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HOME POWER
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Home Power
THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Think About It

"But whether it be dream or truth, to do well is what matters. If it be truth, for truth's sake. If not, then to gain friends for the time when we awaken "

Pedro Calderón de la Barca. 1600-1681.

Cover

David Palumbo stands before his PV powered home and business. Twenty-four PV modules are mounted on rooftop trackers.

Photo by Jay Kennedy

From Us To **YOU**

EMPOWERMENT

Home Power Magazine is so much fun to be a part of.

We and you are surfing a major positive wave of human history: the inexorable swell of Empowerment.

And we get to do so during the exciting late 20th century, while that lofty surge crests and builds on the loving labors of so many beloved ancient and current souls. We are in the tube, stokers, with walls all glasseous.

How do we read the state of the wave ? Well, all you readers can just watch the magazine. The increase in number and sophistication of the advertisers, the ads, the writers, and the articles. Me, I get a special viewpoint by virtue of being the letter column pinhead. The HP mail I consider to be the prime pulsebeat of this home power revolution.

And how is the mail ? Just GREAT. We could publish a whole issue of nothing but letters from excited empowered readers. And, now that we charge $$$, we're even getting constructive loving criticism. Signs of vigorous dynamic health.

Empowerment: We pass on to you what we have learned, knowing you shall further its journey. Building change steadily, inexorably, via a broad base of distributed connected intelligence and heart.

Power has often been closely held. We who are its democraticians offer it to all interested parties. Power to the people. Home-based, of course.

SK

A Note On Subscriptions & Back Issues

Several readers have asked us to begin their subscriptions with a back issue. We are unfortunately unable to do so, and thought we'd explain why.

It's ruthlessly simple. When a magazine goes out as part of our normal print-and-mail routine, the costs are enough under $1 that we can stay in business charging that amount per issue. When a magazine goes out as a back issue, special handling and first class mailing costs jack us up to well over $1. We can stay in business charging $2 per back issue. But no less.

So, if you want to get all issues, just include money for back issues with your subscription. And thanks for understanding. And for the subs and back issue orders.

KP

We Can Never Have Enough Of Nature

Selections from the Spring section of Walden

Henry David Thoreau

Our village life would stagnate if it were not for the unexplored forests and meadows which surround it.

We need the tonic of wildness -- to wade sometimes in marshes where the bittern and the meadow-hen lurk, and hear the booming of the snipe; to smell the whispering sedge where only some wilder and more solitary fowl builds her nest, and the mink crawls with its belly close to the ground.

At the same time that we are earnest to explore and learn all things, we require that all things be mysterious and unexplorable, that land and sea be infinitely wild, unsurveyed and unfathomed by us because unfathomable.

We can never have enough of Nature.

We must be refreshed by the sight of inexhaustible vigor, vast and Titanic features, the seacoast with its wrecks, the wilderness with its living and decaying trees, the thundercloud, and the rain which lasts three weeks and produces freshets.

We need to witness our own limits transgressed, and some life pasturing freely where we never wander.

Independent Power & Light!

David Palumbo

When we decided to make our home in the beautiful Green Mountains of northern Vermont, we had no idea where this new adventure would take us. Looking back at our decision of six years ago to produce our own electricity for our new homesite, I am amazed at how this one choice had such a profound effect on our lives.

The Palumbo Family

Our family is comprised of my wife Mary Val, our son Forrest (four years old), our daughter Kiah (two years), our latest addition Coretta (ten months), and myself.

Mary Val and I purchased land in Hyde Park, Vermont during the summer of 1984. At this time that we began researching the alternatives to paying the local utility $6,000 to connect us to their line one-half mile away. We were encouraged by friends who produced their own power and a visit to Peter Talmage's home in Kennebunkport, Maine. We decided to "take the road less traveled, and that has make all the difference" as Robert Frost (a Vermonter) put it so well. Talmage Engineering supplied the majority of the hardware, and Peter answered my questions. We now use alternative energy at all three of our buildings. Let's look at each in turn, as they occurred in time.

The Cherry House System

In the spring of 1985, while living out of a tent, we built what we call the "Cherry House". This is first of three buildings designed by M.B. Cushman Design of Stowe, Vermont. The Cherry House is a two-story saltbox with 950 square feet of living space, heated by a small wood stove. Power for constructing the Cherry House was supplied by a Winco 4,000 Watt, slow speed, engine/generator that runs on propane. Energy consumption for the completed house was estimated at 1,300 Watt-hours per day. As our primary power source we purchased ten Solenergy 30 Watt PV panels that were on the market as seconds in early 1985. The array was cost efficient, but not really large enough to satisfy our growing power needs. Our battery bank, for the Cherry House, consists of eight Surette T-12-140 deep cycle lead-acid batteries totaling 1,120 Ampere-hours at 12 Volts. Our loads for this house included our Dometic 12 VDC refrigerator/freezer (seven cubic feet). We added rigid insulation to reduce the Dometic's power consumption to 420 Watt-hours per day. Other loads in the Cherry House include a variety of REC Thin Lite DC fluorescents and a 10 inch Zenith color TV set consuming 4.5 Amperes at 12 Volts. When our children began arriving, we added a washing machine and a clothes dryer. The washer and dryer are powered by the Winco generator through the automatic transfer switch built into our Trace 1512 inverter/charger. The transfer switch and charger in the Trace inverter allow us to charge our battery bank and wash the diapers at the same time, all powered by the Winco generator.

The Palumbo Family, David, Mary Val, Kiah, Forrest, and Cory.
Photo by Jay Kennedy, Village Photographer.

The Trace 1512 could not handle the surges of the washing machine. The newer model Trace 2012 will handle most washing machines. We used the Winco propane fired generator to do the laundry and to help our undersized PV array charge our batteries. The generator was also essential (until we later developed our microhydro site) because we are located in one of the cloudier parts of the country. For example, during our first November here we had one day of full sun followed by a delightful December with three full days of sunshine. Wow! We eventually decided to add a hydro system, since rainfall is generally plentiful here, and our site has the elevation differential to support the hydro.

The Barn & Shop System

During the summer of 1987 we built The Barn with three horse stalls, a 500 square foot work shop, and plenty of storage space on the second floor. The Barn is located 450 feet from the Cherry House and 250 feet from the site for the Big House. The distances between these buildings presented us with two choices for the overall power plan. First, we could centralize a battery bank and inverter large enough to handle all of our power needs via 115 vac.

The Cherry House with ten Solenergy 30 Watt PV modules on the roof.
Photo by Jay Kennedy, Village Photographer.

The second choice was to have a separate battery bank in each of the three buildings. I went with the second option because we were building incrementally and the "whole" was only a fuzzy image in our mind's eye early in the project. Also, I was entering a new business, as a designer and installer of alternative power systems. The added experience of three separate systems was desirable and influenced my decision.

Three separate systems may not be the most efficient way to go. I am presently working on another large remote site, with three buildings, several miles north of our land. This installation will take advantage of the products available today. Specifically, NiCad batteries and a powerful inverter located in the garage/shop serving as the power center for all three buildings. The advantages of this approach include saving time & money in wiring, and the ability to use a higher battery bank voltage. This higher system voltage allows the charge source (in this case, PVs) to be located further from the batteries without using the more costly, large diameter wires. For this site, I am designing the system with a 48 Volt battery bank.

Our Barn's power system consists of four Trojan L-16W deep-cycle, lead-acid batteries with a capacity of 700 Ampere-hours at 12 Volts. We are using the Heliotrope PSTT 2,300 Watt inverter. This inverter has worked well in the shop, powering all of the tools expect those requiring 240 vac, which are sourced by the generator. We sold the 4,000 Watt Winco and replaced it with a Winco 12,500 Watt, slow speed, propane engine/generator. We did this because our carpenter needed to use a high powered air compressor with a six horsepower electric motor. The other machines powered by the generator include a large table saw, an eight inch planer, and a six inch joiner. We wired the big Winco so that we are able to turn it on or off from any of the three buildings, using remote four way switches activating the 12 Volt solenoid and starter switch at the generator. The remainder of the electrical loads in the Barn/Shop are all lighting. We used Thin-Lite brand DC fluorescents throughout and are very happy with them. Since the shop is the only heated space in the Barn, cold weather light operation was a must. The Thin-Lites work well in the cold. They are efficient, for example they produce 3,150 lumens of light from a standard 40 Watt fluorescent tube. At 78.7 Lumens per Watt, this is 25% higher than the highly praised PL lights. The 40 Watt tubes are inexpensive, locally available, and come in a wide variety of spectral outputs.

The Heliotrope inverters do not contain battery chargers (like the Trace models). We use a Silver Beauty battery charger that charges the Trojans quite well from the Winco. However, this battery charger must be turned on with a timer switch as it doesn't have the programmable features of the sophisticated charger built-into the Trace inverter/chargers.

The Big House

We felt a traditional, New England, colonial home design offered the features we wanted at a reasonable cost. We were looking for a lot of space, energy efficiency, and country charm. By using all of the space under the roof, we have been able to build a home with 5,300 square feet of heated space. All of this sits on a "footprint" of 2,160 square feet. The Big House has a full basement, except under the garage, that houses the boiler room, the battery & control room, a large play area for the kids, and the cold, root & wine, cellars. Without cramping, we can store up to six cords of wood in the basement to augment the wood sheds outside the garage, which hold seven cords.

We have over 100 acres of good forest land that we are managing for both timber production and wildlife habitat. Our woodlots have a sustained yield of over 1 cord per acre per year to supply our buildings with heat from this renewable resource. "Big's" heat is produced by an Essex Multifuel boiler rated at 140,000 BTUs. We use it as an oil burner only very occasionally, it is mostly fueled by wood. The Essex has a ten cubic foot firebox and cycles on and off to satisfy the thermostats in our four heating zones within the Big House. The Essex burns by a gasification process and is 95% efficient on wood while producing no creosote emissions. We also get all of our domestic hot water from this 1,500 pound beast's two 6 GPM heating coils. We use about 15 cords of hardwood per year to heat the Big House and its water. I hope to install a solar hot water heater soon so I can take a summer vacation from loading firewood and shoveling ashes out of the Essex.

MicroHydro

I began to think about water power after the first rainy fall of 1985, and by 1987 we began work on our microhydro project. We built a pond on the highest site on our property. The pond is situated on ideal soils (heavy silt on top of glacial hardpan) for pond construction. Our pond is kept full by below surface springs and surface run off.

The pond's surface is 210 feet in elevation (known as head) above our turbine. The pipeline (penstock) is buried under the pond's dam and to a depth of four feet for its entire 1,250 foot run. The inside diameter of the pipe is two inches. I vary the water's flow rate depending on how much power we need, while trying to keep the pond reasonably full. By changing the hydro's nozzle from 1/4 to 3/8 inches, I change the flow rate from 17.5 to 38 GPM.

The turbine is an Energy Systems & Design IAT-1 1/2 Induction Generator. It was chosen for this application because of the cost of the long wire runs going from the turbine building to the three buildings. The induction generator makes 3 phase, high voltage ac current, and the higher voltage requires smaller gauge wire on long runs. The longest of these runs is 450 feet to the Cherry House. In retrospect, I would have been better off swallowing the additional expense of larger wires (≈$600) and going with a 24 Volt DC high output alternator, instead of the 200+ vac induction unit.

What I have now is a more complex system because of the three phase ac induction generator. This generator requires just the right amount of capacitance at the generator, and it requires properly sized transformers & rectifiers at each of the battery banks. The biggest problem is that neither the manufacturer, nor anyone else, could accurately specify what was needed for capacitors, transformers, or rectifiers. This is highly site specific, and in our system complicated because we are using the power at three places, each with its own transformer. I finally got the system to put out the power we needed by replacing the induction generator, capacitors and transformers with different sizes. This setup was determined experimentally. It was very frustrating, time consuming and expensive.

Our hydro system is now producing 240 Watts with a 1/4 inch nozzle installed at a net head of 203 feet; this works out to an overall efficiency of 36%. With the 3/8 inch nozzle installed the system produces 430 Watts at a net head of 187 feet; this is an efficiency of 31%.

The Big House's PV Array

As you can see in the photos, putting trackers on the roof is an interesting design feature and a challenging installation. I first got the idea while visiting Richard Gottlieb and Carol Levin of Sunnyside Solar near Brattleboro, Vermont. They have an 8 panel Zomeworks tracker mounted on their garage roof. Why put the tracker on the roof? There are three advantages for us in this application. First, it gets the PV array way up high-- the top of our arrays are 32 feet above the ground. This drastically reduced the number of trees we had to clear to get the sun on the panels. And second, it saves space on the ground for other things like sand boxes and gardens. Thrid, we don't have to look our over the trackers from our windows.

Why use trackers this far north? Usually we do not specify them here because at our latitude (45°N.) they add only ≈6% to the PV power production during the winter and ≈22% of the year. The reason we went with the Zomeworks Track Racks is because we have a hybrid system. I sized the PV arrays to meet all of charging needs during the summer. Our summer is a dry time and our hydro system cannot be relied on then. The trackers add ≈33% to the PVs' power production during the summer. Therefore, I reduced the total number of panels from 32 to 24 by using the trackers. The cost of the trackers was offset by the reduced cost of the downsized PV arrays.

PV Installation

Each of the two arrays above our garage roof holds 12 Kyocera 48 Watt PV modules for a total of 1,152 peak Watts of solar produced power. Over the year our Kyocera panels have consistently outperformed their manufacturer's ratings. On a recent April day, I observed an array current of 42 Amps at 28 VDC. This occurred on a day when the sky had many puffy, white clouds (known as cloud enhancement). On a clear sky, typically I measure 37.7 Amperes charging our 24 VDC battery bank. I have an analog ammeter installed in the cover of the fused PV disconnect for quick

The Big House during the winter with David standing out front. Note the twenty-four Kyocera PV modules on two, roof-mounted Zomeworks trackers.
Photo by Jay Kennedy, Village Photographer.

checks. For more accuracy, I use the millivolt scale on my Fluke 23 multimeter to measure the voltage drop across the precision (0.25%) 50 millivolt shunt on our Thomson & Howe Ampere-hour meter (see HP#11, "Things that Work!" article). A 48 Watt Kyocera panel is rated at 2.89 Amperes, but I measure 3.14 Amperes per panel.

The 24 Kyocera J-48 modules are mounted on two Zomeworks pole-mounted Track Racks. Each tracker was placed on its pipe mast by a crane operated by an expert and a crew of three helpers on the roof. Hiring the crane cost $210 and was worth that and more. Installation in any other fashion would have been asking for trouble- possibly fatal damage to the PV/Trackers and/or potential injury to yours truly and my crew.

The pipe masts themselves are 5 inch schedule 40 steel, each 17 feet long. The masts were cut seven feet from the base and later spliced with a four foot section of 4 inch pipe inside the 5 inch pipes. The splice was necessary because the full 17 feet length would not fit into my shop easily nor would it push up through the roof easily. The lower section of the mast (7 ft.) had a 18 inch by 18 inch plate of 1/2 inch steel welded on its bottom. The steel plate was drilled out for 3 one-half inch lag bolts along each side. The masts were bolted down with eight bolts per mast. The lag bolts went through the 3/4 inch tongue & groove plywood decking and into the 2X10 floor joists and added box bridging. The upper section of the mast (10 feet) was lowered through the hole in the roof by two men to a third man guiding it into the splice insert. A standard roof flange of aluminum and rubber was then placed over the top of the pipe mast and seated onto the roof where it sits under the high shingles and over the low shingles. The seam where the roof flange and pipe meet is sealed with a type of butyl tape called Miracle Seal. This thick, pliable tape expands and contracts with the steel pipe during changes in temperature.

Using a crane to install the trackers with PV modules already attached and wired. Photo by Jay Kennedy, Village Photographer.

The last detail of the mast's installation was fastening the pipe to the roof rafter for stability. Absolute rigidity is as important here as it is at the base plate. Consult with a local building expert or structural engineer if there is any doubt about your roof mounted tracker. We placed the masts right next to a 2X12 roof rafter, added shims there to tighten this union, and then securely bolted the pipe to the rafter with a large steel U bolt. With the pipe fastened securely at its base and at ten feet (leaving seven feet above the roof), we met the Zomeworks installation requirement that half of the mast be buried in concrete below grade. I have witnessed wind gusts of over 55 MPH make the arrays flutter from side to side (buffered by the shock absorbers on the trackers), but the same gusts do not move the pipe masts at all.

We drilled a small weep hole at the very bottom of the pipes to drain condensation and prevent rusting from inside. The pipe masts were grounded for lightning protection with #4 bare copper wire at the base plates. The ground wires were bonded together with a split bolt connector. to a common wire which ended in an eight foot driven ground rod bonded to the main system ground.

The arrays were mounted on their trackers in our garage and wired in series and parallel for 24 Volt operation. Module interconnections were made with #10 sunlight resistant, 2 conductor, Chester Cable terminated in a junction box on each tracker. Once the arrays were in place, we came out of each junction box with #8 ga. Chester Cable. We clamped the cable to the tracker for strain relief and fed it down through a hole tapped on the top of the Track Rack's pipe fitting. A weatherproof connector was used here. Of course, a loop of cable was used as slack before entering the pipe, to be taken up during the tracker's movement over the course of the day. The cable was then fished out of the pipe via another hole tapped at ceiling height and a Romex connector was used here. The two cables were run to the center of the room where a junction box fed with #0 ga. copper cable awaited them. The length of each #8 ga. cable is 26 feet. The length of the #0 ga. copper cable run from the junction box, back through the house, and down to the battery is 90 feet.

Battery Bank and Big House Loads

Our storage batteries at the Big House are Trojan J-185 deep-cycle, lead-acid types. We use 14 of these 185 Ampere-hour batteries in a 24 Volt configuration for a total of 1,295 Ampere-hours (31 kiloWatt-hours) of storage. In our system they are an economical choice because we normally do not cycle them below 50% of capacity. The Big House receives 4.8 kWh per day from the hydro when the 1/4 inch nozzle is being used, and 8 kWh per day with the 3/8 inch nozzle. The hydro power is often switched off at the Big House when the sun is shining, and all the power goes to the Barn and the Cherry House. The PV panels produced an average of 3.9 kWh per day as measured during March and April of 1990 by the

T&H Amp-hour accumulator.

Voltage is controlled at all three of our battery banks by Enermaxer shunt regulators. I chose the Enermaxer because all of our battery banks are charged by multiple sources. The Cherry House is charged by PVs, hydro and an engine/generator. The Big House is also charged by these three sources, while the Barn is charged by hydro and engine/generator. The Enermaxer is connected to the battery bank and to shunt loads. It doesn't matter what the charging

David Palumbo in the power room of the Big House.
Photo by Jay Kennedy, Village Photographer.

sources are as long as the current rating of the shunt loads are equivalent to the highest possible amperage of all charging sources combined at that particular battery. The Enermaxer works well because it smoothly tapers the voltage of the batteries to optimum float voltage (user adjustable to a tenth of a volt).

We average about 4.8 kWh per day of power consumption in the Big House, with 6 kWh peak during a busy, winter-time wash day. We are able to satisfy our power requirements and keep our battery bank quite full without using the generator because of our hybrid PV/microhydro system.

The loads in the Big House (14 rooms plus a full basement) are typical for a busy family of five. Various lighting products (all DC) have been used with good results including LEDs for night lights. During our long winters, we average around 140 Ampere-hours or 3,360 Watt-hours used on lighting per day. Other 24 VDC loads include a Sun Frost R-19 (19 cu. ft. refrigerator) and a Sun Frost F-10 (10 cu. ft. freezer). I recently recorded their individual power consumption on my portable T&H Amp-hour meter over a test period of 3 days averaging a room temperature of 70°F. The R-19 used 23 Ampere-hours (552 Watt-hours) per day. The F-10 used 28.65 Ampere-hours (688 Watt-hours) per day.

Our 120 vac loads include a washing machine (350 Watt-hours per use), a clothes dryer (propane fired with electric motor- 150 Watt-hours per use), an automatic dishwasher (275 Watt-hours per use), a stereo system, a 19 inch color TV that uses 80 Watts with the VCR (65 Watts alone), the controls on the Essex boiler (40 Watts), and other appliances/tools. Our total average 120 vac power consumption per day has been running around 2.5 kWh per day.

The inverter we are using is the Trace 2024 with stand-by battery charger, turbo cooling fan and remote digital metering. It is able to handle the washer, dryer, and dishwasher all at the same time. We do the laundry during the sunny days whenever possible because the batteries are full by the afternoon and the Enermaxer would just be shunting off the power surplus. A better use of the sun's energy is cleaning our 14 loads of laundry per week!

The Big House has more than satisfied our goals for an energy efficient, comfortable, and versatile home for our family and my growing alternative energy business. It has helped bring alternative energy into the mainstream in our area. Our home power system is a demonstration for those considering alternative energy as their power source. It is also an example for bankers who are hesitant about lending on non-grid connected property. We have been able to open some eyes and get a few projects going that would otherwise never left the drawing board.

I wish to thank those contributors I have already mentioned. Also all the fine people who worked on the project, most notably, Gary Cole (Electrician), George Stone (Carpenter), and David Vissering (Jack of All Trades).

Total System Costs

The below total includes all of the excavation, conduit, and wiring used for the underground burials between the three buildings.

