is becoming more valuable as time passes….

Incorporating a solar electric system into Dale's custom designs, however, was new ground for him. Bill & Sara requested that he work closely with Bob-O during both the design and construction phases of the residence. It was a mutual learning experience for all. Dale learned to rethink the value of a kilowatt-hour of electricity in terms of the much higher cost of PV-supplied electrons. PV system designers take conservation, energy efficiency, and reduction of phantom loads very seriously. He also learned that PVs don't come in designer colors! Bob-O learned that architects and general contractors have a hell of a lot to think about and coordinate. It's important to put LOTS of time into explaining all the features and limitations of a PV system and ask LOTS of questions about the electrical devices and loads being incorporated into the design of the building. Bill and Sara learned not to leave things totally in the hands of the "experts" and expect everything to turn out exactly as they had envisioned. Frequent communication and cooperation are all important.

The Epsteins' Power Requirements

While the system design and the original electrical loads estimate changed radically as things developed, Bill & Sara wanted to keep two main criteria. One, that the PV system provide as much of their electricity as practical and two, the system must be as transparent and seamless to their electrical needs as possible.

No matter whether the house was operating from the PV/batteries, the utility grid while the batteries were being recharged, or if the grid was down altogether, the PV/Battery/Inverters system had to provide uninterrupted power to all the home's critical needs. In addition to all the lighting, small appliance, entertainment, communications, and alarm system needs, the 240vac 1 HP booster pump that pressurizes the house and the firefighting water systems had to operate under all conditions. Bill & Sara sustainably manage over 400 acres of forest surrounding their home for timber, firewood, wildlife refuge, and watershed. During the last year or so, the Epsteins have given away over 100 cords of firewood to charitable organizations and other folks in need. Buried beneath the house is a large

Top Right: A view of the home's stone construction and beautiful garden, complete with fountain and pool.

Center Right: The living room is heated by an enormous and energy-efficient fireplace.

Bottom Right: A super-efficient woodstove provides heat for the den.

Top: The power center located in the garage. Note the unltrafine cabinets (with covers removed) that house the batteries.

Below: Bob-O Schultze and Bill Epstein in front of the battery box with its cover in place.

water storage tank which is topped-off often by the utility powered well pump located down the hill and about 500 feet from the residence. This reservoir is the Epsteins' domestic water supply. In the event of a utility power outage, which happens from time to time, it is also their main line of defense against forest fire.

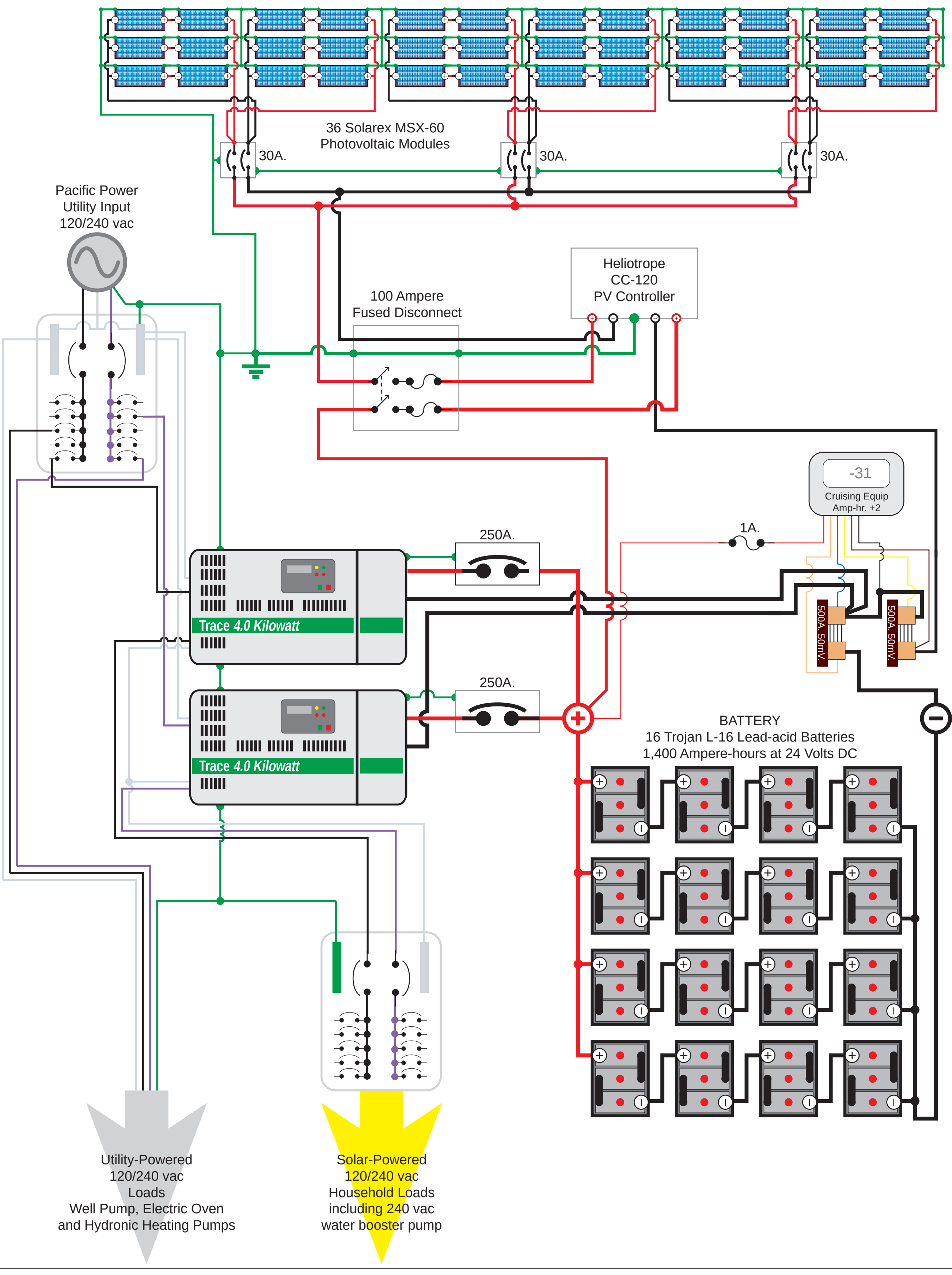
The series connected Trace SW4024 sine wave inverters were an excellent choice for this situation. The internal battery chargers and 15 millisecond transfer relays make the transition from battery to grid and back again seamlessly. The only way Bill & Sara would know if the utility was down would be if the oven didn't work. Or if they get a call from a neighbor wondering why the Epstein house is all lit up while theirs is in the dark! Bill & Sara chose to put their non-essential, but power hungry loads on the utility grid. Besides the well pump, these included the electric oven, hydronic heating, central vacuum and irrigation timer systems.

The Solar Electric System

The Epsteins' PV source is 36 Solarex MSX-60 photovoltaic modules producing about 2,000 Watts peak in full sun. The PV are wired into arrays of 24 VDC each (see system schematic). With Bill and Sara's good solar location, the array produces over 11,000 Watt-hours of energy per sunny day. The PVs are divided into three subarrays of 12 modules each. This was done to limit the current flowing in each array to what could be safely handled by the #10 USE-2 array wiring. Each array is protected by its own set of DC rated circuit breakers and the combined arrays are protected by a 100 Ampere fused safety switch using current limiting RK-5 fuses.

Photovoltaic Regulation

Regulation of the entire photovoltaic array is provided by a Heliotrope CC-120E charge controller. This charge controller feeds the deep-cycle batteries that store the energy. This regulator protects the battery from


36 Solarex MSX-60
Photovoltaic Modules
30A.
30A.
30A.
Pacific Power
Utility Input
120/240 vac
Heliotrope
CC-120
PV Controller
100 Ampere
Fused Disconnect
-31
Cruising Equip
Amp-hr. +2
1A.
250A.
Trace 4.0 Kilowatt
250A.
Trace 4.0 Kilowatt
500A. 50mV.
500A. 50mV.
BATTERY
16 Trojan L-16 Lead-acid Batteries
1,400 Ampere-hours at 24 Volts DC
Utility-Powered
120/240 vac
Loads
Well Pump, Electric Oven
and Hydronic Heating Pumps
Solar-Powered
120/240 vac
Household Loads
including 240 vac
water booster pump

over-charging and instruments the PV array's power production.

Battery Storage

The battery pack consists of 16 Trojan L-16, deep cycle, lead-acid batteries. This battery pack stores 1,400 Ampere-hours at 24 VDC (or 33.6 kiloWatt-hours of energy). This amount of storage gives the house about two days of electrical autonomy. The batteries are fitted with Hydrocap® vents which virtually eliminate the potentially explosive hydrogen gas generated by so many batteries under full charge. The Hydrocaps catalytically recombine hydrogen and oxygen gas into pure water. The vents reintroduce the resulting water back into the batteries reducing the need for battery watering.

Inverters and Instruments

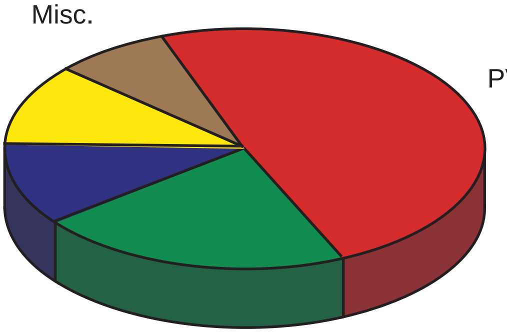
Each of the Trace sine wave inverters is capable of providing 4,000 watts of 120vac power with a 10,000 watt surge capability for starting large motors. When series connected, the inverters can produce 8,000 watts @ 237 vac. Each inverter's input and input cabling is protected by a 250 Ampere Heinemann DC circuit breaker. A dual channel Cruising Equipment Ampere-hour +2 meter keeps tabs on the whole battery/source system. Information about the ac side of the inverters is provided by the multi-purpose digital displays on the Traces.

Inverter/Grid interface

The two inverters are connected to the utility grid through two 60 Ampere circuit breakers. Normally no power flows from the grid to the inverters. If, during periods of overcast or times of very high usage, the battery voltage falls to a user-programmable low voltage point, the Trace inverters perform two functions. One, they quickly (less than 15 milliseconds) transfer the inverter loads to the utility via internal 60 Ampere transfer switches. Two, the inverters essentially run backwards to recharge the batteries. When the batteries recharge and pack voltage rises to a user-programmable high voltage point, the inverters quickly disconnect from the utility and power the house loads. It all happens in a twinkling and the users never notice that it even happened !

Bill and Sarah Epstein's RE System Cost

#	Description	Cost	%
36	Solarex MSX-60 PV Modules	$12,960.00	47.6%
2	Trace 4024 Inverters	$5,364.00	19.7%
	Labor and Mileage	$2,971.50	10.9%
16	Trojan L-16 Batteries	$2,720.00	10.0%
	Cables and Wiring	$907.33	3.3%
	Breakers, Fuses etc.	$846.17	3.1%
1	Heliotrope CC-120E PV Control	$410.00	1.5%
48	Hydrocap Battery Caps	$360.00	1.3%
1	Cruising Equip Amp-hr+2 Meter	$355.00	1.3%
2	Trace BC-10	$187.50	0.7%
2	Trace Conduit Box	$130.00	0.5%
		$27,211.50	



Bill and Sara's electric power bill is $25—$40 per month. Considering the size of this home, we figure that about 40% to 80% of their electric power consumption is coming from sunshine. Most of the grid power goes into water pumping and irrigation. When we talked to Bill and Sara, they mentioned that they rarely see more than 20% discharge on their batteries (as indicated by their Cruising +2 Ampere-hour Meter).

The table and pie chart printed here provide an accurate accounting of the Epstein's expenditures for solar electricity. We figure that this system will produce electric power for the next twenty years at an overall cost under 50¢ per kiloWatt-hour. Does this beat Pacific Power's local cost of 7¢ per kiloWatt-hour? No. But, saving money wasn't Bill and Sara's main concern. Anymore than it was Bill's concern when he flew to Nepal, spending a month, doing free eye surgery for anyone who needed it. These are sunshine superpersons. Their independence and environment come before money….

Intertie Revisited

While Bill and Sara are delighted with their renewable energy systems, they are considering utilizing another of Mother Nature's free gifts at their home; wind.

From the knoll behind the house (see this issue's cover), the terrain drops off sharply all the way to the valley floor. The land drops away in front of the house leaving it well exposed. While Bill and Sara feel the site is windy enough and the trees show minor evidence of flagging, they'll be setting up a recording anemometer soon to assess the value of adding a wind genny.

Renewable energy is addicting! If Bill and Sara decide to go ahead with a wind project, connecting their system with the utility makes even more sense. Because of this and partly to be fair in this article, Home Power contacted Pacific Power again to see if anything had changed. While the unencouraging billing policy is still in place, the attitude of the folks we talked to was definitely different. They were aware of the intertie capabilities and safety features built into the Trace inverters and were willing to take another look at their billing practices and requirements as they relate to these "micro" independent power providers. About 80% of Pacific Power's electricity comes from distant coal-fired plants in Wyoming, Montana, Washington, and Utah. Most of the rest comes from big dam hydro projects in the Pacific Northwest which were severely affected by this year's drought conditions and the competing water needs of anadromous fisheries. Utilities are now having to, or soon will, factor externalities like air pollution and fisheries into their costs of doing business. It's encouraging that they are at least THINKING about moving toward a better pricing schedule for independent power producers who use renewables.

Above: The solar heating systems in Bill and Sara Epstein's home contain enough plumbing for the Starship Enterprise's warp drive. Thirty Thermomax evacuated tube, solar thermal, collectors are located on the roof and gather the sun's heat. This heat is distributed to the home's domestic hot water system and also to the hydronic heating system. The hydronic heating system is primarily propane fueled at this point, but Bill and Sara are considering adding more solar thermal collectors in the future. The hydronic heat is supplied to the home via tubes buried in the thermal mass of the home's heavy tiled floors. This heating system, coupled with the home's three wood-burning fireplaces & stove provide independent and reliable heat in a harsh environment (the snow is often many feet deep on Mt. Ashland).

Above: Jeff Hubbel and his helicopter. Jeff made the off-the-ground photos in this article possible. Kathleen, Karen and Richard had too much fun taking a helicopter ride with our cameras. It was a tough job, but somebody had to do it….

Lights at night…

What it all comes down to is — lights at night and how you get them. The lights are never out at Bill and Sara's, just as they burn brightly in solar, wind or microhydro households worldwide. When it comes to reliable, clean, and sustainable electric power, it's hard to beat what Nature is already providing.

Access

Authors: Richard Perez, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 • email to richard.perez@homepower.org

Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 916-475-3179. Internet email: econnect@snowcrest.net

Special thanks to Jeff Hubell of Timberland Helicopter Service, PO Box 370, Ashland, OR 97520 • 503-488-2880. Jeff got his heliocopter close enough to take the areial photos of Bill and Sara's system (including this issue's cover photo). Thanks, Jeff!

Above:Lloyd and Evan Lasley relax in their sun-drenched living room.

Just DC Kinda Folks

Bob-O Schultze

When Pam ,Lloyd, and Evan Lasley bought Grandma's house in the country outside of Ashland, Oregon, they knew what to expect from the power system. After all, Mary Lasley had been living on solar since the house was built in 1985. What they didn't quite realize is just how little they'd miss the power-gulping "conveniences" of city life.

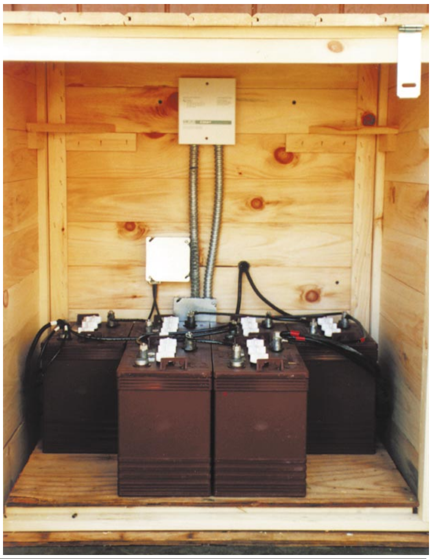
Meet the Lasleys

Pam and Lloyd are anything but the "two hippies in a tepee" scenario sometimes used to describe a DC-only lifestyle. Lloyd is a credentialed grade school teacher and whitewater rafting guide. Pam is an accomplished artist and art supplies purchasing agent.

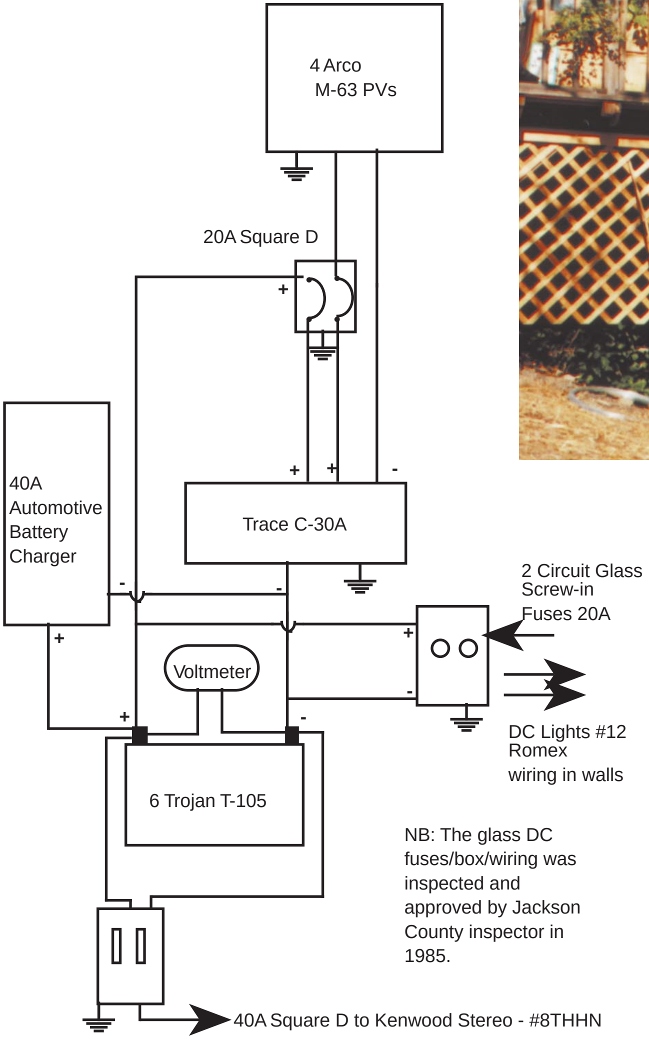
The Lasleys take a different approach to parenting than most couples. When Pam became pregnant with Evan, she had to put her budding career as an artist on hold. Now that Evan is old enough, Lloyd has taken a hiatus from his teaching career to become Evan's primary care giver. This allows Pam to pick up her art where she left off and pursue both her calling and motherhood. While this arrangement is certainly not unique, it is still somewhat unusual in this country. It clearly demonstrates the growing trend toward equality of the sexes in all aspects of American living.

Tis a Gift to be Simple

The Lasleys major use of electricity is for lighting with a minor in music. These needs are easily met by of well placed DC halogen lamps and a high-quality Kenwood car



Above Right: Lloyd's PV array provides 880 watt-hours on a sunny day — all the power they need. Below Right: The batteries live outside, snug and warm, in their own insulated box.



CD/tape/tuner and amplifier. They don't own, or want, a TV. They prefer instead to interact with each other and Evan thru reading, games, and music. They keep in touch with world doings via radio. Lloyd uses a 3.5KW generator to pump water from a well to a gravity storage system and for occasional winter battery recharging, but for the most part they rely on their PV systems to supply all their electrical needs.

On down the Road

As a teacher, Lloyd realizes the necessity for Evan to become computer literate in today's workplace. This will likely mean the addition of a small inverter to the system to run the computer. At that point other interests and needs for power may appear, but for now the Lasleys are keeping it simple, uncluttered, and free.

Access

Author: Bob-O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3402 • Fax 916-475-3401 • Internet econnect@snowcrest.net.

System Owners: Lloyd & Pam Lasley, 4400 Shale City Rd, Ashland, OR 97520.

AAA Solar
full page
black and white
camera ready

7.8 wide
9.8 high

this is page 19

Rate-Based Model for PV Development is Catching on in Europe

Tom Jensen and Bob Johnson

For years, government, utilities, and solar energy advocates have tried to figure out how to properly value solar power and develop self-sustaining markets for photovoltaics. Tackling the issue has been like tackling a greased pig — no one seems to be able to get a handle on it. A new approach in Europe has been cornering the pig for the past few years, and may soon grab hold as more cities continue to adopt the idea. The concept is to shift PV funding support and installation decisions from government and utilities to local utility customers, called the "rate-base".

The concept began in 1991 in the small town of Burgdorf, Switzerland. A per kilowatt hour (kWh) subsidy is paid to utility customers who invest in photovoltaic systems and then feed the PV power back to the grid. The subsidy is financed by the utility rate-base through a 1% surcharge on electric bills. Subsidy amounts and program lengths vary by city and country, while the surcharge holds steady at about 1%. The subsidies range from 50 cents per kilowatt hour to $1.20/kWh, with programs running from two to twenty years. The initial method, commonly called a "model", in Burgdorf pays one Swiss franc per kilowatt hour (69 cents U.S.) for eight years.

The rate-based model does not provide financial assistance for the initial investment in the system. Instead, it provides a market incentive for clean energy production - representing a whole new way of valuing solar energy. By definition, a market incentive creates demand, making it easier for business to justify increasing manufacturing capability.

The idea is to motivate individuals and businesses to install PV systems by giving them a chance to recover their investment over time. As installations increase, the cost of PV goes down, and future subsidies can be reduced. This helps to make rate-based incentives more economically viable and politically acceptable, which should promote long-term growth.

Solarenergie-Fîrderverein e.V. (SFV), a solar energy society based in the German state of Nordrhein-Westfalen, took note of the Burgdorf concept and sought to implement it in their home base of Aachen, Germany. Aachen is a city of 250,000 people near the German-Belgian border, principally known as a fulcrum point in the Battle of the Bulge during World War II. SFV's debate with the local utility and the state's economic minister lasted much longer than the historic battle, taking two-and-a-half years to be decided. But like that battle, it may prove to be the fight that leads to the end of the war. The war in this case being the struggle over the past ten-plus years to develop a self-sustaining market for photovoltaics.

In theory, the rate-based model can provide a transition to self-sustaining markets for two key reasons. First, market demand increases because the public values PV on a broader basis than the economic focus of utilities and government. Individuals' valuation may include a desire for energy security, independence and ownership. Others are motivated by improving the environment and supporting clean energy technology. Broadening valuation makes the market less sensitive to pricing. Market demand for grid-connected PV increases even if the current system price doesn't change. Economics are still the most critical factor in the buying decision, and this model addresses that point by providing an opportunity to recover the initial system investment over time.

The second key factor for rate-based models potentially leading to self-sustaining markets is the stability of the funding source. Funding is provided through the local utility rate base on a consistent long-term basis. Past attempts at market development in the U.S. have relied on government subsidies for up-front investments in PV systems. Those subsidies are much larger than in the rate-based model but fund availability changes due to unstable budget decisions and political cycles. As a result, market volume takes a roller coaster ride of peaks and valleys that match the funding levels.

That roller coaster ride increases risk for manufacturers looking to invest in expanded production, because they can't accurately predict if the market volume will be there to support their investment. With stable funding under the rate-based approach, market volume is more consistent and manufacturers can confidently invest in increased production. The larger production capacity leads to economies of scale, consistent cost reduction, and further market growth.

The rate-based model was introduced in Germany when SFV President Wolf von Fabeck presented the idea to the Aachen City Council in early 1992. He argued that for the model to generate sufficient interest, the public needed to recover their full investment in the system. The proposal called for the rate-base to fund a payback of two deutsche marks per kilowatt hour (DM/kWh). At the time, the U.S. equivalent was $1.20/kWh. Von Fabeck also upped the ante on the program's length, calling for the 2 DM/kWh rate to be paid for the next 20 years for all PV and wind energy fed back to the grid. He also suggested a program ceiling totalling 1 peak megawatt (MWp) each for PV and wind installations. When the ceiling is met, a city committee would review the market acceptance of the program. The committee would then determine what changes have occurred in total system prices, and revise the payback rate accordingly - if it chooses to renew the program.

SFV's rate-based model was approved by the Aachen City Council and the state parliament, but still required the approval of the state's economic minister and the city administrator before it could be implemented. Both were opposed to the idea, responding to the economic concerns of the two local utilities. After several political and legal challenges, the minister approved the program this June, giving birth to what is now known throughout Germany as the "Aachen model." The utilities still dragged their feet on the program, and the Aachen City Council had to vote recently to make the 2 DM/kWh payback rate effective retroactive to September 1, 1994 to prevent further startup delays.

Ironically, during the three years that Aachen was debating the rate-based model, three other German cities had studied the plan and implemented it, including Freising, a suburb of Munich. Meanwhile in Switzerland, Geneva approved a rate-based model in late 1993, albeit at a lower rate of Swiss Franks 0.70/kWh (U.S. 50 cents/kWh). The rate-based roll call is now up to nine cities, three countries and 2.1 million people. The latest country to join is Austria, through the small town of Purkersdorf. The latest addition to the city list is also the most significant. The German northern industrial city of Hamburg, the country's second largest city with a population over 1.6 million, adopted the rate-based model in October. The Hamburg utility signed a 20-year agreement with the city's environment administration to provide a 2 DM/kWh payback rate up to an installation ceiling of 1.5 MWp.

But now, the Hamburg utility is attempting to circumvent adoption of the Aachen model. Legal and political fights between the city and the utility over the signed agreement are expected. If successful, the utility's moves could cause short term damage to the rate-based movement. However, these utility actions could also empower further public support for the model.

The Aachen model is now under consideration in at least ten other German cities, including several of the country's largest cities: Berlin, Munich, Dusseldorf and Frankfurt. SFV reports that it will be difficult to implement the Aachen model in the face of opposition from the larger private utilities in Germany, but discussions continue. The next city expected to implement the Aachen model is the German capital of Bonn, where the newly elected mayor has vowed to implement the rate-based plan within the next 100 days.

The push for rate-based incentives for clean energy generation has gathered significant political momentum over the past year. The potential market is given a relatively good chance of increasing as the total population increases from 2.1 million people today to 3.3 million by the end of 1995. If the four major German cities mentioned earlier were also to adopt a form of the Aachen model, the potential market would grow as the population grows to over nine million people.

Rate-based incentives appear to be taking the same political approach in Germany and Switzerland as the local no smoking initiatives that appeared in the U.S. in the late eighties, and became a national standard by the nineties. Advocates realized they could not implement their agenda on a national level, and chose instead to build public consensus on a city-by-city basis. City government is more responsive to a visible and organized local advocacy campaign. Through collective national resources and local public support, stringent no smoking laws are becoming a national standard. SFV is using the same tactic in advocating widespread implementation of the Aachen model.

Germany's Green Party is advocating that the Aachen model be applied nationally. However, in the recent federal elections the liberal Greens and Social Democrats failed to gain a majority in Parliament. A proposal to apply the Aachen model nationwide would be expected to face stiff opposition and a lengthy debate period. The local political route is likely to pay greater dividends in the short-term than a potential national solution. However, pressure from above on a national level and below on a local grass roots level will both continue to be aggressively pursued.

The rate-based model is designed to redirect priorities toward the marketplace. It motivates the public to consider installing photovoltaics, rewards education and marketing efforts by the PV industry, and provides an economic incentive for utility and commercial investment in solar energy. If the rate-based model could be combined with banks providing low-interest loans for system purchases, market demand could increase dramatically.

Specific benefits to the marketplace include open competition for sales opportunities and system ownership for individuals. The approach not only leads to more competitive pricing for systems, but also calls for customers to shop for the most efficient systems in generating solar kilowatts per hour.

The rate-based model has a few limitations as well. Most of the plans have installation ceilings at 1 MWp, and then require political review before the plan could be renewed. If political opposition is too great during the review period, many of the city programs could reach the installation ceilings and go no further. The ceiling also could arrive at a harmful point, just when widespread market interest is beginning to develop. That interest could be cut off if the subsidy ends. In addition, it would be dangerous if the rate-based model were viewed as the sole market solution. Demonstration programs serve a useful purpose in exposing governments and utilities to the technology and the industry. Their input can help to develop new approaches to valuation, system design and marketing that can improve the technology and assist market development.

Market efforts such as the rate-based model from Solarenergie- Fîrderverein are healthy in bringing new perspectives to valuation and market growth for solar energy. For the Aachen model to be considered in the States, a major paradigm shift would need to take place in the thinking of government, utilities, the PV industry and the public. Current market development efforts are focused on up- front investments from the federal tax base. As a result, the political emphasis is on Washington. This empowers DOE and Congress, and centralizes lobbying and advocacy efforts. The Aachen model calls for customer reimbursement from the local utility rate- base. Political emphasis would shift to decentralized advocacy before local cities and states, as well as regional utilities and state regulators. DOE's primary emphasis would be free to shift from funding domestic market growth to cultivating international markets and supporting R&D efforts.

Deregulation is changing the U.S. utility market. Retail wheeling is being discussed wherein customers are free to go outside of the local utility to buy power at cheaper rates. The concept has been proposed by the Public Utilities Commission in California. Plans under discussion for retail wheeling would allow large industry to choose their own power providers in 1996, and private residents starting in 2002. Self-determination could become an issue not only for large industrial users, but also for cities or residential blocks organizing to buy power. Deregulation can create new market opportunities for cities to consider a rate-based approach to reflect community values.

Some of the public may be opposed to any action that would increase electric rates. However, the Aachen model provides for a directed investment in clean energy generation. Polls have indicated that the public is willing to pay small tax increases if the funds are directed, such as a local gasoline tax to pay for roads and mass transit. In the case of the Aachen model, electric bills are increased up to 1%. A fraction of 1% would provide for vast funding amounts in the U.S. and could gain public support.

For the PV industry, the spread of the Aachen model has already led to some new thinking, primarily as a marketing opportunity. The addressable market for rate-based incentives currently stands at 2.1 million people, and could grow to over 3 million in 1995. Market opportunity for distributors and system integrators would be clearly indicated merely by looking at which communities adopted them.

In the U.S., grid-connected applications will represent less than 3% of total PV installations by dealers and distributors in 1994. With the introduction of a rate-based approach, the residential grid-connected market could grow significantly. The resulting emphasis on market education could benefit the industry at large.