Access

David Palumbo operates as Independent Power & Light, RR#1, Box 3054, Hyde Park, VT 05655 • 802-888-7194.

COST	ITEM
$22,400	Wire, cables, conduit, fuses, breakers, distribution panels, disconnects, boxes, fans, & all labor
$5,600	Cherry House System- including generator, refirgerator, lighting, all wiring and labor.
$4,500	Winco 12,500 Watt Generator setup.
$4,377	Microhydro System- includes everything except building the pond and turbine shed
$3,700	Barn System- everything included
	Big House System Specifics
$9,500	Tracked PV Arrays- 24 @ Kyocera J48 Modules, 2 @ Zomeworks Trackers, installation, etc.
$3,800	Sun Frost R-19 Refrigerator and Sun Frost F-10 Freezer
$3,125	DC Lighting- high efficiency 24 VDC fluorescent lighting
$2,250	Battery Bank- 14 @ Trojan J-185 lead-acid batteries
$1,650	Trace 2024 Inverter with battery charger, turbo, & remote metering
$695	Controls and Instrumentation
$61,597	GRAND TOTAL OF ALL THREE SYSTEMS INCLUDING INTERCONNECTION

IMPORTANT PRODUCT UPDATE

Heliotrope General has just announced the major redesign of the CC-60 charge controller. The updated model, the CC-60B has three major changes. 1) A higher state of charge voltage range which now allows charging of **NI-CAD** batteries. 2) Test output jack which allows measurement of panel voltage, battery voltage and PV charge current rate in Amps. All of these measurements can be made with a voltmeter. 3) **LOW VOLTAGE DISCONNECT** option is now available. The selectable low voltage disconnect is designed to protect your battery bank from harmful and permanent discharge.

For more information contact:

Barry Brunyè or Ken Seiber
Heliotrope General
3733 Kenora Drive
Spring Valley CA 92077
800/552-8838 (in CA)
800/854-2674 (outside CA)

High in the Alaskan Mountians, photovoltaics provide electrical power far from commercial utilities and power lines. In the background is the Wrangell Mtn range and Fireweed Mountain. In the foreground, Kyocera J48 PVs make the power.
Photo by Ed LaChapelle.

Northern Sun Power

Ed LaChapelle and Meg Hunt

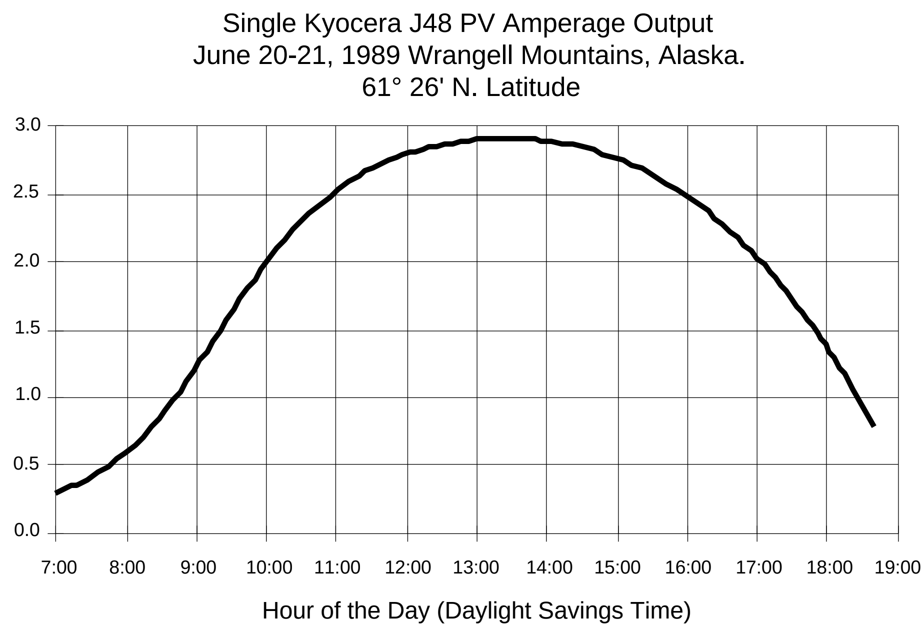
We were a long way out in the Alaskan bush, over 100 miles from the nearest power grid, and spending more & more time in a two-room log cabin while planning our bigger homestead. The little cabin worked on dry cell batteries for a radio, and kerosene lamps. The latter were a fire hazard and would never do on a larger scale. Photovoltaics were the obvious way to go, but we had to start from scratch on the design.

Seasonal Swings

At 61°28' N., the seasonal swings in power demand just for lighting would be huge. No solar insolation data for the area were available. Climate data and our own experience told us that prolonged periods of completely clear weather were limited, occurring mostly in the spring and fall. "Partly cloudy" was the most common sky description, often meaning cloudy part of the day, broken clouds, thin clouds, or clouds over part of the sky. None of these allows clear prediction of power output from solar panels. Our power requirements were also fuzzy, except that we knew they would probably increase as our bush lifestyle developed. All of these factors combined to make us go light on theory and heavy on empirical observations and hard experience.

Gathering Data

So we started out small. For the little cabin we had one Kyocera J-48 PV panel, one 200 Ampere-hour battery (used, from a fishing boat), one PL-13 lamp, a radio and a homebrew manual controller with a good ammeter. A car stereo outfit was added later. We started a regular program of logging panel output throughout the day in a variety of sky conditions. We experimented with panel location, angle and effect of tracking (by hand). When we were away for a couple of months our neighbors down valley, Kirk and Lisa Olsen-Gordon, also solar energy enthusiasts, took over the panel, controller and observations. They gathered many additional numbers for our growing tabulation of available sun power here in the mountains of south-central Alaska.



In the meantime we acquired and remodeled a much larger log cabin nearby. This was going to be our solar-powered homestead. By this time, we had accumulated enough of that hard earned experience to start projecting our power needs and figuring out what would be required to meet them. We took to heart a guiding principle of home power and started first on power conservation and load management.

Conservation

The best way to practice conservation is to unplug it altogether. Among other things, Meg found a good hand-powered coffee mill and an iron that could be heated on the stove top. She also retrofitted her sewing machine with a treadle, finding it more fun & powerful; besides it doesn't generate radio interference. We determined to use PL lamps, which combine good light qualities of incandescents with the power savings of fluorescents., We also knew that we needed to get more natural light into the typically dark log cabin so that we wouldn't use the lamps in the first place.

Skylights

The obvious way to get more light into a log cabin is through skylights. This can be a problem in snow country. The problem is not so much the considerable weight of the snow but what it does when it starts creeping and sliding. A skylight that sticks up from the surface of the roof is in for trouble. Fortunately, I devised a way to build skylights flush with the surface of the steel roofing. We have two 2 ft. x 2 ft. and one 1 ft. x 2 ft. skylights. These, along with existing windows, white panels in the ceiling and a pine floor give us enough light to go lampless from wakeup to after supper from March to October.

Constraints

Our site included a couple of constraints on our solar energy use. One was a surrounding small forest of poplars, the ubiquitous Alaskan weed tree. Fortunately our plans included adding a second storey library space to a separate shop building. A platform on the roof offered an ideal solar panel location, although it meant running about 75 ft. of cable to the batteries. Good solar access more than compensated for cable losses, figured to average around 5-7%. The other constraint was cold batteries. The logical battery location was in an existing cellar underneath the cabin, but in these latitudes not far south of the permafrost zone, the mean annual ground temperature is not far above freezing. The cellar gets well below freezing in winter and creeps up to about 45°F. by late summer. It makes a great refrigerator, but is not a happy place for lead-acid batteries. But it was the only place for the batteries to protect them from winter temperatures down to -60°F., which the cabin will cool to when left unheated. Our system design had to allow for loss of battery capacity, plus run a resistance heater in the battery compartment to compensate for temperature by using surplus power diverted from the PV array.

Final Design

Our final design included eight Kyocera J-48 photovoltaic panels, four Trojan L-16 batteries, a Trace 1512 inverter/charger and a pair of Trace C-30 controllers. This is pretty much a conventional package, but the whole system is hooked up in an unconventional fashion to solve some anticipated problems. A pair of controllers was the result.

Help

Early in the planning stage, I visited the Trace Engineering factory in Arlington, WA. I garnered much useful information from the helpful folks there. Mike Frost, Trace's design engineer, pointed out that when large loads are switched on and off the inverter, there are wide swings in the battery's voltage that could cause trouble for 12 volt electronics on the same battery. This set in motion the design of a split system to operate 12 volt circuits and the inverter from separate battery banks., This system has several advantages. For one thing, it is redundant, offering built-in back-up power in case something breaks down. It also becomes very flexible if provision is made to switch solar panels between the two parallel controller-battery circuits.

The Split-System Control

The heart of our photovoltaic system is a dual-channel controller built around two Trace C-30 PC boards. These boards have been modified by replacing the single pole single throw (SPST) relay with a physically identical relay with single pole double throw (SPDT) contact configuration. This allows the use of diversion power from the array. The A-channel (12 Volt circuits) switches diversion power through a separate controller (Trace C-30A) to charge auxiliary batteries, including a neighbor's hooked up through a set of jumper cables on the cabin's outside. The B-channel (inverter) feeds diversion power to the battery heater. Two solar panels are

Left: Untroubled by a spring thaw, Meg prepares the solar-powered freezer for food storage. Increasing the insulation on this freezer reduced its power consumption to half. Center: The exterior of the split-system charge controller with metering. Left: An interior view of the same charge controller. Photos by Ed LaChapelle.

permanently connected to the A-channel, two to the B-channel. The remaining four panels can be assigned to either channel through bistable impulse relays located in a junction box next to the solar panel array. These relays are controlled by momentary-close switches located on the controller along with LED status indicators for the switchable panels.

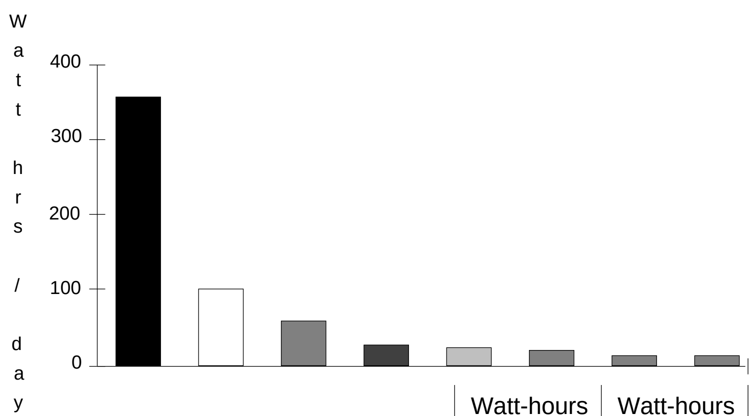
Engine/Generator Backup

When the sun appears only an hour or two a day around the winter solstice and cloudy weather is common, recharging the batteries with an auxiliary generator is essential. In choosing a generator we took careful heed of the fine print in the inverter manual warning about the importance of keeping up ac peak voltage to insure high-rate battery charging. The Onan 3.0 RV has proven very satisfactory in this respect, for it delivers full power even under heavy loads. It is a compact, 3600 rpm model with high-volume axial flow cooling. Located inside the shop space, its blast of hot air can serve as a useful auxiliary heat source. So far, under our present energy demands, we have not needed to use the generator at all from late February until mid-October; the solar panels do it all. Further, owing to the wonderful performance of our Trace 1512, we never have to use the generator to run power tools.

Array Angles

The solar panel array faces due south and has provision for seasonal adjustment of tilt angle. In winter mode, the array is tilted up 72° from horizontal, in summer mode, 48°. The angle is changed around the spring and fall equinoxes. Although some solar energy users at these latitudes simply hang their PV panels on the vertical south wall of buildings, we found that this is quite inefficient on cloudy days. Overall power production is optimum when the panels are tilted back far enough to allow exposure to bright clouds instead of dull trees, eventhough the panel angle may at times be a bit off from perpendicular to direct sun.

Where the electricity goes…



ITEM	Watt-hours per DAY	Watt-hours per WEEK
Freezer	357	2500
Lighting (PL-13 Fluorescents)	100	700
Electronic Typewriter	57	400
AM Receiver & Amplified Antenna	29	200
Short-wave Receiver & Weather Fax	25	175
Power Tools	21	150
Stereo	14	100
Appliances	14	100
TOTALS	618	4325

LaChapelle & Hunt Power Consumption

The town of McCarthy, Alaska. Once a big copper mining town, McCarthy now has about sixty residents in the summer and about ten hardy souls in the winter. If you have electricity in McCarthy, then you make it yourself. Photo by Ed LaChapelle.

Luxury

The installation was completed in the summer of 1987. Since then we have enjoyed the luxury of all the power we need, not only the practical benefits but also the sense of satisfaction from generating silent, pollution-free electricity. In 1989 we added a 12 volt freezer, the only major increment so far in our power consumption. As received from the manufacturer, this freezer was woefully under insulated and inefficient. We covered the body with an extra two inches of blue foam insulation. Then we installed it on the north side of the cabin, where it is well shaded and the condenser coil can draw cold air by convection from a crawl space underneath the cabin. This brought about a notable improvement in efficiency, with the duty cycle now ranging from around 35% down to 15% as mean daily temperature drops from 60°'s down to the 30°'s.

Problems

Our only problems have been cold batteries and radio interference. Even with the battery heater and insulation keeping the batteries about 10° above cellar temperature, the derated capacity still leaves little margin for extra power storage. This problem is compounded by the lack of provision for a finishing charge in the C-30 controllers. Thanks to the dual channel system with switchable panels, we can compensate in part my manually reducing charge rates to top off the batteries. In fact, we have come to believe that the ideal controller would achieve a tapering charge by successively disconnecting panels from the array, rather than trying to taper the full array current by pulse-width modulation.

Planned Improvement

Our next system improvement, scheduled for the summer of 1990, is to put in pocket-plate ni-cad batteries on the A-channel (12 volt circuits) and place all four L-16's on the B-channel (inverter and freezer). Again, the flexibility of the dual system comes in handy, for we can add ni-cads for part of the power storage without having

Solar System Material Cost

ITEM	COST
8 @ Kyocera J-48 PV Modules	$2,232
Onan 3.0RV Generator	$1,590
Trace 1512 inverter/charger/DMM	$1,310
4 @ Trojan L-16 Batteries & 4/0 Cables	$550
Cables, Relays, & Junction Boxes	$400
Controller Parts	$368
TOTAL	$6,450

to dump the lead-acid batteries and replace the whole works.

Radio Interference

Fighting radio interference from a PV system with an inverter is a whole story in itself. The problem is a critical one for us here. Our main radio reception depends on weak, remote fringe area signals from AM stations on the other side of some very big mountain ranges. Extensive shielding and filtering help. Isolating the radio power supplies to separate, auxiliary batteries helps even more. The inverter generates interference even in standby mode, so this is never used. A pushbutton and solenoid allow remote control of the inverter in the cellar, so we can turn it on only when ac power is actually required. We're still working on these RFI problems and are keen to exchange information with other Home Power readers.

Happy to Report

We're happy to report that home power is very much alive and well in our part of the world. Most households we know have or plan to acquire at least one or two panels. Some have systems as large as ours, some even larger. The National Park Service is presently installing a full PV system to power a ranger station across the mountains to the north of us. Owing to the low solar power available in mid-winter in these latitudes, gasoline or diesel auxiliary generators are common, as well as reliance on propane for lighting. Micro-hydro is getting some local attention these days and we know of one case in which full-time diesel generation has been passed up in favor of part-time generation to charge a battery-inverter system. In the next few years expect to see Alaska become a leader in modern alternative energy systems.

Access

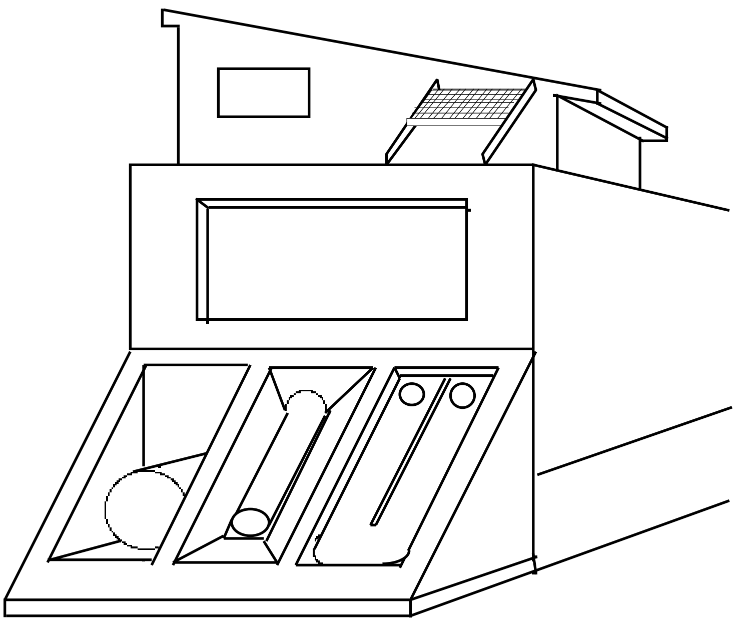
Ed LaChapelle and Meg Hunt, POB 92723, Anchorage, AK 99509

Meg &Ed enjoy the views from their second storey solar deck. The deck also serves for sunbathing & aurora-viewing.
Photo by Ed LaChapell and the autotimer.

"Hands-On" Solar Power

the CMC Energy Efficient Building Students 1989/90

The Colorado Mountain College (CMC) Energy Efficient Building Technology Program teaches the design and installation of solar and energy efficient building systems. Participants receive two semesters of hands-on building construction experience. This article, written by the class, details our recent state-of-the-art passive solar remodel. Client and class member, John D'Angelo volunteered his mobile home for the project. He purchased a trailer with solar retrofit potential. Four different solar systems were designed: 1) a larger window for direct gain heating and a better view; 2) a solar hot air collector; 3) a passive domestic solar hot water heater; and 4) a solar heated natural gas generator.



A drawing of the solar systems on John's trailer.

But First, INSULATE!

Comprehensive weatherization is a pre-requisite for solar space heating. Air leakage reduction (stopping drafts) should always precede "supply side" thinking. Caulking, insulation, storm windows, skirting, etc. are cost effective pre-solar heating procedures. John took advantage of his student status and qualified for the local energy center weatherization program. Now the solar power will work efficiently and help heat the trailer into the evening hours. It doesn't make sense to collect free solar heat if you allow it to leak out as fast as it comes in. Also, efficient domestic hot water strategies should always proceed any solar hot water heater. Quality low-flow shower heads, low flow plumbing fixtures and pipe insulation should always come first.

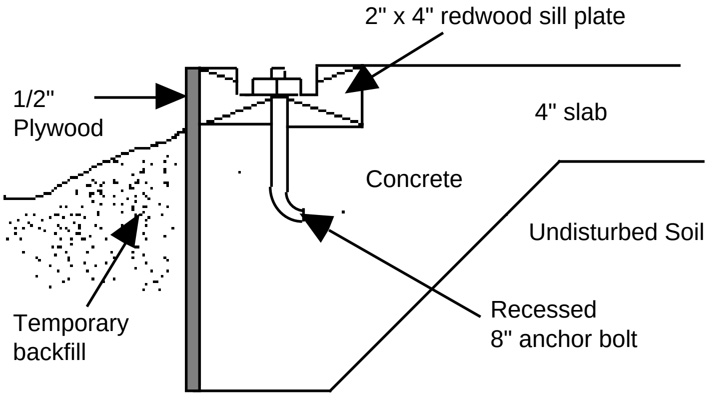
To complete John's solar retrofit he designed a solar powered natural gas generator. He dislikes cooking with electric (frustrating heat control and incompatible with his future PV system) and decided to produce "home grown" natural gas.

Site Preparation

We choose to build a permanent complete foundation system to support the heavy collectors.

The exterior of John DAngelo's trailer showing left to right, the methane digester,the solar hot water heater, and the fan assisted hot air collector. Above them, the passive solar window heats the trailer. On the roof, a photovoltaic panel provides electric power to run the active hot air system.
This trailer is located in the Colorado mountains, and even here solar energy can be cheaply and effectively used.

Photos by the CMC Crew.



The foundation of the solar systems on John's trailer.

"It's called concrete - not cement," reminded CMC instructors to the CMC class of 1990. Cement is just one ingredient in concrete.

The pour was small, 8' x 10', well planned and much work. We used a transit to establish proper elevation and excavated a rectangular slab. A plywood form with reinforced corners was built with drywall screws and cross-taped to establish square corners. The sill plate was attached directly to the inside of the form and anchor bolts were countersunk into the sill plate every few feet. Either pressure treated lumber or redwood can be used. By attaching the sill plate to the form before the concrete was poured, a nailing surface for the wall plate was permanently in place. This enabled us to easily screed the concrete level. The thickened edge slab perimeter was reinforced with # 4-1/2" rebar that was lapped and tied together to the dangling countersunk anchor bolts. Dirt was temporarily backfilled against the form and we were ready for the concrete.

The pour was short. We moved lots of concrete quickly. The concrete is rated at 4000 p.s.i. and reinforced with plastic fibers. By adding these fibers to the mix, we could eliminate the standard reinforcing 6" x 6" remesh.