The rate-based model empowers the consumer to quantify the value of solar energy. Clean energy production is rewarded with a per kilowatt hour subsidy directly controlled and funded by the ratepayers. The model also provides a consistent long-term funding source for market development that helps accelerate demand and reduce the cost of PV. The idea is spreading rapidly in Europe and could provide an effective means for developing markets for clean energy in the U.S.

Access

Author: Tom Jensen, Strategies Unlimited, 201 San Antonio Circle, Suite 205, Mountain View, CA 94040 • FAX (415) 941-5120, e-mail: stratultd@ix.netcom.com

Solarenergie-F/rderverein, Herzogstrasse 6, 52070 Aachen, Germany. Wolf von Fabeck, fax 011-49-241-535-786.

Micro Hydro Power in the Nineties

Paul Cunningham & Barbara Atkinson

Micro hydro power was once the world's prominent source of mechanical power for manufacturing. Micro hydro is making a comeback for electricity generation in homes. Increasing numbers of small hydro systems are being installed in remote sites in North America. There's also a growing market for micro hydro electricity in developing countries. This article is a technical over-view.

Micro hydro power is gradually assuming the decentralized form it once had. Water power predates the use of electricity. At one time hydro power was employed on many sites in Europe and North America. It was primarily used to grind grain where water had a vertical drop of more than a few feet and sufficient flow. Less common, but of no less importance, was the use of hydro to provide shaft power for textile plants, sawmills and other manufacturing operations.

Over time thousands of small mills were replaced by centrally-generated electric power. Many major hydroelectric projects were developed using large dams, generating several megaWatts of power. In many areas, hydro electric power is still used on a small scale and is arguably the most cost-effective form of energy.

Renewable energy sources such as wind and solar are being scaled up from residential to electric utility size. In contrast, hydro power is being scaled down to residential size. The small machines are similar in most ways to the large ones except for their scale.

Siting

A hydro system is much more site-specific than a wind or photovoltaic (PV — solar electric) system. A sufficient quantity of falling water must be available. The vertical distance the water falls is called head and is usually measured in feet, meters, or units of pressure. The quantity of water is called flow and is measured in gallons per minute (gpm), cubic feet per second (cfs), or liters per second (l/s). More head is usually better because the system uses less water and the equipment can be smaller. The turbine also runs at a higher speed. At very high heads, pipe pressure ratings and pipe joint integrity become problematic. Since power is the product of head and flow, more flow is required at lower head to generate the same power level. More flow is better, even if not all of it is used, since more water can remain in the stream for environmental benefits.

A simple equation estimates output power for a system with 53% efficiency, which is representative of most micro hydro systems:

Net Head* (feet) x Flow (US gpm) / 10 = Output (Watts)

* Net head is the pressure available after subtracting losses from pipe friction. Most hydro systems are limited in output capacity by stream conditions. That is, they cannot be expanded indefinitely like a wind or PV system. This means that the sizing procedure may be based on site conditions rather than power needs. The size and/or type of system components may vary greatly from site to site. System capacity may be dictated by specific circumstances (e.g. water dries up in the summer). If insufficient potential is available to generate the power necessary to operate the average load, you must use appliances that are more energy-efficient and/or add other forms of generation equipment to the system. Hybrid wind/PV/hydro systems are very successful and the energy sources complement each other.

The systems described here are called "run of river"; i.e. water not stored behind a dam (see HP#8). Only an impoundment of sufficient size to direct the water into the pipeline is required. Power is generated at a constant rate; if not used, it is stored in batteries or sent to a shunt load. Therefore, there is little environmental impact since minimal water is used. There is also much less regulatory complication.

System Types

If electric heating loads are excluded, 300-400 Watts of continuous output can power a typical North American house. This includes a refrigerator/freezer, washing machine, lights, entertainment and communication equipment, all of standard efficiency. With energy-efficient appliances and lights and careful use management, it is possible to reduce the average demand to about 200 Watts continuous.

Power can be supplied by a micro hydro system in two ways. In a battery-based system, power is generated at a level equal to the average demand and stored in

Above: Building a weir to measure a stream's flow.

DEFINITIONS

Power = the rate of doing work (Watts or horsepower)

1 Watt = 1 Volt x 1 Ampere

1 horsepower = 746 Watts

1000 Watts consumed for one hour = one kiloWatt-hour (the unit used on utility bills). Power is measured in Watts and energy is measured in Watt-hours.

Example: a 100 Watt light bulb uses power at the rate of 100 Watts. During a period of 10 hours, it consumes 100 Watts x 10 hours = 1000 Watt-hours or one kiloWatt-hour of electricity.

batteries. Batteries can supply power as needed at levels much higher than that generated and during times of low demand the excess can be stored. If enough energy is available from the water, an AC-direct system can generate power as alternating current (AC). This system typically requires a much higher power level than the battery-based system.

Battery-Based Systems

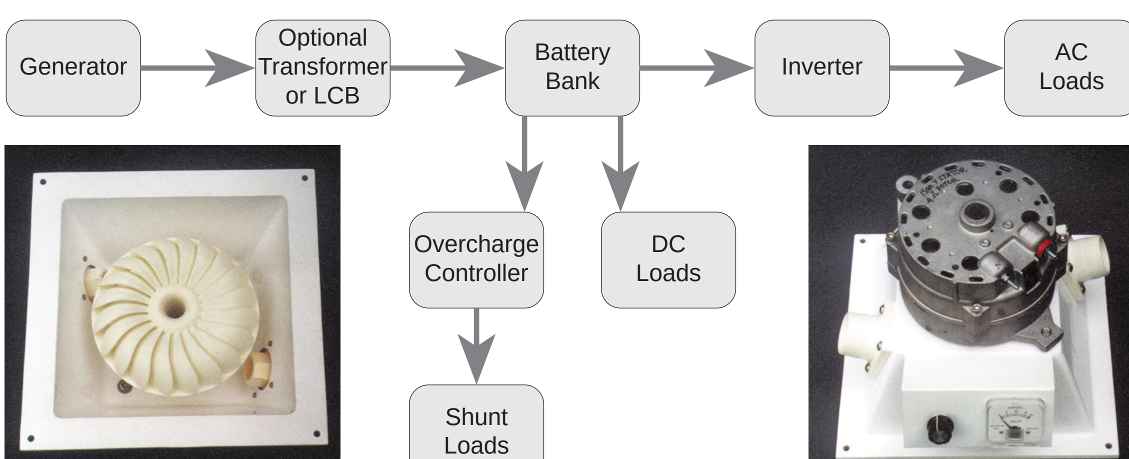
Most home power systems are battery-based. They require far less water than AC systems and are usually less expensive. Because the energy is stored in batteries, the generator can be shut down for servicing without interrupting the power delivered to the loads. Since only the average load needs to be generated in this type of system, the pipeline, turbine, generator and other components can be much smaller than those in an AC system.

Very reliable inverters are available to convert DC battery power into AC output (120 volt, 60 Hz). These are used to power most or all home appliances. This makes it possible to have a system that is nearly indistinguishable from a house using utility power.

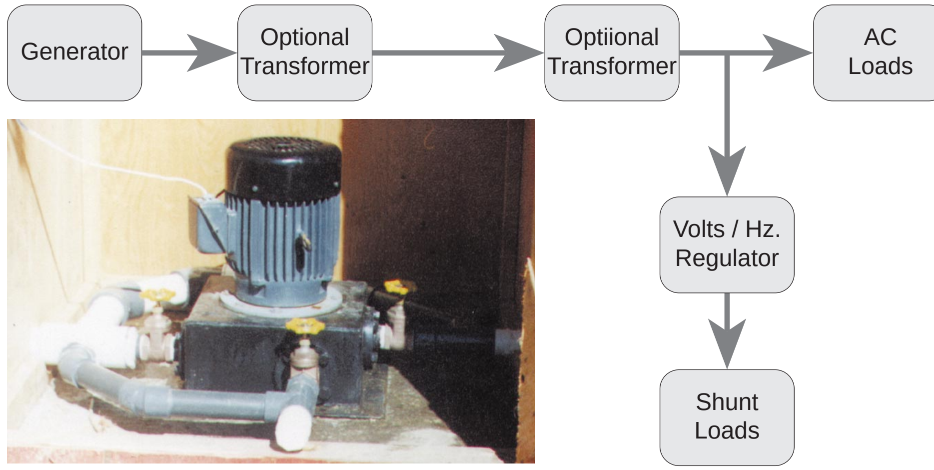
The input voltage to the batteries in a battery-based system commonly ranges from 12 to 48 Volts DC. If the transmission distance is not great then 12 Volts is often high enough. A 24 Volt system is used if the power level or transmission distance is greater. If all of the loads are inverter-powered the battery voltage is independent of the inverter output voltage and voltages of 48 or 120 may be used to overcome long transmission distances. Although batteries and inverters can be specified for these voltages, it is common to convert the high voltage back down to 12 or 24 Volts (battery voltage) using transformers or solid state converters. Articles on this subject appeared in *Home Power* #17 and #28.

Wind or solar power sources can assist in power production because batteries are used. Also, DC loads (appliances or lights designed for DC) can be operated directly from the batteries. DC versions of many appliances are available, although they often cost more and are harder to find, and in some cases, quality and performance vary.

Below: Diagram of a typical battery-based system:



AC-Direct Systems
This is the system type used by utilities. It can also be used on a home power scale under the right conditions. In an AC system, there is no battery storage. This means that the generator must be capable of supplying the instantaneous demand, including the peak load. The most difficult load is the short-duration power surge drawn by an induction motor found in refrigerators, freezers, washing machines, some power tools and other appliances. Even though the running load of an induction motor may be only a few hundred Watts, the starting load may be 3 to 7 times this level or several kiloWatts. Since other appliances may also be operating at the same time, a minimum power level of 2 to 3 kiloWatts may be required for an AC system, depending on the nature of the loads.



Above: AC direct micro hydro block diagram and photo of an AC induction micro hydro turbine.

In a typical AC system, an electronic controller keeps voltage and frequency within certain limits. The hydro's output is monitored and any unused power is transferred to a "shunt" load, such as a hot water heater. The controller acts like an automatic dimmer switch that monitors the generator output frequency cycle by cycle and diverts power to the shunt load(s) in order to maintain a constant speed or load balance on the generator. There is almost always enough excess power from this type of system to heat domestic hot water and provide some, if not all, of a home's space heating. Examples of AC-direct systems are described in *Home Power* #25 and #33.

System Components
An intake collects the water and a pipeline delivers it to the turbine. The turbine converts the water's energy into mechanical shaft power. The turbine drives the generator which converts shaft power into electricity. In an AC system, this power goes directly to the loads. In a battery-based system, the power is stored in batteries, which feed the loads as needed. Controllers may be required to regulate the system.

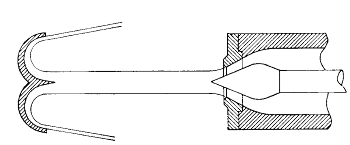
Pipeline
Most hydro systems require a pipeline to feed water to the turbine. The exception is a propeller machine with an open intake. The water should pass first through a simple filter to block debris that may clog or damage the machine. The intake should be placed off to the side of the main water flow to protect it from the direct force of the water and debris during high flows.

It is important to use a pipeline of sufficiently large diameter to minimize friction losses from the moving water. When possible, the pipeline should be buried. This stabilizes the pipe and prevents critters from chewing it. Pipelines are usually made from PVC or polyethylene although metal or concrete pipes can also be used. The article on hydro system siting in *Home Power* #8 describes pipe sizing.

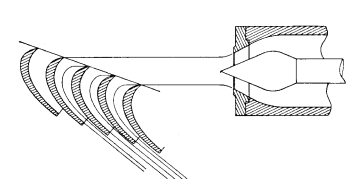
Turbines
Although traditional waterwheels of various types have been used for centuries, they aren't usually suitable for generating electricity. They are heavy, large and turn at low speeds. They require complex gearing to reach speeds to run an electric generator. They also have icing problems in cold climates. Water turbines rotate at higher speeds, are lighter and more compact. Turbines are more appropriate for electricity generation and are usually more efficient.

There are two basic kinds of turbines: impulse and reaction.

Impulse machines use a nozzle at the end of the pipeline that converts the water under pressure into a fast-moving jet. This jet is then directed at the turbine wheel (also called the runner), which is designed to convert as much of the jet's kinetic energy as possible into shaft



Above: Pelton runner.



Above: Turgo runner.

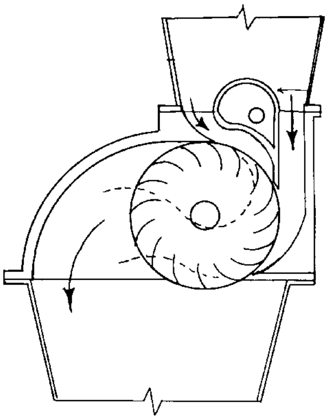
power. Common impulse turbines are pelton, turgo and cross-flow.

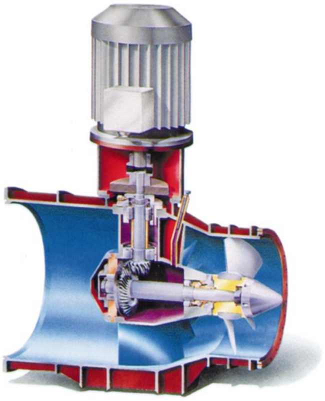
In reaction turbines the energy of the water is converted from pressure to velocity within the guide vanes and the turbine wheel itself. Some lawn sprinklers are reaction turbines. They spin themselves around as a reaction to the action of the water squirting from the nozzles in the arms of the rotor. Examples of reaction turbines are propeller and Francis turbines.

Turbine Applications
In the family of impulse machines, the pelton is used for the lowest flows and highest heads. The cross-flow is used where flows are highest and heads are lowest. The turgo is used for intermediate conditions. Propeller (reaction) turbines can operate on as little as two feet of head. A turgo requires at least four feet and a pelton needs at least ten feet. These are only rough guidelines with overlap in applications.

The cross-flow (impulse) turbine is the only machine that readily lends itself to user construction. They can be made in modular widths and variable nozzles can be used.

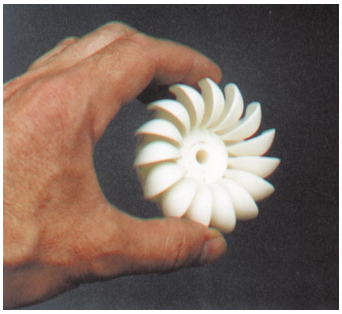
Most developed sites now use impulse turbines. These turbines are very simple and relatively cheap. As the stream flow varies, water flow to the turbine can be easily controlled by changing nozzle sizes or by using adjustable nozzles. In contrast, most small reaction turbines cannot be adjusted to accommodate variable water flow. Those that are adjustable are very expensive because of the movable guide vanes and blades they require. If sufficient water is not available for full operation of a reaction machine, performance suffers greatly.


Above: Crossflow turbine.


Above: Propellor turbine.

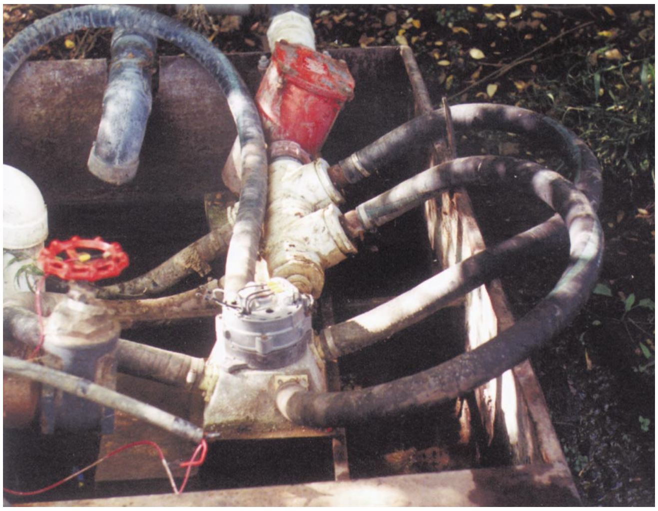

Above: Francis runner.


Above: A bronze turgo runner.


Above: Small impluse runner.

An advantage of reaction machines is that they can use the full head available at a site. An impulse turbine must be mounted above the tailwater level and the effective head is measured down to the nozzle level. For the reaction turbine, the full available head is measured between the two water levels while the turbine can be mounted well above the level of the exiting water. This is possible because the “draft-tube” used with the machine recovers some of the pressure head after the water exits the turbine. This cone-shaped tube converts the velocity of the flowing water into pressure as it is decelerated by the draft tube’s increasing cross section. This creates suction on the underside of the runner.

Centrifugal pumps are sometimes used as practical substitutes for reaction turbines with good results. They can have high efficiency and are readily available (both new and used) at prices much lower than actual reaction turbines. However, it may be difficult to select the correct pump because data on its performance as a


Above: A four nozzle turgo micro hydro turbine.

Above: This micro hydro turbine is producing 40 Watts from a garden hose.

turbine are usually not available or are not straightforward.

One reason more reaction turbines are not in use is the lack of available machines in small sizes. There are many potential sites with 2 to 10 feet of head and high flow that are not served by the market. An excellent article describing very low-head propeller machines appeared in *Home Power* #23.

Generators

Most battery-based systems use an automotive alternator. If selected carefully, and rewound when appropriate, the alternator can achieve very good performance. A rheostat can be installed in the field circuit to maximize the output. Rewound alternators can be used even in the 100–200 Volt range.

For higher voltages (100–400 Volts), an induction motor with the appropriate capacitance for excitation can be used as a generator. This will operate in a small battery charging system as well as in larger AC direct systems of several kiloWatts. An article describing induction generation appeared in *HP* #3.

Another type of generator used with micro hydro systems is the DC motor. Usually permanent magnet types are preferable. However, these have serious maintenance problems because the entire output passes through their carbon commutators and brushes.

Batteries

Lead-acid deep-cycle batteries are usually used in hydro systems. Deep-cycle batteries are designed to withstand repeated charge and discharge cycles typical in RE systems. In contrast, automotive (starting) batteries can tolerate only a fraction of these discharge cycles. A micro hydro system requires only one to two days storage. In contrast, PV or wind systems may require many days' storage capacity because the sun or wind may be unavailable for extended periods. Because the batteries in a hydro system rarely remain in a discharged state, they have a much longer life than those in other RE systems. Ideally, lead-acid batteries should not be discharged more than about half of their capacity. Alkaline batteries, such as nickel-iron and nickel-cadmium, can withstand complete discharge with no ill effects.

Controllers

Hydro systems with lead-acid batteries require protection from overcharge and over-discharge. Overcharge controllers redirect the power to an auxiliary or shunt load when the battery voltage reaches a certain level. This protects the generator from overspeed and overvoltage conditions. Overdischarge control involves disconnecting the load from the batteries when voltage falls below a certain level. Many inverters have this low-voltage shutoff capability.

An ammeter in the hydro output circuit measures the current. A voltmeter reading battery voltage roughly indicates the state of charge. More sophisticated instruments are available, including amp-hour meters, which indicate charge level more accurately.

Conclusions

Despite the careful design needed to produce the best performance, a micro hydro system isn't complicated. The system is not difficult to operate and maintain. Its lifespan is measured in decades. Micro hydro power is almost always more cost-effective than any other form of renewable power.

Who should buy a micro hydro system? In North America, micro hydro is cost-effective for any off-grid site that has a suitable water resource, and even for some that are on-grid. Homeowners without utility power have three options: purchasing a renewable energy system, extending the utility transmission line, or buying a gasoline or diesel generator. Transmission line extension can be expensive because its cost depends on distance and terrain. Even the initial cost of a hydro system may be lower. A gasoline generator may be cheaper to purchase but is expensive to operate and maintain. The life-cycle cost of the hydro system (3–25 ¢/kWh) is much lower than that of a generator (60–95 ¢/kWh). Once the hydro system is paid for, there's no monthly electricity bill and minimal maintenance costs. Since utility rates tend to rise, the value of the power increases, making your investment "inflation-proof."

Notes to budding renewable energy enthusiasts: the future has potential if you use your head. There are many opportunities in this field for creative people with talents ranging from engineering to writing, if you're willing to find them and persevere. Remember what head, flow, and love have in common: more is better!

Access

Paul Cunningham, Energy Systems and Design, POB 1557, Sussex, New Brunswick, Canada E0E 1P0. 506-433-3151

Barbara Atkinson, 1401 Acton Crescent, Berkeley, CA 94702 USA. 510-841-2373

Reviewed by Robert Mathews, Appropriate Energy Systems, 604-679-8589

ask NREL

The National Renewable Energy Laboratory (NREL) is one of ten federally funded national laboratories. NREL has offered to provide answers to technical questions from *Home Power* readers about renewable energy.

Question: *How is the wind resource distributed across the United States?*

Answer: For large wind farms, a wind resource survey is critical for siting many wind machines. A site is selected for a favorable economic return. For small power users who own their local utility, a wind resource survey is also critical. Small power users are often limited to the land they own and will erect only one wind machine so a survey is important. The good news is that, overall, there is plenty of wind resource in the United States. The good-to-excellent wind regions could supply more than one and a half times the current electricity consumption of the United States. The use of wind power is not limited by the wind resource.

Wind power is more than wind speed. While wind speed is a critical component, air density, wind speed distribution, and height are also important. The air density depends on the barometric pressure, temperature, and elevation. Two different locations may have the same mean wind speed, but the wind power could be different if the two sites have different wind speed distributions. The height of the wind machine is very important, as the energy contained in winds at 30 m (98 ft) above the ground is 60% greater than the power density at 10 m (33 ft). (This assumes that the site-average wind speed increases with height according to the “1/7 power law” typical of large areas on the Great Plains.) In *Home Power* #40, page 86, Mick Sagrillo discusses the effect of terrain on wind speeds at different heights. Readers should refer back to this excellent article on site-specific wind resource assessments.

The energy contained in wind is expressed in terms of wind power classes, ranging from class 1 (the least energy) to class 7 (the greatest energy). Wind power classes are based on the average “wind power density,” expressed in watts per square meter (W/m2). This single number incorporates the combined effects of the wind speed distribution and the dependence of wind power on both air density and the cube of the wind speed.

The map, taken from the references, represents the calculated average annual wind power density at 30 m height for well-exposed locations free of obstructions to the wind. These areas include plains, tablelands, hilltops, ridgelines in mountainous terrain, and large clearings in forested areas. Local terrain features that do not show up on the scale of this map greatly affect the amount of energy in the winds at very specific locations. Higher wind areas may occur within regions labeled on the map as low in wind power. Seasonal and daily variations in the wind power density are not represented on this map of average annual values.

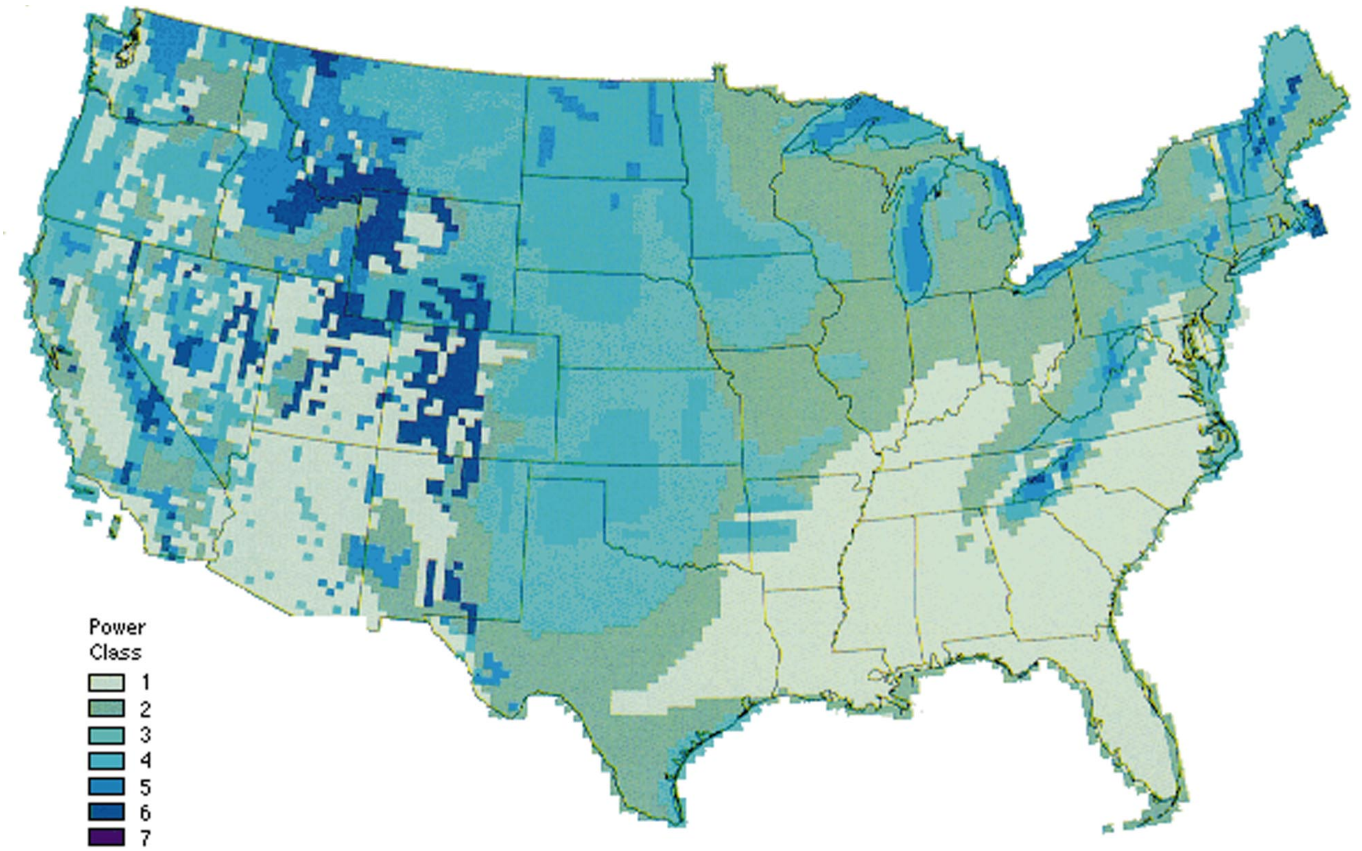
Knowing the wind power density, you can calculate an estimate of energy from a wind machine. For a single wind machine, the electrical energy output is calculated by multiplying together the wind power density, the area swept by the blade, and the wind-to-electricity conversion efficiency. The area swept by the blade is 3.14 X $(d/2)^2$, where ‘d’ is the diameter of the blade. Each machine has a specific wind-to-electricity conversion efficiency — many of the large wind machines have peak efficiencies around 35%, and advanced ones are approaching peak efficiencies of 40%-45%. The hardest part is knowing the wind machine’s efficiency, as typically the manufacturer gives only the power (watts) at a specific wind speed. The efficiency is difficult to measure because you need to calculate the wind power density.

If you are in a class 4 wind power area with a 1-m diameter blade and the hub at 30 m height, then, on average, you can expect 360 W/m^2 X 0.8 m^2 X 25% = 72 W. An average wind-to-electricity conversion efficiency of 25% is assumed. Of course the wind speed is not constant, but is highly variable, so there will be times where the wind machine will produce in excess of 72 W. For the year, you could expect 72 W X 24 hours/day X 365 days/year = 630 kWh. The system’s design must include the expected average power output and the maximum peak current under the best wind conditions.

References

Wind Energy Resource Atlas of the United States, DOE/CH10094-4, March 1987, DE86004442, available from NTIS. [This reference also includes 4 seasonal U.S. maps and individual black & white state maps.]

“America takes stock of a vast resource,” brochure



Wind Energy Resource Atlas of the United States

Wind Power Class	*Wind Energy Resource Potential*	*Wind Power Density (W/m^2) at 30 meters altitude*	*Mean Wind Speed (mph) at 10 meters altitude*	*Mean Wind Speed (mph) at 30 meters altitude*
1	Poor	less than 160	0-9.8	0-11.4
2	Fair	160-240	9.8-11.5	11.4-13.4
3	Moderate	240-320	11.5-12.5	13.4-14.6
4	Good	320-400	12.5-13.4	14.6-15.7
5–7	Excellent	more than 400	13.4+	15.7+

published by the Utility Wind Interest Group, NREL, February 1992.

Access

Authors: Marc Schwartz and Byron Stafford, NREL

Send your technical renewable energy questions to: NREL, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 voice/FAX . Email via HPBBS 707-822-8640 or Internet Email to richard.perez@homepower.org

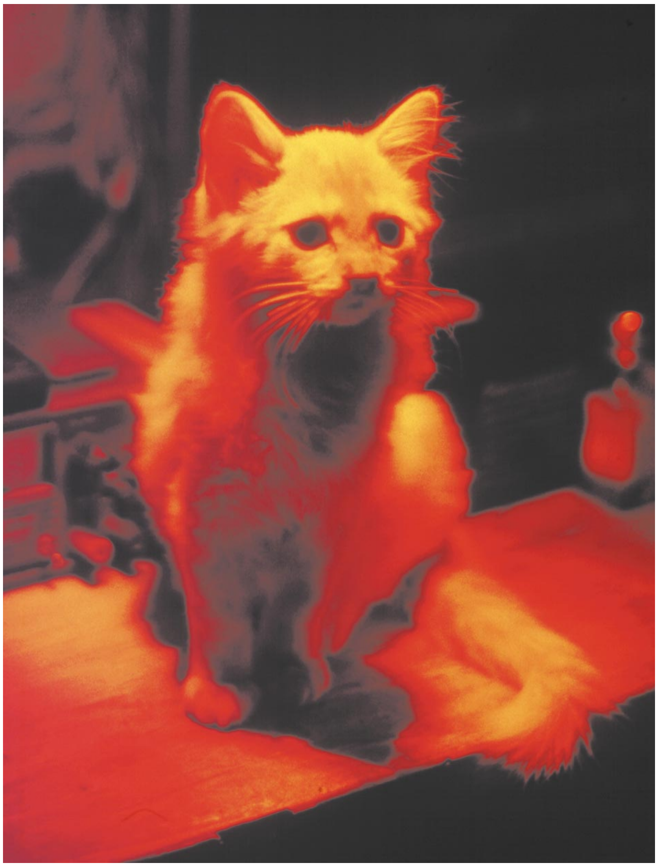
Things that Work!

Things that Work!
tested by *Home Power*

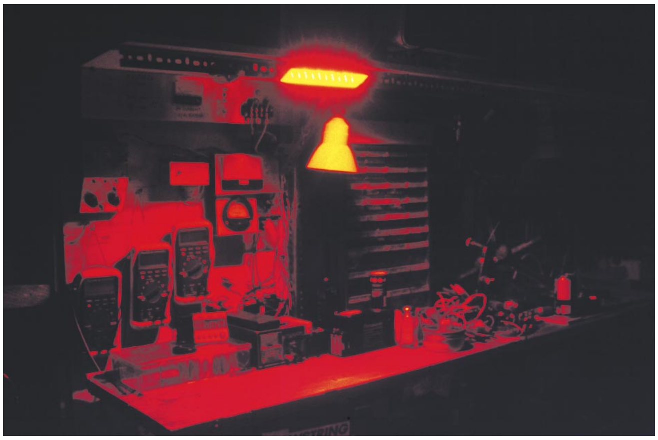
LED Illuminators

Richard Perez

These new LED illuminators are low intensity, room lights that consume less than 2 Watts of power. Average lifetime of these illuminators is 100,000 hours. That's light all night, every night for over 20 years. A single illuminator lights up our front room well enough to navigate at night without stepping on cats' tails or tripping over the furniture.



Above: Karen's favorite puddy, 'Wittle Wendy' sits on the workbench under the LED-7 illuminator.
Below: Our electronics workbench illuminated by the LED-7, which also lights up the enitre room.



Light Emitting Diodes (LEDs)

The LED is the most efficient device ever created to convert electricity into light. The LED is 7–10 times more efficient than incandescent lamps, and 4–5 times more efficient than fluorescent lights. The LED is a semiconductor junction that operates directly on low voltage DC electricity. This makes LED illuminators totally noise-free and totally free of noise or RFI.

Early LEDs were dim and served only as panel indicators. The latest generation of super-bright LEDs have light outputs in excess of 3 Candela (roughly equivalent to 3 foot-candles). These bright LEDs can be real illuminators. In *Home Power* # 34 page 68, I reviewed Delta Light's LED replacement lamps for flashlights. Well, here is the next bright step: LED room illuminators.

LED Illuminators

Bill Mack of Delta Light had the great idea of wiring many super bright LEDs into a single light. I have been using two of his new illuminators. One , called LED-2, consists of 30 yellow LEDs wired into a 2 inch diameter circle. The second LED illuminator, called LED-7, consists of 25 yellow and 5 red LEDs in a rectangular case that is 1.5 inches wide by 7 inches long. Both models consume 150 mA. of current at 12.5 VDC. Their operating voltage range is between 10.5 and 16.5 VDC. Each of these illuminators provides a whopping 90 Candelas of light (at 12 VDC). Delta Light also makes LED illuminators that contain anywhere from 10 to 120 LEDs.

Above left: The workbench under the LED-2, with its 30 yellow LEDs focused to a spot.
Above right: The same workbench under the LED-7 with its 25 yellow and 5 red LEDs. Note that even a few red LEDs really change the color of the light.

LED Illuminator Performance

What does 90 Candelas of light really mean in terms of real world illumination. Well, it's more than enough light to walk about a room. It's enough light to find objects on a table. I can easily perform detailed tasks such as changing radio batteries, operating a computer, and making coffee within three feet of the LED-2 illuminator. The LED-7 is designed for larger area illumination than the LED-2. Every LED contains a built-in lens. In the LED-2 model, all the LEDs are focused together to form an intense spot of yellow light. In the LED-7 model, the LEDs are spread out and have their lens defocused to scatter the light over a wider area.

My favorite is the LED-7. I have it mounted on the upper shelf of my workbench (see photos). It's been lighting the room all night, every night, for the last five months. Overnight it consumes about 20 Watt-hours of energy. This is about 1/10th of the daily output of a single full-sized PV module. Karen loves having this light on all night. No more stepping on the critters' tails, and no more late night flashlight navigation. I like not having to start a compact fluorescent just to find things.

All LEDs produce monochromatic light or light of a single color. Colors viewed under LED illumination will appear strange. The best overall color for LED room illumination is yellow. I asked Bill Mack to put a few red LEDs in our LED-7 which produced more of a rose colored light. If you want illumination that will not affect night vision, then go with all red LEDs. (A note on the photographs printed here. They were shot with a 1 second exposure on Fuji Sensia 400 slide film with a 24 mm, *f*2 lens. It was impossible to get the photographs to accurately show both the illumination level and color of these LED lights.)

LED Illuminator Applications

These 12 VDC illuminators are just the ticket for night lights. They also work well when only a low level of illumination is required. They are great light for listening to the radio, or watching the TV because they don't generate RFI. They make great all night lights for halls and the bathroom. They would be great in aircraft, boats, RVs, and cars because the red LED illuminators will not ruin the driver's night vision.

Energy consumption of these illuminators is so low that they can be powered by a miniscule energy system. Consider this; an LED-7 could be operated all night, every night with a 5 Watt PV module (like a Solarex MSX-5), and a small 2.2 Ampere-hour 12 Volt lead-acid gel cell. The entire system would be tiny and weigh less than three pounds.

Cost

Bill Mack is still experimenting with the physical configuration of these lights. I asked him for a version of the LED-2 which spread out the light more, and he created the LED-7. The LED-2 is now called LED-10 and is available with 30 LEDs and an optional switch for selecting either 10 or 30 of the LEDs at a time. Delta Lights will operate at either 12 or 24 Volts. If you want to go ac these lights work just fine with a wall cube (120 vac power supply). Contact Bill for details about Delta Light's different LED illuminator models. Cost is between $40 and $200 depending on model and size.

Conclusion

The super efficient LED illuminator is the most efficient, low intensity, light ever! Add super long life plus noiseless illumination and you have a real winner. At our house, it shines all night, every night.

Access

Author: Richard Perez, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-3179 • email to richard.perez@homepower.org

LED Illuminator Made by: Bill Mack, Delta Light, PO Box 202223, Minneapolis, MN 55420 • 612-894-6904


GoPower

Do ZEVs Dream?

Michael Hackleman

I'm not qualified to tell you much about the world right now since I've just emerged from a 'hole'. I've mailed the manuscript for *The New Electric Cars* book to Chelsea Green, the publisher. It's a seven month effort that I'm happy to be looking back at, since everything else in my life has ended up in a big pile. I shouldn't complain. While I often think that writing a book is like having a child, it isn't. As every woman knows, all the *real* work would just be starting.

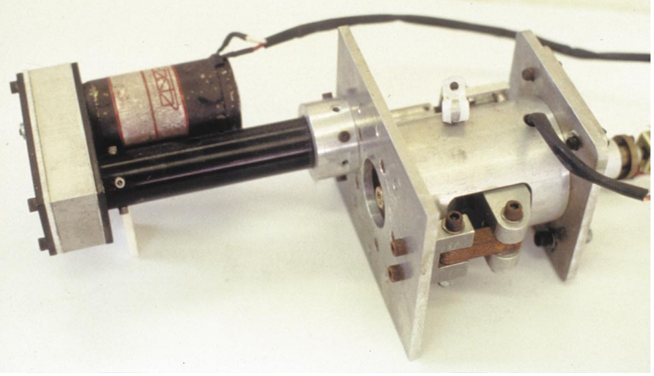
Still, it will be six months before the book rolls off the presses. That's a long time to wait for the fruit of any effort. Meanwhile, I've gotten permission from Chelsea Green to take excerpts from the book for articles. I've done so in *Going Electric in 1995* in this issue. In the months ahead, I'll be aiming articles at the top 30 periodicals in the USA. I'm getting tired of seeing articles talking *about* EVs (electric vehicles) rather than *from* the experience of EVs. It's a sad state of affairs when a technology offering such a marked improvement over internal combustion engines is held back by politics, ego, and ignorance. What *is* it about humans . . .?

The 1998 ZEV Mandate

I'm happy to report that CARB (California Air Resources Board) is holding firm in its commitment to two percent ZEVs (zero emission vehicles) in California by 1998. While only two cars in one hundred are mandated, it represents sales of 40,000 EVs per year beginning in 1998. The mandate increases to 5% (100,000 EVs per year) in 2003 and to 10% (200,000 EVs per year) by 2010. Any car company who sells vehicles in California will be fined $5,000 for failure to meet this quota. This might be a good time for entrepreneurs to start a business converting cars to electric propulsion. Why? What will an auto maker pay for the 'credit' of one EV registered in California in 1998 when it means they can sell 49 more gas-powered cars without paying $5K per car? (Incidentally, the "make" of the vehicle appears unrelated to its exempting qualities, i.e. GM can apply an electric-Ford credit, but this is unconfirmed.) Research by Bill Meurer (GreenMotorWorks) says 3-wheelers don't qualify toward an ZEV credit.

An Electric-Assist Brake

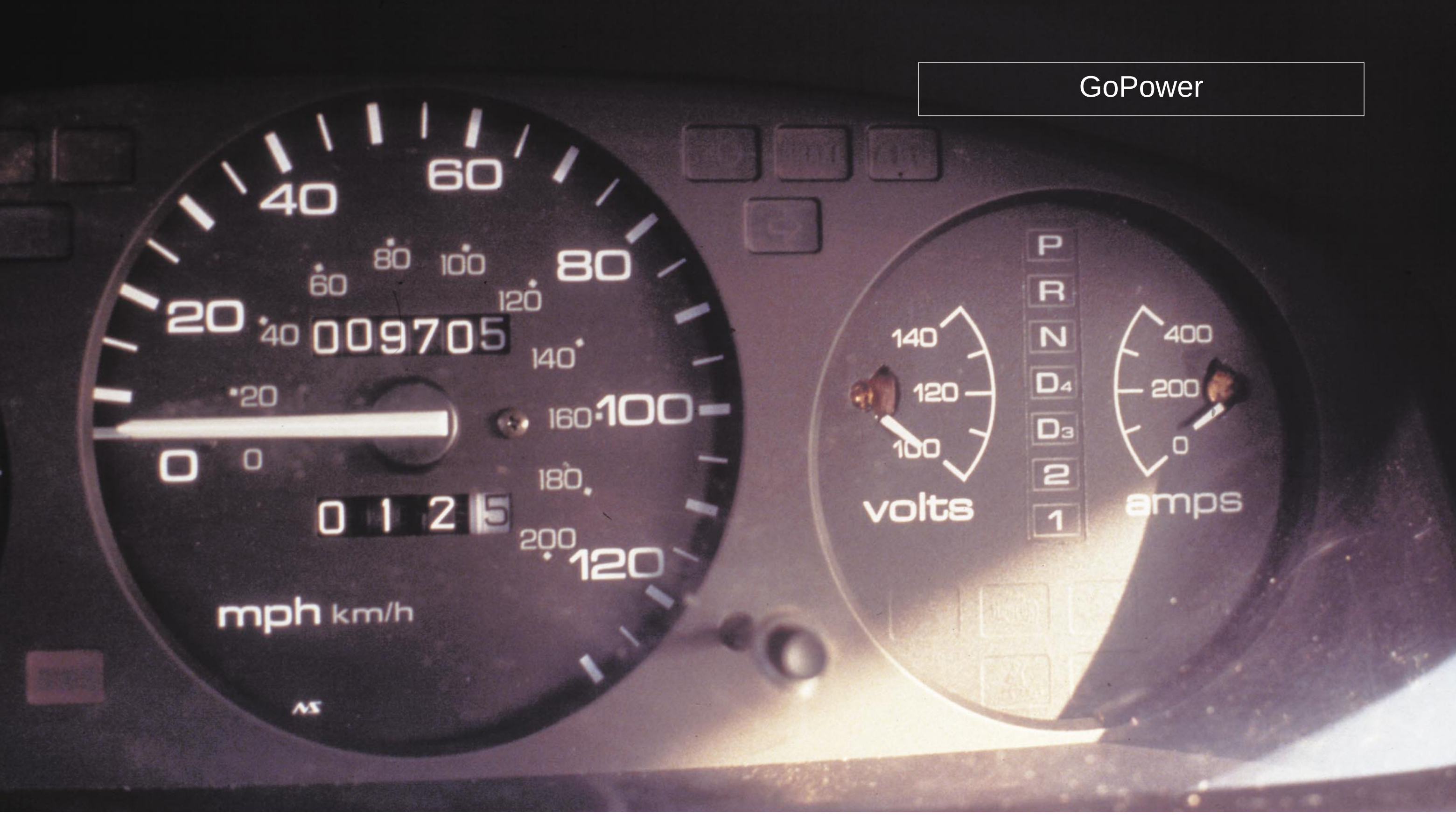
Ely Schless (Schless Engineering, now in Ashland, Oregon) has built the prototype of an electric-assist brake for large EVs. The bane of all EV converters is the 'power brakes' in late model vehicles. These are o vacuum operated. A vacuum is readily available with engines, but absent in EV propulsion systems. An EV converter has a hard choice — add a vacuum pump (noisy), vacuum switch (sometimes unreliable), and a vacuum tank (bulky) to run the 'power brakes' or revert to stock hydraulic brakes that requires more driver foot pressure. Instead, Ely designed an electric-assist brake for his EV prototypes. They work like power brakes, but without the noise, expense, and space-gobble of the vacuum-replicating equipment. A hall-effect sensor handles the degree of pedal-push, informing an electric-powered winch-drive that piggybacks on a stock hydraulic cylinder. A clever linkage ensures that the user still has plenty of brake action if the electric becomes inoperative. I tried it earlier this year and found it intuitive. I wish I had it on my car.



Above: The Schless Engineering electric assit brake.

EV Instrumentation

Another new market for commercializing EV technology is meter drivers. A meter driver is the gizmo that supplies a signal to a meter that provides a calibrated, proportional response to the gizmo's input. In non-techie lingo, a driver wants to see volts, amps, or A-H readings on meters, not engine temperature and fuel level. Most EV owners purchase meters that are added to the center console or under the dash. The instrumentation cluster (see photo) of a Honda EX



conversion by Ely Schless bypassed the 'add on' look of EV instrumentation. Today's cars are designed to minimize the time it takes to make repairs. Removing a few screws provides access for minor graphics changes of the meter faces. Temperature and fuel gauges are air-core meters that easily accept new commands from a "black box". This makes the stock meters function accurately. A vehicle's tachometer is handled another way. Again, Schless engineering came up with a solution. It's a grape-sized gizmo that generates a square wave out of a rotating disk (motor shaft) that drives the stock tachometer. After three years, it's still quietly and accurately doing its job in my Honda. Entrepreneurs should note that Ely (Schless Engineering, 503-488-8226) has no plans to manufacture the electric brake, meter drivers, or tachometer sensor. All that wonderful engineering...

That's it from this corner of California. In your prayers tonight don't forget ZEVs - zevs -zzzzzzzzzzzzzzz.

Access

Michael Hackleman, PO Box 63, Ben Lomond, CA 95005 • Internet email to: michael.hackleman@homepower.org

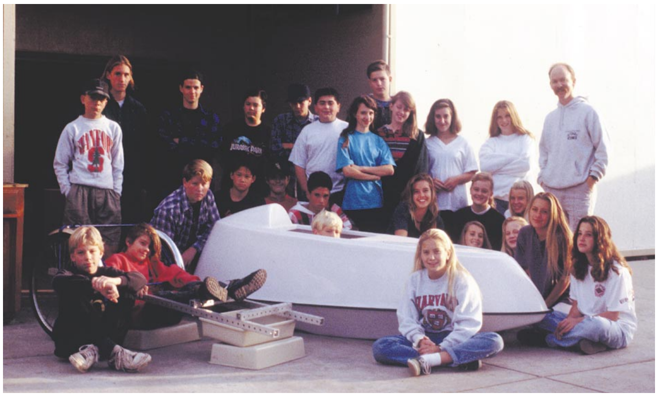
The Panther Electric: A Junior High Project

Michael Hackleman

Well, we did it. The year-long school project to build an Electrathon vehicle at SLVJH (San Lorenzo Valley Jr. High) was completed as the month of June started.

A month before, I didn't believe we'd make it. Named the Panther Electric, the vehicle gained enough form and substance toward the end to revive the students' interest. Entering it in the hometown parade before we were finished helped. A few big afterschool and weekend sessions pounded out the detail stuff.

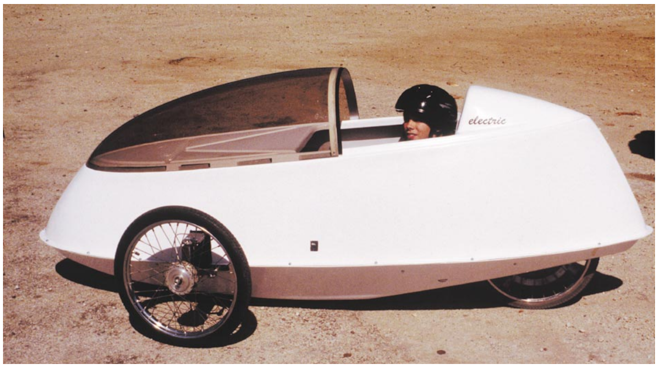
An hour of roadtime both days before the event wrung out problem areas and adjustments were made. Karl Applegate drove the Panther Electric in the parade, doing little figure eights in the roadway to the delight of the crowd, then speeding off to catch up with the parade. Spectators were impressed with the little vehicle and what the students accomplished. The project was part of a cover story for a local Santa Cruz weekly paper. On the last day of school, any student that put in serious time on the project ran two laps on the school's track.



Above: SLV Jr. High's GATE class starts the Panther Electric project.

The Project Starts

The Panther Electric project came about when I engaged my younger son's GATE's (Gifted and Talented Education) class in building an Electrathon vehicle. This involved more than a dozen seventh and eight grade girls and boys enrolled in a Problem Solving class at SLVJH. It was clear that most of the students lacked basic materials-working and tools-handling skills. I'm glad we purchased a blown-ABS Murphy AeroCoupe shell for the body.

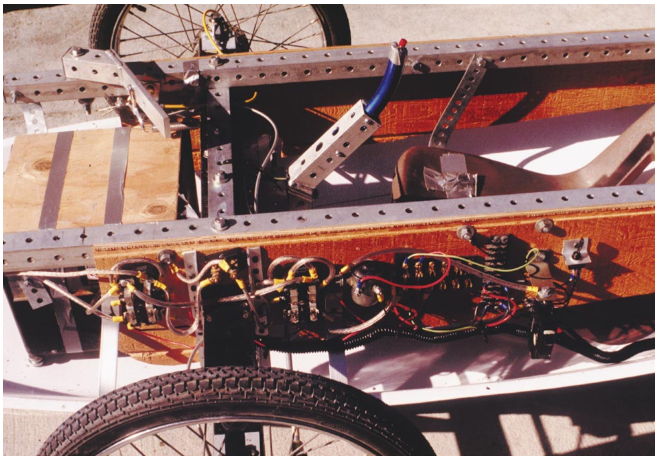


Above: Student Stephen Birmingham prepares the Panther Electric for the Felton Remembers parade.

Construction Begins

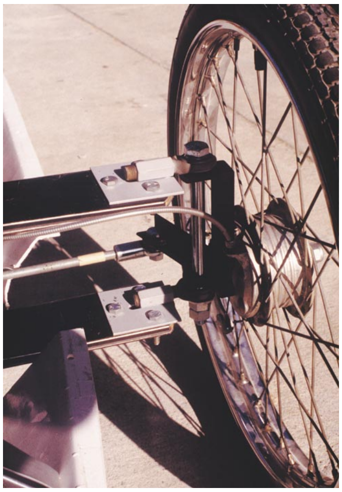
Our smartest move was using Jergenson aluminum box-beam for designing and fabricating the chassis. Like Leggo pieces, this permitted the constant shifting of components, support, and suspension elements throughout the project. In the end, only one component was welded. I'm certain we could have found a non-welded alternative, but we chose expediency over purity to get it done.

Early on we borrowed an idea used in solar race car's, building the front suspension with skis as springs. Two



Above: All electrical components are mounted on the boxbeam sheer plate for easy troubleshooting.

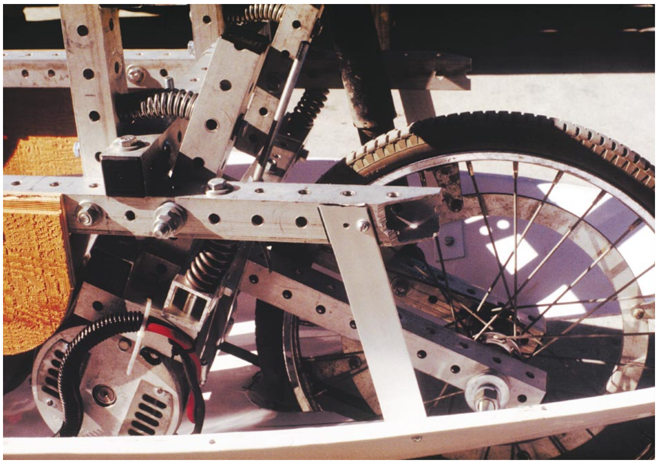
Above: The Panther Electric's core team poses for a Good Time's (newspaper) photo
Photo: Greg Pio



of the laminated micarta/aluminum/steel skis had their tips and tails chopped off. These were spaced and stacked (see photo) to support Hime joints at the top and bottom of the kingpins, approximating traditional twin A-arms. A castor (rake) angle was built in and camber is adjustable.

Students scrounged an amazing array of bicycle parts, rims, and tires during the project year. After several trial setups, we finally settled on a full set of modified moped rims and tires from Dann Parks (See *Home Power* 43, pg. 48).

Using a motorbike layout for the wheels (two steered in front, a single powered wheel in the rear), we assembled a rough framework. Since one of our goals was to have the vehicle licensed for the street, the main inside frame rails were at bumper level. The students were very concerned about safety. They thought it would be smart for the vehicle to be able to bounce away from a collision instead of getting steamrolled. Several students measured the height of bumpers of cars in the school parking lot. We settled on the main rails at 18-inches above the ground.



Above: The boxbeam rear suspension was student-designed and involved no welding.

The rear suspension is a maze of box-beam pieces. I am impressed with the students' tenacity and creativity in designing and building it. The motor shaft is at the same center as the suspension pivot. Irrespective of suspension travel, the tension of the V-belt (soon to become a chaindrive) does not loosen or tighten.

Currently, the vehicle uses the simple series-parallel circuit (12V or 24V) controller described in *HP*#39. A vehicle-reversing relay was added, knowing that we would drive on the road as well as the racetrack.

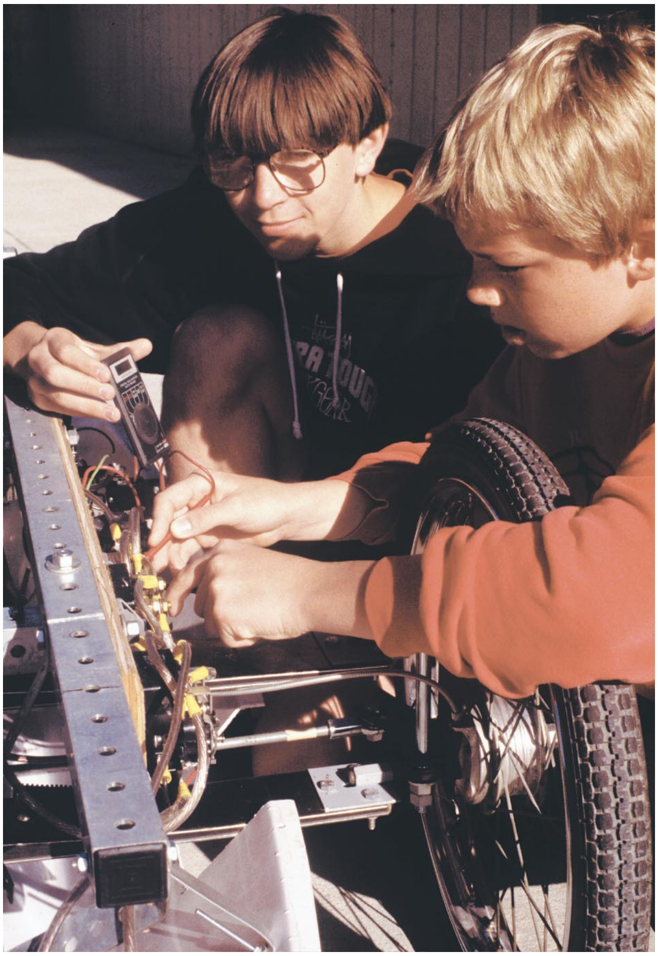
Final Thoughts

This project was a lesson in patience for me. I learned how I communicate (or don't!), how well I listen, and my attitudes about young people and their motivations.

The present vehicle is Electrathon qualified but would not be very competitive. The project itself is completed. A car was built, primarily by students, and it worked! There will be further work on the vehicle. Most likely, it will become an after-school project open to qualified students. Either way, the focus will be on refinements and getting the vehicle roadworthy and street-legal. I'd like to see it in a race at the San Jose Velodrome.

It was interesting to see the students settle into natural areas of interest on the project. Some liked mechanical work, and others were more enchanted with the electric propulsion system. Several students showed real skill at drawings. Many students attempted videotaping, but the majority of the footage was pretty shaky to watch! Fortunately, several students mastered these skills. What a documentary—if it's ever edited!

I think the students obtained some insight into what it takes to accomplish a goal. There's so much more to managing a project than assembling something. How everybody feels at the end, not the vehicle itself, is a reflection of how well the project was conducted.



Above: Josh Shreffler and Glenn Hackleman check control circuitry prior to the first test run.

Access

Michael Hackleman, POB 63, Ben Lomond, CA 95005
• email to michael.hackleman@homepower.org

Above: The City El

Above: The Kewet

Above: The Doran

Going Electric in 1995

Michael Hackleman

The 1998 mandate for ZEVs (zero-emission vehicles) is still a long way off for many folks who are ready right now to roll down the highways in cleaner transportation.

Beginning in 1998, it's expected that 40,000 electric vehicles per year will be registered in California alone. Even if someone is patient enough to wait, the selection available to consumers may be poor. Major auto makers will steer clear of affordable commuting vehicles lest they compete with internal combustion engine vehicles. Fleets are the most likely recipients for vehicles that would fall into this category. Fortunately, there are alternatives in two general categories: conversion and purpose-built EVs.

The conversion of a standard automobile to electric propulsion is the most common way to obtain an EV today. Converted vehicles are available from or performed by a number of companies like Solectria, Solar Car Corporation, ElectroAutomotive, Burkhardt Turbines, KTA Services, MendoMotive, Electric Vehicles of America and others. Kits and components are also available for the DIY (Do It Yourself) crowd. Conversion manuals make it easier to understand what's involved. Do your own skills stop at the business end of a screwdriver? If so, manuals will also help you to select qualified people when you need assistance.

Purpose-built EVs generally fall into one of three areas: production vehicle, kit car, or POC (proof of concept) vehicle. A production EV is one that has rolled off an assembly line somewhere. Kit cars are prototypes that may be duplicated by anyone who purchases a set of plans from the designer/owner. POCs are vehicles that reveal good design features that anyone may integrate into their own prototype.

Don't undertake an EV project until you have read a lot. You can easily spend $75 or more on EV-related material. It will save you ten times that much. If that amount of cash sounds impossible, the same word applies to the probable success of your project!

Production Vehicles

Two examples of production prototypes are the City-El and the Kewet, both imports. The City-El is a good example of a neighborhood EV. It's a nimble three-wheeler that's been around in Europe long enough to have evolved to its current standard. Though limited in speed, it's an all-weather vehicle that's well engineered and easy to drive, operate, and maintain. While there's space for a child (rear-facing), this is primarily a one-person machine. Apparently, liability issues have halted its commercial availability in the USA. Even so, a number of them exist in the Sacramento area. The Kewet is a solid four-wheel machine that seats two and is completely at home on the street. Its no-nonsense look and high visibility to other drivers will give its driver a warm-tummy feeling. (The Kewet's two-year airbag exemption period expired in the USA. An extension has been filed. You may still be able to get one from Green Motor Works, Hollywood, CA).

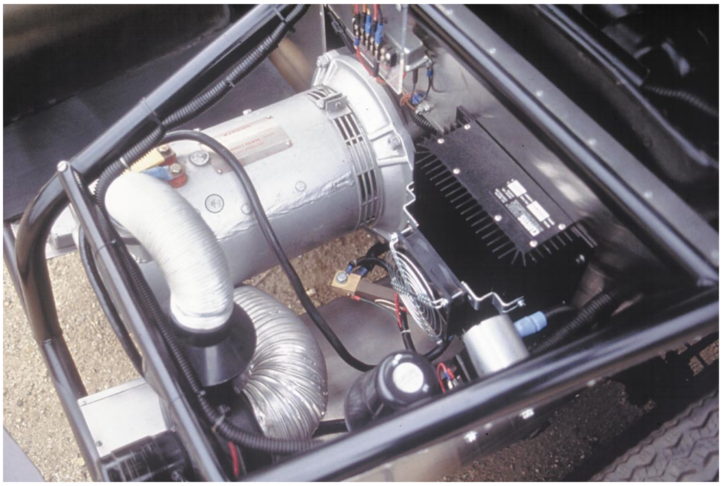
Kit Cars

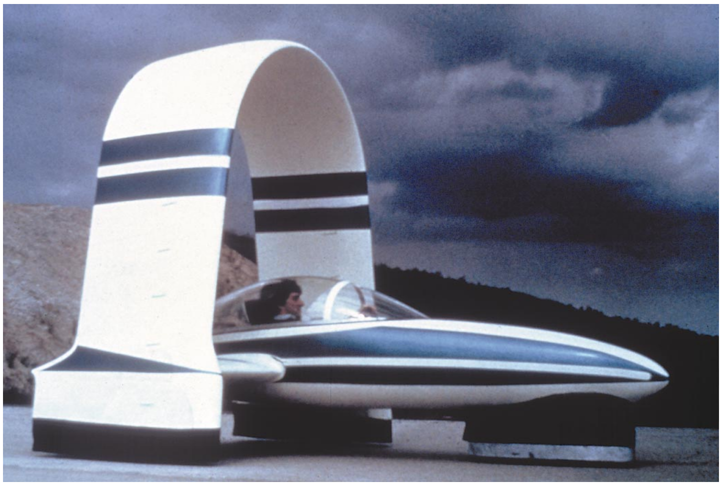
The Doran and Vortex are examples of EV kit cars. Both are three-wheeled, two-seat prototypes designed to be built from plans. Since both vehicles were originally built around engines, they evolved significantly in design through use.