There are many techniques for finishing concrete and I think we practiced nearly all of them. We took turns with the various floats, trowels, and brooms and experimented with different finishing techniques. Hours later, we covered up our work with rigid insulation to prevent it from freezing. Concrete needs three days without freezing to cure properly. Our slab was designed to support the weight of heavy collectors, but this foundation system works well for attached greenhouses and sun spaces.

Daytime Solar Heating

Daytime heating of our houses accounts for approximately one-third of our heating bills. Solar space heating systems that have no supplemental heat storage (like expensive rock boxes or water barrels) can offset a good portion of the daytime heating requirements. They are especially appropriate in living spaces where people are home during the day. Two types of these systems that we installed on this trailer are called Direct Gain (DG) and Fan-assisted Air Panel (FAPS).

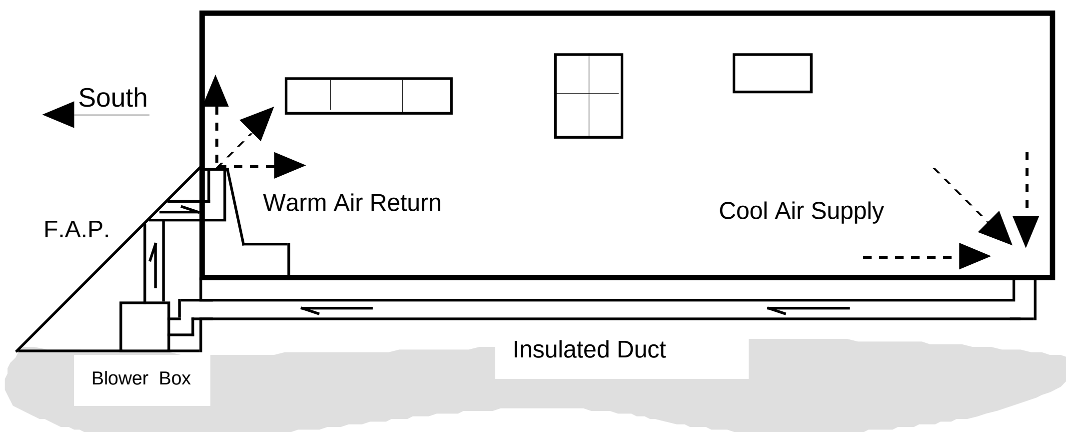
Direct Gain Systems

Direct Gain Systems use a window to allow the sun's heat into the house and some form of movable insulation (MI) to keep the heat in at night. The window or glazing is best at a vertical position to allow the low winter sun to penetrate. Effective movable insulation prevents nighttime heat loss and should have an edge seal, high R (insulation) value, a radiant barrier, and a vapor barrier. Simple MI can be a removable piece of rigid insulation cut to the exact size of the window. Thick homemade drapes with velcro on the edges will help keep the "building envelope" tight and warm. It is important to design DG systems to avoid overheating during the sunny winter days. In Colorado, we recommend the window area be no more that 15% of the heated floor area. "Too much of a good thing" like south facing windows often create uncomfortably hot and glary living areas. The size window we installed on John's trailer can effectively heat only half the trailer.

The window should be facing within 30 degrees of true south- the optimum range of orientation for all solar collectors. Facing east or west by 30 degrees only effects year round efficiency by 10%. East facing windows can provide early morning warm-up, but west facing windows often cause overheating in the spring, fall, and summer. A limiting factor of DG systems is that they are only appropriate for rooms with walls facing close to south.

Fan-assisted Air Panels

To solar heat north facing rooms, Fan-assisted Air Panels (FAPS) are a good strategy.



A schematic of the fan assisted hot air system..

The duct work, and a small solar electric blower move the air through a closed loop between the house and the collector. House air is pulled from a return grill in the north bedroom floor, through duct work, into the blower box and then pushed into the solar collector. A very short hot air supply duct (to minimize heat loss) supplies the warm air back into the house. The temperature of the air entering the house is 75° to 110° F. and varies with the amount of daily solar insolation. Higher temperatures may seem desirable, but actually very hot air lowers efficiency. It is more desirable to have lots of warm air than a smaller volume of hotter air. Since house air is sucked into the insulated return duct on the north side of the house, John receives the added benefit of improved warm air distribution. The blower on the FAP system distributes the heat from the DG window and the wood stove to the cooler end of the trailer.

Collector Tilt

In northern latitudes the rule of thumb for optimum wintertime tilt angle is latitude plus 15 degrees. For most of North America, this results in tilt angles of 45 to 65 degrees from horizontal. However, we prefer to mount solar air collectors directly to the vertical south facing wall. Ease of installation, avoidance of summertime overheating and increased ground reflection from snow have proven strong determinants. John's combination of solar systems and his trailer's south wall dictated a compromise tilt angle solution. For integrated aesthetics and simplicity we installed the air, water and natural gas generator systems all at 45 degrees.

Air Collector Specifications

The solar air collector was designed and built by the class in our campus workshop. Prior site inspection assured proper positioning and duct size. As with all solar air collectors, our system consisted of a frame, covered with a glazing and containing an absorber plate with an insulated air channel.

The frame was built of 24 and 26 gauge paintlock sheet metal fastened with pop-rivets and screws. All joints, seams, and connections were sealed with pure, clear silicone caulk to prevent air leakage. Sheet metal was chosen because it is durable, fire-resistant and inexpensive. Wood should never be used in solar air collectors. Despite how wood is treated, it can cause problems by out gassing and warping. Wood frames do not remain air tight and have charred from long-term exposure to the high temperatures typically reached inside the collector. The collector gets extremely hot when the blower is off. A "stagnated" collector regularly reaches interior temperatures more than 250° F.

The total collector frame size was determined by the glass unit dimensions. A 34" x 76" single pane of tempered, low iron, translucent, 5/32" thick glass was supported by the entire perimeter of the metal frame and protected with flashing. The glazing is isolated from the metal with E.P.D.M. tape and sealed in place with pure silicone caulk. The generous and continuous silicone bead gives structural support for the glass unit. The advantages of glass, versus plastic, as the glazing material are its high transmissivity and extremely long life span. For safety, always use tempered glass units. The standard sizes of low iron glass are 34" x 76", 34" x 96", 46" x 76", 46" x 96" and 46" x 120." Low iron "solar" glass offers maximum solar transmissivity. These units are available in either transparent (clear) or translucent (frosted) with solar transmittance gain the same for both types of glass. For aesthetics, we suggest translucent glass.

A special manufactured selective surface was our choice of material for the absorber plate. It's high absorptivity and low emissivity soaks up the sun's rays and doesn't re-radiate them back out the glass. Our thin (.002") copper selective surface absorber was pop-riveted to the sides of the frame and supported in the middle by an air channel guide. Black, pure silicone caulk was used to seal the seams. The criteria for designing a successful solar system absorber are high conductivity, maximum surface area, & durability.

Insulating the back and sides of the collector improves system performance. Only high temperature insulation is considered. We used 3/4" polyisocyanurate rigid board insulation. To prevent an insulation "meltdown," do not use any styrofoam insulation products. It is important to avoid any possibility, however remote, of the insulation out-gassing and causing air quality problems. We completely isolated the air flow channel with sheet metal thereby eliminating the possibility of long-term degradation that could result in an air quality concern.

Proper selection of materials and attention to detail will insure a high performance solar air collector. Always use non-toxic materials that can withstand high temperatures. Caulk and re-caulk to prevent air leakage. Pure silicone is proven to be the best when sealing metal to metal and glass to metal.

The total cost of the project was $451.01 including duct work and electrical parts. The solar panel was loaned to John from the CMC program.

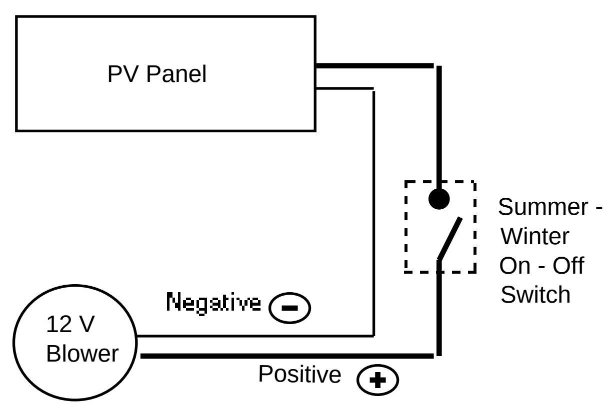
Solar Air System Distribution

A 6", 26 GA round duct insulated with 2 layers of foil ray, (foil coated bubble pack duct insulation); two registers - Inlet 6" x 12", Outlet 4"x 12"; 1 -12 volts, 5 amp shaded pole DC blower; 1 ply wood blower box - shop built, insulated, caulked with removable access panel.

Air System Controls

The controls of a conventional 110 volt FAP system consists of 2 thermostats. A regular heating thermostat is mounted at a central location in the space to be heated. Another thermostat is placed in an accessible spot within the warm air duct. The heating thermostat is set at a desired room temperature and functions like a normal furnace thermostat. The warm air thermostat is set to go on at 110° F and off at 90° F. In this system two conditions have to be met for the blower to turn on: 1) the room temperature has to drop below a desired level, and; 2) the air inside the collector has to reach at least 110° F. When the room reaches the set temperature or the air inside the panel falls below 90° F. the system shuts off.

John is a solar enthusiast and decided to have a Photovoltaic (solar electric) panel installed to power the blower.

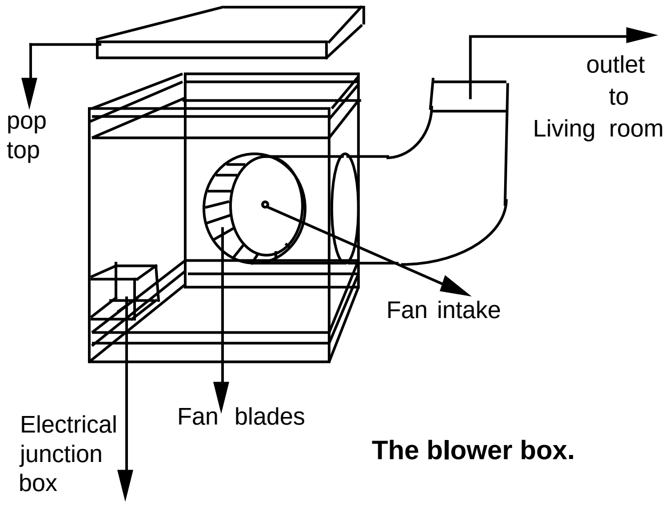


A schematic for the fan's electric system.

We mounted a 12 volt - 50 watt nominal PV module on the roof of his trailer at a 45 degree tilt. It is directly wired to the 12 volt DC blower with an on-off switch inside the trailer. Now, the sun does the control function. As sunlight heats the air inside the air collector, the PV module provides electricity powering the blower. The advantage of this system is that it works proportionally without any complicated devices. As solar energy increases the temperature inside the air collector, it also also increases electricity from the PV module. Therefore as the blower speed increases more warm solar air is blown into the trailer. Elegantly, the solar powered electricity is proportional to the amount of heat produced by the collector, thus making this control strategy almost ideal.

A Blower Box for the FAPS

To provide convenient installation of the electric blower for the solar



The blower box.

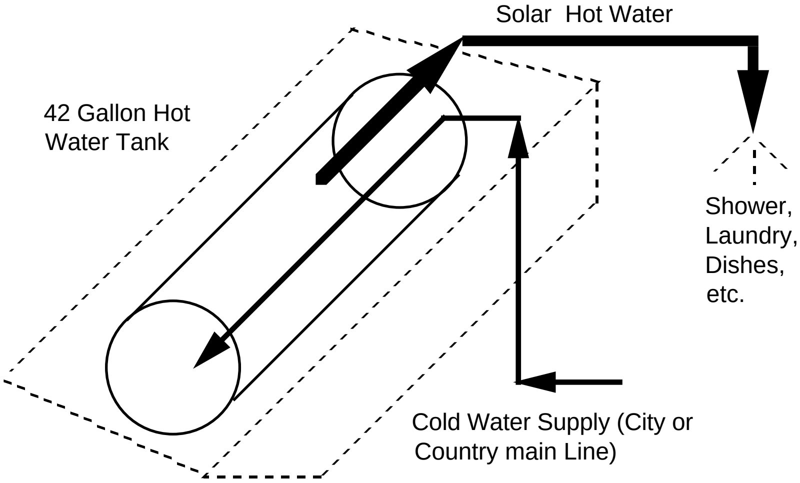
air system, we built a plywood plenum box.

This box simplifies duct work and maintenance procedures. The blower blows house air into the collector, keeping the collector under positive pressure. This prevents active cold air leakage into the hot collector. Installing the blower in the cool air duct also allows increased blower life by preventing motor overheating.

Passive Solar Domestic Hot Water System Design

John choose a batch solar hot water heater because it is so simple and almost maintenance free. There are no pumps, controls, sensors or mechanical BS. It is a black water tank inside an insulated box. A reflective surface inside the box increases the amount of solar energy striking the water tank. One commercially available unit is the Cornell Model 480. It has a fiberglass box with polyisocyanurate insulation, a steel tank wrapped with selective surface and an enhanced multi-layered glazing. Because it is insulated and contains a 42 gallons of water it has withstood outside temperatures of -35° F. Pipes that go into the tank must be heavily insulated or have electric heat tape to prevent freezing. We recommend both for Colorado's cold winters. Do-it-yourselfers should avoid building solar water heaters with wood or insulation that is not heat tolerant.

The solar water heater should provide 100% of John's hot water for eight months of the year and work as a preheater for the other four months. One 42 gallon batch heater usually provides an adequate amount of hot water for 2 people. For larger households, two or more batch heaters can be hooked up in series. Typically 20% of the total household energy goes to heat hot water. We estimate this system will provide 60-80% of John's hot water when supplemented with other efficiency measures such as energy efficient shower heads.



The solar hot water heater.

Installation Details

We installed the collector at 45° for aesthetic reasons and to use water's natural stratification to always obtain the warmest water possible. With the collector oriented and tilted correctly, plumbing began. Copper pipe (3/4" and 1/2") was used throughout. High temperature, low lead, 95/5 solder was used to solder all joints.

A tempering valve was installed to prevent "scalding" water temperatures from reaching faucets. It is an important safety equipment item. Water in passive SDHW systems can easily reach 160° F on a summer day.

In John's system, four thermometers will be placed on lines going into and out of both the solar hot water heater and the small electric heater (17 gallon, 120 VAC electric). Knowing these temperature differences, John can evaluate solar system performance.

Manually operated ball valves were placed at strategic points in the system. John's plumbing enables him to have three distinct modes of operation: solar only, preheat and auxiliary only. Please refer to the valving schematic. All ball valves are placed close together and labeled. The valves are easily visible and accessible under the kitchen cabinet. Providing for convenient operation and maintenance is part of good system design and installation.

Natural Gas Generator

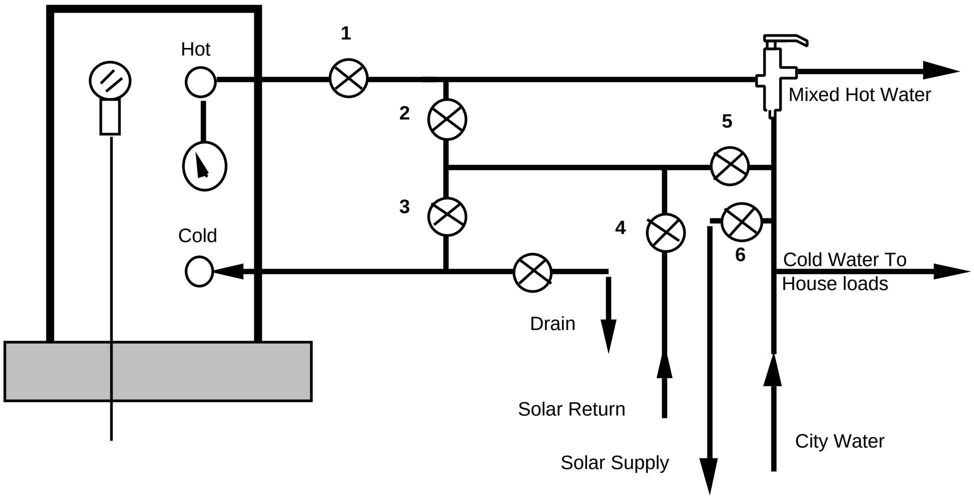
The last section of the system is a natural gas generator (commonly known as a methane digester). This unit will provide John with gas cooking and supplementary heat during the winter time. The unit is experimental. John made natural gas from cow manure years ago and thought it would be exciting to do it on a home size scale.

The system has two basic units. A 65 gallon plastic tank and a gas storage unit. The tank lies in a horizontal position inside a direct gain solar space. There will be an inlet to load the tank with raw materials and on outlet to remove the "dijested" material. There will be several tubes in the top of the tank to place temperature sensors and for thermostatic control of a small heat pad for auxiliary heat. A natural gas meter will be placed in the line so John can collect performance data. Gas will be generated 24 hours a day so a plastic storage tank is necessary. John likes plastic because it can be recycled, is not effected by methane, is easy to work with, lasts a lifetime and is inexpensive.

To obtain the best performance, the ideal liquid temperature is 98°F. John estimates 85% of the energy required to heat the liquid will come from direct solar gain and the balance will come from an auxiliary heat source.

John does not know exactly how the unit will do during the cold winter nights. In the winter he plans to use some auxiliary heat from the 450 watt heat blanket to keep the liquid at the optimum temperature. He is counting on the thermal mass of the liquid and superinsulation to moderate the temperature swings. In the summer the solar glazing will be covered most of the time except when heat is required. He plans to have a temperature swing of 20°F., from 100° to 80°. The closer he can maintain a constant temperature the better his gas production. His goal is to have natural gas year around with a minimal amount of effort and energy. John plans to write a follow up article for HP about the generator's performance.

Summary & Access



Valve	1	2	3	4	5	6
Solar Only	Closed	Open	Closed	Open	Closed	Open
Preheat	Open	Closed	Open	Open	Closed	Open
Auxilary	Open	Closed	Open	Closed	Open	Closed

A schematic of the valving of the hot water system.

The CMC Crew, clowning around after a job well-done.

The project was a great "hands-on" learning experience and fun for all. The class knows after they were done it was another small step toward a cleaner environment.

Many thanks and appreciation goes to those who wrote different parts of this article and actively participated in the project: Students: Gary Beckwith, Marlene Brown, John D'Angelo, Evan Lawrence, Juan Livingstone, Zoe Shinno, Markus Stoffel, and Mark Wolf. Instructors: Johnny Weiss and Steve McCarney.

For further information on the Energy Efficient Building Technology program write Colorado Mountain College (CMC) , P.O. Box 10001PB, Glenwood Springs, CO. 81602 or call 1-800-621-9602 in CO or 1-800-621-8559 outside CO. For any information on the trailer project contact John D'Angelo, 0171 Hwy 133 C-2, Carbondale, CO or 303-963-9632.

Water Supply For The Independent Home: Running Submersible Well Pumps On Inverter Power

Windy Dankoff

The submersible well pump is one of the great inventions of the 20th century. From domestic use to remote livestock watering, the "SUB" has replaced all sorts of hand pumps, jack and piston pumps, chains, buckets, windmills, etc. It is inexpensive, reliable and reasonably efficient. Millions are in use worldwide.

PUMPING IN HOME POWER SYSTEMS

Homes beyond the power lines often have alternative energy systems, usually photovoltaics with storage batteries. There are perhaps 50,000 such homes already in the U.S. and a growing industry to serve their special needs -- low voltage DC lights, appliances, pumps and electronic inverters. An inverter converts the stored DC power to household AC. Most independent homes use a combination of DC and AC appliances. A variety of special DC pumps are available. See articles in Home Power #5 and #11.

DC "Solar Pumps" are typically more energy-efficient than AC submersibles powered by inverters, but they are often more costly. Even if less efficient, there are times when AC pumping makes sense in alternative energy systems. The lower cost of the AC pump must be weighed against the cost of additional PV modules, batteries, and the inverter required to power it. AC pumping may be economical if one or more of these factors apply:

(1) Water requirements are low and/or energy system is relatively large so energy usage is not a critical factor.

(2) The appropriate DC pump for your particular needs is not available at a reasonable price (compared to inverter/AC sub).

(3) Your well is hundreds of feet from the power system. (Inverter's high voltage output greatly reduces line loss and therefore the need for large-size, expensive wire.)

(4) You already have a good AC sub in your well.

(5) You need an inverter for other tasks, and it will have enough available capacity to power an AC sub.

HOW DOES A SUBMERSIBLE PUMP WORK?

THE PUMP: All conventional AC subs work by centrifugal force. Water is drawn into a spinning disc called an IMPELLER, and forced outward at high speed. It is then funneled upward to another impeller, which adds more pressure, and another and another. The more impellers the pump has, the higher it will push and the larger the motor must be. The impeller stack is a single moving part, without sliding surfaces to wear.

THE MOTOR: A submersible AC motor is sealed and filled with water or oil. It is exceptionally slender, fitting in well casings as small as 4" in diameter. It is an "induction" motor with only one moving part. Home-size pumps range from 1/3 to several horsepower. The power required depends on vertical lift, pressure required at the house, capacity of the well, and water demands of the home.

ADVANTAGES OF AC SUBS

Given proper selection, proper power, no dry running and fairly clean water, AC Subs are very reliable. Many have lasted 10-20 years with little attention required. They are common, easily available and competitively priced.

DISADVANTAGES OF AC SUBS

(1) ENERGY LOSSES: Small AC subs are consumer products that are not designed with efficiency as a primary factor. Their energy losses are most severe at low flow rates (under 6 GPM) in deep well situations. Inverter and battery losses compound to bring overall efficiency down to the poor-to-fair (15-45%) range.

(2) STARTING PROBLEMS: Induction motors require a high STARTING SURGE of current. The sub's surge requirement is higher than other motors of similar HP, due to high speed design and constricted motor diameter. Modern inverters are specially designed with induction motors in mind, but a large 2000 watt inverter may exceed its surge limit starting even a small (1/2 HP) AC sub.

NOTE: Why can't you put a DC motor on a submersible pump? A true DC motor (with brushes) cannot be liquid-filled, so DC subs use either unique sealing methods, or use a combination of inverter electronics and a specialized AC motor (called a "brushless DC motor"). This is a new and growing field. DC subs are used for solar-direct power where there is no battery system nearby. They are less mass-produced, and are more expensive.

HOW TO FIND THE MOST EFFICIENT AC SUB:

(1) Ask your driller or pump dealer. Specify ALL your pumping requirements AND the characteristics of your well. Good pump distributors have engineers on staff who can understand your needs. Get a second opinion from a distributor who carries different brands.

(2) Higher flow pumps tend to use energy more efficiently. Shop for the highest flow rate you can get for the HP, without exceeding your well's capacity or the capacity of your inverter. If you will be in danger of overpumping your well (running pump dry) consider the Franklin "Pump Tech" dry run controller.

NOTE: Vertical lift or "head" on an AC sub is measured from the water surface in the well. (Submergence does not effect the work the pump will do, since the water seeks its own level in the pipe.) In many wells the water level draws down during pumping. It is this pumping level that is important to consider. Your driller (or written records) can give you an idea of your well's "recovery rate" and anticipated draw-down.

HOW TO MINIMIZE STARTING PROBLEMS:

(1) Get a "Three-Wire" pump rather than a "Two-Wire". It employs an above-ground control box that reduces surge requirement and eases maintenance.

(2) Avoid pumps with "Solid-State Starter". They are not tolerant of extreme dips in voltage during starting surge. However, if your pump of choice has one, you can either get a relay kit to convert it to a conventional starter, or use another brand of control box.

MORE TIPS:

(1) Don't skimp on wire size. The wire is sized according to the power requirement and the length -- the TOTAL length from the power source to the motor. Check the pump manufacturer's recommendations. WARNING: A 115V pump requires larger wire than the more common 230V pump. Be sure your installer uses the proper wire for the lower voltage.

(2) Get one or two spare "start capacitors" from your supplier, right away. Obtain ones with SLIGHTLY higher microfarad (MFD) rating than the original. They tend to fail if sluggish starting occurs.

HOW TO SELECT AN INVERTER FOR DEEP WELL PUMPING:

(1) Remember that AC subs are the hardest motors to start. Be sure the inverter you select can handle its power needs, including the surge requirement.

(2) If you are using a 230 Volt pump, try to get 230V inverter output without buying an accessory transformer. Note however, that this may limit the 115V power that the inverter will deliver. If you use a transformer, wire the pressure switch in its primary circuit, or it will draw power when the pump is off.

(3) If you expect your inverter to run other appliances at the same time as the pump, be sure it is large enough. OR --

(a) Design for more DC utilization, to relieve loads from inverter

(b) Use more than one inverter

(c) Pump several days' supply of water into a storage tank, then use a DC booster pump for your pressurizing. This way the AC pump can stay off for days at a time.

(4) If your inverter will be dedicated to NOTHING but pumping water, consider a specialized motor-starting inverter that may be more economical.

NOTE ON GENERATOR POWER: Small generators have the same potential problems starting AC subs as inverters do. A 1500 watt generator could theoretically run a 3/4 HP sub with ease, but it will never start it. The guidelines above apply to generator power too. WARNING: Inadequate generator power may run your pump, but low running voltage will overheat and ruin the motor. Be sure to obtain professional advice in all power system design.

HOW TO MINIMIZE ENERGY USE FOR PUMPING WATER:

(1) MINIMIZE WATER USE! The less water pumped, the less energy consumed. Low-flush toilets can cut domestic water use in half. (The Eljer Ultra-One one-gallon model is available nationwide.) Keep hot water lines short. Consider waste-water recycling. Consider drip irrigation to make extra-efficient use of water. Use water timers so that irrigation is not left on by mistake. Catch and store rain water for irrigation. Plant drought-tolerant species and use mulch to conserve water in your soil.

(2) USE A LARGE PRESSURE TANK. A typical home pressure tank is 40 gallons in size and will store/release about 12 gallons of water between pump cycles. This is called "draw-down between cycles". A larger tank is better, to reduce start/stop cycles and energy-robbing surges. This also reduces wear on the pump. If you have a minimal sized tank now, you may add a second tank for more capacity. Use the modern "captive air" pre-charged tank, rather than the old "galvanized" or "plain tank" which needs re-charging periodically.

(3) PLUMB FOR EFFICIENCY. If you haven't yet plumbed your house, use one size larger piping than usual throughout (such as 3/4" instead of 1/2"). This will reduce the pressure required to provide satisfying flow at your faucets. It is FLOW that you perceive, NOT PRESSURE. Typical house pressure is 30-50 PSI (lbs. per sq. inch). To produce this pressure, your pump does the equivalent work of lifting water an additional 100 feet high! Generous pipe sizing allows you to obtain the same satisfying water delivery at 1/3 less pressure. The result is increased pump flow and efficiency.

(4) SET YOUR PRESSURE TO THE MINIMUM amount that will satisfy your flow requirements. This is done by adjusting the pressure switch. The lower the pressure, the higher the pump's flow rate and efficiency. A lower pressure range will also allow your pressure tank to deliver a longer cycle. After you have determined a good pressure setting, readjust the pre-charge pressure in your tank to maximize its capacity (see tank manufacturer's directions).

(5) CONSIDER A STORAGE TANK and a separate DC booster pump. This way, you can pump enough water in an hour to last for several days. This will also keep your inverter free for other tasks nearly all the time. If you will be dependent on a generator for much of your pumping power, this is definitely the best way. Stored water can also be held as reserve for fire protection. See Solar Pumping article in HP #11.

HOW TO DETERMINE ENERGY REQUIREMENTS:

In order to design the energy system that will run your pump, calculate its energy requirement in WATT-HOURS PER DAY.

(1) CALCULATE YOUR DAILY WATER REQUIREMENT: Typical domestic use requires 50 gallons per person per day (using 1-1.5 gal. toilets -- double that for 4-5 gal. toilets). A young fruit tree in dry weather needs 15 gal/day. A typical lawn sprinkler uses 360 GPH. Cattle average 10 gallons per head per day in summer. Estimate average GALLONS PER DAY requirement as best you can. Remember, if you overestimate here, it can cost you a lot of money.

(2) SELECT THE PUMP YOU PROPOSE TO USE. Consult the pump's specification sheet (or ask your driller/dealer) to determine the optimum flow rate and the required horsepower.

Motor Horsepower	Watts
1/3 hp.	500
1/2 hp.	700
3/4 hp.	980
1 hp.	1240
1 1/2 hp.	1780

Estimated Electric Power Requirement for 115 or 230 Volt AC Submersible Pumps.
Courtesy of Franklin Electric.

(3) ESTIMATE ELECTRIC POWER REQUIRED using this table:

NOTE: For induction motors, multiplying voltage by amp rating will give you a higher than true watts figure. The current draw is out of phase (not synchronized) with the voltage.

ALSO NOTE: Many brands of pumps use "Franklin" motors, as described in chart above. Some other motor manufacturers have a so-called "1/3 HP" model that is really a 1/2 HP motor and will surge accordingly. If you want a true 1/3 HP pump, be sure its current rating is not over 9 amps.

(4) CALCULATE AC ENERGY REQUIREMENT:

$$\text{AC WATT-HOURS/DAY} = \frac{\text{PUMP WATTS} \times \text{GALLONS PER DAY}}{\text{PUMP FLOW RATE (GPM)} \times 60}$$

(5) CALCULATE DC ENERGY REQUIREMENT: Inverters have conversion losses in converting DC to AC power. Inverter manufacturers advertise peak efficiencies exceeding 90%. HOWEVER, losses are higher for "highly inductive loads" including

our beloved AC sub. Efficiency depends on many factors but it is safe to assume an average inverter conversion efficiency of 82%.

$$\text{DC WATT-HOURS/DAY} = \frac{\text{AC WATT-HOURS/DAY}}{0.82}$$

If you use a step-up transformer to obtain 230 Volts, change the 0.82 figure to 0.75 to accommodate transformer loss.

(6) DETERMINE THE SIZE AND COST OF THE ENERGY SYSTEM REQUIRED: Use a guide book or your dealer's help to determine how many watts of PV modules and kilowatt-hours of battery storage you will need (relative to your climate) to supply the water pumping portion of your energy budget. Don't forget to figure in the battery loss (15-20%). Include costs for wiring, controls, mounting racks, installation etc.

(7) OPTIONAL -- CALCULATE OVERALL SYSTEM EFFICIENCY:

$$\text{System Efficiency} = \frac{\text{Total Dynamic Head (in ft.)} \times \text{Pump GPM}}{\text{Pump Watts} \times 5.31}$$

Total Dynamic Head (Ft.) = Vertical Lift + Piping Friction Loss (Ft.) + Service Pressure in Feet (PSI X 2.31). NOTE: This formula may be applied to any electric pumping system.

An inexpensive, low-efficiency system MAY be economically viable if your water needs are minimal -- "It's a gas hog, but it was cheap and I only drive it on Sundays". BUT, if you need all the water you can get from a modest sized energy system (especially photovoltaic power in a cloudy climate) consider a high-efficiency DC pump. The higher cost of the pump system may be more than offset by savings in energy system cost. OVERALL SYSTEM cost is the BOTTOM LINE.

REQUEST FOR FEEDBACK:

We are gathering performance data on various pump/inverter combinations. If you have experience in this field, we would appreciate knowing --

PUMP: make, model and voltage, 2 or 3-wire, any modifications.
INVERTER: make, model, voltage
SYSTEM SET-UP: pressure-demand or storage tank, age?
PERFORMANCE: flow rate, amp draw AC and DC (if known)
LIMITATIONS: problems, particularly with multiple loads on inverter.

ACCESS

Windy Dankoff is the owner of Flowlight Solar Power. He has been selling and living with wind and PV home power since 1977 and has specialized in solar pumping since 1982. Flowlight manufactures Solar Slowpump, Flowlight Booster Pump and Solaram solar pumps. Contact Windy at Flowlight Solar Power, PO Box 548, Santa Cruz, NM 87567 (505) 753-9699.

A home made wind machine, using an automotive alternator. Mick built the machine and took the photo.

So You Want To Build A Wind Generator?

Mick Sagrillo

There seems to be a renewed interest in wind energy. The last few years have brought increasing numbers of inquiries by do-it-yourselfers about the availability of plans for building wind generators. Whenever anyone asks about building a machine, my usual advice is to buy a new one. Too expensive for a limited budget? Then buy a used unit and rebuild it.

Some Wind-system Basics

Normally, I try to discourage folks from building their own wind generator from scratch. My reasoning? The failure rate of home-built wind systems is extraordinarily high.

The principle reason for these failures is a lack of understanding of the two major laws of physics concerning wind power. In simple terms, the first law states that the power available in the wind is proportional to the cube of the wind speed. This means that if the wind speed doubles, say from 5 to 10 miles per hour, the power available at the wind generator blades increases by a factor of eight! Even small increases in wind speed yield major gains in power. An increase in wind speed from 10 to 11 miles per hour results in a 33% increase in the power of the wind.

The second law states that the power available to the blades is proportional to the square of the diameter of the rotor. In other words, if you double the diameter of the rotor by making the blades twice as long, you increase the power by a factor of four.

Many folks think, "As long as I'm building by own blades, why not make them twice as long as I think I need them?" You will get more power when the wind is blowing lightly, but unless everything in the windmachine is designed to support the larger blades, it will be destroyed by the first violent windstorm.

The purpose of this discussion is to warn the prudent to err on the side of caution. We all know what happens to weak links. Something flimsy or underbuilt will probably be the downfall of the project. Remember that you are dealing with machinery that may weigh as much as an automobile engine, mounted high in the air, with extremities that are rotating at several hundred rpm.

Generally speaking, it can be said that the more advanced the design, the longer the components will last. "Advanced" does not mean complicated. (Remember the KISS rule: "keep it simple, stupid".) The wind systems that have lasted through the decades almost always have simple designs. Stay away from complex electronics, hydraulics, and mechanical systems on the tower.

While lots of levers and springs and gizmos may look neat, they will consistently come back to haunt you.

Wind-system Plans

These plans for wind systems have been gleaned from the hundreds of designs published over the last six decades. Only the best, most workable designs, and only those plans that are still readily available to the public are listed.

The plans are categorized in three classes based on the following criteria:

Beginner: relatively simple designs that can be fabricated with the use of hand tools.

Intermediate: more complicated designs that require the use of such tools as a drill press, band saw, sheet metal brake, or welder.

Advanced: the most sophisticated designs requiring skilled use of such machine tools as a metal lathe or milling machine.

The "intermediate" and "advanced" projects listed are, for the most part, tried and true designs with the bugs worked out of them. Those categorized as "beginner" may need some modifications and refinement.

While it is unlikely that your local library will have many of the books or periodicals listed below, a good library should be able to get them for you through their interlibrary loan program. Be sure to give the library all of the information listed.

Beginner

Home Six-Volt Wind-Electric Plans, by H.F. McColly and Foster Buck, published by the North Dakota Agricultural College Extension Service, Fargo, ND, January, 1939. Reprinted by the *Mother Earth News* in 1975 as Stock #81005. This 19 page booklet describes a very simple direct-drive design that can use any automotive generator, not just 6 volt, for generating up to several hundred watts. Included is a section for carving a 5' wooden blade.

Wind and Windspinners, by Michael Hackleman, Peace Press, 1974. This classic walks you through the design and construction of a Sovonious rotor coupled to an automotive alternator. S-rotors are low-speed drag devices more suited to pumping water. They are low tech and easily fabricated. Good beginner projects for low budget, low wattage applications.

"Recycled Wind Generator", Energy Primer, by the Portola Institute, 1974 (ISBN #00-914774-00-x), pages 86 and 87. This article details the building of a tilt-up, 300 watt generator similar in design to the old Parris-Dunn machines (now used by Southwest Windpower in their Windseeker II). Included is information on rewinding the automotive generator for slow speed. No details on blade construction.

"Transformation of an 1880's Wind Pump to a Wind Generator at King School", by John McGeorge, *Alternate Sources of Energy Magazine*, #24, 1976 (ISBN #0-917328-14-0), pages 18-22. A simple design using an automotive alternator. Details included for carving a good 10', 3-blade rotor from wood.

"The Flight of the 'Red Baron'", *Mother Earth News*, #92, March/April, 1985, pages 96-102. Very low-tech sailwing type of wind generator using plumbing fittings for the mainframe and fabric for the "blades". Output is about 70 watts.

"The Blue Max: Affordable Wind", *Mother Earth News*, #93, May/June, 1985, pages 100-105; with an update in *MEN*, #94, page 101. The second generation of the "Red Baron", and considerably larger at 350 watts. Like its predecessor, the "Blue Max" is also constructed of pipe fittings and fabric.

"The Wind Blows Free", by John McGeorge, John's Workshop, *Alternate Sources of Energy Magazine*, #43, May/June, 1980 (ISBN #0-917328-33-7), pages 34-38; with an update in *ASE*, #47, January/February, 1981 (ISBN #0-917328-37-x), page 53. Construction of a complete micro-wind system using a 3 watt bicycle generator and a model airplane prop. Schematics for a voltage doubling control panel are included. This is for the tinkerer with very modest needs.

Three others should be mentioned. While not complete plans, there is enough information in the citations for the clever person to work with.

"Build Your Own Budget Windcharger", by Harry Kolbe, *Mechanix Illustrated*, February, 1978, pages 56-60. Diagrams illustrate the basics for building a downwind sailwing generator using an automotive alternator with step up sprockets and chains.

"Here's How I Built A Wind Generator", by Winnie Red Rocker, Handbook Of Homemade Power, published by *Mother Earth News*, 1974, pages 198-203. This same article was also published under the title "Build A Wind Generator", in Alternative Sources of Energy -Book One, edited by Sandy Eccli, 1974 (ISBN #0-8164-9247-6), pages 70-71. Describes a system using an automotive generator, with tips on constructing a 7' wooden blade.

"I Built A Wind Charger For $400", by Jim Sencenbaugh, Handbook Of Homemade Power, published by *The Mother Earth News*, 1974, pages 186-197. Also published under the same title in *Mother Earth News*, #20, March, 1973, pages 32-36. Still another plan using chains, sprockets, and an automotive alternator.

Intermediate

"Do-It-Yourself Wind Generators", by Jim DeKorne, Producing Your Own Power, Rodale Press, 1974 (ISBN #0-87857-088-8), pages 43-60. While not complete plans, this excellent article describes a copy of the old Jacobs Twin Motor, a wind generator utilizing two aircraft generators, to produce up to 4800 watts. Contains a lot of good tips, and a few details on rotor construction.

Design and Construction of a Propeller Type Wind Electric Generator, by Jack N. Krueger, Bulletin #76-01-EE-02, The Engineering Experiment Station, University of North Dakota, Grand Forks, ND, January, 1976. This 61 page bulletin walks you through the construction of up to a 3kw wind generator. Included is a section on building fiberglass-coated wooden blades.

"The Noble Windgenerator" by Haven Nobel, *Alternate Sources of Energy Magazine*, #24, 1976 (ISBN #0-917328-14-0), pages 4-10. Very good plans for a timing belt driven automotive alternator. Construction techniques for fiberglass-over-foam blades, details for a governor, and data on rewinding an alternator for 120 VDC.

Plans for Construction of a Small Wind-Electric Plant for Oklahoma Farms (Publication #33), by Arnold Benson, Oklahoma Agricultural and Mechanical College, Stillwater OK; June, 1937. This 34 page bulletin contains details for rewinding small generators, and a good section on blade building including an excellent set of blade templates. Portions of this bulletin were reprinted in *Wind Power Digest*, #4, March, 1976, pages 42-55, under the title "A Small Wind-Electric Plant", by the same author.

"A 1000 Watt Windplant You Can Build", by John Shelley, *Wind Power Digest*, #16, Summer, 1979, pages 38-49. Another gear driven automotive alternator. Contains details for a governor and unique set of sheet metal blades.

The LeJay Manual, by Lawrence D. Leach, copyright 1945 by LeJay Mfg. Co. This 32 page book belongs on every tinkerers bookshelf. It has recently been republished by Lindsey

Publications, P.O. Box 12, Bradley, IL, 660915-0012, and is available for $6.70, postpaid. Included in the many projects are several small wind generators, generator rewinding data, and the wooden blade plans that most of the above citations employ.

High-Speed Windgenerator Propeller Plans, by Kucharik Wind Electric, copyright 1980. Available from American Performance Products, P.O. Box 1351, Island Heights, NJ, 08732-1351. Details the construction of a workable 2-blade airfoil for wind generators. While Kucharik Wind Electric is out of business, Jim Kucharik has agreed to make the plans available for $12, postpaid.

Advanced

Building 3-Phase Alternators From 3-Phase AC Motors, copyright 1977 by Norbert Klemp. Seven intense pages of data describing how to rewind an ordinary 3-phase motor into a permanent magnet, direct-drive, slow speed alternator for wind applications. Available for $15, postpaid, from Norb Klemp, 4806 W. Cedar Creek Rd., Grafton, WI, 53024.

"Concentrated Alternator Design", by Edwin R. Fitzpatrick, *Alternate Sources of Energy Magazine*, #38, July/August, 1979 (ISBN #0-917328-28-0), pages 18-19. Enough information is available in this short article to rewind a 3-phase AC motor to a wire-wound field, direct drive, slow speed DC generator.

All of the following plans are well drawn sets of blueprints that any machinist should be able to follow. Postpaid prices are listed in parenthesis. Available from Tom Hill, RD #3, Box 806, Boyertown, PA, 19512.

Plans To Build Your Own 3 Bladed, Blade Activated Governor, 13'8" Diameter Rotor ($8.00).

Plans To Build Your Own 2 Bladed, Blade Activated Governor, 13'8" Diameter Rotor ($8.00).

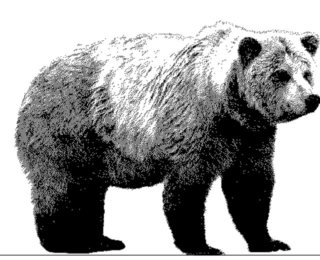
Plans To Build Your Own 2 Bladed, Blade Activated Governor, 9' Maximum Diameter Rotor ($8.00).

Plans To Build Your Own 6'6" Jacobs Type Blades for the Blade Activated Governor ($4.00).

Access

Any feedback is appreciated. If anyone knows of any other notable designs, send the details to "Letters to Home Power".