The Doran was designed and built by Rick Doran. Three wheels were chosen to minimize weight, decrease rolling resistance, and ease licensing. The Doran's front-wheel drivetrain is built around a 1980-89 Subaru Hatchback transmission and transaxle assembly. Two steered wheels up front makes an aerodynamically clean, teardrop-shaped body possible. A common fear held by the general public is that a 3-wheeler is more susceptible to a rollover than a 4-wheeler. Nonsense! A properly designed 3-wheeler can have an overturn resistance as good as or better than most modern sedans. In tight turns, the tires will lose adhesion long before enough side force can be developed to flip the vehicle. The specific physics of 3-wheelers, along with construction plans and diagrams (including fiberglassing notes) are thoroughly discussed in Rick's 94-page book. My copy is getting worn from use.

Above: The Vortex

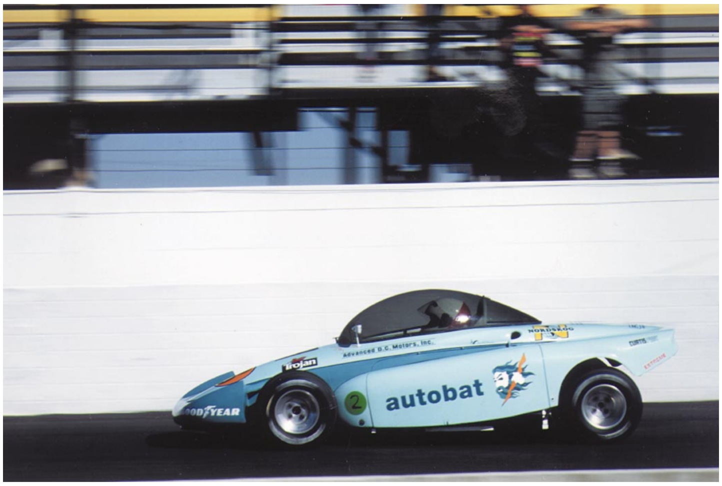

Above: A Kitcar Porsche


Above: The Porche's motor compartment



Above: The Windmobile

Above: The Sylph



Above: The Formula E Autobat

The Vortex is a three-wheeled sports vehicle designed by Steve Pombo. It's intended to be home-built from plans. The builder need only possess average tools and craftsman skills. In this design, the rear wheel assembly is powered. The rear swing-arm, axle and tire are built into a cradle for easy removal. The Vortex body is hand-shaped and built of urethane foam and fiberglass. The chassis uses a plywood monocoque structure. The front suspension is a sophisticated double A-arm unit from the Triumph Spitfire. It includes the Spitfire's rack and pinion steering, anti-roll bar, and oversized disk brakes. The vehicle is built directly from engineering plans (CAD-drawn plan sheets) and a 64-page booklet.

Proof of Concept Vehicles

POC vehicles point the way toward a successful, scratchbuilt EV. Scratchbuilt vehicles have a very important attribute. It may be the only way to get *exactly* what you want. But there's a price to pay. Contrary to popular opinion, a scratchbuilt EV is *not* the fastest, easiest, or least expensive way to own an EV. It will take a long time to do. It will probably cost as much as a conversion. It also demands an honest evaluation of your competence and ability. One thousand pounds of human and machine hurtling along at any speed is horribly unforgiving of design or construction error. The wise scratchbuilder does not reinvent the wheel. Instead, this person mixes existing sub-assemblies from other vehicles. They combine the right proportion of weight, aerodynamics, rolling resistance, hill-climbing ability, efficiency, ergonometry, and crashworthiness. Each machine must unite frame, brakes, suspension, steering, and body-shell with the propulsion package. It's a big, big job. Think legal. An EV that will use the roads must be certified, registered, and licensed. Purchase a copy of the current Vehicle Code for your state. Look it over for anything that might apply to an EV. Don't get snagged on a technicality!

For the virtues they hold, and the direction they may give in "rolling your own", I've included six photos of POC vehicles. They include a kitcar Porsche, the Windmobile, the Sylph, the Formula E Autobat, an HPV Vector, and an Aerocoupe.

• John Sprinkle put a replica fiberglass Porsche body on a VW chassis to ease the overall process of building an EV. He quickly abandoned an early hybrid arrangement and enjoys cruising and commuting in his pure-electric machine.

• Jim Amick's Windmobile combines good crashworthiness and a dual-drive system (twin motors at each of the rear wheels) with lots of aerodynamic detail. It helps to live in a *very* windy area or enjoy lots of attention.

• The Sylph was designed by Matt van Leeuwen at a time when good EV components were unavailable. Despite the use of a Goldwing engine, this prototype represents the kind of packaging that would complement today's EV technology. It keeps a high-profile for street use, arranges the driver and passengers in spacious 3-seats, offset tandem style, and maintains cleans lines, despite its payload.

• The Formula E racer was built by Ely Schless and raced at Phoenix by the Hackleman-Schless team. It swept the 1st place trophies in its class in both events in 1992 and 1993. Its exchangeable saddlepack battery modules, combined with a single-ratio drive, a 10 HP propulsion motor, and a curb weight of only 1,200 pounds represents an exciting template for designers of 4-wheel street machines. Positioning a driver and passenger above the battery pack for better visibility would make this a strong, unlimited range vehicle.

• The Vector and Aerocoupe are lightweight, 3-wheel body-shells designed for HPV (human-powered vehicle) use. The Aerocoupe is used extensively with electric-assist or electric-only operation in the Electrathon racing circuit. Their value to the prospective EV builder is their commercial availability. This bypasses the need to use fiberglass for the body and windshield. Purchasing either one (or similar body-shells) can shave a big chunk of time and nastiness off an EV project.

Access

Author: Michael Hackleman, POB 63, Ben Lomond, CA 95005 • email to michael.hackleman@homepower.org. This article, includes condensed material excerpted from *The New Electric Cars: Simple, Efficient and Reliable*, by permission of Chelsea Green Publishing. Available in May 1995. • Doran Book ($39.95) available from: Rick Doran, 6290 Sunrise Meadows Loop, Reno, NV 89509

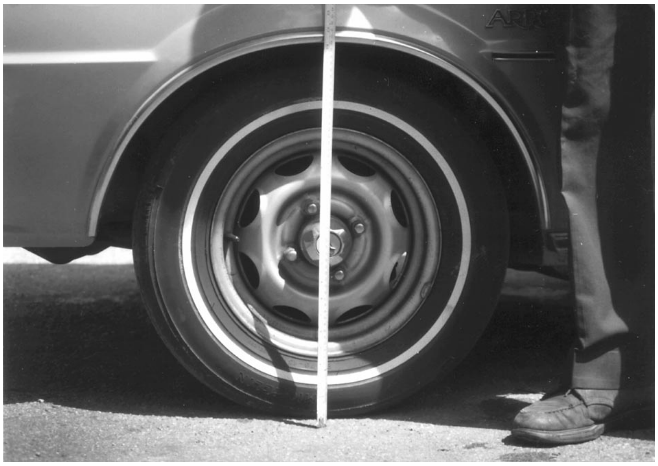
Vortex Design Plans ($40.00) available from: Dolphin Vehicles, PO Box 110215, Campbell, CA 95011

Above: The Vector

Above: The Aerocoupe

Electric Vehicle Suspension

Shari Prange



Above: Ride height is measured through the center of the wheel, from the ground up to the wheel arch.

One important aspect of an EV that is too often ignored is the suspension. A typical conversion has over a thousand pounds of batteries. This means the car overall is 800 pounds (or so) heavier than its original weight.

Importance of Suspension

It's easy to spot the EVs with bad suspension; they're low-riders. Many are tail-heavy and nose-high. A few are nose-heavy. Some just squat on all four wheels. If you look at them from the end, you may see wheels splayed outward.

Poor suspension can cause other problems besides making you look silly. It will not be possible to get a proper alignment on the wheels. The most serious result of this is poor handling, especially in an emergency situation. If you have to make a quick maneuver, the car may not steer properly.

If the wheels are splayed out (a condition called "excess negative camber") the tires won't be able to grab the road properly. They'll wear prematurely and unevenly, mostly on the inside edge where you might not notice.

Also, if the car's springs and shocks are continually compressed, they won't be able to do their job properly.

Getting Data

Now is the time that some of the numbers you recorded before the conversion will come in handy. If possible, drive the car to a public scale and weigh it three times: front axle, whole car and rear axle.

Even if you can't take it to a scale, drive it just enough to get it settled down on its springs. Then park it on a flat, level spot and measure the ride height at each wheel. This is the measurement from the ground to the top of the wheel arch, at the centerline of the wheel.

These numbers tell you how much weight you added to each axle and to the car overall. You'll also know how many inches of ride height you gained or lost.

If a car is heavy on one end, the other will be too high. Raising the heavy end will bring the light end back into line. If this is your situation, consider first whether you can redesign the battery layout to re-distribute the weight evenly.

Your suspension may be coil springs, leaf springs, or torsion bars. There are options for beefing up all of these.

Adjustments

Some kinds of suspensions, such as torsion bars, can be adjusted. You may be able to adjust the suspension enough to restore your ride height.

Dealership Springs

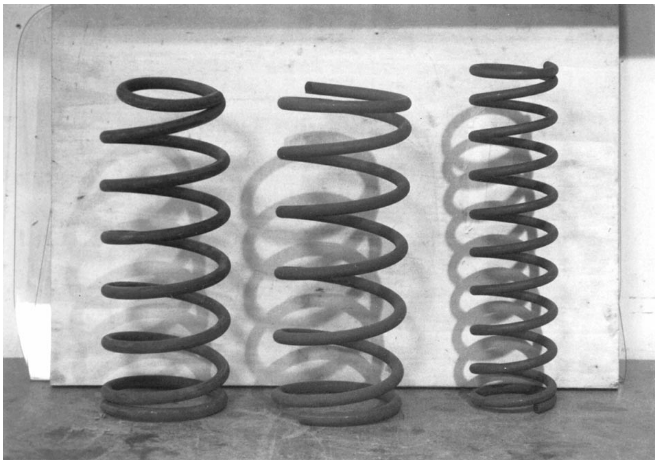
The easiest way to identify replacement springs is through the dealership. Find out if there is another model of car with a heavier-duty spring that would bolt in. This could be a luxury version of your car with a larger engine, air conditioning, or a towing package. It might be a completely different model - one that is heavier but uses suspension parts with the same dimensions.

If you can identify these parts through the dealer, you may be able to locate them in a wrecking yard and save a lot of money.

Aftermarket Springs

Another solution is an aftermarket replacement spring. Some models of cars are more likely to be modified by their owners than others. Those models will have commerically available overload springs.

Be sure you are getting good quality springs. The extra cost is worth it. If you have coil springs, don't be seduced into purchasing "coil spring helpers". These



Above: Springs come in different sizes and end styles. Shown are (left to right): late Rabbit front, early Rabbit front, and Rabbit rear.

little devices are installed between the coils of the spring. They prevent the spring from compressing in the way it was designed.

If you have leaf springs, there may be a good "helper" kit available for your vehicle. These are actually extra leaves that you add to your springs to stiffen them.

Custom Springs

If you have no luck with the dealer or parts houses, you may need to get custom springs built. These may cost as much as $150 per wheel. Look in the Yellow Pages (of the major city nearest you) under "Springs".

The spring maker will want a lot of information about your old springs: height fully extended, height fully compressed, number of coils, diameter of coils, diameter of spring material, spring rate, and end mounting style. The mounting style refers to the way the end of the spring attaches to the car. The spring itself may be a continuous tube all the way up, or it may tighten into a "pigtail" at the end. It may be mounted "outer diameter constrained" or "inner diameter constrained".

As you might guess, the easiest way to get most of this information to the spring maker is to send him one of the old springs. He will also want to know how much weight you've added to each wheel (axle weight divided by two) and how many inches of ride height you need to restore.

Your new springs will probably look exactly like the old ones. They may look rusty since this type of metal develops a harmless surface coat of oxide. The difference is in the spring compression rate. This is the amount of pressure needed to compress the spring.

Air Shocks

Finally, for cars with coil springs or torsion bar suspension that do not enclose the shock absorber, air shocks are an option. These can be pumped up with air to carry the necessary weight. If these are carefully installed in the beginning, they will give years of satisfactory performance without leakage problems.

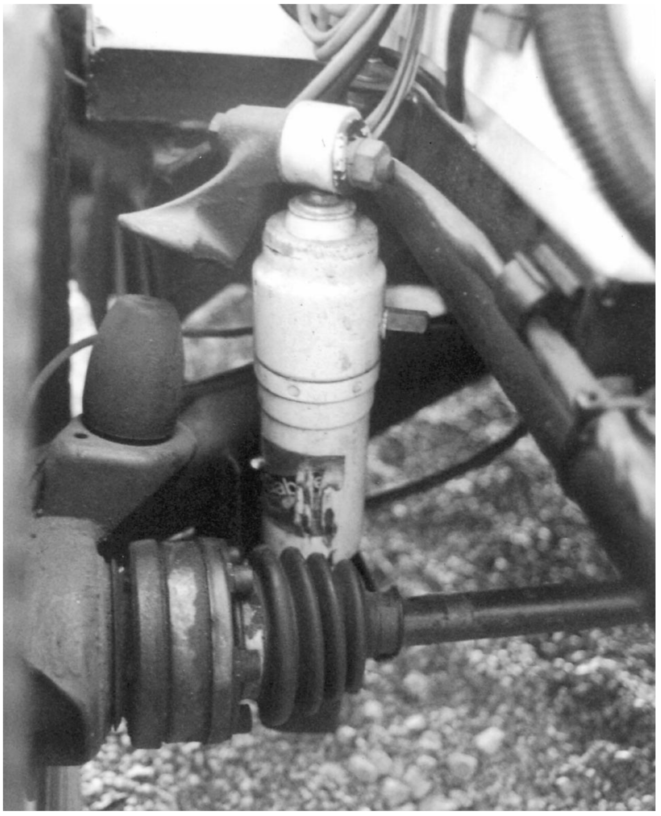
If you have trouble finding air shocks for your model car, go to your aftermarket parts house and ask to see their KYB catalog. KYB has shocks for a wide selection of cars and trucks. Their catalog makes cross-matching easy.

First, locate the drawing and description that matches the dimensions and mounting style of your car's original shocks. Note the KYB designation for this style. Then check the charts to see which other models use this same style. Pickup trucks are good bets.

While the parts house may not show any listing for an air shock for your car, they may have one for another model which uses an identical shock.

Struts and Shocks

While we're on the subject, let's talk about struts and shocks. If you aren't using air shocks, this is a good



Above: Air shocks are a good option on many cars such as this VW Bug.

Above: Helper leaf springs beefed up the suspension of this Datsun pickup truck.

time to replace your struts or shocks with heavy gas-filled versions.

The purpose of the shock is to provide some resistance to motion and dampen the oscillations of the springs when your car goes over a bump. Your EV has more weight bouncing on those springs so a stronger dampening force is needed.

Do NOT attempt to change MacPherson strut inserts yourself. The springs are held onto the strut assembly under great tension. If you release that tension without the proper tool to contain it, you will create an instant unguided missile. The cheap “strut compressors” that use a piece of ready-bolt and a couple of hooks do not work. As you try to tighten them down, they simply “walk” around the spring.

Instead, take your whole strut assembly (or whole car) to a shop that specializes in that model of car and let them replace the inserts for you. It’ll be much cheaper than a trip to the emergency room.

Anti-Sway Bars

Anti-sway bars are not essential but they are recommended if they’re available for your car. When you take a curve, the heavy batteries will try to continue to move in a straight line. Anti-sway bars counteract that tendency and help the car stick to the road in the curves. A good source for anti-sway bars is any place that caters to stock car road racers.

Alignment

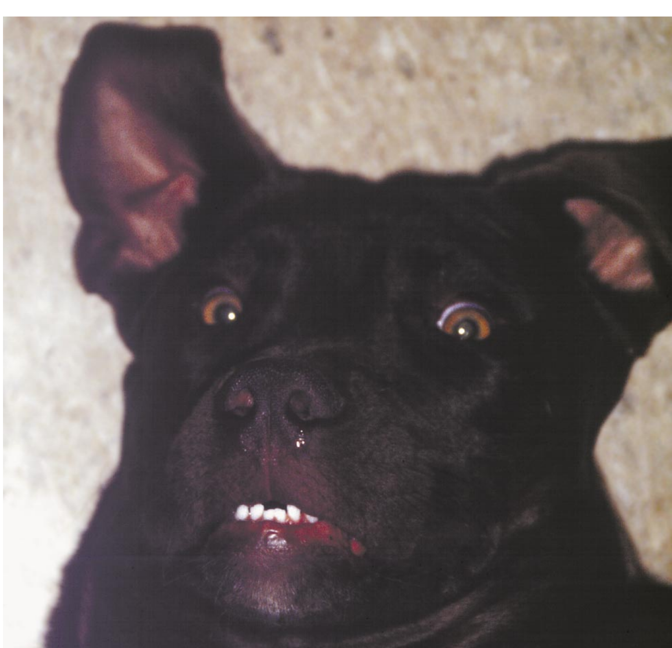
After you’ve installed your new suspension, take the car to a good alignment shop and get a full wheel alignment. Improper alignment will increase the car’s rolling resistance which will decrease its efficiency and range.

Finish the Job

A proper suspension will make your EV more pleasant to drive. It will increase the car’s range and make your tires last longer. And most important, it will make your car safer on the road. After you’ve put this much effort and expense into your conversion, take the time to give it a good suspension and finish the job properly. You won’t regret it.

Access

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



Solar Cooking in Southern Peru

Andy McDonald and Mark Schimmoeller

In August 1993, Sister Patricia Gootee of the Medical Mission Sisters in Arequipa, Peru contacted Appalachia Science in the Public Interest (ASPI). ASPI is an appropriate technology demonstration center in Kentucky. Sister Gootee asked for help starting a solar cooking project in Southern Peru. It was through the help of ASPI and the Lexington, KY Jesuit community that we found ourselves beginning an exciting project in Arequipa's "Pueblos Jóvenes", the youngest and most impoverished section of Arequipa. Arequipa is a desert city with more than one million inhabitants. We had five months to design an efficient, inexpensive solar cooker from readily available materials and to train local people to carry on the project after our departure.

A Slow Start

We arrived in Arequipa during the rainiest season in 40 years. This wet season lasted from January until March—we wondered if solar cooking would work in Peru. During this time we did build a solar cooker from bricks and tin but we didn't make any real progress until March.

In mid-February, with our work going so slowly, we decided to take a trip into the mountains to visit some friends of the Sisters who live in a convent in an old pueblo called Yanqui. They run a health clinic and a comedor, which is part of a national program that provides meals to families in need. With the help of several women and men from the community, Sisters Sarah and Antonia provide bread, cheese and soup to as many as 1000 people every morning. In Yanqui we saw how valuable solar cookers would be in rural and urban areas. In the cities, families do most of their cooking with kerosene, which is very expensive. Families commonly spend 25–50% of their income on cooking fuel. Kerosene is a very dirty and dangerous fuel to use in their homes, as is the typical fuel in rural areas, firewood. The people of the mountains, campesinos, simply do not have the money to spend

on kerosene. They cook over open fires in smoke-filled kitchens using brush collected in the countryside. Campesino families usually spend one day per week simply collecting firewood, thus from many prospectives solar cookers hold great promise.

After we returned from Yanqui we were determined to get a good solar cooker working. We hoped the weather would improve. We were dissatisfied with the brick cooker we had built. We had baked apples and granola in it, but it wasn't getting hot enough. We decided to adapt a cardboard and aluminum cooker described by Joseph Radabaugh in his "Heaven's Flame, A Guidebook to Solar Cookers". This book proved invaluable to us. This cardboard cooker became our standard model.

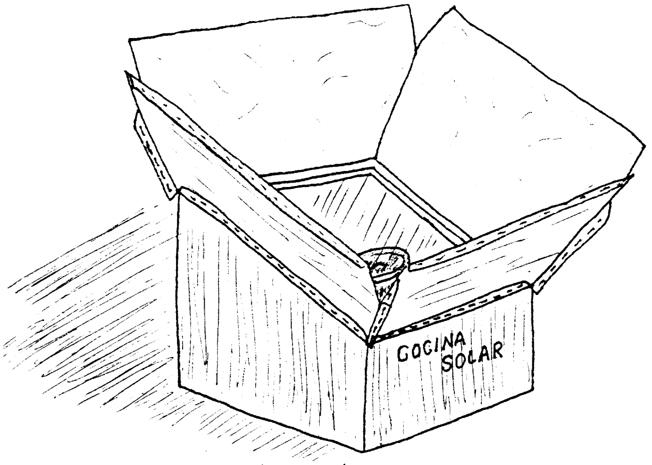


Figure 1: The standard solar cooker model used in Arequipa, Perú.

Cocina Solar

The inner box of our cocina solar (solar cooker) is common corrugated cardboard painted black to absorb more of the sun's energy. The cocina's walls and base each contain 7 cm of insulation, usually crumpled newspaper or paper bags which once contained flour and sugar. The base is filled entirely with cardboard to avoid compression. The window atop the box is common glass and allows the sun's energy into the box while serving as the oven door. The inclination of the box top is a feature we decided to employ to avoid having to incline the entire cooker towards the sun; see figure 2. This avoided several difficulties, including the design of an inner cooking rack to keep the pots in a level position.

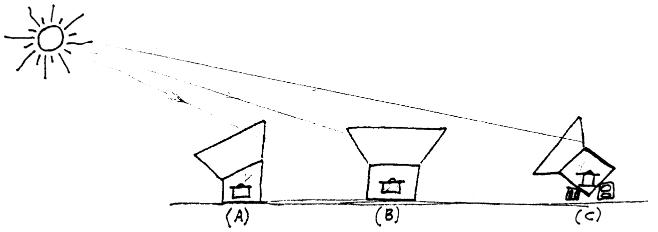


Figure 2: The glass top of the oven must be tilted towards the sun to allow the sunlight into the box. This can be accomplished by inclining the box top (A), or by inclining the whole cooker (C). In case (B) the inside of the box will be in shadows and not get hot.

The angle of inclination was determined primarily by the design of the reflectors. One of the problems Sister Patricia had encountered when experimenting with solar cookers previously had been stabilizing the reflectors against wind, which can be strong at times in Arequipa. The trapezoidal reflector design we borrowed from *Heaven's Flame* collects a large amount of the incoming solar radiation while being very stable because the four reflectors are sewn together and tied to the box during use. The reflectors are made of cardboard, aluminum foil (which we were surprised to find in Peru), glue and string. See Figure 3.

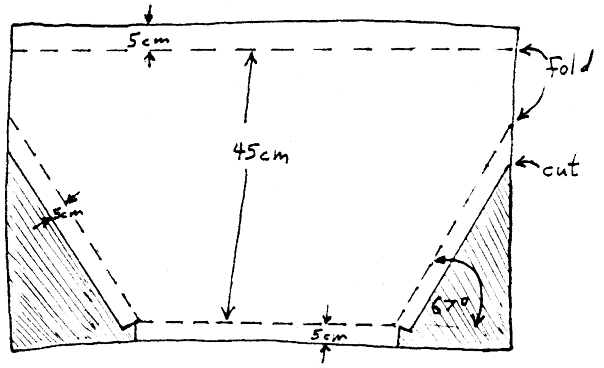


Figure 3: Reflector Design - The top and bottom flaps are folded over to reinforce the reflector, and the side flaps are sewn to the other reflectors to form a single unit. The reflector is made from a single piece of cardboard.

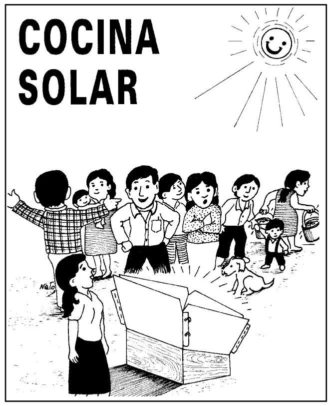
To teach the basics of solar cooking, it was important to have a standard model which could be simply explained and built. We always pointed out that our cooker was only one of many possible designs. The cooker worked well but we wanted to encourage people to modify and improve upon the design. We were there merely to sow the seeds of solar cooking. We repeatedly challenged people to improve our cooker — and our cooking — which left a lot to be desired, as we were often told!

Promotion Begins

By mid-March we had a well-functioning solar cooker that was inexpensive and easy to build. A cocina solar costs about $10 to build, including a thin plywood outer box to make the cookers stronger and more durable. Even this small amount can strain the budgets of many Peruvian families. If the cookers are used regularly they pay for themselves in unused kerosene or time saved collecting firewood.Even we were surprised by how well the cooker worked. On a typical day the cookers reached 350°F–400°F before we put the food in to cook at mid-morning. After 2–4 hours, depending upon the type and quantity of food and solar insolation, our dinner was ready to eat. From late March we cooked our dinner nearly every day using only the sun's energy. This was an excellent promotion for solar cooking. The building we lived and worked in is a community center and bakery that has many visitors. Everyone was impressed by the fact that our food was cooked using the sun's energy. We developed a friendly competition with the manager of the bakery over whose oven could bake a better cake. She would laugh at us on the occasional cloudy day but our cocina solar never burned cakes as hers regularly did.

The most difficult phase of our project was promotion and education. Geovana Quezada Rivera, a nutrition student at a local university, aided this phase immeasurably. She joined the project to help us adapt traditional Peruvian dishes to solar cooking, but quickly became an integral part of every aspect of the project. Her ingenuity and enthusiasm were remarkable.Geovana became the project's main promoter.

We faced a rather dismaying situation when almost everyone who saw a cocina solar wanted one—to buy. We wanted to educate and empower people, not run a business. We wanted people to learn the techniques themselves, so Geovana and Sister Patricia put together a pamphlet explaining the construction and use of the cocina solar. This proved to be a great asset. We taught classes to various groups. An essential part of the process was to instruct school teachers so their students could learn to build and use solar cookers.



Students can then make cookers for their families. When students build cocinas solares in school, they bring this valuable technology home to their families and they have the ability to do it for themselves and others in the future.

In early May we returned to Yanqui, this time with tools and building materials. Working with several local residents, we made three cookers in three days. One of the cookers was for Sisters Sarah and Antonia. They used it with great delight. Everyone we worked with assured us that they would teach the process to others. Even Geovana's grandfather, who lives in Yanqui, built a cooker.

The Sun Still Rises

By the time we returned to the States in June, there were twenty solar cookers in use in Southern Peru. Even more important was the core of trained teachers continuing to promote solar cooking. From the day we arrived we knew that the ultimate success of the project depended not on how many ovens we built or demonstrations we gave, but on the people who would carry on. The commitment and ability we witnessed from Geovana, Sister Patricia and others has made us optimistic about the future of solar cooking in Peru. Sister Patricia and Geovana attended the Second International Solar Cooking Conference in Costa Rica. Several women in Arequipa will be making cocinas solares for sale. This provides employment and meets real social, ecological, and community needs.

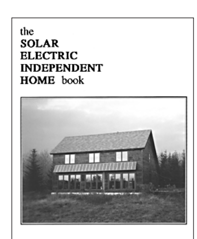
It is remarkable how well solar cooking works in Southern Peru. Inti, the Incan descendants name for the sun, shines with dazzling clarity upon Arequipa. Our project was merely an acknowledgement of Inti's power. This project would have come to nothing if the Peruvian people had not been willing to try something completely new. We are grateful for the kindness and enthusiasm they shared with us.

Access

Andy McDonald, 364 Barden Rd, Candor, NY 13743, 607-659-7553

To order the Cocina Solar Pamphlet send $4 to:

Centro De La Famila "Anna Dengel", HNA. Patricia Gootee, TLF: 217832, Av. Alfonso Ugarte 917, Porbenir Miraflores, Apartado 970, Arequipa, Peru



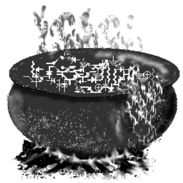
Notice

Natural Energy Co. is ending its 18 year wind generation business. We are accepting Bids to Purchase on the following items which will be released to the highest bid as of February 28, 1995 FOB Davenport IA. Bids may be for single or multiple items.

(1) **Dunlite** 2KW, 110v.
(2) **Jacobs** 2.5KW, 32v.
(2) **Jacobs** 1.8KW, 32v.
(1) **Paris-Dunne** 1KW, 32v.
(1) **Gemini** Synchronous Inverter 4KW, 110v.
(1) **Best** Inverter 3KW 32v. to 110v.
(1) **Soleq** Sine Wave Inverter 6KW, 110v.
(1) **Rohn** 45G Tower-55ft, guyed
(1) **Rohn** 45G Tower-90ft, guyed
(1) **IBE** Battery Charger 3KW, 110v.
(1) **Winco** Gas Generator, Battery Start 6KW, 110v.
(1) **Square D** Fuse Box, D.C. 110v.
(4) **Motors** 1/4–1/2 HP, 32v.
(1) **Maxim** Wind Indicator 90 ft.

Misc. 6v and 12v. Windcharger, Handheld Wind Indicators, and Electrical Components—Request in Writing.
All items are used, but in good condition, and can be inspected at our facilities; or to obtain a description of individual item(s), send a stamped, self-addressed envelope to:
Natural Energy, 2744 W. 72nd St. Davenport, IA 52806 USA

Constant Current Charger



Homebrew

Andrew Bean

What? Another Battery Charger?

Well yes, of course. Why? Because other chargers I've built suffered from one or more drawbacks. The first? Low efficiency. The second? It allowed the charge current to vary as the battery or supply voltage changed. The LM317 voltage regulator connected as a constant current source is an example of the first drawback. The "Pulsar" (HP #30) is an example that partly fits the second. Each charger has its advantages. The LM317 version is cheap, period. The Pulsar is more efficient and great for zapping dendrite growth in NiCds. In fact, I'd recommend a Pulsar for just that purpose. I wanted better. I found something close to my ideal in the Linear Technology Application Note 51 titled "Power Conditioning for Notebook and Palmtop Systems". I figured the efficiency problem was solved. I made a few changes to their basic circuit to get the one shown here. It isn't the simplest or cheapest design, but it does what I wanted.

Table 1 shows some measured efficiencies for my original circuit as well as some calculated values for an LM317 circuit in the same application. The original circuit used an LT1072 and a 2 mH inductor. Hosfelt was running low on 2 mH inductors, so changes were needed. Because of the decreased inductance, the modified circuit is 5-8% less efficient at low charge currents (<100 mA) or with fewer cells. Efficiency is about the same for both circuits at higher currents.

Table 1 Notes:

a. Circuit efficiency = (Power out/Power in) x 100. Power is equal to Volts x Amps. Example: 2 cells @ 50 mA yields the following: Efficiency = (2.78 V x 0.05 A) / (26.0 V x 0.017 A) x 100 = 31.5%

b. LM317 efficiency calculations are based on the same current into the battery as from the input supply. Example: Efficiency = (2.78 V x 0.05 A) / (26.0 V x 0.05 A) x 100 = 10.7%

c. "Amp-hours Saved" are based on the difference between the supply current used in an LM317 circuit versus my circuit, multiplied by the number of hours needed to charge the battery.