Mick Sagrillo, Lake Michigan Wind & Sun, 3971 E Bluebird RD., Forestville, WI 54213 • 414-837-2267.



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FOR OUR PURPOSES WE DEFINE ALTERNATIVE ENERGY AS ANY ELECTRICAL POWER NOT PRODUCED BY OR PURCHASED FROM A COMMERCIAL ELECTRIC UTILITY.

I NOW use alternative energy (check one that best applies to your situation).

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

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

I want to use alternative energy in the FUTURE (check one that best applies).

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

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

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

☐ **Photovoltaic power** ☐ **Water power**

☐ **Wind Power** ☐ **Other** ______________

HP#17

I now use OR plan to use the following alternative energy equipment (check all that apply).

NOW	FUTURE		NOW	FUTURE	
☐	☐	**Photovoltaic cells**	☐	☐	**Gas/Diesel generator**
☐	☐	**Wind generator**	☐	☐	**Batteries**
☐	☐	**Water power generator**	☐	☐	**Inverter**
☐	☐	**Battery Charger**	☐	☐	**Control systems**
☐	☐	**Instrumentation**	☐	☐	**PV Tracker**

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COMPARISON BETWEEN LEAD ACID AND NICKEL ALKALINE ELECTROCHEMICAL CELLS

Data complied by Richard Perez and Chris Greacen

	LEAD ACID SYSTEMS			NICKEL ALKALINE SYSTEMS				
				CADMIUM			HYDRIDE	IRON
	Automotive	Deep-Cycle	Gel	Sintered	Pocket Plate	Reconditioned Pocket Plate	Sintered	Pocket Plate
Cell Capacity in Amp-hours/Cell at77°F.	33 to 340	60 to 2,000	1 to 120	0.5 to 4	20 to 1600	20 to 1600	0.5 to 3.8	20 to 1600
Cell Operating Voltage	2	2	2	1.25	1.25	1.25	1.25	1.25
Cell Full Charge Voltage	2.5	2.5	2.5	1.5	1.65	1.65	1.5	1.5
Cell Discharge Cut -off Voltage	1.75	1.8	1.8	1	1	1	1	1
Cost in $/kWh- Average	$69	$98	$375	$1,800	$668	$267	$3,372	$351
Cycle Life (discharge to 20% SOC)	200	1000	500	1000	3000	3000	500	3000
Cost in $/kWh/Cycle in Deep Cycle	$0.34	$0.10	$0.75	$1.80	$0.22	$0.09	$6.74	$0.12
Calendar Life in Float Service	3	15	10	10	40	40	10	40
Cost in $/kWh/year in Float	$22.84	$6.50	$37.46	$180.00	$16.70	$6.68	$337.17	$8.78
Energy Density by Weight (Wh/lb.)	16.40	17.22	16.48	12.50	9.14	9.14	23.75	7.03
Energy Density by Volume (Wh/cu. inch)	1.97	1.71	1.43	1.63	0.58	0.58	2.99	0.58
Self-Discharge Rate in %/Week- NEW Cells	6%	6%	6%	5%	2%	2%	10%	10%
Self-Discharge Rate in %/Week- OLD Cells	50%	50%	50%	10%	5%	5%	15%	10%
Cycle Rate -Cell's ability to transfer current	High	High	Medium	Very High	High	High	High	Low
Temperature Performance	Fair	Fair	Fair	Good	Good	Good	Good	Good
Capacity available at 104°F.	105%	105%	108%	98%	98%	98%	98%	98%
Capacity available at 32°F.	70%	70%	87%	90%	90%	90%	90%	90%
Capacity available at -20°F.	20%	20%	40%	78%	78%	78%	75%	65%
Ease of Use	Low	Medium	Medium	Medium	High	High	High	High
Cell Maintenance Requirements	High	High	None	None	Medium	Medium	None	Medium
CellDamaged by Total Discharge?	Yes	Yes	Maybe	No	No	No	No	No
Memory Effect?	No	No	No	Yes	No	No	No	No
Cell Requires Equalizing Charges?	Yes	Yes	Yes	No	No	No	No	No
Cell Portability: is it sealed?	No	No	Yes	Yes	No	No	Yes	No

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Acid vs. Alkaline: the Electrochemical Cell Shootout

Richard Perez & Chris Greacen

Ever wonder how different battery technologies stack up? Which is best? Which lives longest? How do different battery technologies compare in cost, weight or volume per amount of energy stored, temperature performance, self-discharge rate, and many other operating characteristics? Well, this is a comparison between the most used battery technologies. Included in these comparisons are three types of lead-acid cells and five types of nickel cells. All the info is in the table and the text here merely helps define how the info is categorized.

Electrochemical Cells- the contenders

In the table to the left, there is information about eight different types of cells. Three of these types are lead-acid cells: automotive, deep-cycle, and gel. Five of the types are nickel cells using alkaline electrolyte. Three of the nickel systems use cadmium as a cathode, while one uses a variety of metal hydrides, and the other iron. All of the cells mentioned are are secondary cells. Secondary cells can be recharged, while primary cells (like flashlight batteries) can only be discharged once and cannot be recharged.

Lead Acid Cells

All these cells use lead compounds as their anode and cathode material. The first type listed are automotive batteries. These are the standard car battery with plates constructed out of lead sponge. The car battery is designed to do one thing, start your car at the minimum price. The deep-cycle cells mentioned are heavy-duty types whose plates are made from scored sheet lead alloyed with antimony. For example, the Trojan L-16W is such a deep-cycle battery. The third lead-acid type is the gel cell. Gel cells have a jellied electrolyte and are sealed cells. All these lead-acid systems use a dilute solution of sulphuric acid as their electrolyte.

Nickel Alkaline Cells

Sintered plate nicads are small sealed cells, like AA, C or D sized cells. The pocket plate types are vented wet cells, and two types are mentioned- new and reconditioned. As an example of the pocket plate nicad consider the Edison ED-160. The nickel-hydride cells are a new type of sealed cell being made by Ovonics. They use a variety of metal hydrides as their cathode material. The last type of alkaline secondary cells is the venerable nickel-iron type. All of these cells use a dilute solution of potassium hydroxide as their electrolyte.

The Comparisons

Here are the criteria and standards used in these battery comparisons.

Capacity

This row details the range of available cell capacities, expressed in Ampere-hours, for each particular cell chemistry. The lead acid gel cells are becoming available in larger capacities, now up to over 100 Ampere-hours. The new nickel hydride types are not yet manufactured in sizes bigger than 3.8 Ampere-hours (a "C" sized cell). The other types are made in everything from tiny cells to ones you need a forklift to move.

Cell Voltages

Three types of voltages are covered for each cell at 78°F. The first called "Cell Operating Voltage" is a nominal voltage value for the cell under moderate discharge. All the lead acid types produce about 2 Volts. The nickel alkaline technologies all have cell voltages around 1.2 to 1.25 VDC under moderate discharge rates. "Cell Full Charge Voltage" indicates the voltage of a cell that is full and still undergoing recharging at a C/10 rate. "Cell Discharge Cut-off Voltage" is the voltage at which the cell is considered to be fully discharged and still under a moderate (≈C/10) discharge rate.

Cost

For the cost figures, expressed in dollars per kiloWatt-hour of power stored, we used the following collections of cells (batteries). The lead acid automotive battery was a standard type from the local Les Schwab tire shop. The lead acid deep cycle battery is a Trojan L-16 W. The lead acid gel cell is a Panasonic 6.5 Ah model. The sintered plate nicad is a Panasonic "D" sized cell. The pocket plate nicad (both new and reconditioned) is an Edison ED-160. The nickel hydride cell is an Ovonics "C" sized cell. The nickel iron cell is a Gould 35 Ah cell.

What follows in the table is an analysis of the cell's cost for its cycle lifetime and calendar lifetime. Cycle life is the average number of discharges (to 20% State of Charge) that the cell will undergo before failure. Calendar lifetime is rated for cells in float service. Float service means that the cell is continually under charge and only rarely sees a shallow (<10%) discharge cycle. All these figures are averages and are placed at extremes of service, i.e. regular deep cycling and virtually no cycling at all. As such, these lifetime figures cover the spectrum of longevity that an average user may expect.

Lifetimes on all electrochemical cells are greatly dependent on the cell's user. A careful user, one who follows the rules for that particular cell technology, will receive greater lifetimes than those on the chart. A slob will receive less. It's up to you to learn how to properly use your cells and then to do it.

Energy Density

We rated energy density in two fashions, one by the cell's weight in pounds, and the other by the cell's volume in cubic inches. One very notable feature here is the high powered Ovonics cells.

Cycle Rate

This row ranks the cells according to their ability to be rapidly cycled. It details the cell's ability to be discharged and recharged at fast rates (≥C/5). Electrochemical cells that power an inverter must deliver high rates of current in relation to their capacity.

Ease of Use

This category summarizes the characteristics listed below it into an overall rating of low, medium or high. "Ease of Use" gives the prospective battery user a look how easy it will be to keep the battery up and running. Many things, like physical maintenance, equalizing charges, etc. are all part of life on some electrochemical cells. This category summarizes the characteristics listed below it into an overall rating of low, medium or high.

Conclusions

Not in a minute. The table contains the data, you can make up your own mind about what type of electrochemical cell best suits your application.

We will, however, point out some interesting data on the table:

1) While lead acid automotive batteries are the cheapest to buy in $/kWh of storage, they are more expensive to operate than their lead acid cousins. Car batteries cost over three times more to use in either deep cycle or float service than do deep cycle types.

2) The self-discharge rate for all lead acid systems goes out of sight at the end of the cell's life. All nickel alkaline technologies maintain constant rates of self-discharge throughout their life.

3) Memory effect is limited to the sintered plate nicads and NOT shared by any other nickel alkaline types.

4) If you're running cells at low temperatures, then they had better be nickel alkaline types. Lead acid systems lose much of their capacity at low temperatures.

5) If you require maximum energy density, then the Ovonics nickel hydrides (NiH) are the only ones to consider. The energy density by weight of the Ovonics NiH is over 31% higher than any other type on the chart. The volumetric energy density is up over 50% from the nearest competitor. This, coupled with the NiH cell's sealed package, make it the best to use in portable service.

Access

Battery data and/or questions? No problem. Write or call: Richard, C/O Home Power, POB 130, Hornbrook, CA 96044 • 916-475-3179.

Batteries Can Be Dangerous

John Wiles

In the last issue we covered the requirements for overcurrent devices. DC rated circuit breakers meet these requirements and combine the overcurrent function with a switching function They also increase system reliability and in many cases lower cost because of fewer parts count. There is a problem, however, in that most DC rated circuit breakers, switches and fuses have limited ability to interrupt short-circuit currents. The fuses and circuit breakers, while functioning properly to open the normal overloads of 150-1000% of rating, can only break or interrupt short-circuit currents of around 5000 Amps. When subjected to higher short-circuit currents, they may be destroyed-- literally blown apart.

Batteries are real Powerhouses

It has been estimated that a single 220 amp-hour, 6 volt golf cart battery can deliver 8000 amps into a terminal to terminal short-circuit for a fraction of a second. In PV systems we frequently use batteries of higher capacity and even parallel them which creates significantly greater short-circuit current capabilities. To some extent, the magnitude of the short-circuit currents is reduced by the series resistances of the wiring, fuse holders, switches and circuit breakers. But, when we use 4/0 cable between the inverter and the battery, these resistances are measured in milliohms and do not limit the short-circuit currents a great deal.

Current Limiting Fuses

A current limiting fuse should be used in the positive conductor of the battery bank in all stand-alone systems. These fuses have a special internal construction that helps to extinguish the internal, direct current arc created inside the fuse when a short-circuit occurs. When the current limiting action takes place, the peak let-through current is significantly reduced For example, the DC rated UL listed, RK-5 current limiting fuse made by Littelfuse Company has a DC interrupt rating of 20,000 Amps. In ratings up to about 150 amps, this fuse can reduce the short-circuit let-through currents to less than 5000 amps which can be handled safely by lesser rated fuses and circuit breakers. Beware of using current limiting fuses with only an ac rating--they have not been certified by UL as having the necessary DC rating and may not function properly in DC circuits.

The calculations required to determine how to use current limiting fuses are quite complex and not even the battery manufacturers have a good handle on the short-circuit current capabilities of their batteries. To simplify the design of a safe PV installation, it is suggested that every 700 amp-hours of battery bank capacity (i.e. two Trojan L-16's in parallel) have a disconnect switch and a current limiting fuse in series with the positive conductor. The switch is connected nearer the battery and there should be another switch elsewhere in the circuit to insure that both ends of the fuse are dead when it is serviced. If no battery charger is involved, either external to or in the inverter, then the PV disconnect switch will serve as the extra switch removing the only other source of power in the system. For simple systems without inverters see the diagrams in Code Corner in HP 16.

DC rated, fused disconnects are available from Square D and Siemens I-T-E among others, which combine the fuse holder and a switch. Another option is to separate the components with a fuse holder and switch in different enclosures. In either case, there must be no exposed wiring and the single conductor cables must be in conduit. All metal cabinets and boxes must be well grounded-- a subject for the next issue.

Access

DC rated, UL listed current limiting RK-5 fuses are made by Littelfuse. See Code Corner in HP 16 for the address. DC rated, UL listed fused disconnects are available from Square D and Siemens I-T-E at 3333 State Bridge Rd, Alpharetta, GA 30201. Call 404-751-2000 for regional I-T-E representative who can steer you to the nearest source. Joseph Pollak Corp at 195 Freeport Street, Boston MA 02122, phone 617-282-9550 makes a 180 amp 36 volt heavy duty switch. It is not UL listed, but your local inspector might let you use it. Ask for info on product #51-302. JC Whitney and Northern both carry it.

John Wiles, SWRES, POB 30001/Dept 3SOL, Las Cruces, NM 88003

Things that Work!
Home Power tests the Heliotrope HC-75 Battery Charger

testing conducted by Richard Perez and Laura Flett

A battery charger allows us to refill the battery from a 120 vac engine/generator when the weather is cloudy and the PVs aren't producing much electricity. Battery chargers come in all sizes, from little dinky 10 Amp models at the auto store, to giant 70+ Amp industrial models too heavy to move. The Heliotrope 75 Amp charger is unique- for its high power output, it is tiny- only 9 pounds. Almost all battery chargers have low output power when fed by a generator, but the HC-75 loves working with a generator.

What is an HC-75?

The Heliotrope HC-75 is a very compact and efficient 120 vac to 12VDC battery charger. It uses switching power supply technology to instead of a large transformer. It is rated by Heliotrope at 75 Amperes and has a voltage ceiling of 14.8 VDC. It weighs only nine pounds and is tiny- 4" X 7.25" x 15.5". A comparable transformer based charger like IBE Model 6GPU100, rated at 70 Amps continuous, weighs in at 83 pounds and is 15" X 14" X 22".

Switching power supply technology has been in use in computers and other electronic hardware for years. These "switchers" have proven reliability, high efficiency and very small size in relation to their power handling capabilities. The HC-75 is a large switcher designed to recharge batteries.

Shipping and Documentation

The HC-75 arrived from Heliotrope in fine shape via UPS. The docs are short, a single sheet, but then with only two wires and an ac male line plug, not much more is needed.

Test System

We installed the HC-75 in Jim and Laura Flett's system on Camp Creek outside of Hornbrook, CA. See HP#13 for a complete description of their system. The HC-75 would be taking 120 vac power from a Honda ES6500, 6.5kW generator and recharging a pack of six Trojan L-16Ws (1050 Ampere-hours at 12 VDC). The previous charger in this system was a rather anemic built-in battery charger in a nameless inverter.

HC-75 Performance & Specs

With the battery voltage below 13.5 VDC we measured 76 Amperes of current out of the HC-75. By the time the battery was regulating at the voltage setpoint of 14.8 VDC, current had tapered to 65 Amperes. The previous charger was transformer based and its output would radically drop (>60%) as the batteries filled. Not so with the HC-75, its output amperage remained fairly constant (≈13%). The previous charger never did put out its rated amperage. According to its maker, the peak voltage of a generator was not enough to drive the nameless inverter's charger to max output. The HC-75 had no problem digesting the generator produced 120 vac and putting out full power. I checked the incoming voltage from the generator and it was above 160 vac peak, just as it should be, RMS voltage was 119.2 vac. All within specs. It takes a fair amount of power to run the HC-75 about 1.1 kW. input, but then at 75 Amps its a big charger. The HC-75 comes with a built-in thermostatically controlled fan to keep the little fellow cool. Our measurements show the HC-75 to be about 90% efficient, in comparison with 50% to 70% efficiencies on transformer type chargers. The HC-75 can be setup with one of two voltage limits: 14.8 VDC for lead acid batteries and 16.5 VDC for nickel cadmium batteries.

On the side of longevity. I have witnessed an HC-75 (NiCad model with voltage of 16.5 VDC) working **all** the time at Lon Gillas' battery recharging setup at Pacific West Supply in Amity, OR. These fellows are not kind to their battery chargers. They make them work all day and all night and weekends too. If the HC-75 will take this brutal service for months on end, then it is just about bullet proof for the average user. After all, most of us would rather eat a bug than start the generator. But it's nice to know that when we do have to start the generator, we can refill our batteries quickly and efficiently. The cost of the Heliotrope HC-75 is $350. Its warranty is one year.

Warts

The only noticeable wart on the HC-75 was slight interference on the AM radio. To the HC-75 credit, it is very much quieter than the nameless inverter's built-in charger. At least the HC-75 doesn't get into the FM Stereo and TV.

Conclusion

There is a lot of high technology packed into this small box. It works significantly better, especially on generators, than transformer type battery chargers, even the finest, very expensive, electronically controlled types.

Access

The HC-75 is available from Heliotrope General, 3733 Kenora Drive, Spring Valley, CA 92077. In CA 800-552-8838 and outside CA 800-854-2674.

Hydro Systems Using LCBs™

Paul Cunningham

For a given magnetic field, and driven by a water jet of given pressure and flow, a DC hydro generator will produce its greatest power at a certain combination of voltage and current. This combination is called the "maximum power point". The problem of running a PM generator at near its maximum power point voltage while charging a battery at a significatly lower voltage has a simple solution- a linear current booster or LCB.

Conditions

Most hydro machines will only perform well under certain conditions and only perform at their best under one set of conditions. Using a variable field, as with automotive alternators, is one solution. These machines can be used with an RPM range of around 1000 to 4000 or more. Although these alternators are low in cost and fairly reliable, they have low efficiency, typically 50% or less, depending on conditions. So with variable field strength, controlled electronically or with a rheostat, an optimum match between input power and output power can be made.

Improving the situation

Let's look at some ways of improving the situation. The automotive alternators have a place. But at low-head sites they work poorly or not at all. The problem is made worse because they not only are less efficient at low speeds, but more power is required to operate the field as the speed (head) is reduced. The only practical solution is a generator that uses permanent magnets (PM) for the field. This can be done using either stationary magnets with a rotating armature like DC motors have, or the rotor can contain the magnets with the armature and its coil of wire being stationary. Either way, the permanent magnets supply the magnetic flux that moves in relation to the output coils (where the power is generated). Because no energy is added to produce the magnetic field (and for other reasons) permanent magnet generators are significantly more efficient than their wound field counterparts. PM hydro machines can operate at very low heads and low rates of water flow because of their higher efficiency.

Half Solved

This is a step in the right direction, but the problem is only half solved. The field strength must be controlled (or some other techniques used) to produce optimum output. One way is to custom build each generator for each site (ARGH!). Another is to mechanically adjust the distance of the magnets from the armature (ARGH again!). In the case of stationary coils and PM rotors, it is possible in some designs to reconnect the output coils to vary the loading. But this cannot be done in small increments. And I won't even discuss mechanical drives like belts and pulleys for these very small machines. This is because of their complexity and losses.

Maximum Power Point Trackers

Wouldn't it be nice if this could be done electronically so one machine could be used at widely differing sites? There are devices called Maximum Power Point Trackers that do this. They automatically seek out the best operating point of a power source and effectively match the power power source to the load . The only ones I know of are very expensive. We aren't going to benefit if the operation is successful but the financial strain kills the patient.

LCBs

Recently, I used a standard LCB™ (linear current booster) made by Bobier Electronics (type 3-4-8-T) with a permanent magnet, DC hydro machine and had excellent results. This machine (model DCT-1) could charge a 12VDC battery with a five foot head. I wanted to operate it at a 15 foot head. This meant that if the PM generator was connected directly to the battery it would run too slowly and the power output would decrease. The PM generator would produce a higher power output if the generator could turn faster which meant operating the system at a higher battery voltage. The optimum voltage increases in proportion to the speed of the PM generator. With an LCB the generator can operate at this higher optimum voltage and in a sense trade voltage for current thus charging batteries at their voltage.