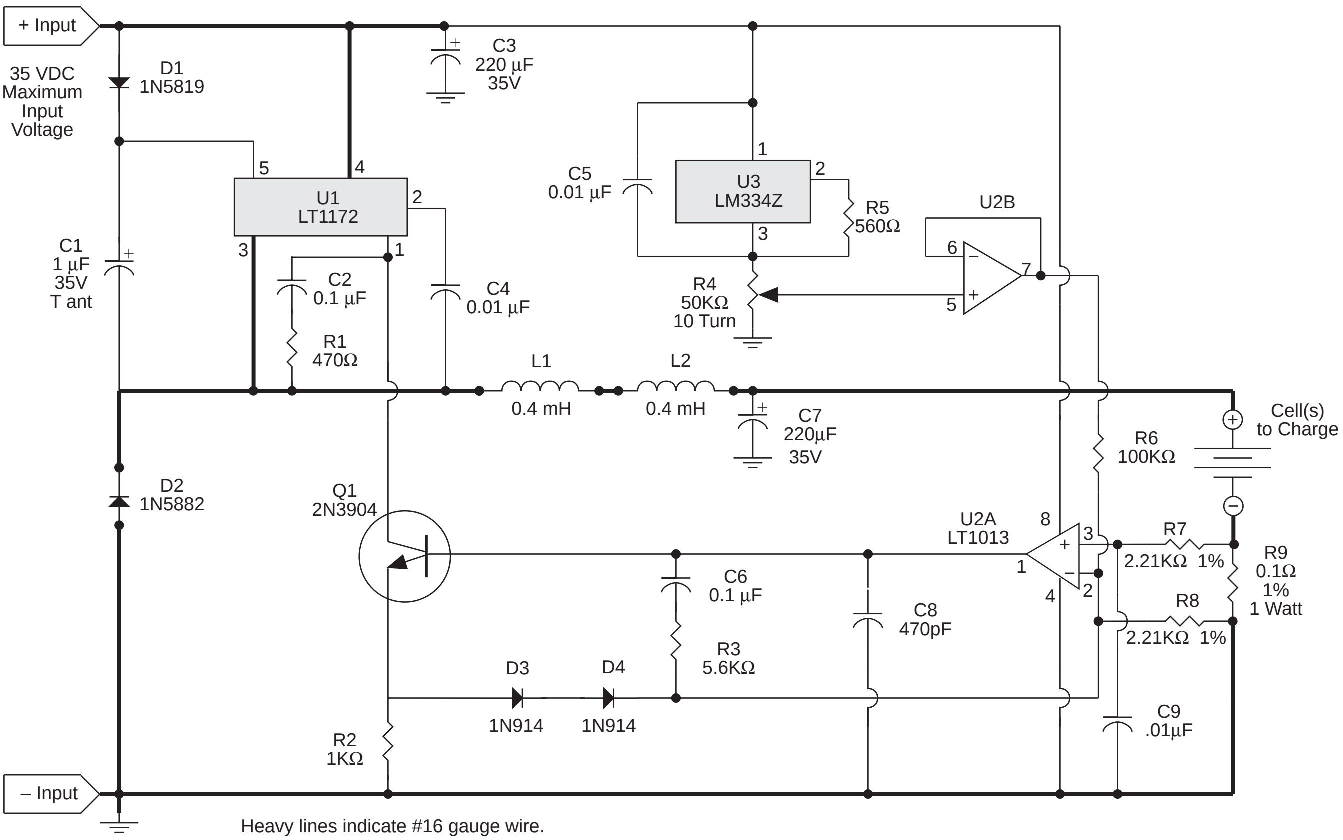
What are the LT1172, LT1013, and LM334Z?

If you haven't seen these IC's before, here's a brief description:

The LT1172 is a 1.25 Amp, 100KHz switching regulator. This IC was designed for transformer or voltage inverting applications. It can also do step down conversions. Pin 1 combines the functions of control voltage, IC shutdown, and current limiting. The voltage on pin 1 should always have a value between the voltage on pin 3 and +2 volts above that voltage. By connecting pin 2 to pin 3, U1 goes into shutdown mode, drawing less than 100 uA. Voltages between the pin 3 voltage and +2 volts over that voltage will result in various amounts of current limiting. Pin 2 is the voltage feedback connection. Pin 3 is ground. Pin 4 is the collector of an NPN transistor with the emitter connected inside the IC to pin 3. Pin 5 is the positive supply connection

TABLE 1: CIRCUIT EFFICIENCIES

Battery		*Input*		*Output*		*Circuit Eff*	*LM317 Eff*	*Amp-hrs*
# Cells	*Cell Capacity*	*Volts*	*Amps*	*Volts*	*Amps*	*%*	*%*	*Saved*
2	500ma-hrs	26.0	0.017	2.78	0.05	31.4	10.7	0.50
2	500ma-hrs	25.8	0.025	3.10	0.10	48.1	12.0	0.56
2	500ma-hrs	25.8	0.032	3.27	0.15	59.4	12.7	0.59
4	500ma-hrs	26.0	0.025	5.42	0.05	41.7	20.8	0.38
4	500ma-hrs	26.0	0.040	5.80	0.10	55.8	22.3	0.45
4	500ma-hrs	25.9	0.054	6.30	0.15	67.6	24.3	0.48
8	500ma-hrs	25.8	0.037	10.68	0.05	55.9	41.4	0.20
8	500ma-hrs	25.8	0.060	10.86	0.10	70.2	42.1	0.30
8	500ma-hrs	25.8	0.082	11.11	0.15	78.8	43.1	0.34
6	2.0A-hrs	25.8	0.080	8.33	0.20	80.7	32.3	1.80
6	2.0A-hrs	25.8	0.152	8.93	0.40	91.1	34.6	1.90
6	2.0A-hrs	25.8	0.239	9.55	0.60	92.9	37.0	1.80



Heavy lines indicate #16 gauge wire.

for the IC. For more detail on using this family of IC's, get the Linear Technology Application Note 19. WARNING! The mounting tab is connected to pin 3 (ground). Be sure you remember this! It's important later.

The LT1013 is a low power, single supply (< 40V), dual op-amp. The LM358 would be a cheaper alternative, but it consumes more current (about 3x) and is rated 32 volts maximum. Remember, low efficiency was one of my big gripes. I also wanted to use this charger at input voltages up to 33 volts to match my 24 volt nicad home system. If you use a lower input voltage, then U2 doesn't have any other advantages in this circuit.

The LM334Z is really a neat device. It's a constant current source that can supply up to 10 mA, but works best at less than 1 mA. It's a great substitute for an energy wasting zener/resistor voltage reference. This IC needs its input voltage to be about 1 volt above the output voltage to maintain the desired output current. The current is set by the equation "0.064 divided by the resistance connected between pins 2 and 3". In this circuit, the current equals 0.064/560, or 114 uA. The LM334Z will keep that current constant in spite of input voltage changes. The input voltage rating is 30 volts maximum. This is fine on top of the voltage developed across R4. A zener and resistor would have needed about 5 mA at the lowest input voltage, so the LM334Z is saving me 30 times the current over that combination.

Now We're Familiar. How Does It Work?

As seen from the schematic, U1 is "floating" on the positive battery terminal (remember, pin 3 is ground for U1). WARNING; the mounting tab of U1 connects to pin 3. You'll short your charging source if you ground that tab. D1 and C1 provide an isolated supply voltage for U1. This is important because the NPN switch inside U1 shorts the input voltage on pin 4 to the floating ground on pin 3. Without D1/C1 in the circuit, U1 would constantly be shorting out its supply voltage! We don't use the voltage feedback connection (pin 2) so it's allowed to float with C4. C2 and R1 are used to stabilize U1's operation. C3 damps out some of the voltage spikes from U1's switching operation.

To control the current limit of U1, we need to vary the floating voltage on pin 1. This is done using Q1 and R2. R2 allows the current through Q1 to hold the voltage on U1 pin 1 between the +2 volts and the floating ground mentioned earlier. Q1 gets filtered base current from U2A via R3, C6, and C8. Diodes D3 and D4 are used to counteract the voltage drop in Q1 and eliminate any negative voltage swings. U2A monitors the voltage across the 0.1 ohm 1% resistor (R9) with some filtering by C9 and a bias voltage from R6. U2A takes the difference measured between pins 2 and 3 and puts out an adjustment current to Q1. U2B is connected as a voltage follower for voltage stability

The current pulses from U1 are fed into the combination of L1/L2, C7 and the battery. L1 and L2 in series give 0.8 mH, which is pretty large. They're a bargain for the price. Three of them in series will boost low current efficiencies, but anything beyond 2-3 mH is no big help. It also results in a very low ripple voltage going into the battery. There's no need for a true RMS meter to set the charge current. All current from the battery negative passes through R9 and out the supply negative or through D2 to close the loop with L1/L2. Charging current is measured across R9. The voltage across R9 is measured in millivolts. Multiply that value by 10 to get the true charging current.

To set the charge current, adjust R4. R4 is fed a constant current of 114 uA from U3. This results in a full scale voltage across R4 of roughly 5.7 volts. That value is necessary to get the maximum current (1.25A) out of U1. NOTE: R4 is a 10 turn pot. You'll go insane using a regular pot to do this adjustment. I know. I tried. Then I changed the pot. C5 is essential to get the maximum current out of U1. It filters the 100KHz noise on the supply line that affects U3 operation.

Construction

I put all but the inductors and pot on half of a Radio Shack breadboard part # 276-170. The 5 pins of U1 can be spread apart to fit on the breadboard. Keep all component and connecting leads short. This includes the input supply, floating ground, and supply grounds. All major current should pass through heavy wire such as 16 gauge. Keep the connections of C2, C4, and R1 as close to U1 as possible. The connections for C6, C8 C9, R3, R7, R8, and R9 should be as close to U2 as possible. Otherwise, the part lay out is up to you.

Use a small heatsink on U1. A suitable heat sink (Digi-Key part number HS114) is less than 50 cents. With the heat sink, U1 runs only mildly warm with 1 Amp of charging current.

Things Not To Do

U1 is floating - DON'T GROUND THE TAB OF THE IC! Make sure that the heat sink isn't touching anything. R9 must be a 1.0% resistor or you won't get accurate charge rates. Try to use 1% resistors for R7 and R8 too. Don't change the values of R1, C2, R3, C6, L1/L2, or C7. These parts were all selected to match the resonant frequency of L1/L2 and C7. Changing them could result in circuit oscillations. C1 should not be less than 1 uF or greater than 2.2 uF. Don't use any resistance value less than 100K for R6 or you'll have trouble controlling U2. Don't let the input terminals touch while a battery is connected to the output terminals or the battery will rapidly discharge through the circuit.

Let's Put It To Use

At startup, the supply voltage to the circuit must be at least 3 volts greater than the battery you're charging. (The circuit simply shuts down if the voltage drops too low.) Once the circuit is running, it only needs to be 2 volts higher. The maximum input voltage is 35 volts; minimum is roughly 7 volts. That means those of you on 12 volts can charge 6 series cells at a time. Those like me on 24 volts can charge up to 12-13 series cells. As shown in Table 1, the charger is more efficient with more cells in series and at medium charging currents. I've measured the best efficiencies around 700mA, with the charge voltage across the cells roughly half the supply voltage. That means this charger is well suited to fast charge large NiCds. It can also easily charge one cell at a time. With a 10mA minimum charging current, it will work on smaller cells too. If a solar panel is used as a power source, remember that the maximum charging current will be limited by the panel and the amount of light it receives.

To use the charger, set R4 to a minimum. Next, connect the battery to be charged. Attach a voltmeter capable of measuring up to 100-125 mV across R9. Connect the charger inputs to your DC supply. Adjust R4 until you get the desired charge current. REMEMBER! THE READING IS ACROSS 0.1 OHM. YOU MUST MULTIPLY THE READING BY 10 TO GET THE CHARGE CURRENT. Since this circuit uses an inductor with a switching regulator, you may hear a slight whine at times. This is normal.

Changes You Can Make

The maximum charge current can be increased by using an LT1171 instead of the LT1172. The LT1171 is rated for 3 Amps output current, so you can fast charge the biggest C cells with it. You'll need to change R6 to 39K and C3 to 1000 uF. You'll also need to change R9 to a 2 watt resistor.

An LM358 can be used for U2, but its maximum input voltage is 32 V. U3 and R5 could be replaced with a zener/resistor combination. Either of the last two changes will lower the circuit efficiency by 1-5 percent.

If you don't mind using a small screwdriver to adjust the current, you could put a 15 turn trimpot in place of R4. This will save you big bucks, but you'll have to figure out how to mount the pot to make it accessible.

Capacitors C3 and C7 are HFS series from Digi-Key.

TABLE 2: PARTS LIST AND PRICES

Parts obtained from Hosfelt:

Part	Description	Hosfelt Part No.	Price
C1	1uF tantalum capacitor	15-216	$0.18
L1, L2	0.4 milliHenry choke	18-118	$0.75
R4	50K ohm 10 turn 2 watt pot	38-174	$8.99

Parts obtained from Digi-Key:

Part	Description	Digi-Key Part No.	Pkg. Price	Qty	Option Price
C2, C6	0.1uF ceramic disc capacitor	P4164	$1.60	10	
C3, C7	220uF "HFS" capacitor	P1246	$0.74	10	
C4, C5, C9	.01uF ceramic disc capacitor	P4161	$1.34	10	
C8	470pF ceramic disc capacitor	P4181	$0.69	10	
D1	1N5819 (option SR104) diode		$0.56		$0.47
D2	1N5822 (option SR304) diode		$1.09		$0.90
D3, D4	1N914 (option 1N4148) diode		$0.61	10	$0.77
HS	Heatsink	HS114	$0.31		
Q1	2N3904 NPN transistor		$0.29		
R1	470 ohm 1/4 watt 5% resistor	470Q	$0.26	5	
R2	1K ohm 1/4 watt 5% resistor	1.0KQ	$0.26	5	
R3	5.6K ohm 1/4 watt 5% resistor	5.6KQ	$0.26	5	
R5	560 ohm 1/4 watt 5% resistor	560Q	$0.26	5	
R6	100K ohm 1/4 watt 5% resistor	100KQ	$0.26	5	
R7, R8	2.21K ohm 1/4 watt 1% resistor	2.21KX	$0.52	5	
R9	0.1ohm 1 watt 1% resistor	SC1A0.1	$1.99		
U1	LT1172CT		$5.06		
U2	LT1013(Option LM 358)		$3.83		$0.84
U3	LM334z		$1.80		

Table 2 Notes:

a. All electrolytic and tantalum capacitors are rated for 35 volts. Disc capacitors should be rated for 50 volts minimum.

b. R4 is listed at 2 watts but the circuit doesn't use even 1/10 watt.

c. "Option price" reflects the cost of the optional item shown.

Access

Author: Andrew Bean, 5867 W. Countryside Drive, New Palestine, IN 46163 • 317-861-5999

Digi-Key, 701 Brooks Ave. South, P.O. Box 677, Thief River Falls, MN 56701-0677 * 1-800-344-4539

Hosfelt Electronics, Inc., 2700 Sunset Boulevard, Steubenville, OH 43952-1158• 1-800-524-6464

Linear Technology Corp., Literature Department, 1630 McCarthy Blvd., Milpitas, CA 95035-7487 • 1-800-637-5545 (The application notes are usually free for the asking.)

These capacitors are designed with lower internal resistance for switching power supply applications. Other capacitors with the same capacitance and voltage rating will work, but the circuit efficiency may decrease slightly.

What'll It Cost?

Depends on how much stuff you already have. The prices listed in Table 2 are for your benefit. Mine cost about $45 with a nice case, binding posts, battery clips, etc. By making the changes noted earlier, and/or by using parts you already have, you could shave $5-15 or more off what I paid.

Independent Power Providers

Don Loweburg & Bob-O Schultze

Who Are We?

IPP members can be broken down into two main groups: 1) Dealers, manufacturers, and installers. These members provide direct access to renewable energy technology and information benefiting residential and commercial end-users. 2) Renewable energy end-users and RE advocates. These are members committed to supporting a decentralized and diverse infrastructure of energy providers. They prefer direct customer access to energy resources. This second group, especially RE system owners, have as much at stake with utility involvement in RE as those of us "in the biz". The utilities, through their vast resources and buying power can have a huge impact on the price or supply of RE products. When that happens the independent providers, whether they supply energy only for themselves or for others, could easily find themselves on the short end of the supply stick. This could well mean a RISE in the price of renewable energy products, especially PV modules.

Our position with regard to utilities and renewables can be summarized as follows: Renewables, being inherently decentralized, offer the possibility of turning the electric power grid inside out. This process of decentralization has happened in the information and communications industries already. Restructuring in California marks the formal beginning of this process in the electric power industry. Informally, the process started years ago with the development of the off-grid, cogeneration, and wind power markets. The future of renewable energy must be guided by those with the vision to see what "can be" rather than by the vested interests of centralized electric power monopolies. Unchecked, they will attempt to shape this future to fit their model of centralized control and ownership.

IPP actively promotes and supports:

- End-user ownership of renewable energy technology, including renewables owned by co-ops and municipal utilities
- Net billing for grid-connected residential producers and co-ops
- Licensing and standards of expertise for members that install professionally
- Technical performance standards for renewable energy systems
- Conformance to building codes
- Developing financing opportunities for owners of renewable energy systems

You are invited to join us in creating the future. We are now a non-profit corporation. Your tax deductible donation is greatly needed and appreciated. Join up as an active member. See the "Access" information at the end of this article for contact information.

Singing Our Song

Worldwatch Institute is releasing a new book titled, "Power Surge". Power Surge predicts a turbulent next decade. Large energy companies will struggle to preserve the status quo while newer firms and their environmental allies fight to change government policy and open up energy markets to greater competition. Some giant oil, auto, and utility companies may find themselves in the current position of IBM — squeezed out of markets they have dominated for decades by fast moving entrepreneurs. Sound familiar? This Worldwatch book costs only $10.95. You can order one by calling (202) 452-1999.

The September 1994 issue of Scientific American has a very interesting short article on page 96. It's titled "Turning Green: Shell International projects a renewable future". The Shell study runs counter to many other fossil-energy groups' analysis. These analyses often minimize the future role of renewables. The Shell study sees a significant role for renewables driven by demand in developing nations coupled with increases in energy efficiency.

SCE's Off-grid Program

Edison has put out to bid its first off-grid systems. As mentioned previously, the jobs are sized by Edison and contractors are asked to provide a system to produce the specified KWH/day. As we had predicted, there is absolutely no attempt by Edison to encourage conservation on the part of the customer. On the load sheet Edison provided were large, extraneous electrical loads and all incandescent lighting. These systems will cost more (Edison's revenue is based on system cost), and show PV in a bad cost/benefit light. While competition will keep installers' margins low, contractors are burdened with million dollar insurance requirements and stringent warranty requirements in excess of manufacturer's commitment. Edison, manufacturers and distributors will do well financially. The customers pay far more than needed and contractors will bear undue burden with a low profit margin. What a deal!

Some months ago, we reported that Edison was commissioning a survey of the off-grid market and PV industry. This was done as a PUC prerequisite to offering wireless power. The report, done by NEOS Corporation of Lakewood, CO, is complete and seriously flawed. According to their report brief, only 44% of those in the industry responded to the survey. This is hardly conclusive. Of the remote residential surveys mailed, only 24% (550) were returned. Of those, apparently only 166 were used to compile the data in the report. What happened to the other 334 respondents? Bad attitude? Bad breath? Most interesting were the questions asked and their context. People determined to be living off-grid were asked if they would be interested in off-grid electric power service from Edison if available. Eighty two percent of respondents said "yes". When asked to value the PV service at several different monthly rates they would be willing to pay, only 40% of respondents living off-grid without PV said they would be willing to pay as much as $150 per month for a 1KW system. The survey concludes, "a majority of off-grid customers are interested in Edison providing PV services!" This is very misleading.

Look at the question concerning system cost. We do not believe it will be possible for Edison to offer a 1KW system for $150 per month. Perhaps a 1KW array but certainly not a complete power system with generator backup. Not mentioned in the survey is the fuel for the backup generator which comes out of the customers' pockets and realistically needs to be added to the monthly power cost. Had the question placed the monthly cost of the system at a more realistic cost of $300 a month, we suggest they would have found a much different response. The implication that a PV system is available at such a low cost distorts any conclusions made from this survey. Samuel Clemens once said, "There are three kinds of lies. Lies, Damned Lies, and Statistics." You make the call. It's all in the questions asked. Read the results of HP's Renewable Energy Survey in HP#43. Different questions — different answers.

Utility On-grid Programs

Activity quickens as the UPVG (Utility PhotoVoltaic Group) request for proposals (RFP) date nears. (Be sure to read the IPP report on the UPVG and "Project Team Up" in HP #43.) Successful projects will receive Federal (DOE) cost-share funding of up to $4/watt. The program applies to on-grid systems only. Plain and simple, this is a taxpayer subsidy to the utilities.

The PV system ownership issue remains unresolved. The California PUC's Division of Ratepayer Advocates (DRA) has recently come out strongly against utility ownership of photovoltaics on customer sites. An example of this is the SMUD model where the rooftop mounted PVs are owned by the utility. The power is fed to the grid on the utility-side of the meter and the homeowners are charged a premium for the privilege of participating in the program. The UPVG calls this "PV Friendly Pricing". Friendly to whom? Under "PV Friendly Pricing," customers receive no reduced consumption savings or other direct benefits from PVs.

In a letter to the California Energy Commission, the DRA writes, "As you know, ratepayer advocates have had fundamental concerns about proposed programs to permit utilities to own rooftop photovoltaics (PV) as utility generation. After pausing to reflect on our concerns, (we) continue to believe that the competitive potential of photovoltaics is best realized by commercializing customer-sited photovoltaics as a competitive alternative to utility generation. Utility ownership of photovoltaics on customer sites such as rooftops would inherently conflict with this vision.

This is because as the entity in control of the bottleneck resource (i.e., the utility grid), the utility has the ability to thwart competition by providing preferential treatment to its own generation resources. This is as true for distributive generation such as photovoltaics, as it is for central generation. Photovoltaics is a modular and mass-produced form of self-generation, analogous to cogeneration in its potential to increase competition in the electric supply market. Utility ownership of photovoltaic generation on customer premises, like utility ownership of cogeneration, is inimical to competition between utility generation, and independent or self-generation. For this reason, we remain opposed to utility-owned photovoltaic generation on customer rooftops that are currently proposed for Project TEAM-UP and beyond. This includes proposals such as 'PV Friendly Pricing', which involve utility-owned rooftop photovoltaics connected on the utility side of the meter."

IPP completely agrees with the DRA position. We think that the user (taxpayer) should own the system. The DRA position is a bombshell dropped on the utilities PV schemes. It will have far reaching implications for the rest of the country as well. We will be attending a meeting of the California Collaborative of the PV4U group on November 30th in San Francisco to deal with this issue. IPP is trying to work creatively with all stakeholders to forge an equitable commercialization plan. We all need one that recognizes a significant grid-connected, non-utility market where end-users, not the utilities, own their share of the sun and are paid a fair price for the renewable energy they provide.

And the Winner is...

At SEER'94, IPP started a raffle to raise sorely needed funds. The prize was something so unique that it could not be purchased for any amount of money–a LIFETIME subscription to Home Power Magazine. The winner was Judy Van Rooyen of Stockton, CA. Congratulations Judy and thanks to HP for the generous gift. Many thanks also to all of you who participated and donated. IPP workers are unpaid volunteers who often incur pretty substantial out of pocket expenses attending meetings and gathering information on the utilities' latest schemes. Without your support, the job can't be done. Whoever said the price of freedom is eternal vigilance knew his stuff.

Access

Authors: Don Loweburg, PO Box 231, North Fork, CA 93643 • Email via: ofln@aol.com

Bob-O Schultze, POB 203, Hornbrook, CA 96044 • Internet email: econnect@snowcrest.net

To Join IPP: By E-mail: i2p@aol.com, or by phone: (209) 841-7001 or (916)-475-3402

Write and send tax-deductible donations to: IPP, PO Box 231, North Fork, CA 93643

Electricity for Dummies, Part 1

Dan Lepinski

We use it but we can't see it. We store it but we can't touch it. It's an integral part of life. For most of us, electricity is one of the least understood forms of energy. Tired of being in the dark? Want to know more?

Loosen your seat belts, folks. We're about to take a slow, calm journey into the electric world of Dr. Demento. What!? You're not familiar with electricity? You're not a rocket scientist either? Not to worry. This is one time where you don't have to be. No techno-jargon here. Just plain everyday words. With each visit, we'll discover something new about this strange thing called electricity. All you need is imagination... and a desire to learn.

Introductions and Analogies

Hi! The gang at Home Power Central calls me Dr. Demento. Why? Probably because I learned about electricity the hard way. My electrical career began as a youngster. Perhaps out of curiosity, I inserted a stray hairpin into an outlet. Sparks flew. Surprised but undaunted, I wanted to learn more about this strange creature that lived in the wall. I didn't understand it at first. The big words were confusing. In self-defense, I developed "mind pictures" to help relate the bewildering aspects of electricity to everyday life. Most people call these mind pictures "analogies". Not sure about analogies? They're easy! You'll like them. I use them frequently.

Electricity

What is it? A magic potion inside batteries? Some weird substance hiding in wires? Neither. And both. Electricity is simply a type of energy. Like light. Or heat. Electricity comes in three basic flavors; 1) the kind that just sits there ("static" electricity); 2) the kind that moves only in one direction ("Direct Current" or "DC"); and 3) the kind that moves back and forth ("Alternating Current" or "AC"). Eventually, we'll spend most of our time on the back and forth or "AC" variety. To do that, we'll have to discuss the other two flavors first.

Static Electricity

"Static" electricity? As used here, "static" means "not moving". Under the right circumstances, it has the ability to perform work. For now, it isn't. Time for our first analogy... Let's start with a balloon. Pretend you've inflated it but haven't tied the end. As long as you hold the end closed, the balloon doesn't move. The air inside is like static electricity. It has the ability to do something. It's just that it hasn't - yet. Now release the balloon. FRRAAZZBBBB! The balloon zips away. The stored air escapes rapidly as it moves the balloon. The stored air is performing work. The balloon continues to move as long as there is pressure inside. When the pressure is gone, the balloon stops. Static electricity is like the air in the balloon. It's stored energy, waiting to be unleashed.

But balloons aren't perfect. They leak. In time, all balloons deflate. Why? Tiny holes in the balloon material let the gas escape very slowly. Static electricity also "escapes". For instance, walk across a carpet and immediately touch a metal object. A spark will jump between your finger and the object. Walk across the carpet again but wait a while before touching anything. When you finally do touch the object, nothing happens. No spark The electricity you accumulated gradually dissipated, just like the air that escaped very slowly from the balloon. Where did it go? Out into the air, just like the gas from the balloon.

Wind and Water

To be useful, electricity must be moving. Why? Simple! Consider air. Calm air doesn't do any work. It just sits there. Conversely, a strong breeze can pump water, move sailboats or make kites fly. Unfortunately, we can't control the wind. But we can control water. Best of all, water works well as an analogy to electricity. For example, water in a pond is "static". It doesn't move. It might be good for fishing or swimming, but not for performing work. Static electricity doesn't do any work either. We must first find a way to make it move.

Water flowing in a stream or river is capable of doing work. Years ago, water turned water wheels at grain mills. The water wheels were connected to large stones that ground wheat into flour and corn into corn meal. The water was doing something useful. As the water flowed downstream, it was used for many labor-saving applications.

Large rivers can turn immense water wheels. Small streams can't. Why? The difference in current flow. Current flow is measured in gallons per minute, cubic feet per minute, or something similar. No matter what the measurement unit, current is the amount of water flowing in the river or stream.

Now wait a minute! Water won't move on its own. Something has to make it move. Something like gravity.

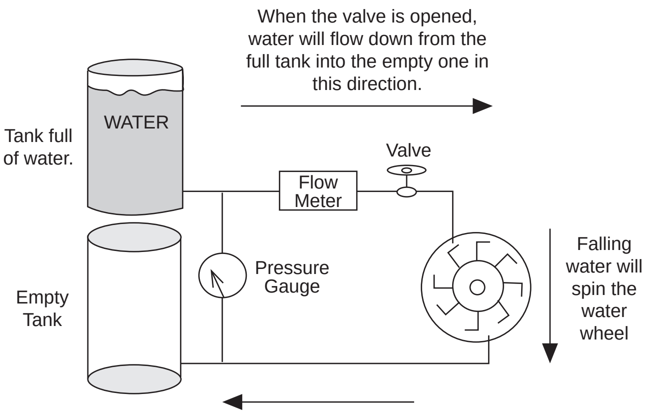
Or water pumps. Or wind. Water has to be pushed or pulled. Otherwise, it just sits there. Look at a stream or river. What makes the water move? Gravity! Water flows from a higher point to a lower point. There's a difference in potential energy between the two locations. Water moves from a location of higher pressure to a location of lower pressure. If the water were in pipes, we might measure this pressure in pounds per square foot ("PSF") or kilos per square meter ("KSM"). A simple gauge is all that's needed to measure the pressure difference between the water inside the pipe and the air pressure outside it.

Water Tanks

What does all this have to do with electricity? Plenty! Electricity is just like water. It must be moving to be useful. It flows from an area of higher pressure to an area of lower pressure. We measure the pressure and current flow with gauges and meters. See the similarities?

Look at Figure 1. It's a "water circuit". In the "circuit", water flows from the full tank into the empty one below when the valve is opened. The flow continues as long as there's water in the upper tank and the valve is open.

Figure 1.



The Electric Connection

Snug up your seat belts a bit. We're about to see how electricity fits into the picture.

We discussed flowing water. In streams and rivers, it's called a current. Funny thing about electricity. Its flow is also called current. Instead of gallons or liters, we measure electrical flow in units called AMPERES, or "AMPS" for short. Just as gallons per minute measures current flowing in a stream, AMPERES measure the amount of electricity flowing in a circuit.

Look at Figure 1 again. See the "Flow Meter"? This is a water meter. It measures the amount of water flowing in the pipe. However, it doesn't display the rate of flow at any given instant — only the total amount. Its analogy time again! Ready? Think of a motor vehicle. It has a gauge called a "speedometer". It doesn't show how far you've gone — just how fast you're getting there. A speedometer shows the amount of Earth moving under your vehicle at any instant. The AMOUNT (or rate of flow) of electricity moving in a circuit is measured in AMPERES. An AMPERE METER (also called AMP METER or AMMETER) measures the AMOUNT of electricity moving through a circuit at any instant. An AMMETER is connected directly in line with a circuit, the same as the Flow Meter.