Easily Retrofitted

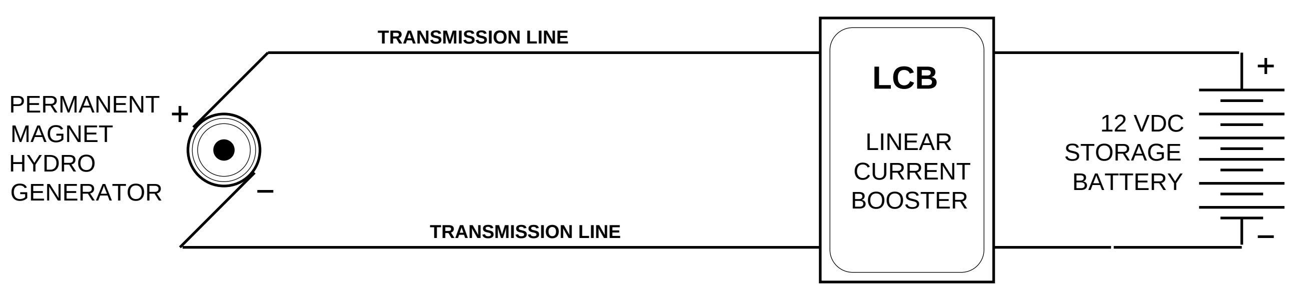
An LCB can easily be retrofitted to a hydro site. If you have a PM generator, or in some cases an induction machine, you may benefit. With a PM generator, if the no-load voltage exceeds twice the battery voltage, a performance increase is possible.

The installation of the LCB is very simple. It should be installed according to instructions as if it were operating in a PV system, see the figure below. The LCB should be mounted near the battery bank. Then it can simply be adjusted for maximum output current.

This is a nonstandard use of the LCB and you are advised to use an LCB with twice the current rating of the PM generator.

The Proof of the Pudding

At the 15 foot head site, the no load voltage was around 47 VDC. This meant that the correct voltage under load should be about 23 Volts. By using a variable resistance, I determined that the



maximum power point was at 22.l VDC and 2.1 Amperes giving 46.4 Watts. Connecting the generator directly to a 12 VDC battery produced 3.0 Amperes and 12.5 VDC or 37.5 Watts. This is about 81% of the maximum that was produced at 22 VDC. Using the LCB in the circuit produced an output of 3.6 Amperes at 12.6 VDC giving 45.4 Watts. This means the efficiency of the whole system, with the LCB is around 98%. It is important to note that the power increases will rise as the difference between generated voltage and battery voltage increases. LCBs are available from Bobier that are rated up to 250 VDC.

Other Benefits

There are other benefits from using an LCB. Whenever nozzles are changed, the machine can easily be re-adjusted for maximum performance. Another plus is that the generator voltage is increased which greatly reduces transmission line losses.

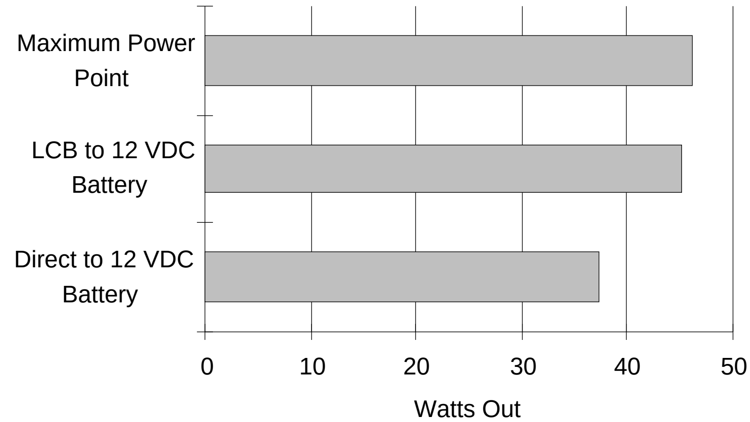
Bobier has just introduced new models of LCBs. Devices specifically designed for use with batteries must be ordered.

Access

Paul Cunningham, Energy Systems & Design, POB 1557, Sussex, N.B. Canada E0E1P0 • 506-433-3151

Bobier Electronics, 800-222-3982

Hydro System using PM Generator & Linear Current Booster



	Load Voltage	PM Generator Current in Amps	Power Out in Watts
Maximum Power Point	22.1	2.1	46.4
LCB to 12 VDC Battery	12.6	3.6	45.4
Direct to 12 VDC Battery	12.5	3.0	37.5

MREF UPDATE

Admission

Daily Admission: $2*
Weekend Pass: $5*
Evening Concerts: $4/night
Children 12 and Under: free
*does not include evening concerts

T-shirts will be available on the fairgrounds for $12. (T-shirt and pass to all fair activities available immediately for $25 personal donation.)

Display Booths

Display booths are available for manufacturers, dealers and cottage industries to sell and promote renewable energy and energy conservation products and services.

Rates:
$500 Sponsorship Level Booth
$125 Business Level Booth
$25 Not-for-Profit Educational Booth

Information

If you would like more information on exhibiting or attending, contact us at

715-592-4458

or write:

Midwest Renewable Energy Fair
286 Wilson Street
Amherst, WI 54406

The Midwest Renewable Energy Fair will be powered by photovoltaic and wind systems.

Schedule of Events

Friday, August 17

1:00 MREF opens to the public
*Sales and information booths open
*Food booths open
*Demonstrations
*Children's activities
1:30 Opening Address: Richard Perez, editor of Home Power Magazine
2-4:00 Workshops
6:30 Speaker: Paul Gipe, spokesperson for the American Wind Energy Association & author of Wind Energy: How to Use It
8:00 Evening Concert: featuring Greg Brown and Otis and the Alligators

Saturday, August 18

8:00 Main office opens
9:00 MREF opens to the public
*Sales and information booths open
*Food booths open
*Demonstrations
*Children's activities
10-12:00 Workshops
1-3:00 Workshops
2:00 Children's Concert: featuring Tom Pease and Larry Long
3:30-5:30 Workshops
6:30 Speaker: Richard Perez
8:00 Evening Concert: featuring Larry Long and The Stellectrics

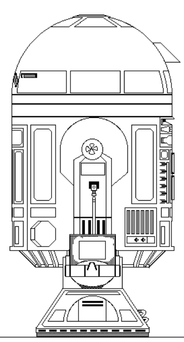
Sunday, August 19

8:00 Networking breakfast
10:00
*Sales and information booths
*Food booths
*Demonstrations
*Children's activities
10:30-12:30 Workshops
3:00 Fair Ends

Workshops

1. Fundamentals of Energy, Electricity and Electronics: Spark Burmaster, E.E. (APPRO TECH Energy Management Services, Chaseburg, WI)
2. Integrated Systems: Spark Burmaster, E.E.
3. Farm and Residential Water Systems: Spark Burmaster, E.E.
4. Batteries: Richard Perez (Electron Connection Ltd., editor Home Power Magazine and author, The Complete Battery Book, Medford, OR)
5. Small Scale Wind Systems: Mick Sagrillo (Lake Michigan Wind and Sun, Forestville , WI)
6. Grid Interconnected Systems and PURPA: Mike Sagrillo
7. Wind Energy Come of Age: Paul Gipe (American Wind Energy Assoc., author, Wind Energy-How to Use It, Tehachapi Pass, CA)
8. Photovoltaics: Bob Ramlow (Snowbelt Solar, Amherst, WI) and Jim Kerbel (Photovoltaic Systems Co., Amherst, WI)
9. Solar Thermal-general: Bob Ramlow
10. Solar Thermal-water heating: Bob Ramlow
11. Solar Thermal-air heating: Bob Ramlow
12. Air to Air Heat Exchangers: Doug Stege (Altech Energy, Madison, WI)
13. Passive Solar Architecture: Ken Woods (Illinois Solar Energy Society, Naperville, IL)
14. Construction Techniques for Super Insulation: Mark Klein (Gomme Shelter Construction, Almond, WI)
15. Closed-loop Ecosystems: Terry Kok (Facilitator, Earth-Base Projex, Bloomington, IN)
16. The Politics of Energy: Doug LaFollet (Wisconsin Secretary of State, Madison, WI)
17. Wood Burning: John Kjos (Energy Concepts, Mankato, MN)
18. Photovoltaics for the Rural Residence: Jim Hartley (Photocomm Inc., Downers Grove, IL)

19. The Lure of Manure-Methane Generation: Dan Friesen (Technical Director, Harding Think Tank, Grand Haven, MI)
20. Micro Hydro Systems: Bob-O Schultze (Lil Otto Hydroworks, Hornbrook, CA)
21. Electric Vehicle Retrofitters: John Emde (Fox Valley Electric Auto Association, Downers Grove, IL)
22. Hydrogen Production and Use: Jim Sievers (Iowa Alternative Energy, Cedar Rapids, IA)
23. Photovoltaic Systems and the National Electric Code: John Wiles (Manager of PV Programs, Southwest Region Experiment Station, New Mexico State University)
24. Sunseeker: Design, Construction and Racing of a Solar Powered Vehicle for the GM Sunrayce U.S.A. 1990: Terry Parker (Student Project Leader, Jordan Energy Institute, Grand Rapids, MI)
25. Energy and the Environment: Dr. Mark Hanson (Environmental Studies and Urban and Regional Planning, UW-Madison, WI)
26. Community Environmental Activism: Joe Passineau (Director, Central Wisconsin Environmental Station, Amherst Jct., WI)
27. High Efficiency Appliances: Joanne Leonard (Wisconsin Public Service, Wausau, WI)
28. Successful Cooking with a Sun Oven: Thomas J. Burns (Burns Milwaukee Inv., Milwaukee, WI)
29. Utility Conservation Program: Jack Bohman (WI Power & Light, Iola, WI)

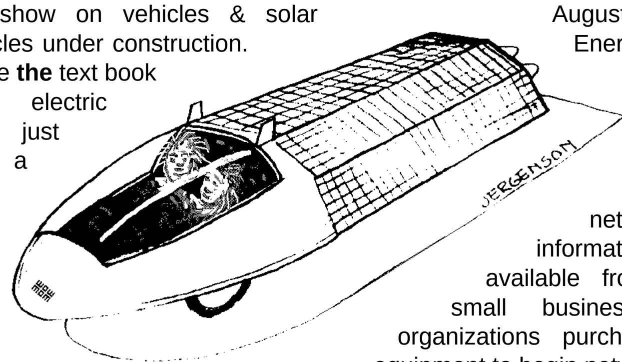


SEER '90 UPDATE

SEER '90

The local movie theater is donating the 500 seat theater for our 3 day weekend. The theater is only three blocks away from the fair site & the new owners are asking for ideas on any feature films which are appropriate for the weekend.

One of our featured speakers Michael Hackleman has offered to put on a several hour slide show on vehicles & solar electric vehicles under construction. Michael wrote **the** text book on building electric cars & is just completing a vehicle with the Cal-Tech team in L.A.



Christopher Swan of Light Rails fame will be talking about reviving the trains. Christopher is the author of a book on photovoltaics & futuristic, but practical, transportation systems.

The response from electric & solar vehicle builders has been fantastic. The timing of our event was coordinated to utilize the solar vehicles built for the Sunrace which goes from Disney World in Florida to the GM technical center in June. Pictured is the Stanford car.

One of our rally coordinators Jon Frey, just went to the American Tour de Sol time trails this April in Vermont. He met five rally teams who are very jazzed about our event.

California Congressman Vic Fazio has just driven in his first solar vehicle in a parade in Sacramento. The vehicle was built to participate in SEER'90 this summer by Suntools in Willits, California. Congressman Fazio was also given a SEER'90 T-shirt and was recently awarded for being congressman most supportive of solar energy.

SEER'90 ACCESS

Solar Energy Expo & Rally (SEER'90)
733 South Main Street, Suite 234
Willits, CA 95490
707-459-1256

SEER '90 EDUCATION UPDATE

Home Power has run information in past issues for the ATA Professional Photovoltaic Workshop. There are still a few remaining positions open. To register contact ATA directly at (303) 963-2682.

The Redwood Community Action Agency (RCAA) has confirmed that they will be offering a two-hour workshop on Saturday, August 11, focusing on Energy Networking with computers. This is a hands-on demonstration of the hardware, software and existing networks including information on **funds** available from RCAA to help small business and non-profit organizations purchase the necessary equipment to begin networking.

There will be several other "hands-on" workshops demonstrating how to construct and install renewable energy devices/systems. Contact the SEER'90 office for more details.

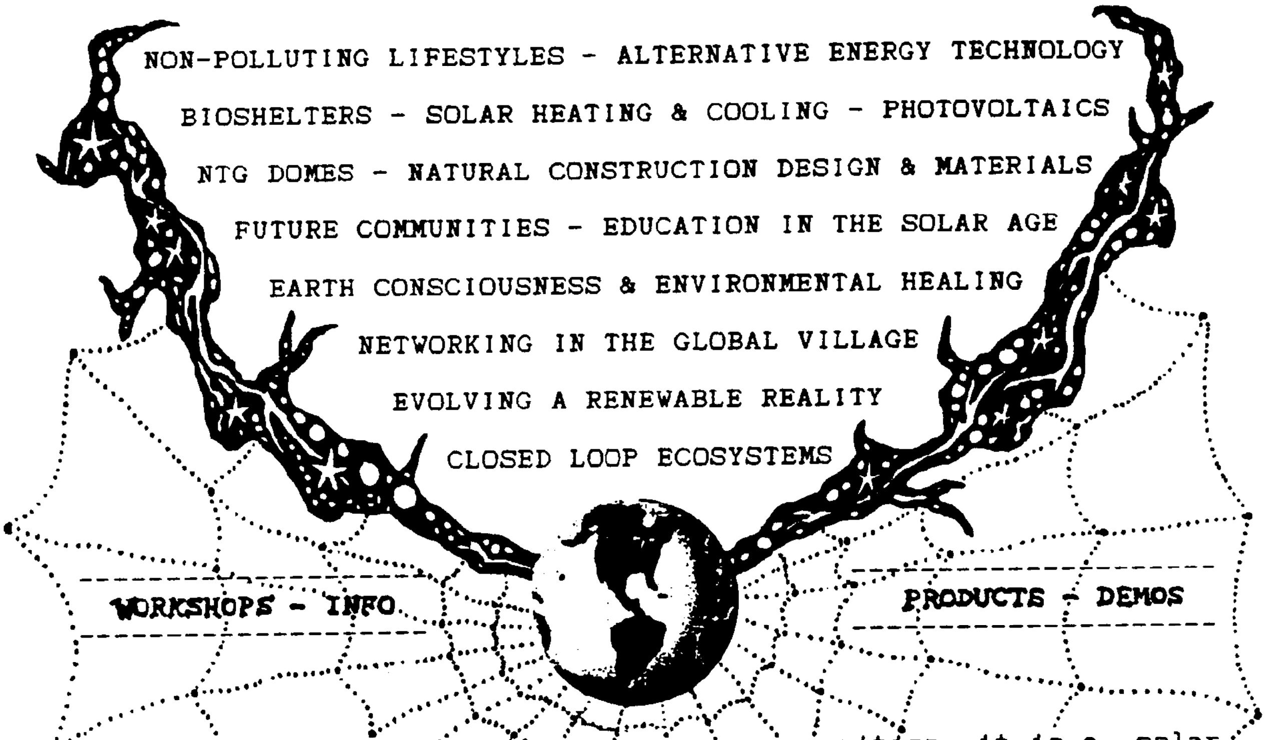
TRUXTON

FULL

PAGE

ADVANCE REGISTRATION FORM - PLANET FEST '90 - July 12-15th
return to: PF'90 c/o EBPX, Box 1328, Bloomington, IN 47402

a celebration of planetary consciousness



PLANET FEST '90 is more than an energy exposition, it is a solar age cultural event. Workshops and performances welcome. Costs include camping space (firewood, drinking water, privies provided) and display space (for crafts, AE technology, education). Natural foods concession on site. Stores and motel nearby. BYO camping gear and display tables. Pass out literature. Promote products or projects. Share fun and information. VERY RELAXED ATMOSPHERE ****

****PLANET FEST '90 is being held on the 109 acre LOTHLORIEN nature sanctuary, located 23 miles South of Bloomington, Indiana (a map will be sent with pre-registration). Hike, explore, & enjoy!

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costs: adults (18yrs up) $50*
teens (13-17 yrs) $40*
12yrs and under: FREE
(4 days and 3 nights)

day pass rates (Fri-Sun, 9AM-6PM)
adults $8, teens $6, kids FREE

*registration rate BEFORE July 1st
add $10 for at-gate registration

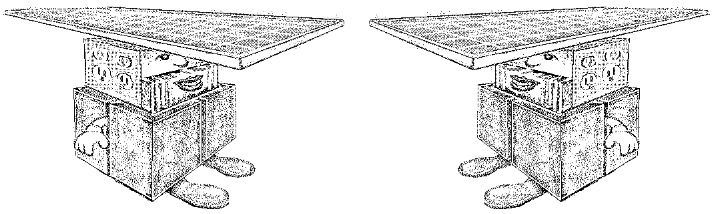
alternative ~ENERGY FAIR

SEND CHECK OR MONEY ORDER TO PF'90 c/o EARTH-BASE PROJEX, Inc.

PLANET FEST '90

July 12-15 Bloomington, IN

System Shorties



A System In The Forest

We live in the middle of a pine and Douglas Fir forest, in a canyon that sits right in the middle of the biggest wheat-producing county around. Where we live the canyon's about one quarter mile wide. We lose several hours of direct solar gain in the winter, when we need it most. This far north, days get down to only about eight hours around the winter solstice . So just when we need the most light, we get the least electricity. It's too cold in the winter to run water pipes very far above ground, so micro- or nano-hydro is not practical for us. Besides, the streams flood in the spring, and occasionally during a winter thaw, unpredictably. There is just a chance that I might be able to use a small wind plant to augment the photovoltaics in the winter, but living in a canyon as we do, really strong winds are infrequent.

We have a Toro 2.5 kilowatt generator that we use for laundry and simultaneous battery charging. With seven people in the family, mostly under 12 years old, we do a lot of laundry. We've had the Toro for four years and have had NO problems with it, other than USER malfunction. It still starts on the second pull. We have two Interstate 12 Volt forklift batteries that we use in parallel in the summer and separately in the winter. Each battery is rated at 115 Amp hours. My wife's friend Jean lives in the nearest town, where I work two days a week. When we have a week or more of overcast, I take the lowest battery in to Jean's house and put it on a trickle charge for a few days, in exchange for a half hour or so of wood splitting. If, as sometimes happens, we have two weeks of overcast, I just swap batteries every week until we do get sunlight. We charge our batteries with four old 30 Watt photovoltaic panels that we bought used for $150 each. They are mounted together in an array at ground level where I can manually adjust their angle every month and clean them when they get dusty, snowy, etc. My wife and I and our 5 kids live in a five bedroom, semi-underground home, lit by a hybrid lighting system composed of 12 Volt incandescent, 12 Volt PL fluorescent, plumbed-in propane fixtures, and portable kerosene lamps. We also use flashlights a lot, but this is changing as we get more of the house wired for 12-Volt, and gradually can afford to change our incandescent lamps for PL types. We hope soon to buy a computer, and power it with a small inverter, such as the Power Star.

We heat our entire house with just the wood-fired cookstove in the kitchen, using only dead wood we cut in the woods. Most of our neighbors do the same.

Donald Fallick, Rt. 3, Box 72-F, Davenport, Washington 99122

Tall Towers And Kinky Batteries

We built our house and set up its electrical system before getting Home Power, but we seem to have lucked out in gleaning information from old electrical manuals, etc., that weren't nearly as accessible, but contained much of what we needed.

Our current setup uses a 32 Volt, 10 foot blade, "750" Watt "Giant" Wincharger on a 45 foot tall tower, with a Kyocera model J59 solar panel as a backup. The real kinky part of our system is the set of twelve nickel-iron Edison cells we got free for the hauling from a neighbor who salvaged them from some place he worked.

He didn't know anything about them except that they weren't filled with acid. My college chemistry book explained their operating principles, voltages, electrolyte, etc. An engineering manual gave me the Amp-hour capacity (600 Amp-hours), further chemistry, etc.

A problem: how to match a 32 Volt wind machine to a 24 Volt solar panel and a 17 Volt battery bank while ending up with a nominal 12 Volt output. Since our valley location often has light winds we sacrificed half the wind machine's wattage in order to put electricity into the batteries at lower speeds. We did this by wiring it through a blocking diode and fuse directly into the battery. We wired the J59 solar panel in the same way through another diode.

Another problem was with the solar panel. On bright days I've measured it producing up to 74 Watts. The diodes rob a measured 5.25%. That seemed OK when we considered the alternative: the cost of a controller and its relative lack of usefulness in charging a battery bank this big.

We solved the output voltage problem with an expanded scale analog voltmeter and four 30 Ampere switches. They allow us to tap power from 9, 10, 11, or all 12 cells, while charging the full bank of batteries at all times. We've rarely had to switch in over 9 cells since buying the solar panel. Output voltage varies from 12.6 to 13.9 Volts depending on charging conditions.

Our batteries are true Edison cells. The spring-loaded rubber-sealed vents on ours have the inventor's name and address embossed on top. They yield a higher voltage per cell than nickel cadmium batteries. Richard Perez' Battery Book tells of more gassing in our cells, but we haven't experienced it at our low C/30 charge rate. We've lost about an inch of water in a year, and the cells have a 6 inch capacity over the plates.

Bob Dahse and Lara Meier, Route 3 Box 163A, Winona, Minnesota 55987

Temporary System While Building

I have a temporary photovoltaic system. It is hooked into an old mobile home while my house is built. At that time I will move the system to the house. I will probably invert 100% of the energy to 120 volts AC, due to the building codes, and the resultant extra costs of 'non-conforming' construction.