See the "Pressure Gage"? It measures the difference in water pressure between the two tanks. The higher the water level in the top tank, the greater the water pressure. Just as pressure moves the water through the pipes, a special type of pressure also moves electricity through wires. It's called electrical pressure. The unit of electrical PRESSURE is the VOLT. Electrical pressure is measured with a VOLTMETER. Sometimes you'll see a voltmeter called a "DVM". This is an abbreviation for "Digital Volt Meter". A DVM displays the values directly as numbers. A DVM is easier to read and is much more accurate than old style voltmeters with a moving needle.

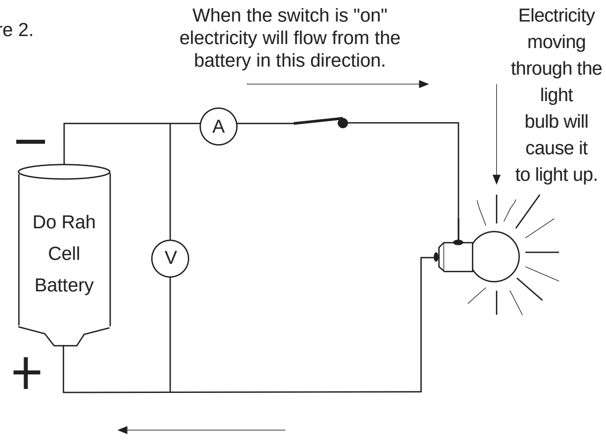
Doing OK so far? Only three more items to consider. See the "Valve"? When closed, it blocks all water flow. When open, the water flows freely. There's no in-between. It's either completely open or completely closed. This valve is working like a "switch". A switch connects one part of a circuit to another. It's just like touching two wires together, only safer.

Now locate the "Water Wheel". Years ago, the water wheel would have been connected to gears, flat circular stones, or other "machinery" (there are even some still in use today!). That machinery may have ground grain into flour, pumped water uphill or shaped metal into tools, to name a few. In our circuit, the water wheel represents a motor, lights, a radio, or any other electrical device. This is where the electrical energy is converted into another form of energy such as motion, light, or sound.

Finally, look at the water tanks. Any guess what they represent? What device stores electricity and releases it when connected into a circuit? The water tanks are a battery!

In the water circuit, components exist that represent a battery, voltmeter, ammeter, switch, wires, and an electrical load. We simply used easy-to-visualize parts that are close mechanical equivalents.

Figure 2.



Look at the drawing of a simple electrical circuit in Figure 2. Its component layout exactly matches that of the "water" circuit in Figure 1. Compare the two drawings. See how the water circuit compares with its electrical counterpart.

Scissors and Doors

Figure 1 shows water flowing downhill, always in one direction. This is Direct Current or DC. Batteries produce DC. So do solar panels. While DC is very useful, it isn't always the best tool for the job. What!? Something is better than DC? Sometimes. Try to imagine using scissors without alternately opening and closing them. They wouldn't work. Think about the front door on your home. What if it couldn't move back and forth? What if you had to use a door that moved in only one direction? You'd have to use a revolving door. The best tool for the job? Nope. Impractical, but it would work. There are times when a steady flow of electricity is second best too.

Where do we find water moving back and forth? How about the beach? Ocean waves constantly move onto shore and back out again. So how do we use wave energy? Just place a water wheel where the waves will flow under it. When a wave moves up the beach, the water wheel will spin in one direction. When the wave retreats, the water wheel will spin in the opposite direction. Just connect the water wheel to a grindstone, add some wheat and...presto! Flour! The results are no different than using a stream or river! Electricity too can be made to move back and forth, just like the waves. When electricity changes direction, alternately moving one direction, then the other, it's called ALTERNATING CURRENT, or AC. Why do we use AC? See Part 2 — next issue of *Home Power*!

Access

Author: Dan Lepinski (aka "Dr. Demento"), Route 1 Box 268A, Exeland, WI 54835 • 715-943-2525 Voice. Email via the Home Power BBS 707-822-8640 or via Internet: dan.lepinski@homepower.org

The Good, The Bad, and The Ugly

John Wiles

In the last two months I have been involved in two aspects of PV power systems that have created conflicting emotions. First, I had an opportunity to visit and inspect a number of PV systems that have been installed within the last year in the Southwest. After seeing these systems, I was ashamed to be a part of the PV Industry. More on those systems later. Second, I attended a facilitated discussion with other members of the PV industry. The results from this conference will evolve into a PV system procurement manual for municipalities and counties. The members of the PV industry that participated in this all-day discussion and the results left me with very warm feelings about the future of PV.

Inspection of Southwest PV Sites

First the bad news. A large southwest utility had purchased the systems at the sites I visited via competitively bid contracts. In some cases the specifications were tight, in others quite loose. The largest installation, a 100 KW utility-interactive system was sold, designed, and installed by a small company specializing in large-scale PV systems. Another small PV systems house sold and designed other grid-connected systems. Local electricians did those installations, using kits supplied by the design firm.

A company that sells PV-powered hydro pumps had sold, designed, and installed a water pumping system to run sprinklers for an athletic field. I also inspected a lighting system designed by a major PV distributor and sold and installed by a regional PV dealer. Another regional PV dealer had designed and installed PV lighting.

These systems were not as good or as safe as they could have been. Some of the systems had failed after only a year.

Grid Connected 100 KW System

For the most part, this system was a delight to inspect and test. The installers has used high-quality components and workmanship. Although the inverter was experiencing some operational problems, the manufacturer quickly identified and remedied them. Only in one area did I see a need for additional safety features. The main number 4 AWG conductors from the row-combining boxes to the inverter were not protected from faults. I recommended that fuses be added at the inverter to protect these cables.

Grid Connected 2.5 KW System

The installation used 16 AWG conductors to connect the modules to the inverter. The cables were held in a tray and were rated for 8 amps (NEC Section 340-7 and Table 402-5). The 15 amp fuses at the DC disconnect did not provide overcurrent protection for this cable.

The modules had a rated short-circuit current of about 7 amps, but short currents could be higher on clear days near solar noon. When the inverter was off-line or detected a ground fault, it automatically shorted the array, subjecting the cables to overheating. An 8-10 amp fuse should be installed in the string junction box to protect these cables. An 8 amp fuse meets the NEC cable ampacity requirements, but the high operating currents exceeds this.

The use of 2000 volt cable used in this system was an excellent choice since the operating voltage is near or over 600 volts. I noted some cable damage caused by sharp conduit edges.

Cable under-sizing was also a problem. The 10 AWG ac output cable only handled 30 amps; however the inverter output circuit was rated for 34 amps (4KW). The inverters internal 50-amp fuse did nothing to protect the undersized cable. Although the inverter can't deliver more than 34 amps of current when connected to the 2.5 KW array, the output cable should be 8 AWG, rated for at least 42.5 amps.

Disconnect switches were mounted high on a wall, out of reach.

Suggestions:

1. Change and fuse module conductors to handle the larger 12–13 amp current seen at peak power operation.
2. Replace the present unfused ac disconnect with a fused ac disconnect. Identify the circuit breaker in the building's ac load center for back-feeding. Secure it to the load center enclosure with additional mechanical fasteners.
3. Protect all metal conduit and fittings with insulating

bushings to prevent cable damage on sharp metal edges. Replace the Bussmann NOS DC input fuses (which have only a factory DC rating) with Littlefuse IDSR fuses which are UL-Listed for use at 600 Volts DC.

4. Mount disconnect switches so that the handles are no higher than 6.5 feet above the floor.

Grid Connected 2 KW System
The comments on the preceding installation apply to this one, even though the inverter had been removed when inspected.

The ambient-air temperature sensor was mislocated. It should have been mounted outside, exposed to the same air temperature as the modules.

PV Powered Sprinkler System
This system pumped water up from a well to supply sprinklers on an athletic field. The site was a hazardous nightmare. To start off, I could find no equipment or system ground, ground rod, or surge protection!

The system had other major mechanical and electrical safety problems caused by poor workmanship. The well pump motor shaft was left exposed. The enclosure containing the sprinkler pumps and controls was crowded and lacked enough space to work safety.

I found electrical junction boxes mounted at or slightly above ground level. They were already corroding. The installers had put a load center designed for indoor use in an exposed outdoor location. An open right-angle pull box held cable splices.

They had used hugely oversized 100 amp fuses to protect very small conductors. Wires and cables lacked any labels indicating wire size or routing. Battery cables were not protected from fault currents. Circuit breakers were used as disconnects with no fault current protection. Charge controllers were mounted in outdoor locations where dirt and moisture would cause the mechanical relays to fail prematurely.

Battery water levels had fallen below the tops of the plates, indicating possible battery damage. The charge controllers were cycling and the battery voltage was 28.2. The batteries were not insulated and their performance suffered in cold weather. The system failed to include compensation during charge. The builders installed multiple battery charge controllers instead of a single large one. Battery terminals were not sealed and had already begun to corrode.

Every aspect of the system was sloppy. The designer had ignored row-to-row module shading at low sun angles during the winter. This caused unnecessary and annoying reductions in power output.

Major inefficiencies marred system performance. Multiple small pumps were operating in parallel when a single large DC motor connected to a single sprinkler pump would have wasted less energy. Use of battery storage severely affected water pumping efficiency. Possibly 50% or more of the PV energy was being lost in battery charging/discharging! To avoid these losses, PV systems for water pumping usually omit batteries and feed energy directly to the load. The sprinklers did not appear to be designed for athletic field use. They didn't have provisions for contact from above and were eroding nearby soil. The low-quality externally mounted sprinkler timer mechanism was already rusting.

Suggestions:
Safety
1. First and foremost, GROUND THE SYSTEM! Don't even think of operating it before this is done.
2. Have a qualified electrician rewire the system using the proper cables, overcurrent devices, disconnects and enclosures.
3. Add surge protection on the PV and motor conductors.

Function
1. Redesign the entire system. Increase the north-south spacing between rows of modules to reduce winter shading.
2. Eliminate the batteries except for a small one to power any timers or control devices. Operate the pumps in the daytime only, connect the PV array directly to the well pump to fill the tank. Reconnect the PV array directly to a large sprinkler pump with zone valves to water the field.
3. Use a linear current booster to get better early morning and late afternoon performance.
4. Use full-tank and empty-tank switches to control the charge between well pump and sprinkler pump operation.
5. Use a simple timer to control and operate the zone valves. This may require a small battery system and an inverter. Timer operation may not be accurate with devices that sync off the 60 Hz powerline frequency. Radio Shack has 120 volt ac timers that generate their own reference frequency and are accurate even if the inverter's frequency output varies.
6. Use a day-of-the-week timer or manual override switch to avoid watering the grass on game days.

Lighting System
This installation had only one module powering an 18-watt lamp and probably couldn't procure much light on cold, short winter days. It also had functional and safety problems.

Safety was badly neglected. The system was not grounded and had no surge protection devices. It lacked any disconnect for the PV or the batteries. No properly rated overcurrent devices were installed to protect array or battery wiring. Exposed battery terminals represented a safety hazard for service personnel and had no anti-corrosion protection.

The batteries were located in the same compartment as electrical devices; a major mistake. Even with catalytic recombiner caps, batteries produce corrosive gases and hydrogen gas. Even sealed batteries may vent explosive gas under some conditions. Enclosures should be partitioned with hermetic seals and be well vented. Batteries should be mounted above electrical components to allow hydrogen gas to escape upward and be mounted in acid-proof containers to avoid corroding metal surfaces.

The rest wasn't much better. Battery water was low, but still above the plates. There was insufficient space to properly water the batteries or service the system. Batteries were not insulated against cold weather and the charge controller lacked any temperature compensation or regulation. The timing device appeared overly complicated and inappropriate for this environment. It had already failed.

Suggestions
Modify the system, in order of priority, as follows:

1. Ground the pole, all equipment cases, and the negative conductor of the system (if allowed by the lighting fixture design). Add surge arrestors on cables to PV modules and lamp.
2. Add pull-out fuse holder/disconnects with appropriately rated DC fuses for PV and battery conductors.
3. Seal off the battery compartment and vent it outside.
4. Spray battery terminals with Permatex battery-terminal fluid after installation. Cover exposed battery terminals.
5. Replace the separate charge and lighting controllers with a combined PV lighting/charge controller.

Flashing Lights - Pedestrian Crossing
This system had a sufficient number of modules and sealed batteries to perform well. Safety-wise it had major deficits, including no apparent system ground. One of the brackets holding the flashing light was cracked open.

All of my preceding comments about battery safety apply here, with one important addition. The system is located near the roadway where passing vehicles could strike the battery enclosure. If one did, the battery terminals could contact the metal enclosure—with possibly explosive results.

Suggestions:
1. Ground the pole, the equipment and the negative conductor unless there are equipment restrictions to the contrary. Add surge suppression to the PV and lighting circuits.
2. Add the fused disconnect previously described.
3. Fully insulate and protect the battery terminals and surrounding metal surfaces.
4. Consider enclosing the base of the lights with protective barricades.
5. Insulate the battery compartment.
6. Repair or replace the broken bracket.

Specifications and Bids
The results of my inspection were disheartening. The PV industry can do and has done better. I have seen systems that are well designed, safe, and performed as specified without unexpected failures. To some extent the problem lies with the purchaser, who writes loose specifications and then goes looking for the lowest bidder. As in all other endeavors, you get what you pay for. Low bid, loosely-specified PV systems usually turn out to be unsafe and give less than optimum performance.

When purchasers get tired of poorly performing PV systems, they will start tightening contract performance specifications and demanding warranties. In future contracts, PV purchasers will examine a company's past performance and history of customer satisfaction.

To help prospective PV purchasers and encourage higher standards in the PV industry, I have begun developing a PV procurement manual. Parts of this are outlined below. It is intended for municipalities, utilities, and other agencies. The PV industry must look at these requirements and use them to design, bid, and install better systems.

Photovoltaic Power Systems: Specifying and Verifying Performance
Photovoltaic (PV) Power Systems are a relatively new technology. Few systems are available off-the-shelf for any particular application or level of power output. PVs initial cost is often higher than the cost of other non-renewable power systems. Reliability has been a problem; prospective PV buyers cannot always assume long-term, maintenance-free performance. Cost and reliability issues create a dilemma for those who want PV.

Although it is not legally mandated in every jurisdiction, the National Electrical Code (NEC) contains a comprehensive set of requirements and good engineering practices that can ensure a safe and durable PV installation. The NEC should be called out as a basic requirement in any system.

The following spectrum of procurement styles and performance assessments cover the range of PV purchases.

Minimum Technical Expertise
1. Procure a Turn Key installed system with performance specifications.
2. Write performance guarantees and warrantees into the contract. A maintenance contract will usually be required. Penalties are required for delays in delivery and poor performance.
3. Performance is assessed by easily observable or measurable output quantities. The quantities may be directly observed or read from standard meters. For instance: A PV-powered light must produce usable illumination from dusk to dawn, 365 days per year for five years. A specified amount and quality of AC energy in kilowatt hours is to be produced each month for ten years.

The vendor is fully contractually responsible for the initial and long-term performance of the system.

Moderate Technical Expertise
1. Determine the required performance specifications.
2. Initiate bids for a system that meets those specifications.
3. Require the following milestones in the contract.
A. Review and acceptance of system sizing and performance design calculations.
B. Safety review of electrical and mechanical design.
C. Inspection of electrical and mechanical installation.
D. Performance testing of the installed system.
E. Require long term performance and maintenance warranties as needed.
F. Perform periodic testing if output not easily observable.

If not otherwise specifically contracted, initial and long term performance of the system is the responsibility of the owner.

Expansion of the milestone tasks in this section is presented in the Milestone Section that follows.

Substantial Technical Expertise
1. Design the system with in-house personnel, specify components, procure material, build system, and install system.
2. Set up a maintenance program, if required.
3. Test and evaluate installed system at time of installation and yearly thereafter. Install monitoring hardware if necessary (larger systems) and monitor system performance.

There are no system performance warranties. The individual components have factory warranties.

System Contract Milestones
Write contracts so that each of the following milestones are reviewed and approved by the purchaser before moving on to the next. The contract should require timely submission of data necessary to evaluate these milestones. State that the vendor must implement any required changes to the design, material, or installation before approval will be granted.

Make it clear that purchaser approval of any or all of these milestones does not relieve the vendor from meeting any system performance or warrantee contractual requirements.

System Sizing Review
The vendor must furnish all information and calculations used to size the array, inverter, and storage system (if any). They should also provide sources of data or actual data for solar insolation and weather used in these calculations. The vendor should give the efficiencies of components such as charge controllers, inverters, and other electronic devices.

System Safety Review
The vendor and purchaser will review the detailed electrical and mechanical design for safe engineering practices. This review shall be made early in the contract before any equipment is purchased.

The review should examine the electrical design for compliance with the requirements of the National Electrical Code (NEC) in the following areas:

1. Short-circuit currents in all conductors.
2. Conductor voltage and ampacity ratings.
3. Overcurrent device ratings and locations.
4. Disconnect ratings and locations.

The vendor will furnish full and complete electrical specifications for each component used. These include manufacturer's specification and ratings and any equations or tables (NEC) used in the electrical design. The vendor must also use UL-Listed (or equivalent) components where possible.

Qualified civil engineers will examine the mechanical design for compliance with applicable building codes. Emphasis will be placed on wind and snow loadings and other factors affecting the durability and safety of the exposed systems.

The planned battery storage installation should provide the necessary degree of safety for operating and maintenance personnel.

System Installation Inspection
After the system has been installed, inspect to determine if the equipment in the electrical and mechanical design is installed safely and durable.

Conduct the following tests:

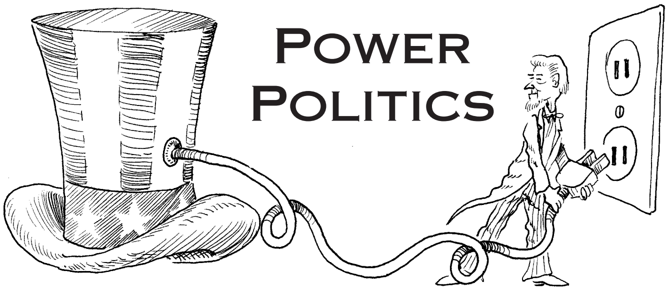
1. Perform dry and wet insulation tests on the conductors and PV array.
2. Verify the mechanical and electrical integrity of electrical connections.
3. Assess the mechanical operation of disconnects and overcurrent devices.
4. Verify the installation of a grounding system and equipment grounds.
5. Perform appropriate mechanical inspections as required.
6. Verify the performance of the module/array tracking system (if used).

System Performance Testing
Use the following electrical tests to determine the performance of the system immediately after installation. Perform only the measurements needed to verify contracted performance specifications.

1. Perform I-V Curve Tests on modules, strings, or array.
2. Rate the DC array output at standard test conditions (STC).
3. Measure the efficiency of the inverter.
4. Measure the storage system capacity.
5. Measure the power produced by the system under STC.
6. Measure the AC voltage, current and harmonic distortion produced.
7. Measure the frequency stability.

Continuing System Evaluation
If the output of the system is not readily observable, or the output decreases over time, it may be necessary to perform some or all of the tests listed under "System Performance Testing" on a periodic basis. The test results might be used to establish the need for system or component maintenance. They could also be used to identify trends in system performance that could be used to prevent system failures.

Access
Author: John C. Wiles, Southwest Technology Development Institute • New Mexico State University • Box 30,001/Dept. 3 SOLAR • Las Cruces, NM 88005 • 505-646-6105



Exciting New Way to Promote Decentralized Renewable Energy

Michael Welch

The Germans are doing it. We should be too! Many German cities now offer rate-based incentives to customers wanting to sell photovoltaic-generated electricity back to the utilities. These incentives are not for equipment purchase, but pay for excess power generated. Germans participating in these programs are earning a phenomenal $.50 to $1.20 per KWH for power they put on the grid! At those rates, a photovoltaic system would pay for itself in just a few years. See the full story on the German projects on page 20 of this issue.

An Opportunity For Positive Change

Question: What's the most exciting thing about rate-based incentives? Answer: We could be doing it here too! This column is a general "how-to". It's intended to encourage readers to work on getting rate-based incentives in their areas. It won't be easy, but the time is ripe. With utility deregulation visible on the horizon (see Power Politics in HP43), NOW is the best time to make sure new incentive programs for renewables are in place.

We want to encourage you to make this effort in your own community. Anyone undertaking these efforts can expect the full support of the Home Power Magazine staff. Do you have other major initiatives or changes you'd like to see happen in your community or state? The approaches suggested here can be applied to them too.

Making these changes won't be easy. They'll require a major commitment and much perseverance. The payoff can be great, sometimes surpassing the immediate goal. Often, persons or organizations spearheading such efforts can be compensated from funds available for PUC interventions. In the case of local programs, they can actually create a paid position for themselves.

If we sit back and let the politicians take care of it on their own, these programs may never happen. Worse, it may be done in a half-hearted manner, which can do more harm than good.

The Way Things Are

For many years, most strategies in the U.S. for increasing reliance on renewables have been limited. The only offerings were: 1) government funding for research and development and 2) funding and support for implementation of large-scale PV installations. Both of these strategies appear to be aimed at increasing the supply and decreasing the cost of modules.

The R&D strategy has helped reduce manufacturing prices significantly, but not enough. This has mostly benefited two groups; 1) those of us who are too far away from the grid; 2) those of us who, in the name of self-sufficiency or idealism, wanted to avoid the grid. So far, this strategy has failed to yield large scale investment in PV manufacturing facilities.

The funding and encouragement of a handful of large scale installations hasn't helped the effort much either. They've been fraught with technical problems that often accompany the "bigger is better" attitude. Huge orders for modules don't seem to be in the cards from this strategy for quite a while, if ever. In fact, the premature dismantling of one major system made a glut of used modules available, further hindering the market.

Keep in mind that many utilities don't want to see module prices come down. They fear folks might install them on their roofs in direct competition with their own fossil fuel and nuke plants. The utilities still haven't figured out a way to put meters between us and the sun. They appear to feel threatened by the possibility of large numbers of consumer-owned systems.

The Germans are now leading the way. They're showing us a fresh method of jump-starting new manufacturing facilities. These facilities are needed to keep the supply up so we can all afford rooftop PV systems.

What Does "Rate-Based" Mean?

Rate-based incentives mean a utility collects a certain percentage extra from all ratepayers. That money is then made available to provide a good payback for home-scale PV electricity fed back into the utility's grid.

In theory, such a stable funding source will encourage PV manufacturers to invest in greater numbers of more efficient manufacturing facilities. It will also provide a myriad of mini-demonstration projects. These projects will show other individuals that they can do the same thing. This should further increase the attractiveness of new manufacturing facilities.

What Kind of Utility is in Your Area?

This new strategy is ripe to be tried in the U.S., especially in areas that have community-based utilities. Unfortunately, most utilities operate in regions beyond the local community and are monopolies regulated by their state's Public Utility Commission. There are only two ways for such a utility to implement a rate-based incentive program. One is to gain the permission of the PUC to implement such a program. The other is to be ordered by the PUC to do so. In most states, the PUCs are appointed commissions. Subsequently, politically influential utilities have a lot of control over their own regulators. Obtaining rate-based incentives in these cases may be very difficult. It might involve long drawn-out legal proceedings and high-priced attorneys.

Often the best strategies for implementing new ideas for public utilities involve going directly to the state legislatures, bypassing the PUCs. PUCs make regulations, but they must be within the law. If laws are passed that require renewable energy incentives, then the PUCs are legally required to implement them.

However, many of these same public utilities are required by law to collect utility taxes on behalf of local governments — if the locals order it. This may be the answer for getting rate-based incentives installed in your community. Local or city governments that see declining state and federal revenues commonly pass utility taxes to help make up the loss.

In my opinion, there are more appropriate ways of spending utility taxes than on a community's general fund. Rate-based incentives for renewables should be high on the list, along with energy conservation, efficiency expenditures and incentives.

Still other utilities are municipal in nature. These utilities are not fully regulated by the PUCs. They can be approached with proposals directly through their quasi-governmental boards, community governments and/or local ballot measures (initiatives). This type of utility may provide the easiest road to the needed incentives. They are often very forward thinking since they answer almost directly to the customers they serve.

How To

In any of these scenarios, here's what needs to be done. First, develop a proposal. Use information from the article on the German programs. Next, have the proposal evaluated by as many experts as you can. They will help you develop the real inner workings of such a proposal. You'll need to talk with experts in renewable energy, utility regulation, local weather and other related fields. Remember — the more input you get, the more widely accepted your proposal will be. More input also makes a more workable proposal.

As you approach the point of finalizing your proposal, start lining up political allies that will help get it passed. If you don't know who they are, then it's time to find out. Begin with those most likely to be proponents and work from there. Increased support means increased chances of success.

Now it's time to take the proposal to your local government. If you can't get satisfaction there, then decide whether to go to the next higher level. For example, if the city council won't pass the law, you may want to try your county board of supervisors. From there, consider the state legislature. You also have another option. Let's say you approached the city and were turned down. If you feel you can get widespread community support, then go directly to the community. Get enough voters' signatures on an initiative to put it to the vote. This final strategy is available in most cities, counties, and states, but unfortunately not with the federal government. Isn't democracy wonderful?

The point is to keep plugging away at it until you make it happen. It's helpful to have a strong, driving individual pushing the program. It's also very effective to have a reputable organization of helpers to do much of the legwork. I highly recommend using or forming local, grass-roots groups to help.

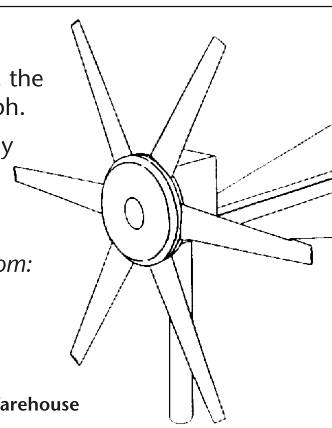
A Word of Caution

Many of us remember the 70's and 80's. Back then, there were strong incentives promoting the installation of solar domestic hot water systems. The immature renewable energy industry lacked reliable equipment. Hundreds of unqualified system installers jumped in to make a fast buck on the programs. Many customers were cheated. Since then, the industry has made great strides. DHW systems are extremely successful, but solar got a horrible reputation that's been hard to overcome.

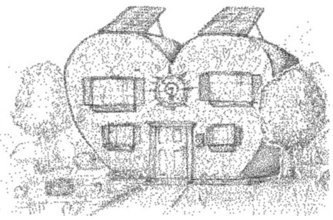
It appears the photovoltaic installation industry is maturing nicely. Solid and dependable systems are readily available. However, if any significant incentives are put in place for home-sized photovoltaics, we must be cautious. Education and maintenance training programs should be a part of every proposal. Rate-based incentives could be an answer to a decentralized, renewable future. We need to make sure that it does not set our efforts back a another decade.

Access

Author: Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95521 • (707) 822-7884 voice, (707) 822-8640 computer BBS. Internet: michael.welch@homepower.org



Home & Heart



Kathleen Jarschke-Schultze

I first saw a drawing of Sam Irwin's 'Solar Chef' solar cooker in Joseph Radabaugh's book *Heaven's Flame*. At SEER '94 I saw the Solar Chef up close.There was a large eighteen year old model that had traveled from Colorado. There were new models for sale. They sold out.

In the Beginning

Sam Erwin was trying to develop an idea he had for a solar water heater. It wasn't working very well as a water heater, so he took it off of his roof. He thought it might work as a cooker. He put a chicken inside a coffee can — it cooked surprisingly well. He began fine tuning his design for the Solar Chef. That was around twenty years ago. There have been refinements over the years. Sam brought an 18 year old, restaurant size model to SEER '94. It still had the old block-step design for focusing. This large oven was in constant use at the three day event and did lots of cooking; even pies. Talk about product longevity.

Appearance

The Solar Chef is a handsome unit. Each oven is handmade according to Sam Irwin's patented design. A center cooking enclosure covered with a faceted glass cover is the focus of the many mirrors, cut and mounted just so, that surround it. The outside is plywood painted a neutral brown and cream. The aluminum frame and wheels are what make the 'Chef' so easy to use. Mine has a painted wooden cover that slips underneath the cooker and provides a smooth surface for the wheel assembly. This is an attractive, useful and interesting addition for your yard.

Usage

Although the Solar Chef is not really a portable unit I took mine to a 25 year reunion of Bob-O's commune. I wanted people to see solar cooking in action. I also took a Burn's Milwaukee Sun Oven. In side-by-side testing I cooked three consecutive pots of rice in the Solar Chef in the same time it took to cook one pot in the Sun Oven. Of all the solar ovens that I've used so far, the 'Chef' comes the closest to regular cooking times.

He doesn't include a thermometer with the Chef because it's misleading. The temperature of the air in the cooking chamber is lower than the temperature of the pot and its contents. I've found this to be true. To get a true temperature reading use a meat thermometer in the food itself.

I had to change some solar cooking habits with the Chef. You can't put in your casserole in the morning and come back in the evening to a cooked meal. You have to pay attention. That's okay. I can put something in early, like a pie, bake it, then put in the main dish and its done in the same time my propane stove would take. On short winter days, I can cook a whole meal with just a few hours of sun.

Easy

The Chef is so easy to use. I have the smaller size, which is big enough for large pots. The aluminum frame has small wheels and a caster so you can turn it with one finger. The cooking chamber and mirrors are below the edge of the bowl-like housing so it is completely wind proof. Boy, do I like that. The adjustment to the sun's angle can also be done with one hand. The inside shelf is adjustable to any inclination. There is a small copper tube that exhausts from the cooking chamber. If you use a baking bag, wire tie the opening of the bag to the tube and all the greasy steam goes outside the cooker. Sam cooked a sixteen pound turkey this way at the Home Power Solar Cooker Contest. It tasted great!

On the top edge of the Chef, a small painted white triangle which has a short wooden dowel sticking up from it. When focusing the unit you make the shadow of the dowel disappear and you're done. If you are going to leave for a while you can set the oven so the sun is coming into focus by turning it until the dowel's shadow points straight to the left, if you're standing behind the oven. Be sure to wear your solar cooking safety equipment. Sun glasses and cooking mitts or hot pads are de rigueur with any solar cooker that uses polished surfaces to reflect light.