I have eleven Arco model 16-2000 solar panels charging four Exide 6 Volt 'commercial' lead-acid batteries and a Trace 612 inverter. I also have 12 Volt DC wires going to automobile cigarette-lighter type receptacles.

I run a small Norcold recreational vehicle refrigerator off of the 12 Volt DC power. I run a remote control 13" color TV off of a Powerstar inverter.

Pat Weissleader, 71455 18th Avenue, Desert Hot Springs, California 92240

A 32 Volt Wind System

I have a Jacobs wind plant. It produces up to 1800 Watts of power at 32 Volts. I have two strings of Edison batteries and three of ni-cads hooked in parallel to the Jacobs through a voltage regulator. All light bulbs are 32 Volts. I'm planning to buy 250 more new 75 and 100 watt 32 Volt bulbs. They are getting hard to get. I have a 2500 Watt, 32 Volt DC input, 100 volt ac output, rotary inverter. It runs at 1800 revolutions per minute. The thing I need now is a 32 Volt to 12 Volt DC to DC converter of high capacity (1000 Watts or more). Anyone have ideas on this?

I may buy some photovoltaic panels when they get cheaper.

Ken Sorensen, RR3, Box 67A, Winterset, Iowa 50273

Enjoyable Photovoltaic Life

We enjoy our photovoltaic living. We have been using PVs for nearly 9 years. We have six Arco model ASI-2000 solar panels hooked to a bank of ten batteries, and a Tripp-Lite remote-control inverter. In the future we would like to expand the array and install a tracker.

L. Van Helsdingen, RD Carr Hill, Cortland, New York 13045

A Good Diesel Is Hard To Find

I have been living in remote areas of Nevada for a long time. Hope to get converted to some form of solar energy. I have part of the system in now: batteries, inverter, and battery charger. But I still rely mostly on diesel generators.

I do have a good generator. It is an eight kilowatt Witte. The engine is slow speed (700 revolutions per minute), single cylinder, with flywheels. It burns about 8 gallons of diesel in 24 hours. These engines will run for 10 to 15 years between overhauls.

Don Jung, POB 69, Austin, NV 89310

A Small Home In The Open Fields

I have six solar panels and six Trojan model 105 batteries. I live alone in a small home in the open fields. I have more than enough juice to fill my needs. I recharge flashlight batteries with a charger and a 100 watt inverter. It works fine. I also recharge the car batteries with the inverter. The inverter is really good if you handle it right. The only item that is not on the solar setup is the well. It is 531 feet deep and needs about 4500 watts to pump the water. So I use a 7000 watt Generac generator for that. It would cost too darn much to have a jackpump installed. How much I would like to have that.

Willem de Dood, PO Box 386, Bangor, California 95914

A System In The Desert

I am in the pool business out in the low desert. We have all kinds of sun here for solar, but most people do not utilize this free energy.

I have invested over $9,000 in my solar system. Both my 22 foot travel trailer and my house have their own separate and complete solar system.

I now have three banks of eight Arco model M-55 solar panels on the roof of my house. Each bank has its own regulator. Two regulators are the new Trace model C-30A. The first regulator I purchased was the B.O.S.S. model PCU 12-30.

If I only had one 100 Amp regulator, rather than three thirty Amp regulators, and it went bad, our whole system would have to shut down. Also, as I learned: my three thirty amp regulators were a lot cheaper to buy than a 100 Amp regulator.

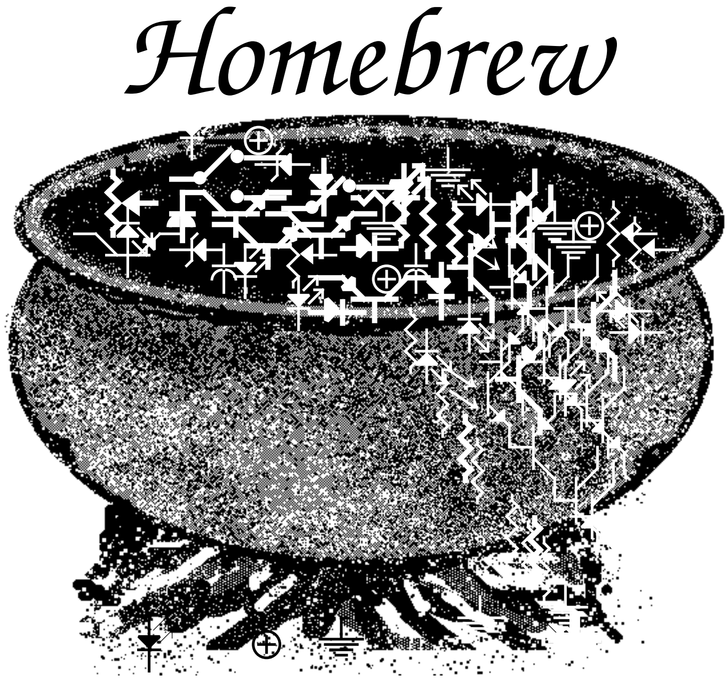
Originally I had all three banks of M-55s on the roof facing due south. Now I have one bank facing southeast, one facing south, and one facing southwest. In the early morning, the batteries are low from using them for lighting the previous night. They get charged by the array facing to the southeast. Likewise, in the late afternoon the batteries charge off the bank facing to the southwest.

My six by six foot swimming pool is heated with four solar panels. The pump has a one-sixth horsepower 120 volt AC motor powered by a Trace 2012 inverter. The water goes through a 60 foot cartridge filter.

My 22 foot boat has its own Arco model M-65 solar panel. My 22 foot trailer has four Arco model M-55 solar panels. I installed six golf cart batteries and a Trace 1512 inverter in the trailer. When the trailer is parked its six batteries are wired directly into the house' 18 golf cart batteries, as is the 9 foot cab over camper with its own 2 batteries. Both the trailer and camper batteries are kept fully charged, and they supply a total of eight more batteries for my house. This helps keep the cost down. Money is scarce.

Charles Hubler, 30-900 Happy Valley Road, Desert Hot Springs, California 92240

System Shorties are brief notes from readers about their home power systems. To join the party, send material similar in spirit to what you see here. We will edit for clarity and conciseness.



AN ACTIVE SOLAR TRACKING SYSTEM

Jeff Damm

In the spirit of fine home-brewing, this tracker uses cheap ubiquitous parts - a windshield wiper motor and a 555 circuit - as the guts for an efficient machine which keeps panels aimed at the sun.

How This Tracker Works:

Driving a threaded shaft attached to the tracker's underside, the windshield wiper motor is powered by a circuit controlled by two phototransistors which are turned on and off by a shading device. The phototransistors and shading device are mounted on the face of the tracker and the tracker rotates in the appropriate direction so that the shading device blocks sunlight to both phototransistors. State B in Figure 1 shows the tracker facing the sun so that both phototransistors are in shade. As the sun progresses across the sky the right hand phototransistor is turned on (state C) and the tracker moves (clockwise in Figure 1) until both phototransistors are in the shade (state B). This CBCBC...BCB pattern ends at night in state B. In the morning the tracker is in state A (it is in the same position, but the sun is on the other side!) and the motor turns on swinging the panels from their night time position until they face the sun.

The Electronic Works

The phototransistor sensing and motor control circuitry in Figure 2 has a left and right side which are mirror images of each other. When Q1 is shadowed, it is turned off, and there is no current flow through R1 and R2. The voltage on the zener's cathode is below the 5.5V threshold necessary for any current to flow through the zener, so Q3 and Q4 remain off. The 555 timer output is low, and Q9 and Q10 are turned off, leaving the motor with no applied voltage.

Light shining on Q1 will turn it on, applying 12 Volts across R1 and R2 and the 10k current limit resistor. R1 and R2 are sensitivity adjustments allowing the user to accommodate various photo-transistors. Q3's threshold is determined by the sum of the zener voltage and two base-emitter diode drops through Q3 and Q4 or Q5 (whichever is greater). When Q4 and Q5 turn on, Q4 will discharge the 4.7µf capacitor connected to pins 2 and 6 of the 555 timer. When pins 2 and 6 of the timer are below 4 Volts (1/3 of the supply voltage) the timer output (pin 3) will go high. Pin 3 will source current into the base resistors of motor driver transistors Q9 and Q10, turning both of them on. The motor will begin to turn, moving the PV panel in the proper direction to shadow Q1 from the sunlight and turn off the motor. The 555 timers were used to generate a pulse extension that would ensure a small amount of mechanical overshoot for the motor so that the system will not draw current during shadow mode. Total idling current is on the order of a few milliamps.

The right side of the circuit works almost identically as the left. Close inspection of the right channel circuit reveals that the motor control transistors have been "swapped" in terms of the polarity. This makes the motor run in reverse when needed.

The two transistors (Q5 & Q8) provide insurance against short-circuiting the power supply through Q9/Q12 and Q11/Q10 by assuring that only one channel may operate at any time. Q5 disables the right channel when the left channel Q1 is turned on and the reverse scenario happens with Q8 when the left side is energized.

The circuit as it stands is flexible. It will run on supply voltages between 6 Volts and 16 Volts without any modifications or performance degradation. The 2N3904 transistors are not critical. They may be replaced with virtually any small signal switching transistors, like the 2N2222A. The zener diodes could easily be replaced with versions having zener voltage anywhere between 3V to 9V. I used heat sinks on the motor control transistors for reliability. With the present circuit it should not be necessary to bother with heat sinks on Q9-Q12. There is nothing special about the 2N5294 transistors. They were cheap and readily available. I did like the TO-220 case outline since a single 4-40 screw is the only necessary hardware. Substitutions for Q9-Q12 only need to have collector current maximum ratings that will accommodate the specific motor used. All resistors used can be 1/4 watt dissipation. Add some series resistance to the motor if you want it to operate more slowly. This will allow you to use motors that have high RPM at rated voltage.

The schematic of Figure 2 is one that I developed back in 1978. It is by no means perfect and there are many ways to accomplish the

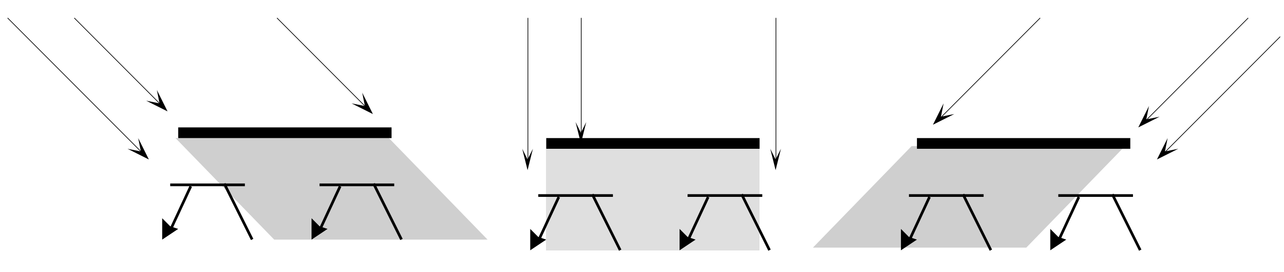


Figure 1. Phototransistor operation

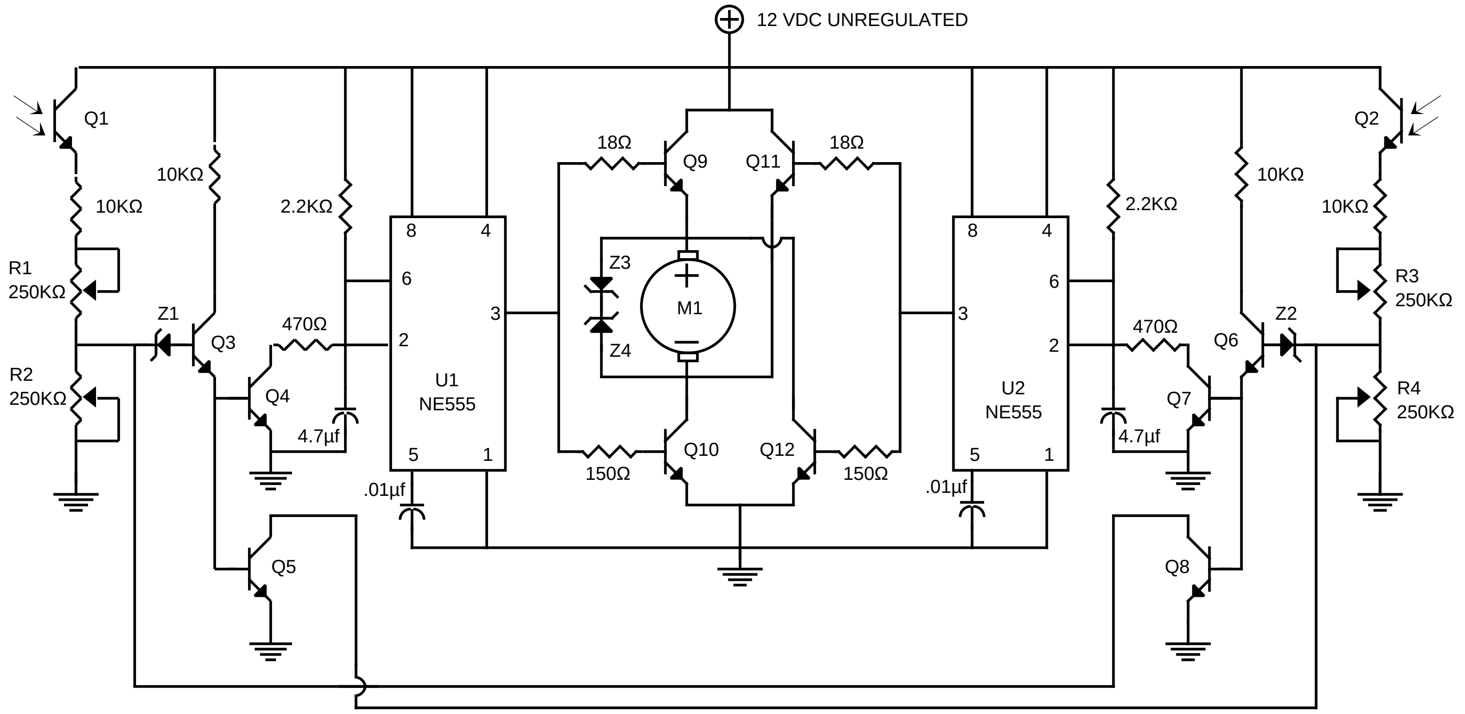


Figure 2. Schematic for an active tracker

same thing. I am presenting this design as an experimental version that does work. The point here is that a circuit like this is destined for some evolutionary changes, especially if enough people start experimenting with the idea. I have used this exact circuit to drive a windshield wiper motor and a threaded shaft hooked to a piece of plywood. It all worked just fine. Watching a piece of plywood track the sun was real satisfying, even though it sounds rather demented. Actually it really WAS demented, but electronics tends to do that to it's practitioners. I did not have any PV panels back in '78 either!!

Parts List

Integrated Circuits
U1 & U2 NE555 Timer, in 8 pin DIP

Transistors
Q1 & Q2 Phototransistors ECG 3031- $10.84, ECG 3032- $11.13, ECG 3034- $1.68
Phototransistors from slotted optocouplers- SDP 8403-301 Radio Shack Infrared phototransistor - $1.98
(See HP#12 , page 35 for mail order parts addresses.)
Q3 - Q8 2N3904 or any small npn 2N2222A, etc
Q9 - Q12 2N5294 or any NPN with Ic > motor current

Zeners
Z1 & Z2 3V-9V zener
Z3 & Z4 18V - 24V zener current rated >1/2 motor current

I was motivated to get this idea out so that guys like Bob McCormick in British Columbia can have a possible alternative to manual tracking. See HP#13 (page 20)

Special thanks to my sister, Pamela Damm, for loaning out her Mac to generate this article, and my AE buddy Mark Schonbrod for technical and motivational support. And especially Richard and Karen Perez for a wonderful weekend of shop talk and advice on how to do these articles.

Access

Correspondence may be addressed to:Jeff Damm, 6565 S.W. Imperial Dr., Beaverton, OR 97005 • (503)-645-0213

Using Kwh Meters On 120 Volt Systems

DAVID W. DOTY

A simple way to monitor energy consumption through an inverter is to use a standard KWH (kilowatt/hour) meter of the type used by power companies. These meters are available used from surplus suppliers, electrical utilities and some alternative energy suppliers. They are also available new from some electrical wholesale houses and sometimes directly from the power company.

The majority of KWH meters, for residential application, are designed to work on 240/120 volt three wire systems. This type of meter consists of a potential coil to measure system voltage and two current coils to measure the ampere flow on each "hot" lead (see figure one). The magnetic forces generated by these coils spin an aluminum disk in the meter. The speed of this disk is directly proportional to the amount of load on the system. The disk is connected to a register by gears to show the cumulative kilowatt/hour consumption. There was some question whether or not a three wire meter would work on a 120 volt, two wire system. Most inverters of the 2KW and under size only put out 120 volt power. After some research, I built a test bench to try it out. The meter I used for testing was a General Electric single phase watthour meter, type I-50-S, model ARI. This meter is rated at 15 amp, 240 volt, 3 wire, Kh 3.6. This is the type of meter used for residential services in the 100 amp range. I obtained this meter (used) from my local power company, free of charge.

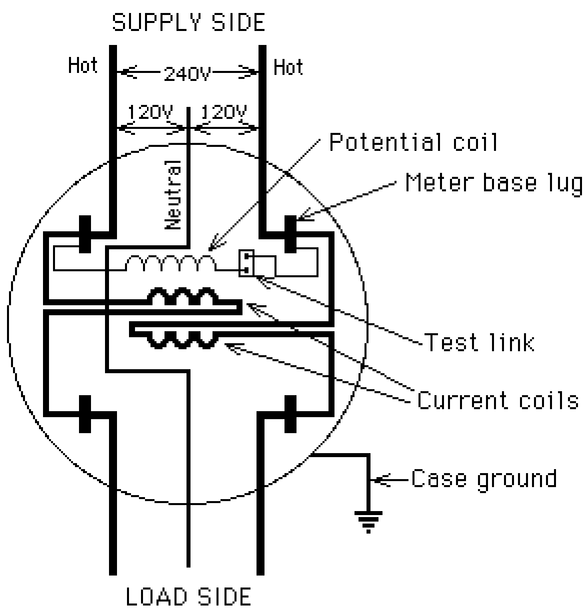


FIGURE ONE

The meter was wired for 120 volt operation, as shown in figure two, using a standard meter base (available from any electrical supply house). The meter was then tested at three different load levels--52 watts, 258 watts, and 1153 watts. The loads used were all resistive in nature. The voltage level and current consumption at the load were carefully monitored using a Fluke model 23 DMM and multiplied to calculate the wattage of the connected load. The rotation of the meter disk was then timed using a stop watch and the load calculated by the speed of the disk, via this formula:

P (watts) = N (rev/min) x Kh (watt-hr/rev) x 60 (min/hour)

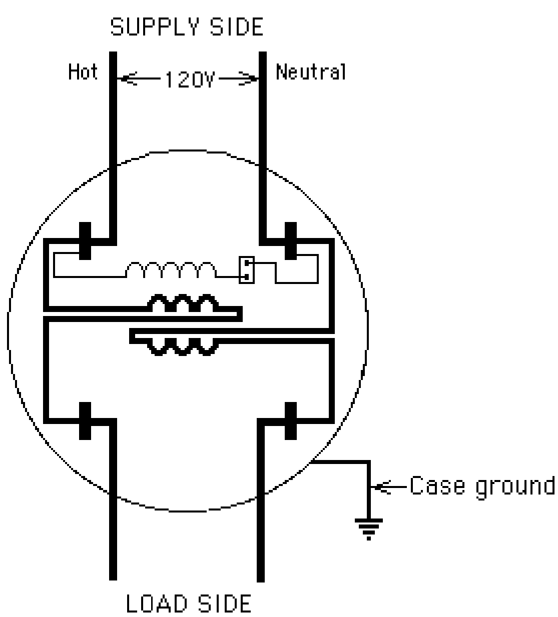


FIGURE TWO

The Kh rating of the meter I was testing is 3.6. This value (the number of watthours per disk revolution) is always stamped on the meter nameplate. With my test load connected, it took 242 seconds for the disk to make one complete revolution. This equals .248 revolutions per minute. Then, using our formula, P = .248 x 3.6 x 60 or P = 53.57 watts. The test load was operating at 118 volts, and drawing .44 amps according to my DMM. Using Ohm's law, this calculates out to 51.92 watts. Therefore, this KWH meter was reading approximately 3% high at this load level. With the 258 watt test load, the meter was reading only .6% high and at the 1153 watt load it was reading 2% high. This level of accuracy is quite acceptable for general metering of your AC power consumption.

I have come across literature that indicates most meters manufactured after 1956 should work fairly well at 120 volts. These newer meters have better voltage compensation to accommodate the lower operating voltage. Also, meters with lower Kh numbers should give you better resolution on low power systems. Meters that show a test current of 2.5 amps are rated for use on circuits up to 60 amps. Meters rated at 15 test amps are good for up to 100 amp circuits and meters rated at 30 test amps are used for circuits up to 200 amps.