Conclusion

I loaned my Chef to a neighbor who had never used a solar cooker. He really liked the looks and the ease of use. He asked if he could take it to his children's school to cook for the kids. Even though the Chef is not an easily portable unit mine seems to travel a lot. I took it to a solar cooking demonstration I gave at the local gardening club. It fits in the back of my station wagon with room left over. It's not heavy, but does take two people to lift it because of its bulky shape.

The Solar Chef is really designed to sit in your yard and cook your food. It does this very efficiently and is highly attractive to boot. A lot of back yards sport a gas barbeque. The Chef is more versatile than a barbeque and would be used more often. The large model is $380 and the smaller model is $285. I know this is a large investment, but the Solar Chef is well designed, well made and works. As Sam says, “Its the oven that burns only sunshine.”

European Update

In my last column I mentioned Asko brand appliances from Sweden. Since then Bob-O and I have been thinking about getting a front loading washing machine because they are very water efficient. White-Westinghouse makes the only American front-loader. They also have the worst repair history, according to Consumer Reports.

The Asko front-loader has a drawback. The Asko only has a cold water water hookup. This washer uses a heating element to heat water. Apparently this is common in Europe. Asko’s are an expensive appliance. It is extremely well-made and has a good repair record.

After looking at the White-Westinghouse we wondered where laundromats got their front-loaders. We figured they’d be good for continual usage, without problems. Bob-O crouched under the front loaders in our local laundromat. They were made in Sweden too.

Mike Rainey, who’s spent time in Europe, called me. He says that the stores there have about thirty brands of front-loaders. Unfortunately, they’re not available here. He sent me information on a German brand, the AEG OKO-Lavamat, imported into New Jersey. It is 220VAC and needs a transformer to run. It’s well built with stainless steel inside, like the Asko. It also has the cold water only hook up. Its price is lower than the Asko. Mike asked if it will run on a modified sinewave? I don’t know.Does anyone know if the heating element can be defeated? Most people wash in cold water now any way. My solar-heated water is hot enough without boosting the temperature. I’d appreciate any feed-back.

Access

Kathleen Jarschke-Schultze is now traveling the Information Back Road at her home in northern-most California, c/o Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-0830. Internet Email: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

Solar Chef, Sam Erwin, 2412 Robinson Rd., Grants Pass, OR 97537 • 503-471-4371

Asko, Inc., 903 N. Bowser #200, Richardson, TX 75081

AEG OKO-Lavamat, The Andi Co., 65 Campus Plaza, Edison, NJ 08837 • 908-225-8837

HAPPENINGS

AFRICA
The 1995 ISES "In Search of the Sun" Conference, "The World Solar Energy Exhibition and the finish of a solar car race is scheduled for September, 11–15, 1995 in Harare, Zimbabwe. For exhibitor and attendance information contact Peter Armstrong, exhibitor director, In Search of the Sun, PO Box 2851, Harare, Zimbabwe, Phone: (263-4) 730707, Telex: 0907 (26623 ZW), Fax: (263-4) 730700, e-mail: xcarelse@zimbix.uz.zw

NATIONAL
American Hydrogen Association Bulletin Board System: Solar Hydrogen BBS, 415-494-3116, 1200–14,400 baud V.32bis. V.42bis 8N1, Prosperity without Pollution: also AHA Tempe BBS (602) 894-8403.

Free Energy-Saving Information for homeowners who are preparing for the arrival of winter and would like information on cutting their residential energy bills. The Energy Efficiency and Renewable Energy Clearinghouse (EREC), is offering a free booklet entitled "Heating The Home".To obtain a copy contact EREC by calling 1-800-DOE-EREC (363-3732) or by writing EREC, PO Box 3048, Merrifield, VA 22116

EAST COAST
American Tour de Sol — National Road Rally Championship for Electric and Solar Electric Vehicles, May 20–27, 1995, Waterbury, CT—Portland, ME. For more information about the event, volunteering, participating, sponsoring, or exhibiting please contact Northeast Sustainable Energy Association (NESEA), 23 Ames St, Greenfield, MA 01301, (413) 774-6051, Fax (413) 774-6053.

ARKANSAS
Sun Life is now conducting "Third Saturday Seminars" on inexpensive building techniques. The focus of these seminars is to teach others how to build their own homes from materials that can last a thousand years and cost less than conventional wood-framed homes. These are hands-on, all day workshops. Contact Loren at PO Box 453, Hot Springs,AR 71902

CALIFORNIA
Convert It: The Workshop: Electro Automotive in Felton, CA is offering a hands-on electric car conversion workshop, February 22–25, 1995. The class is for the amateur mechanic interested in learning about converting a car to electric. The four day class will include lecture segments, but the primary focus will be the actual assembly of an electric conversion. This is a hobbyist version of a workshop previously offered only to professional mechanics. Students will learn which shortcuts can make their conversion easier and which ones lead to disaster. Emphasis is on producing a safe, practical, professional-quality conversion. The instructor is Mike Brown, author of Convert It. The cost is $400.00 per person. Pre-registration required, space is limited. Call Electro Automotive at 408-429-1989 for information.

SMUDs Brown Bag Series VII — every other Thursday, Noon to 1PM, at SMUD Energy Services, Conference Rooms 1 & 2, 6507 4th Ave ste 500, Sacramento,CA. Dec 1—Solar Water Purification for the Developing World; Dec 15—Cost-Effective Utility Photovoltaics Applications.

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

MINNESOTA
SOLAR '95 Conference, 10,000 Solutions: Paths to a Renewable Future will feature the 24th American Solar Energy Society Annual Conference and the 20th National Passive Solar Conference. Billed as the largest and most comprehensive solar energy conference. Solar '95 will emphasize practical cost-effective applications of solar energy that can improve the nations economy. Speakers are leaders in solar research and commercialization efforts. Tours and workshops are planned. July 15–20, 1995 in Minneapolis, MN. For more information contact: American Solar Energy Society, 2400 Central Ave G–1, Boulder, CO 80301, 303-443-3130, fax 303-443-3212

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

OHIO
Solar electric classes taught at rural alternative powered home with utility back-up. Maximum of 12 students. $30.00 fee per person, $35 per couple, lunch provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will see equipment in use. Dates: Dec 10, 1994. Jan 14, 1995. All classes held from 10:00am—2:00pm on Saturday. Call (419) 368-4252 or write Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537.

The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more information contact, Larry Dussault, GLEAA, 568 Braxton Pl E, Westerville, OH 43081-3019, 800-GLEAA-44 or (614) 899-6263, Fax (614) 899-1717. Internet address DUSSAULT@delphi.com.

OREGON
The Lost Valley Educational Center is an intentional community and learning center devoted to developing the skills and awareness that will create a sustainable lifestyle. They are offering various low-cost workshops covering everything from low-cost underground housing to building solar ovens. For more information call or write Lost Valley Educational Center, 81868 Lost Valley Ln, Dexter, OR 97341, 503-937-3351

WASHINGTON, DC
March 26–30, 1995—American Wind Energy Conference: Windpower '95. Contact Linda Redmond, Meetings Coordinator, AWEA, 122 C St NW, Washington, DC 20001, (202) 383-2500, Fax (202) 2505.

the Wizard speaks…

A Dream: 2027 AD

I'm driving home from the solar-powered office in my hydrogen-powered, fuel-cell-driven eco-car. I pull off the road at a new hy-station to refuel. Here, hydrogen is produced on site by a combination of PV, wind, and stirling engine technologies. It is stored underground in hydride storage tanks, using the same storage technology as my vehicle. I fill my tanks and I'm on my way home.

Coming up my driveway, I can see the solar panels and wind machines that power my dwelling place. Soon, the collectors that produce hot water, and those that power the built-in solar cooker will become visible. The first thing I do is check the hydride storage tanks and the new 90% efficient fuel-cells that have replaced my battery bank After a good solar-cooked meal, I spend some time with my satellite-direct interactive entertainment system. Then it's off to bed. As I drift off to sleep, I think of how it must have been back in 1994.

NOTE: As with cold fusion, we must carefully assess the potential environmental effects of using hydrogen as a fuel. This usage takes water out of the biosphere and replaces some of it with water vapor in the atmosphere. This needs to be studied.

Kansas Wind Power Low Prices "Since 1975"

We have been helping folks save money on renewable energy equipment for many years. Our catalog lists most items shown in this ad along with hundreds of more items.

Super Sale on used Inverters and **Amp Hour Meters**

Best Buys on efficient

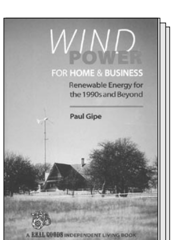
Sun Frost Refrigerators

Model RF12:
AC **$1640** DC **$1720**

New — wonderful — **DC Compact Fluorescent** Lights

DC Permanent Magnet Motors at bargain prices. Great for fans, pumps, shop tools, small electric vehicles, etc. 1hp $60 + shipping

Sun-Mar Compost toilet
New Model, AC/DC, No Water needed **$885**



Special

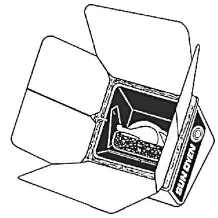
$26

Plus **$4** shipping USA

Wind Power for Home & Business/*Renewable Energy for the 1990's and Beyond* by Paul Gipe A **$35** value

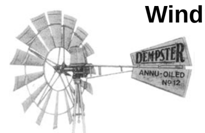
Solar Electric Modules
Wind Generators
New & Used
see catalog for more info

SUN OVEN



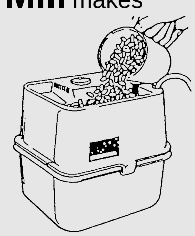
$139 plus
$20 shipping to 48 States

Bake bread, roasts, fish, chicken, casseroles, grains, vegetables, beans. 350°F **$200 value**
Solar Chef® & Sunflash™ also available



Windmill Water Pumper Catalog $5
Windmills • Pump Jacks
Towers • Hand Pumps
Cylinders • Leathers

Fresh homemade flour & corn meal!
The **Kitchen Mill** makes

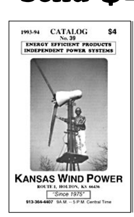


fine flour fast & easy. 1.5 cups per minute. Large capacity. Mills all grains, oat, beans, corn, rice, popcorns, barley. Self-cleaning milling chamber.

120 volt AC 10"x8"x6"
Made in USA, 5 year warranty. **$250** value
$9 ship to 48 States

Very popular **Sale $195**

Send $4 for catalog of



Independent Power Systems & Energy Saving Products.

Contains: Solar Electric Modules • Wind Generators, towers • Wind Measuring Instruments • Hydro Electric • Charge Controllers • PV Mounts, Trackers • Meters, volt, amp, amp hour, watt hour • Batteries, lead acid, NiCad, NiFe • Circuit Breakers • Fuse Boxes • Battery Chargers • Auto Transfer Switches • DC Motors new & used • 12 volt Power Drills • DC Water Pumps • Survival Pocket Tools • Hydraulic Ram Pumps • Inverters • DC & AC Lights • Sun Frost Efficient Refrigerators •SERVEL Gas Refrigerators • Propane Lights • Gas Space Heaters (non-electric) • Fans • Evaporative Coolers • Solar Water Distillers • Tankless Water Heaters • Wood Fired Water Heaters • Solar Cookers, Books, Plans • Grain Mills, hand & electric • 12 volt Bed Warmers • Fence Chargers • Shortwave Radios • Composting Toilets • Low Water Toilets • DC Electric Garden Tractors

Trace ENGINEERING

Kansas Wind Power has been a popular source of Trace Inverters for over 8 years

Newest models are highlighted

Model	Watts	Volts	Charge Amps
812	800	12	
812SB	800	12	25
724	700	24	
724SB	700	24	12
DR1512	1500	12	70
DR1524	1500	24	35
U2512	2500	12	
U2512SB	2500	12	120
U2624	2600	24	
U2624SB	2600	24	60
U2232	2200	32	
U2232SB	2200	32	45
U2536	2500	36	
U2536SB	2500	36	40
U2548	2500	48	
U2548SB	2500	48	30
M1512	1500	12	70
U2512RV/M	2500	12	120
U2624RV/M	2600	24	60
U2232RV/M	2200	32	45
SW4024	4000	24	120

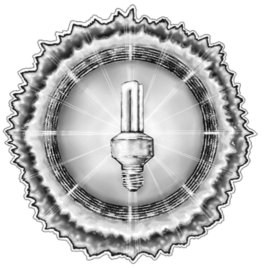
Shown below are 4000 watt sine wave & low cost 1500 watt inverters

Great Trace Dealer Pricing!

Kansas Wind Power

13569 214th Road, Dept. HP44, Holton, KS 66436 *"Since 1975"* 913-364-4407

Home Power's Business



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

Display Advertising

Advertising Rates per Consecutive Insertion

	Single Insertion	*Three Insertions*	*Six Insertions*	*Ad Area sq. in.*
Full Page	$1,200	$1,080	$1,020	64.13
Half Page	$672	$605	$571	32.06
Third Page	$480	$432	$408	21.38
Quarter Page	$377	$339	$320	16.03
Sixth Page	$267	$240	$227	10.69
Eighth Page	$214	$193	$182	8.02

For full color rates, spot-color rates, inserts, and/or current subscriber/circulation demographics, please call us.

Home Power is published bi-monthly. Ad deadline for the Feb / Mar 95 issue (*HP* #45) is 21 December 1994. Call 916-475-3179 for further details.

International Subscriptions

Due to the high cost of international mailing, we charge more for Home Power international subscriptions.

1 YEAR — 6 ISSUE INTERNATIONAL RATES:

All payments in U.S. currency ONLY!

Canada:	Air — $30	Surface — $20
Mexico:	Air — $31	Surface — $20
Western Hemisphere:	Air — $33	Surface — $20
Europe:	Air — $44	Surface — $20
Asia and Africa:	Air — $53	Surface — $20
Pacific Rim:	Air — $53	Surface — $20

Surface shipment may take up to three months to get to you. All international issues shipped in mailing envelopes. International subs are best paid for by either VISA, MasterCard or funds from a U.S. bank.

Mercantile Advertising

One insertion per customer per issue. We can typeset mercantile ads. We do our best to make your ad look good. If you send too much copy, then the type will be small. Flat rate $80 per insertion. Advance payment only, we don't bill Mercantile ads. Your cancelled check is your receipt.

Back Issues of Home Power Magazine

Back issues through #20 are $3 each ($4 each outside USA) while they last. Sorry, no more issues #1 – #10 or #15, or #36. Back issues of #21 through this issue are $4.50 each ($6 each outside USA). Back issues shipped first class mail in an envelope or box. See ad index for specials.

MicroAds

MicroAd rates are 10¢ per character. Characters are letters, numbers, spaces, and punctuation marks. $15 minimum per MicroAd insertion. Send check with your ad. We do not bill MicroAds.

Home Power Magazine for Resale

Quantities of Home Power Magazine are now available for resale by distributors, newsstands, bookstores, energy business, and others. Please call or write for rates and shipment specifics.

First Class Home Power Subscription

Home Power Magazine (6 issues) via First Class U.S. Domestic Mail for $30. Many of you have asked for faster delivery of your issues. So here it is: First Class Home Power. All First Class issues shipped in an envelope. We start your subscription immediately with the current issue.

Second Class Home Power Subscription

Home Power (6 issues) via Second Class U.S. Domestic Mail for $15. Second Class is forwardable for one issue (2 months), so let us know immediately if you move! We start your sub with the next scheduled issue, so please allow ten weeks for your first copy to arrive.

ACCESS ➠ Home Power, POB 520, Ashland, OR 97520 USA
916–475–0830 Subscriptions and Back Issues
916–475–3179 Advertising and Editorial

Letters to Home Power

Too Much Access
A reader whose letter we printed with their street address sent us a letter they received from someone who was going to "look them up". They really didn't want a visit from someone they didn't know...because you just never know — too many fruitloops in the ozone these days. I guess we've been living in the outback so long that having someone just show up was not a problem we really considered. Our address is a PO Box. No one can show up on our doorstep unannounced. In order to find us you'd need a map, a key, and a really good sense of direction. We were focused on the networking possibilities and didn't fully comprehend the potential problems. So, due to potential fruitloops in the ozone, in the future, we'll only print a street address if the letter writer specifically requests it or if it's from a business. Sadly, it's a sign of the times. Thanks. Karen Perez

Own or Rent?
Dear Home Power Magazine Crew, readers, and IPP Members:

Hope my survey response makes it in time for the compilation of survey results. The renewable energy scenarios I favor the most were difficult to rate because of the way they were stated. Yes, I want to own the equipment. I think most people wouldn't want to buy electricity from equipment sitting on their property. But who maintains what parts of the system? As Richard points out, "know thy customer/know thyself" (HP#40, pg 72). Most people don't change the oil in their car or fix their own bicycle. We can't expect most people to bother checking their system's batteries.

This reality must inform the Gridman vs. IPP debate. Electrical utilities and other energy mega-corporations will serve the renewable-energy market. To avoid being on the defensive, I suggest IPP and RE providers draw up plans for determining the cost of energy, determining system configurations, and providing service and maintenance. Draw up the solutions!

To work for realistic system standards, for example, draw up your own system standards for PV systems, instead of having to defend yourselves against Edison's out-of-touch standards (HP #42, p. 63). Every system's custom? Fine, draw up a decision flowchart. A given path through the flowchart would determine the system's configuration.

Solutions to the cost-of-energy debate: show that efficiency improvements are the lowest-cost system components, thus addressing the system standards at the same time.

More solutions to cost-of-energy: decide which cost-of-energy plan to push. Consider a compromise like net billing for the first 500 kWh per month returned to the grid, and something less than net billing for energy beyond the first 500 kWh. Perhaps IPP and others can force the utilities to show their hand with regard to what their peak electricity costs, and what that cost includes. (Is it just fuel cost? Does it include transmission-and-distribution maintenance? Return to investors? Cost of capital? So-called "external" costs?

Solutions to maintenance: offer service contracts with varying levels of user participation and commensurate costs. For example, some RE users could get a postage-paid maintenance check-off list instead of a bill every month. Others may want a service technician coming to their house.

Thanks for listening. With high regard, Alex DePillis, Project Engineer, Energy Islands International, Inc., 111 King St #32, Madison, WI 53703 % 608-284-0700

Renewably Powered Publishing
I wanted to let you know that alternative energy powered publishing is growing. Since May I have been editing a bi-monthly magazine from my solar powered home in Central New York! Our house has a small system with 220 watts of PV panels and 330 amp-hours of storage at 12 Volts. We're old fashioned and operate primarily 12 Volt DC appliances: lights, a small refrigerator, stereo, answering machine and computer (with an adaptor). I print proof copies on our inverter-powered Stylewriter II printer, but go to a service bureau for final output. It is refreshing to be able to extend our efforts at self-reliance and withdraw support from the greedy, polluting utility companies.

I do my computing on a Macintosh Powerbook 160, which is a great little machine, except when it comes to page layout. I can do it, but my eyes sure don't appreciate that little screen. I tried renting a portrait size greyscale monitor, but it wouldn't run on my little Power Star 200 inverter. According to the ratings there should be plenty of power there, but it just wouldn't operate. My guess is that the ac power from the inverter isn't clean enough for the monitor. I'm wondering if this is likely to be true for the other similar monitors on the market. Any ideas, particularly those which avoid going to a true sine wave inverter would be appreciated.

For Home Power readers who might be interested, The Nonviolent Activist is the magazine of the War Resisters League. It features inspiring accounts of successful activist efforts, analyzes political realities and provides tools to people who want to make the world a less violent and more just place. It includes book reviews, letters, etc. Subscriptions are available for $15/year from War Resisters League, 339 Lafayette St, New York, NY 10012. To check out a copy, send $2.

Thanks for the great job you do on Home Power Magazine. In Peace, Andy Mager, Truxton, NY

Hi, Andy. Try using a bigger modified-sine wave inverter which has the snort to start up the larger display. I advise running all your computer equuipment from a true sine-wave inverter. In the long run, it's cheaper and more versitile. Richard Perez

Code Corner - Voodoo Electronics?

I have to take exception to John Wiles' interpretation of the NEC in HP#43 as it applies to using Square D circuit breakers in 24VDC systems. Article 690-7 of the NEC states that in a photovoltaic system the voltage considered shall be the rated open circuit voltage. While the article does mention that the installer should note the anticipated temperature conditions at the site and make appropriate rating adjustments, it states nothing about UL Standard 1703 or the 125% of rating factor. This would seem to be some UL "ballpark" port-over from the 125% requirement for overcurrent devices.

The Square D QO breakers have a working voltage rating of 48VDC. Under working conditions, a 24VDC system remains well within that voltage rating even when the near mythical 125% of rating is factored in. To apply that formula to the terminals of an open switch when no current is flowing is clearly not the intent of the NEC regardless of whatever "best guesstimate" verbiage UL has come up with.

To then go on to say that this very same breaker is perfectly acceptable when used by Mr Wiles' good friends at APT in one of their UL-approved cans, but bad news in a Square D box, stretches whatever credibility he might have to the breaking point. I ask you folks, THIS is science?

Fortunately, the final word on things like this is in the hands of the local inspector. Since most inspectors come from the ranks of working electricians and contractors, they pretty much know, from experience, the difference between safe and silly. Good thing, eh? Bob-O Schultze, POB 203, Hornbrook, CA 96044

More On Humid Sun Frosts

Hallett Douville's letter about the use of Sun Frost's in humid climates in your June/July (HP#41) issue caught my eye. I have a Sun Frost freezer, but use a modified conventional refrigerator (two actually) with good results.

His power consumption figures seem OK to me. My freezer runs in a place where summer temperatures are held down to about 83F during the day by air conditioning. I guess it runs about 20-22 hours per day duty cycle to maintain a 0F interior temperature. In the winter, my freezer only runs an 8-10 hour duty cycle, with ambient room temperatures ranging from 50F to 65F. The compressors on Sun Frosts are quite a bit smaller than those on conventional freezers, so large temperature gradients mean long duty cycles.

If I had it to do again, I would probably not buy a Sun Frost. I realize this is dangerous heresy in the world of energy efficiency and renewable energy, but hear me out.

For a long while my house refrigerator was a late seventies energy hog. It wasn't until I measured its consumption with a meter - it was drawing 7 kWh per day! It is one of those with the condenser coils and compressor underneath the cabinet. The heat must travel out and up the back to escape into the room. It's like putting a stove burner under the cabinet and trying to keep it cool. The first thing I did was to try a heat diverter. This was a 1 x 8 board which rested on pegs driven into the wall, which intercepted the heat as it made its way up the back of the cabinet and allowed it to flow out the side and into the room. The back of the cabinet was spared contact with the heated air from the bottom of the machine. This made little difference because the condenser coil was too small. Heat was not only being poorly placed, but it was being inefficiently removed as well.

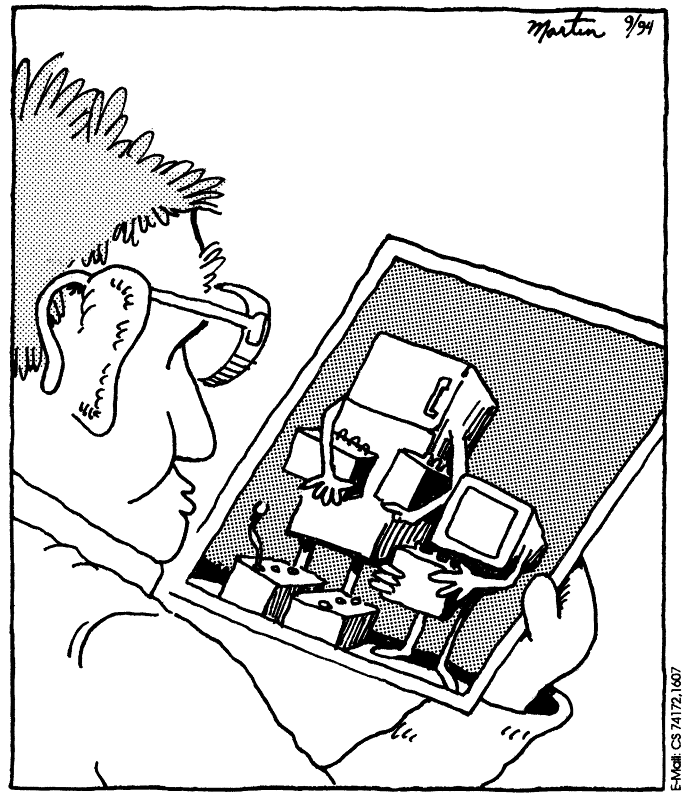
I found that I could cut its energy consumption by about 20% by running it with a plug-in motor controller. Since I had a slightly smaller refrigerator out where my Sun Frost is now I decided to make the large refrigerator into a storage locker until I can replace the condenser and compressor with something more efficient and use the smaller one for the house refrigerator. This machine has a large, flat condenser on the back. I have found that the best way to improve the efficiency of such a refrigerator or freezer (Sun Frost take note!) is to elevate it about two inches (bricks work fine), ensure that it has about eight inches of clearance from the rear wall and to modify the condenser coil. Elevating the refrigerator and giving it more wall clearance helps to ensure adequate air flow to cool the condenser and compressor.

Make three or four small wooden blocks from a durable hardwood, drill them and install them with long screw under the condenser coil mounting brackets. Move the coils, which are hot, an inch or two further from the cabinet, which is cool. Take some of the reflective foil insulation normally used to reflect heat from attics, cut it to fit and install it about an inch behind the condenser coil. Attach it to the same brackets with tape. Run a little more of this foil from the bottom of the reflector to the bottom of the cabinet above the compressor so that it is continuous with the cabinet. This will reflect most radiant heat produced by the coil and prevent heated air from rising up the back of the cabinet. You might want to put a bead of latex caulk between the foil and the metal cabinet to restrict heat conduction between the reflector and the cabinet.

I have not actually tried to move the compressor yet. I plan to unfasten its mountings and reposition it four to six inches out from the cabinet. This would restrict radiant and convective heat transfer from the compressor back to the cabinet and if the new compressor mount is wood, conductive transfer as well. Then after I've installed a plug-in motor controller, I might want to start doing creative things with super insulation on the cabinet. One thing to remember with super insulation, especially in humid climates, is that moisture will condense against a cool surface. You have to be very sure that your insulation is tightly enclosed with good carpentry and caulk so that there's not a continuous supply of moisture diffusing, or moving with convection, into your insulating material and condensing onto it from the surface of your refrigerator cabinet. I found out the hard way when I happily slid my Sun Frost up against a wood-paneled wall, only to find water damage behind it after a year or so. A bead of caulk around the back of the machine (easily removable clear caulk) solved the problem.

My house refrigerator now draws about 2 kWh/day in summer and about 1 kWh/day in winter. Once I make some additional modifications, I expect to cut consumption even further. That would make it within "ball park" range of the Sun Frosts.

I've found that all plug-in motor controllers are not created equal. It is worthwhile to have a few on-hand, made by different manufacturers, so that you can try several on any given appliance until you find the one which works best.



The mystery was solved. Frank's hidden camera caught the refrigerator and computer in the act of raiding the battery room for extra power.

There is one product I would like to see the appliance manufacturers offer, especially for very hot climates. If a refrigerator or freezer has its compressor and condenser coils inside the house, as they all do, then the heat produced enters the room and usually must be picked up by the air conditioning system. This is not as efficient as it would be if the machine came as two units. One unit being the cabinet and evaporator system inside the house and the other being the condenser and compressor located in a weather-tight cabinet.

In summer it might seem that the duty cycle of such a system was too long. But, you have to remember that a heat pump refrigerator would take the load off of the air conditioning during the summer. The net effect would be a reduction in power consumption. There would have to be an insulated door in the wall, big enough to slide the condenser/compressor unit outside. This would allow the refrigerant lines to run through the wall. Perhaps the savings would not justify the added cost of construction. Certainly, it wouldn't in the north where keeping heat indoors is more important for most of the year.

Some day, I may want to try to build a solar system to take over some of what I run on grid-power. This will happen shortly after someone invents an economical, trouble-free battery which lasts 30 years! For now, it seems that for most on-the-gridders it makes more sense to experiment with more efficient ways to use utility power. If what you're doing is working, keep on doing it. If not, try something else. The possibilities are endless. Frank W Bellows, Jr, Houston, TX

Hi Frank! Larry at Sun Frost says that the F-10 at 90F ambient temperature, with the freezer at 0F, should run about 21 hours per day and draw about 1 kWh per day. Karen Perez

A Little Piece of Heaven

Dear Power People, I am on my second year as one of your subscribers and have enjoyed many days of reading and planning for the day when I would be able to start using this newly acquired knowledge.

Six years ago we bought 40 acres on Willow Creek Mountain, 25 miles NE of Yreka, CA & 11 miles south of the Oregon border. This was completely undeveloped. We are four miles from the last power pole and telephone service. We have put in our well, septic system, improved the pitiful excuse for a road and put a mobile home in. This summer we finally made the transition to our little piece of HEAVEN.

We have six sets of used Carrizo Quad Lams that came unframed (we framed them in extruded H & C channel), 14 Trojan L16 batteries, Trace 2512SB inverter & a Windseeker to help in winter. I went to the local electric company to get our heavy gauge wire (they call it surplus), sold by the pound very reasonable. They also had all the connectors available and were extremely helpful to my cause. There are some other things I need to get together. Then we can start assembling this big tinker-toy set. Until then we are still on the part-time generator.

Your publication and advertisers have made this dream of ours become a reality and we would like to THANK YOU for a GREAT job. Jim & Jean Hershberger, Montague, CA

RE Survey Survey Comments

The following comments are from our Renewable Energy Survey published in Home Power #42, page 16.

I'm somewhat undecided about what's best. Let's take an extreme case - China, which needs 15,000 MW of new capacity every year for the next couple of decades. Central planning tends to disfavor anything over 50 MW in project size, which may become untenable. To some this is opportunity unlimited, to others a beginning of environmental doom. How many solar panels and wind generators is this, not to mention land and cadmium batteries? It's unrealistic and myopic to look at the USA only. Pine City, MN

After losing a long fight in the legislature, Governor Hickel strong-armed 1.5 million of state $ to fund a grid extension about 20 miles long to serve about 50 hook-ups despite strong opposition from 90% of the people on my road. One guy at the end of the road signed-up and they're ramming the poles down our throats - and into one of the nicest views in the world. Most grid extensions no longer make sense. Denali National Park, AK

Just as every household should be responsible for recycling its own trash, every household should be responsible for generating a portion of its power, or conservation at the least. Quartzsite, AZ

Any scenario which uses the sun to make electricity, whether home-owner generated or utility generated, is a positive step. We need both the tiny, self-contained solar producers and the mega-sites. Home Power's suspicion of the utilities is understandable and should continue. Home Power's focus on remote home power and EV is very valuable. Decorah, IA

I would like to see the utilities use renewable energy sources. Ideally, selling surplus power to the utilities at a fair price would put a smile on my face. Coyote, CA

We live way out in the boonies - now a family of 5 - with no reasonable chance of being connected to the grid. I believe our country has the lowest electrical rates in the world. We've come a long way from kerosene lamps and hand pumping water to our current lifestyle of electric clothes washer, dishwasher & even breadmaker. The potential of solar power(s) is really something. Conventional electricity would be easier and cheaper but, for even a free hook-up I wouldn't jump at it, I wouldn't even take it. Orondo, WA

While it is difficult to set-up renewable energy sources in a rented apartment in Brooklyn, NY consumption can be kept down as we learn new ways to conserve. Our stay in NY is limited, and in time we hope to live in a different environment where we have greater control. We are interested in the average consumption levels of the respondents and how we compare, Brooklyn, NY

I support the use of renewable energy and welcome as many suppliers and or sponsors (including utilities) as would care to participate. Long Beach, CA

Our goal is to get to 3.3 KWh/day. I didn't know about Home Power Magazine, but started my own energy conserving program. Last month we got our lowest bill ever @ 420 KWh/mo. I chopped $12 off my bill by installing a clothesline. We dumped our water beds & fish aquarium. We still have 50% incandescent bulbs installed, but have chopped over 2/3 of the lights that we use more than one hour a day. The fixtures that we are planning on working on include ceiling fixtures that can only take Phillips Earth Lights. I figure twelve to go (12 X $26=$312!) I buy two a month, so it's taking a while! We still have to change the refrigerator & chest freezer to Sun Frosts (have Sears junk) and replace the Sears electric dryer to natural gas (and thanks to Kathleen an ASKO washer). Until we can build our solar passive home we still have to run a window air conditioner 24 days per year - but we're changing for the better. This month I dump nine of ten phantom loads. Another happy subscriber! Winnebago, IL

Another possible scenario is: A third party (not a utility) owns the renewable energy plant. We buy the renewable energy via the utility's distribution network. La Habra, CA

On-grid users need to be able to add RE to the grid. This gives the neighbors RE whether they like/know it or not. Users need to be responsible for their use. Utilities need to pay one to one for user provided RE - it makes $'s for them (avoided cost, clean generation, distributed generation, avoidance of new up-graded distribution hardware). We need more incentives (measurement of externalities). We need to end subsidies to non-renewable energy. We need to promote acceptance of RE and rejection of the polluting alternatives. Cost of pollution must be recognized. Port Wing, WI

We are fortunate in Wisconsin. Most areas have low electric rates Wisconsin. Electric is $.068/KWh. Kaukauna Power has hydro generated power, hence the low rates. Combined Locks, WI

Sorry I couldn't be more helpful, but this house is over 350 years old & has never had plumbing or electricity. I am very interested in solar electricity & solar hot water though. After two months of research & investigation I still know next to nothing about solar energy. What is the big secret? No one wants to give up the info. It's like asking for free money. Anyway, I think I'm on the right track. I found out about your mag by accident & it seems to be a veritable wealth of information. Having just read the first 16 pages I feel like a darn expert already. Now if I could only get some 2nd hand equipment....West Tisbury, MA 02575

In 2-3 years I plan to move off-grid. As of now I'm converting over a school bus to solar power. (No, it will still use petrol.) Since age five I've read solar power books because it's fascinating. Nowhere in my education was "energy" discussed thoroughly, I had to learn it all myself. I often wonder why nobody taught energy issues in school. It's all pretty basic, but to me it never seemed as though school worked to "empower" us by preparing us for the future. I'm in a battle with PG&E to consider lowering our bill. HA, but they won't listen. Once on-the-grid, forever their slave. So after speaking to many a closed mind I plan to sever my relationship and lose the chains. Oakland, CA

I really like being somewhat independent, self-sufficient, environmentally conscious and having a low impact upon the finite, limited resources of our planet Earth. Also, it appears to me you folks are placing far too much emphasis on electric vehicles. They can only be beneficial if charged-up on renewable/alternative energy sources. You must know that many of these vehicles are charged from conventional grid electric, and therefore contribute to further depletion of precious resources. If every single electric vehicle was to be charged from renewable energy sources, then they might begin to make some sense, but they still cannot perform in adverse condition such as snow, mud and up steep rocky hills (where many of us live). Think alcohol and hydrogen! Taos, NM

Watching the world from the Central Mountain area of New Mexico, I see the economic forces of America becoming shadowed by the reality that solar power makes sense and is more viable in many many more forms than grid power will ever be. In Albuquerque there are solar street lights. Camp grounds in the Sandia and Manzoino Mountains are powered by solar and I personally know of fifteen homesteads that are powered independently. Grid power in the third world is a far cry from what it became in the US. The capitalistic surplus-of-production dream world isn't going to fool the rest of the world as there are many forces (population explosion, pollution, etc.) at work that will shortcut any future brief romance with the fantasy of conventional energy. I have always wondered about how the power brokers that be are so well loved by Americans, but power and convenience are the very core of our lives. Too bad solar electric wasn't invented before industrial ac. Being born and raised on alternating current, I feel like a real brat, and now living independent of power bills, the contrast illuminates the waste and fraud associated with its convenience. Any monopolization of this new found freedom will only exacerbate the feelings of the hard working people who dedicated their lives to proliferating a new and profound way of living with the earth, now having to grit their teeth and wait while the courts of manipulation and exploitation determine the course of things to come. The prospect of seeing the utilities become a thing of the past instead of the only way for all time is scary to watch as the battle rages on. Knowing the third world is becoming solar powered while America bumbles about in bureaucratic molasses is very heartening. Tijeras, NM

We hope to expand our system using micro hydro to make us independent from our mains (British speak for utility grid). Would be helpful to have a cable wire conversion table from AWG to metric. Home Power (systems and magazine) is essential and superb!! Wales, United Kingdom

New Zealand is at a crossroads, our utility purchases its electricity from ECNZ (electricity corporation-nationwide monopoly) as do most (if not all) other utilities. All New Zealand utilities are required to separate their supply & energy costs to the consumer, so the more we save the higher the proportionate supply charge becomes. Our supply & unit used amalgamated cost is 18 to 19 cents per kilowatt hour (approximate). Some utilities are considering building their own generating plants, however, most of these plans involve fossil fuels. Locally in Wellington some consideration is being given to wind power. Palmerston, New Zealand

Renting renewable is not necessarily "bad". Most consumers today "rent" their electrical generation equipment from the power company. Just as many people rent their housing, renting the power company is not unreasonable. For those of us who can afford it, we'd prefer to own our power generation equipment. There is room in the market place for both economic models. Neither owning nor renting is necessarily the best: it depends on individual situations. Ultimately, let each customer choose the best solution for their own needs. Let's work to preserve that choice. Issaquah, WA

Q&A

Battery Equalization

Every time I think I understand "Equalization" I read something that gives me a problem. In HP #42, your article "Build Your Own 12 VDC Engine/Generator" I conclude that to equalize charge you should recharge between C/10-C/20 for at least five hours with battery voltage at or above 16 Volts. If this is so, then it appears I can not equalize with my current equipment. I have a set of Trojan L-16s, three Kyocera LA51s, a Trace 812SB and a C30A controller.

If I understand your article I should charge my battery pack for five hours at 16 Volts with at least 17.4 Amps. My PVs are rated at 16.9 Volts but the maximum Amps is only 9 Amps-OK on the Volts but the recharge rate is C/38. The Trace charger is 25 Amps but it has a maximum 14.7 Volts before it cuts off-OK on the amps but can't get to 16 Volts.

I live in SE Arizona and even here it would be difficult to get five hours at 16 Volts with a C/20 rate even if I had three additional panels. I have had this system for two years and the method I have been using is to "boil" the battery for 3-4 hours, one day a month. This brings the battery up to 15-15.5 Volts. I have my controller set to shut off at 14.7 Volts. Very seldom (four or five times a month) does the controller not shut off every day, so I don't think I am deep cycling the battery. I am using about 40 Amps a day, on average. Also I have used about 1 1/2 gallons of water in two years (regular caps-not Hydrocaps).

Two questions: 1) Am I taking proper care of my battery? 2) Is there any way to get the 16 Volts-C/20-5 hours charge without building an engine/generator like the one in the article? I already have a Honda ES6500 generator to run my well pump and Trace 812SB. Would appreciate any help you can give me. Thanks!! Tom Morse, Wilcox, AZ

Hi, Tom. Don't worry you are doing OK by your batteries, but you could be doing even better. First off, you don't have to get the battery up to 16 VDC to equalize. If you do equalize at a C/20 rate or faster, then expect the battery voltage to go over 16 VDC. In fact, the voltage is allowed to float during an equalizing charge — it really doesn't matter what the voltage is. What counts is giving the already recharged cells an overcharge. This overcharge can be at rates far slower than C/20, but the overcharge must continue for a longer period. For example, a 12 Volt lead-acid battery equalized at C/40 or so will only attain voltage in the region of 15.5 VDC. The actual voltage depends on temperature, colder cells will show higher voltages during equalization.

In your case I would recommend setting your Trace C30A regulator at a higher voltage such as 15.0 to 15.2 VDC. Set the return voltage at above 14.3 VDC. This will give the battery micro-equalizing charges on a daily basis. If your controller is shutting off the PV power daily, then you are wasting valuable equalization power.

From the description of your water usage, you are undercharging your cells. You should use a gallon of water in those two Trojan L-16 batteries every six months. Water consumption is a very good indicator of cell overcharging. When I flew a pack of two L-16s, they would use a gallon of water every two months. I flew the battery hard, with daily deep cycles and regular equalization. I would equalize about once a week at C/20 for five to seven hours. That set of L-16s endured twelve years of brutal service. A more modern approach is to set the voltage regulators in the system to provide daily micro-equalizing charges. The key is watching water consumption. Gallons per month mean too much overcharging. A gallon per year means too little overcharging.

In your case, if you want to equalize from your generator, then get a new battery charger. Statpower makes a series of very smart, three-stage chargers, that will run great on your generator. And it will equalize. Almost all of the battery chargers built into inverters are anemic, but they are inexpensive since the inverter already has a big transformer anyway. Richard Perez

Dirty Power

About two years ago our lights were flickering, as they had intermittently for about ten years. This time they were really bad, going dimmer and much brighter. An electrician was next door, as chance would have it. He had panic in his eyes & said "You'd better measure the voltage at your distribution box". Well, I had checked it before & it was always between 107 volts & 123 volts, sometimes balanced, sometimes not. Two licensed electricians had checked it & said everything was OK. I did have to replace four major appliances in 15 years. (Stupid me.) This time when I measured the legs (from common) they were about 78 & 146 [volts]. I thought that the power company would be responsible about providing quality service, but when I turned in a claim for the last major appliance they informed me that it was the CUSTOMER'S responsibility to ensure that the power company provides the customer with the proper service. It turned out that when the service was installed (underground) to the two houses the nuts on the connector block were only finger tight. Well, combine weather conditions, time, corrosion, varying loads & voila! Look Ma, no common! I'm not an electrician, but this experience has helped us to learn. This is probably an isolated, rare incident that almost never happens, but I'll bet that quite a few people that read this and are still shackled to the grid will turn on all their appliances and run out and check both legs of their 220 volt service.

My question is this: does it matter whether or not the load is balanced, no I'm sure that matters (but not why)-if you lose common is the flickering due to an imbalance between the legs of the 220 volt service? Are there other more common sources of flickering than loss of common?

Please continue your great magazine. Mr Watts going on and off anyway? San Antonio, TX

No, load imbalance doesn't matter — to a point. The point? ALL service entry connections must be good. You discovered this. Typical grid-connected homes have three wires providing power - two 240 volt "hot" legs and a "neutral" leg. Voltage from either hot leg to the neutral is 120 volts. Your 120 volt appliances connect between one hot leg and the neutral. House wiring is designed to divide 120 V loads equally between the 220 V legs. Drawing current from just one leg (up to its current limit) is perfectly acceptable, but not recommended. Poor contact with the neutral WILL cause dimming and flickering lights. All bad connections drop voltage. Heavier loads mean greater drops and even more dimming. Worse yet, a bad neutral leg will force the electricity to try to find neutral elsewhere. The results can be unpredictable - even dangerous. Flickering can also be caused by an overloaded power grid, brief heavy power demands, brownouts, storms, drunks hitting power poles, and assorted other reasons. While it may be up to the customer to validate the service initially, the power company should be responsible from there. If your power company isn't responsive to your complaints, document and report your problems to the Public Utility Commission in your area. Dan Lepinski

Solar Crafts

I am writing in hopes that you might put me in the right direction for any information on using solar power in a furnace application, i.e. low mass, high temperature solar mirror or such directing solar power onto an item in a crucible for purpose of reducing or melting the item.

Also, Some of the folks here do craftwork with polymer plastic, which requires 325F baking for about 20 to 40 minutes. Could something like the solar cookers or ovens be useful for this? Our oven goes all day sometimes when their creative juices are in full swing. George Anderson, Vernon, CT

Hi George! For a reducing/melting furnace, the only possibility that we can think of are Fresnel Lens. Fresnel lens can increase the sun's energy 50 to 200 times. Richard has an 8" x 8" Fresnel lens that can fuse dirt. In order for this to work for your application, it would have to accurately track the sun's movement. Midway Labs in Chicago, IL makes a wonderful PV concentrator using Fresnel lens (see HP#40, page 28). Maybe they can help you with surplus Fresnel. Also, Edmund Scientific sells a 2 x 3 foot Fresnel lens they say can produce 1600F. Most solar ovens can easily reach 325F. The Sun Oven's average internal temperature in full sun is between 275-325F, depending on your latitude. Of course, a solar oven's temperature will drop when cold food is first added and rise as the cold stuff warms up. The Solar Chef does even better. It's the only solar oven that I've cooked in so far that will burn food if you forget to check on dinner. Soon we'll have a Zomeworks parabolic cooker on site to try. Parabolics can attain temperatures high enough to pop popcorn. Again, tracking would be necessary. In HP #37 there's an article for a labor-intensive, but cheap, manually tracked parabolic cooker. Karen Perez

NESEA
camera ready
b&w
3.7 wide
4.8 high

Technologias Solares

•Installation •Consultation
•Education •Translation

Juan Livingstone has returned to his native Chile after 17 years in the United States to promote renewable energy in Latin America.

Juan's qualifications include 10 years of solar design, installation, troubleshooting, bilingual instruction and technical translation.

If you need help with your
Latin American project contact:

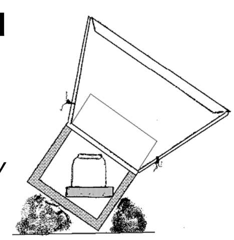
Juan Livingstone
c/o Marcel Duhaut
2733 #506 Providencia, Santigo, Chile
Phone 011-562-274-4639

Associate of Solar Energy International, Colorado, USA

Get out of the kitchen and into the sun!

Heaven's Flame

a Guidebook to Solar Cookers by Joseph Radabaugh



Joseph Radabaugh's book of 96 pages with 11 photographs and 50 illustrations, provides plans to build an inexpensive, efficient solar oven from foil, glass, and cardboard boxes. Full color cover and durable binding. For under $15 (including the cost of the book) you can be cooking with the sun. Cook delicious food, save money on cooking fuels, and have more time to do the things you want to do.

Available for $10 postpaid inside USA (Mexico - Canada add $1, elsewhere outside USA add $2 S & H).
Please allow four weeks for delivery
Make check or money order payable to:

Home Power Inc.

POB 520, Ashland, OR 97520 • 916-475-0830
VISA / MC

GREAT NORTHERN

Waking Up the Northland to Renewable Energy & Sustainable Living!

Bringing the finest in technology, equipment, and knowledge to the northern midwest.

Solarex & Kyocera photovoltaic modules
Trace & Heart inverters
controllers, meters & more!

SOLAR

Great Northern Solar

Route 1 Box 71, Port Wing, WI 54865 (715) 774-3374

Home Power MicroAds

Rates: 10¢ per CHARACTER, include spaces & punctuation. $15 minimum per insertion. Please send check with ad. Your cancelled check is your receipt.

USED WIND GENERATORS, Towers, inverters, & Water Pumpers: 80 systems in stock, 1500 Watts to 10kW. We repair & make replacement parts, blades & governors for most wind systems, pre-REA to present models, specializing in old Jacobs wind generators. We build tilt-up towers and tower-top adaptors for the Whisper Wind Generators. Best prices on Bergey, NEO, Whisper, & Windseeker. Plus we pay shipping to the lower 48. Call with your needs or write to Lake Michigan Wind & Sun,3971 E Bluebird Rd, Forestville, WI 54213, 414-837-2267, Fax 414-837-7523

DWELLING PORTABLY in tents, domes, vans, trailers, wickiups, remote cabins, unfinished houses, etc. What works and what doesn't. $1/issue. POB 190-hp, Philomath OR 97370

PURE CASTILE & VEGETARIAN SOAPS. Handmade in an AE environment. We also have hard to find natural bath & body care products. FREE catalog: SIMMONS HANDCRAFTS 42295 AE, Hwy 36, Bridgeville, CA 95526

HYDROELECTRIC SYSTEMS: Pelton and Crossflow designs, either complete turbines or complete systems. Assistance in site evaluation and equipment selection. Sizes from 100 watts to 5 megawatts. Manufacturing home and commercial size turbines since 1976. Send for a free brochure. Canyon Industries Inc., P.O. Box 574 HP, Deming, WA 98244, 206-592-5552.

LOW WATTAGE KIRBYS (110 VAC) As reviewed in HP#23 Home & Heart.& HP#32 Things That Work. Rebuilt- 6 mth guarantee. 3 Amp- $175 4 Amp- $150, tools- $25 + UPS - $15-25. SANDERSON'S 20295 Panoche Rd., Pacines, CA 95043 or (408) 628-3362

XXXXXXXXXX USED SOLAR MODULES XXXXXXXXXXX
XXXXXXXXXXXXX 16-2000 - $165.00 XXXXXXXXXXXXX
XXXXXXXXX SIEMENS M51 — $185 XXXXXXXXXXXXX
New PowerStar Inverter's 1300 watts-$795. Trace inverter 2512 $1095. 1000 watt sine wave inverter 48V $200, new 14 cu ft gas refrigerator $1795, new & used ni-cads from AAA to 250 AH. Will match or beat anyone's prices on equipment. Call or write for free flyer. Craig, 10192 Choiceana, Hesperia CA 92345, 619-949-0505. Trade-in's welcome. M/C VISA Discover accepted

---

AVAILABLE NOW FROM THE MIDWEST RENEWABLE ENERGY ASSOCIATION: Renewable Energy/Efficiency Directory. A great networking tool listing users, providers, networkers, educators and "do-it-yourselfers" in the RE fields. Send $5.00 (includes postage and handling) to: MREA, POB 249, Amherst, WI 54406.

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

THE AFFORDABLE SUBMERSIBLE 12V, 24V, 115V sub pump 1 yr warr., 150/head, 2.5 GPM $272. Free info. PO Box 330, Berry Creek, CA, 95916 916-589-5481

VERMONT SOLAR ENGINEERING — Expert design & consultation, professional installation, sales & support, repair & upgrades — PV, Hydro, Wind & DHW (domestic hot water). Our extensive field experience makes the tough choices easy. Custom systems, kits & components at most attractive prices. FREE UPS ALL ITEMS!! Complete catalog $3.00. Call Kirk toll-free, 1-800-286-1252, 802-863-1202(local), 863-7908(fax). 69 Thibault Pkwy, Burlington, VT 05401. We Use What We Sell.

CEILING FANS: The largest selection of DC Powered (12 & 24VDC) ceiling fans anywhere in the U.S. From traditional to modern, classical to custom design. For brochure and list of dealers send SASE to R.C.H., 2173 Rocky Crk Rd, Colville, WA 99114. Dealer inquiries welcome FAX 509-684-3973

START YOUR OWN TECHNICAL VENTURE! Don Lancaster's newly updated INCREDIBLE SECRET MONEY MACHINE II tells how. We now have autographed copies of the Guru's underground classic for $18.50, Synergetics Press, Box 809-HP, Thatcher, AZ 85552. (602) 428-4073, VISA/MC.

INTERESTED IN INTENTIONAL COMMUNITY? Growing Community Newsletter offers practical information about forming/joining intentional community. Alternative buildings and structures; home power generation; legal, financial & land options; food & agriculture; decision-making, consensus, leadership; conflict resolution; successful communities; communities now forming in the West. What works, what doesn't work, how not to reinvent the wheel. Quarterly, 16 p. Sample $3; one year $21. 1118-HP Round Butte, Ft. Collins, CO 80524, 303-490-1550

GENERATOR, CHINESE DIESEL, water cooled, electric start. 5KW to 25KW, Industrial grade. Prices start at $1995 Complete. China Farm Machinery Co. Tel (909) 657-0379 Fax (909) 657-8120

ELECTRIC MINIVAN by Jet Industries. 20 hp G.E. series motor, PMC controller, 12" radial tires. 102/12 Volt Lestronic battery charger. 21,000 miles. 50 mile range. $4800 with new 102 Volt battery, $3900 w/o battery. 916-284-7849 Bill

---

CRYSTAL SET HANDBOOK build crystal sets, listen to AM radio without batteries or electricity. Includes projects, formulas, and 3 issues of our newsletter, $12.95. Join the XTAL Set Society, receive 6 newsletters, $9.95. POB 3026, St Louis MO 63130

EARTH-SHELTERED HOMES This definitive manual by noted authority Loren Impson features detailed building instructions for the amazingly affordable and practical Ferro-Cement Dome Home. Only $15 from Sun Life P.O.Box 453, Hot Springs AR 71902

NO BIG AD JUST GOOD HONEST SERVICE, prices and equipment. Dealer for Kyocera–Bobier–Dekka Batteries–Trace–Wind Baron and much more. Over 18 years experience with complete design and installation available. Solar Supply and Engineering, 39 Courtland, Rockford, Michigan 49341 (616) 866-5111. Call or write for FREE catalog.

WAREHOUSE SALES has access to a quantity of non-moving/slow moving Photovoltaic related products and is selling it to the retail public at drastically reduced prices. This is older inventory that has been replaced by newer model equipment as well as excessive stock of certain items. All equipment is new & in good working condition and your cost is well below regular retail. Please call Toll Free 1-800-223-7974 for a free 12 page list of sale items, or write to: Warehouse Sales — P.O. Box 14670 — Scottsdale, AZ 85267-4670

HEAT EXCHANGER. Liquid to liquid. Mounted in the top of a tank it offers efficient delivery of domestic hot water from passive water storage tank. Used in the bottom it will deliver heat from the solar anti-freeze system to the tank. $250 + shipping. Call/write for free brochure and specs. Prairie Technologies, P.O.Box 2132, Iowa City, IA 52244. (319) 338-0836.

SOUTHEAST ARIZONA (Tombstone-Bisbee-Sierra Vista) 160 acres adjacent to federal riparian habitat preserve (San Pedro River) 4000', grass/mesquite, 2BR doublewide MH, 12'x20' shop/shed, well, 400w PV w/tracker, Trace inverter, $128,000. Incredible views, isolation, quiet, perfect climate. Call 505-585-9655 for more info.

BUILD YOUR OWN MINI PV PANELS for charging small nicads. Simple method costs less than three dollars per charger. Five dollars for plans and list of ideas for the feeding, watering and protection of crops, livestock and people. Remote automatic sensing and controls. SASE and one dollar for list. P.O. 1584 Tuolumne, CA 95379

"SELF-REGENERATING" Electric Auto. Info. $2.00 (SASE) Ganther Engine Works, P.O. Box 1144 HP, Marshfield, WI 54449

FOR SALE 3.5 ACRES and 30 x 56, 3 bed rm house, 24 x 30 attached garage thru breezeway, deck, ground source heat pump. House fronted by pond, stocked with fish, sand beach, child's pole tree house, good location, scenic overview, good solar site, good wind site. 2 mi west of Princeton, MO on 136 acres $120,000. Ph 515-876-5665.

SPECIAL PURCHASE OF GNB ABSOLYTE II & IIP (Gell Cell). The Best Gell Cells You Can Buy! These batteries are surplus, but in like new condition. Save over 75% by buying surplus over new. • 100A–45, 840 A/H, cost@12V $840. 24V $1680. Dimensions@12V—L22 1/8" X H17 3/8" X D24 5/8" weight 750#s. Dimensions@24V—L22 1/8" X H34 1/2" X D24 5/8" weight 1500#s. • 100A–45 1680 A/H Cost@12V $1680, 24V $3200. Dimensions@12V—L22 1/8" X H34 1/2" X D24 5/8" weight 1500#s. Dimensions@24V—L22 1/8" X H69" X D24 5/8" weight 3000 #s. • No water additions or hydrometer readings are required. Freeze tolerance is -40° F. 1200 cycles to 80% of the capacity at 77°. 2400 cycles at 50% of the capacity at 77°. Northwest Energy Storage, 10418 Hwy 95 N, Sandpoint, ID 83864, (208) 263-6142.

What Are You Missing?

Need some back issues of Home Power?

If you don't know what you're missing, check out the index in HP#42. Issue 42 contains an index of articles in issues #1–#41.

You can buy them individually:

$3.00 each for #11, #13, #14, and #16 through #20
$4.50 each for #21 through #43 (except for #36)

Or

Deal #1: buy all 30 available issues for $90

Deal #2: buy 6 or more issues (of #21 through #41) for $3.50 each (sent bound printed matter).

for U.S. ZIP codes only, see page 81 for international back issues.

(Sorry, we're out of issues 1 through 10, #12 , #15 and #36). We are planning to compile them into a book. Until then, borrow from a friend. If you have a computer (or a friend with one) download the article you're missing by calling the Home Power bulletin board at 707-822-8640. Or check with your local library; through interlibrary loan, you can get these back issues. Jackson County Library in Oregon has all issues as does the Alfred Mann Library at Cornell Univ.)

Home Power, POB 520, Ashland, OR 97520 • 916-475-0830 VISA / MC

Index to Advertisers

Home Power's Mercantile

One insertion per customer per issue. $80 per insertion paid in advance. Your cancelled check is your receipt.

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #44

December 1994 / January 1995

$3.50 U.S.

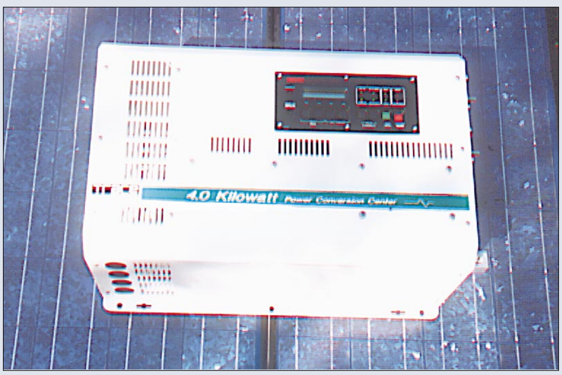
$4.95 CAN.

Display until February 1

No Power? No Problem!

From System Design to Installation...
Renewable Energy systems for your home and lifestyle.
Electron Connection - Call Toll Free 1-800-945-7587
Photovoltaics • Microhydro • Wind • Water Pumping
Consultation • Site Survey • Direct & Mail-order Sales • Installations
CA Electrical Lic#613554

TRACE ENGINEERING

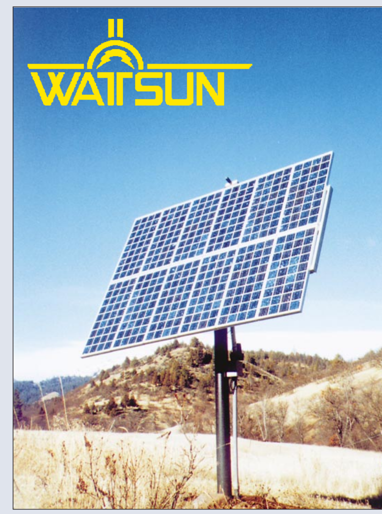


Trace 4,000 watt Sinewave Inverter
Equally at home on or off the grid!
Utility intertie and battery — the best of both worlds!
Super sophisticated battery charger
Clean sinewave power
Over 90% efficiency and low idle power

In Stock!

Sun Spot™ Solar Oven
- *Lightweight — 1¼ pounds!*
- *Portable — it folds up!*
- *Expandable cooking chamber!*
- *Heats to 350°F!*

$30 shipped free in USA



WATTSUN all-electric trackers.
Unaffected by wind or temperature.
Up to 40% more power from your PVs.
Single or Dual Axis Trackers available. CALL!

Dear Folks,
Electron Connection doesn't publish a catalog. There's lots of them out there already and I can't see wasting the trees for yet another one. If there is some particular product or system that you're interested in, I'll be happy to send you product literature and information.

I specialize in custom solar, wind, and hydro systems design and safe, code compliant installations. If I can help you with a project, please write or call with the specifics.

Thanks & Merry Christmas!,

Bob-O

- **Photovoltaics —** Solarex - Siemens - BP
- **High-Quality Batteries —**Trojan - US Battery
- **Power Inverters —** Trace Engineering - PowerStar - Exeltech - Vanner
- **Instrumentation —** Cruising Equipment - Fluke - Wavetek
- **Charge Controllers —** Heliotrope General - SunAmp - Trace
- **Trackers & PV Mounts —** WATTSUN - Zomeworks
- **Microhydro Electric Powerplants —** Harris Hydro - Lil Otto Hydroworks! - ES&D
- **Pumps —** Solar Slowpump™ - Flowlight - Solarjack - SHURflo - A.Y. McDonald
- **Water Heaters —** Myson – Aquastar
- **Solar Cooking —** Sun Oven - Sun Spot

• Sun Frost • APT • Heinemann • Cutler & Hammer • Square D Products

OptaPhone+
OptaPhone STAR
Authorized Dealer & Installer

SOLAREX

SIEMENS ProCharger™ 4

BP

SUN FROST

PowerStar™ PRODUCTS • INCORPORATED

Trojan The Better Battery

EXELTECH

SERIOUS DEALER INQUIRIES INVITED
Join Electron Connection's growing network of home power installing dealers. I offer dealers technical support, system design assistance, prompt shipment, and fair pricing. Electrical competence required. Find out why Electron Connection's dealers are prospering!
Write today for your dealer application.

Electron Connection
POB 203, Hornbrook, CA 96044 USA
VOICE • FAX 916-475-3401
Internet: econnect@snowcrest.net