When using a KWH meter on an inverter supplied system, you may have to adjust the load sensing feature of the inverter. This will prevent the inverter from "turning on" from the small load imposed by the potential coil in the meter. If there is any doubt in your mind about how to wire a KWH meter into your system, get help from a licensed electrician.

ACCESS:

KWH meters are available from the following sources:

C and H Sales Company, 2176 E. Colorado Blvd., Pasadena, CA. 91107 (800) 325-9465

Steamco Solar Electric, 2700 Cantu Lane N.W., Bremerton, WA. 98312 (206) 830-4301

Also check with the metering department of your local power company (if there is a power company in your area!). Often they will give you one of their old meters that has been removed from service, if you explain your intentions to them.

David W. Doty, 14702 33rd Ave, N.W., Gig Harbor, WA 98335 • 206-851-2208.

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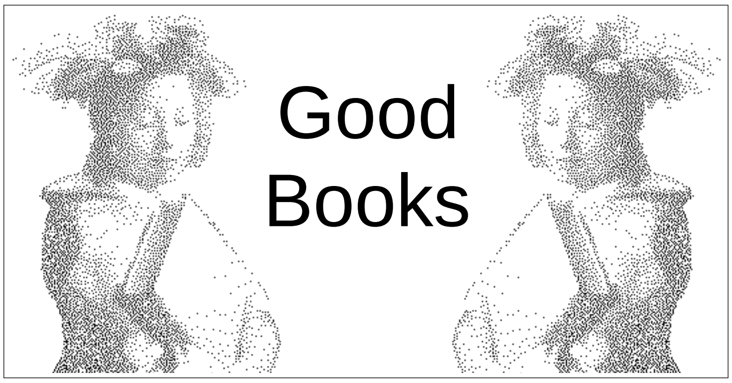
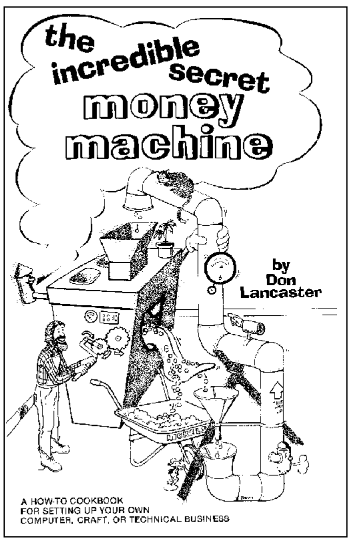


The Incredible Secret Money Machine

by Don Lancaster

Reviewed by Stan Krute

If you want to run a small business from your home, but have neither the time nor money for lots of mistakes or a business school diploma, BUY and READ this book. It may be all you'll need.



I'd scanned this book over the years, but never really sat and read it thoroughly cover to cover until now. I wish I'd done so many mistakes ago. It's one of those books whose reading you may punctuate every few paragraphs with whispered cries of, "Yes. Mmmm hmmm. Yaaaas. Yes !!!!".

No, it's not one of those "eventually buy Manhattan starting with $0 cash down" or "build a garage operation into a hive of MBAs just before selling out to some megacorp" scams. What Don does here is give you the nuts and bolt details of turning a small-scale technical or craft vocation into a solvent make-a-living operation. Page after page is filled with nuggets you want to copy and post on your walls.

A Lancaster money machine works if:

"You are into a technical or craft trrip on a total lifestyle basic.

You want to stay in control.

Money for money's sake doesn't matter.

You are gentle to others and the environment."

Fill those requirements, mix in some horse sense, throw out all trendy standard traditional business advice, add a lot of intelligent personal value, and Don thinks its tough to fail. I think he's right.

Book chapters cover: strategy, tactics, getting started, keeping informed, communication via words and pictures, unmatters, tax dodges, and investments.

A few more quotes now:

"Cash flow is everything."

"Separate frugality from stupidity."

"The library is where it's at."

"Never confront any government official on any level at any time for any reason."

"Sign nothing major without cooling off."

"Give them something extra .... and leave them wanting more."

"Expand by bootstrapping."

"Get some stationery."

"Words should be transparent."

"Avoid information sinks."

"Shut up after the sale."

"Stay in school forever."

Don puts his own scheme into action. He's a writer. His hobbies include spelunking, biking, and tinaja questing. (A tinaja is a monolithic rock basin with water in it year round. Remember, Don lives in Arizona.) He is the author of many classic technology-prodding books, including the pivotal 1976 titleThe TV-Typewriter Cookbook and the ubiquitous reference The TTL Cookbook..He also writes regularly intelligent columns for Computer Shopper, Radio Electronics, and Midnight Engineering.

Repetitiously Summarizing: this is a great book for anyone running their own small business. Buy it. It may be the most important book Don's written.

Access

This book is officially out of print. However, Don's company has some available, and will print more as necessary. The book is $11.50 postpaid from: Synergetics, Box 809-HP, Thatcher, Arizona 85552. Phone: 602-428-4073.

Alternative Energy Sourcebook 1990

by Real Goods

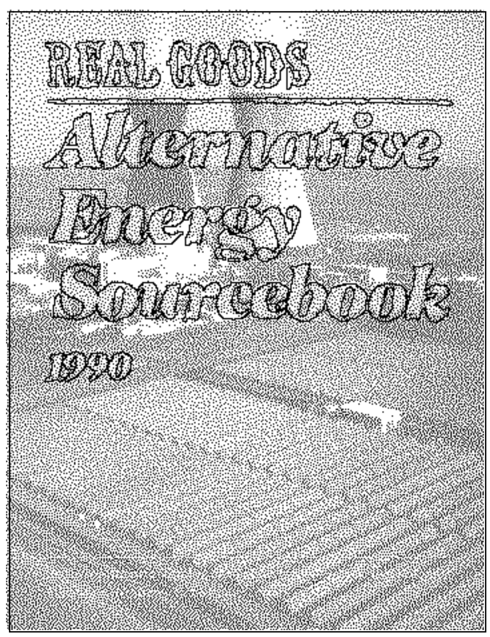
Reviewed by the Wiz

The Alternative Energy Source Book is not just another catalogue and price list. It is also an information resource. As a catalogue is gives you information about the products. There are articles, reports, comparisons, and test reports. There are also many tables and graphs to help you determine your system needs. At $10.00 it is a worthwhile addition to your AE bookshelf. 318 pages, available from:

Real Goods,

966 Mazzoni St.

Ukiah, CA 95482.



We usually don't review catalogs, but in this case we've made an exception. This Sourcebook is over 50% good solid info. We use it and think you will to. RP

the Wizard Speaks…

Life and Entropy

In the natural universe the one system that, more than any other, tends toward anti-entropic behavior is that system which we call life. Life builds up order rather than breaking it down, incorporating in its structure the refuse of otherwise entropic processes. Entropic processes constitute the status quo. Being non-changing, non-evolving processes, the status quo or entropic matrices eventually decay. Life being ever changing, however, uses the breakdown and decay of entropic processes to build newer and more ordered structures for itself.

At each evolutionary level life produces information processing systems whose orders are a degree higher than the information they process. The result is a quantum leap of information processing ability for each step up the ladder of evolutionary change, and consequently there is a quantum leap in externalized technology for each evolutionary step. These status quo technologies which will eventually eventually decay, serving as a resource base for the next evolutionary leap, and consequent technology. These evolutionary leaps are fueled by the partial and necessarily incomplete processes whose degree of order is equal to and in some special cases greater than that of the present evolutionary level of the life form in question.

The above analysis is also true when applied to the sociological, political, economic, and religious processes of humanity. Those which refuse to change and evolve will eventually decay to become the resource pool for newer and better interactive human matrices. In truth, death and decay come only to non-evolving status quo systems.

Home Power, not just the magazine but the entire event matrix associated with its concepts, is one positive sign of an impending evolutionary leap and their are many others. At least a portion of humanity is about to come of age.

Writing for Home Power Magazine

Home Power specializes in hands-on, practical information about small scale renewable energy production and use. We try to present technical material in an easy to understand and easy to use format. If you want to contribute info to Home Power, then here's how it is done…

Informational Content

Please include all the details! Be specific! Write from your direct experience- Home Power is hands-on! We like our articles to be detailed enough so that a reader can actually apply the information. Please include full access data for equipment mentioned in your article. Home Power readers are doers. They want access data for the products you mention in your article.

Article Style and Length

Home Power articles can be between 500 and 10,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short and to the point. We like the generous use of **Sub-Headings** to organize the information. We highly recommend writing from within an *outline*. Check out articles printed in Home Power. After you've studied a few, you will get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

Editing

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

Photographs

We can work from any photographic print. The best results happen if we have a black & white print rather than color. We can work from a negative if necessary.

Line Art

We can work from your camera-ready art. We can also scan your art into our computers, or even redraw it via computer. We usually redraw art from the author's rough sketches. We can generate tables, charts, and graphs from your data.

Got a Computer?

We would like your article on computer disk if possible. This not only saves time, but also reduces typos. We use Macintosh computers. Please format all word processor files in "TEXT" format. We can also read text files on 3.5" IBM disks. Please format the IBM word processor file as ASCII "TEXT". Format all graphics in either PICT, EPS, or TIFF formats. Use the Helvetica 9 point font for all text embedded within graphics.

What your material returned?

Please include a stamped, self-addressed, return envelope. Otherwise your material will not be returned.

Copyrighting

If you request it, we will copyright your work in your name. Otherwise we will copyright the information in Home Power's name. The copyright on your material is yours for the asking.

Got any questions?

Give us a call at 916-475-3179. This saves everyone's time.

RP

Muddy Roads

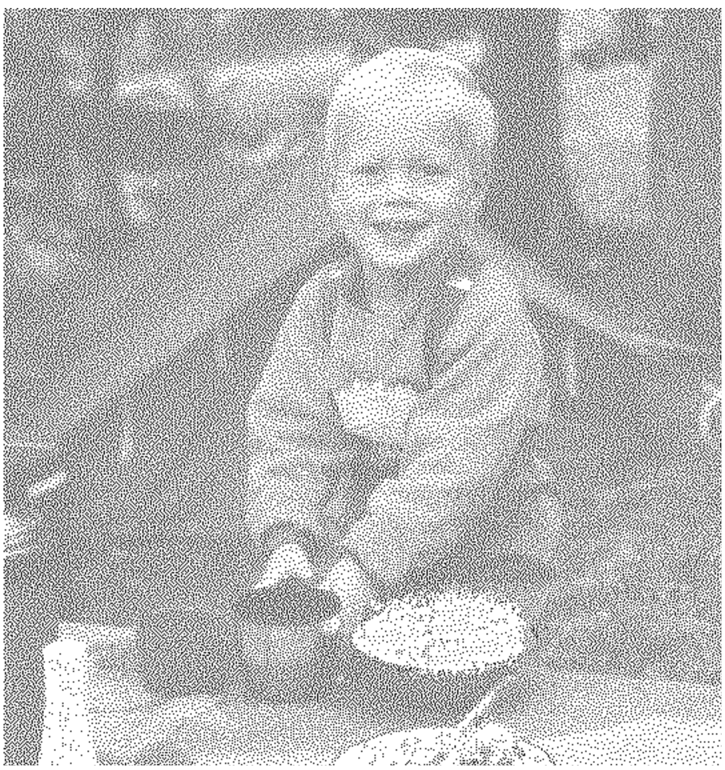
Laura Flett

Perfect

A camping trip for Mother's Day. What a perfect idea. It was to be the big chance to test out all functions on our newly purchased 20 year old travel trailer prior to a big trip in it this summer. We would get to our camp site on Friday night after work and spend Saturday getting everything working and having a family day. Saturday evening at 5 PM Jim would drive an hour down the mountain to a country schoolhouse. Here he would rendezvous with my mother, escort her to the camp, and we would all have the night and Mother's Day together.

That Afternoon

At 4 PM Jim left camp. Our four year old was in a deep nap in the trailer. Our one year old went with Jim for the drive. I settled down for one of those very rare moments in motherhood of the potential of two hours of solitude. I even resumed some cross stitch I haven't worked on since baby #2 arrived.



Camping **can** be fun. photo by L. Flett

Whoops !

Forty five minutes later Jim hiked in with the baby on his shoulders. The truck was stuck in a small patch of snow 15 minutes down the road. Jim had taken a "short cut" out. All we had for digging tools were a frying pan, a claw hammer, a cookie sheet, and a tire iron.....and visions of the mother waiting stranded at a remote schoolhouse. Carrying both kids the brisk walk back to the Bronco very few words were exchanged. After two hours of digging with above-mentioned implements we had the tires freed up, the differential visible, both axels showing and various pans under the center freed. The truck still would not budge. The kids were screaming. The fingers were beyond numb and the clothes were soaked. And who knows what the mother was doing. We abandoned the truck on the patch of snow that couldn't have been more than 5 feet longer than the truck and headed back to feed and bed kids and sleep with visions of a stranded mom in our heads.

Help Arrives

It froze hard that night and our digging implements were no longer of any use. Now it was time to wait for the thaw. At 9:30 AM a nice group of gentlemen pulled in to fish for the day. They had a truck They had four wheel drive. They had chains. They had a shovel. In less than five minutes the truck was yanked off of the patch. The final job was to attempt to find an upset mom and patch up Mother's Day.

CQ HOME POWER HAMS

KE5HV • KG6MM • N6HWY • KB6HLR

Regional Home Power Nets
(local times indicate local nets)

7.230 MHz on Sundays at 1330 Pacific, Central & Eastern.
3.900 MHz on Wednesday at 2000 Pacific & Eastern time.
14.290 MHz Sunday at 1900 UTC.

Novices

Wednesdays at 0300 UTC-
7.107 to 7.110 MHz. Listen for Dave KB6HLR
7.110 MHz on Wednesdays and Saturdays at 0500 UTC.

AAA

HAPPENINGS

ATA Summer 1990 Workshops

Now's the time to sign up for ATA's intensive PV Workshops, the nations leading PV design and installation course (Solar Age, May 1986). ATA's two week workshops take you from theory (first week) to hands-on application (second week). You may sign up for 1 or 2 weeks, the cost is $350 per week. David Palumbo, Independent Power & Light is hosting one of the workshops starting June 18, 1990 at his PV powered home in Stowe, VT (see page 6, HP#17). Call David for more info.

Another workshop will be in conjunction with SEER'90. The Willits session starts July 30th. The hands-on part of the course (2nd week) will include helping set up the energy systems for the fair.

Sign up soon if you're interested, the courses are filling up fast. For more information contact Johnny Weiss or Ken Olson, ATA, 410 Garfield, Carbondale, CO 81623, 303-963-2682

SunAmp Seminar

SunAmp Power Company will hold a two day PV seminar on July 20th and 21st 1990. This seminar is designed for everyone from professionals to do-it-yourselfers. Some of the topics will be: introduction to PV hardware, demonstrations of systems, instrumentation, information access, system design and marketing.

Cost of the seminar is $145.00 ($100.00 for each additional person in the same party) which includes two lunches, refreshments, syllabus & classroom materials. For more info., contact Steve Bass at SunAmp Power, POB 6346, Scottsdale, AZ 85261, 602-951-0699 • 800-677-6527.

Summer Workshops on Creating and Sustaining Healthy Environments

A series of weekend workshops on architecture and ecologically sustainable design techniques will take place from June to November at the Farallones Rural Center near Occidental in Northern California.

Workshop topics include: architectural design, eco-cosmology, taming nature/wilding man, creating healthy buildings, and the myths of nature.

The eighty acre Farallones Rural Center will serve as the workshop site and participants will be housed in solar cabins which dot this model "eco-village". Wholesome meals, featuring fresh produce from Farallones organic garden, will be provided. The site also features resource conserving systems, rolling hills and redwood forests.

For a registration packet and further information about other upcoming workshops, write the Farallones Institute, 55 Gate Five Rd., Ste. C, Sausalito, CA 94965 or phone 415-332-ECOS.

Letters to Home Power

We Print 'em 99.9% Unedited

Selected, Entered, & Illustrated by Stan Krute

Noiselessly Leave The Power To Us

We are very pleased with your magazine and have found it to be most interesting. We are now using solar panels to charge batteries on our converted Greyhound bus. We live in the conversion, and will be traveling, and we have found that the solar energy is so efficient & QUIET! We never use our generator! When we decide to settle down again we will be using solar and water power to power our home.

We are sure your magazine will be of great help.

Bud and Nancy Dibble, P.O. Box 1003, Old Saybrook, Connecticut 06475

(((You have my silent congratulations and thanks. SK.)))

Famous Travelling Bicyclist Checks In

Excellent publication! I had heard of you, but just saw issue #8 at a local ham club. The lead article in that issue is excellent and fits my immediate plans.

I've traveled about 16,000 miles on a computerized, ham-radio-equipped recumbent bicycle -- with all systems solar powered. New model under construction carries 92 watts of SX-series modules, regenerative braking with VR hub motors in the trailer, and computer controlled battery management.

I look forward to future issues.

Steven Roberts, P.O. Box 2390, Santa Cruz, California 95063

Thanks, Steve. I've had the pleasure of examining Steve's vehicle at several computer-related gatherings. It's very magic. You may have seen articles about his system in various computer-related mags. He has been known to modem from phonebooths. SK

City Of Angelic Electric Cars

I'm an aerospace engineer with Hughes Aircraft. Your publication helps make my dream of self-sufficiency a reality. In it I learn of all the latest equipment, how to use it, and where to buy it. I am currently building an electric car. My 750 watt photovoltaic array on my house in Los Angeles will help me charge it. I'm looking forward to seeing many more enlightening articles.

Sincerely, Greg Glenn, 12561 Indianapolis St., Los Angeles, California 90066

Solar Ovens And Treadle Power

Dear Home Power,

Thank you for doing the article on solar cookers some issues back. It inspired me to think more seriously about making one. I'm now assembling materials to do so. I'm trying to get a substitute that's ligher and less breakable than glass, because I'd like a portable cooker for use when camping.

I'm enclosing an article you are welcome to use, about hand powering a sewing machine. *(See tend of letters section. SK.)* I'd be interested in seeing an article on treadles (of different designs). I've seen some nifty home-made wooden ones at spinning shops. I assume they were made for spinning, but that they'd work for powering any device that doesn't require much force (such as a grain grinder does). Treadles have more bulk and weight than my hand powering device, but they leave both hands free. (Another place I saw one was in the magazine **Threads**. It was a photo of a treadle(for spinning) that employed a bicycle wheel. Seemed very ingenious. Ah, yes I made a note of the issue#: April/May 1986, and also February/March 1986. I saw **Threads** in the library at Oregon State University. It might be in other schools' libraries.)

Best wishes for spring time.

Julie Summers, POB 190, Philomath, Oregon 97370

Thanks for the article and note, Julie. Anyone got treadle experiences they want to share ??? SK.

Chilling Burnout & Hot TV

I run a small Norcold recreational vehicle refrigerator off of 12 volt DC power. It is connected with automobile cigarette-lighter type parts. It regularly burns out these 12 volt sockets, and I have to replace them. (1) Is there a heavy duty automobile cigarette lighter type socket that won't burn out ? (2) Or should I switch the refrigerator to its 110 volt AC setting and run it off the inverter ?

I also run a remote control 13 inch color TV off of a Powerstar inverter plugged into the 12 volt DC part of my system. The Powerstar gets very hot. (3) I wonder if it is hurting it to leave it plugged in. (4) Should I unplug it at all times when it is not in use? My problem is not saving power, since my usage doesn't even dent the capacity of my system.

Pat Weissleader, 71455 18th Avenue, Desert Hot Springs, California 92240

(1) Solder the wiring to the reefer. Then it's low loss forever. Your reefer draws ≈20 Amps. Cigar lighter stuff is good for 7 Amps MAX.

(2) No, your reefer is doin' OK on 12 VDC if you can keep from torching the cigar lighter plug.socket combo.

(3) & (4) Yes, don't leave the Power Star on line if you're not actively using it. The heat does it no good and the TV may be a phantom load. Consider putting a 20+ Amp switch in line with the inverter's input. RP

Seeking Windmill Control Mavenoid

Could you put me in touch with somebody that could help me with a simple automatic voltage regulator for my windmill ?

L. Van Helsdingen, RD1, Carr Hil 4073l, Cortland, New York 13045

Try Mick Sagrillo at Lake MI Wind & Sun. See his article and display ad in this issue. RP

Grid Power Pigs No More

To K&R, from K&R:

This letter basically says: THANK YOU THANK YOU THANK YOU! You folks have made it clear to us that home/personal power is not only possible, but can be cost-effective even in marginal situations like ours.

We designed and built a solar-assisted house in the hills of Richford ("centrally isolated in Upstate NY") over the last few years. Things always take longer than they ought to, but what the heck. We are pretty pleased by what we have accomplished so far, and are looking at moving in this summer.

The house is an asymmetric two-story of about 1600 sq-ft built on a slab (no basement). It has a large 36 foot by 8 foot plexiglas sun box on the south-facing second floor, which we expect will augment the wood stove.

Between the power company and the contractors required to put in a connection to The Almighty Grid, we'd have to lay out about $10,000 to run a line the half-mile or so to the nearest power. And we would end up owning (read: maintaining) the line as well. All this for the privilege of paying the ever-increasing electric bills.

We're committed to putting in a solar-driven power system (photovoltaics) and are working with Jon Hill of Integral Energy Systems, who has been extremely helpful in specifying the components and suggesting better ways to do things. Unfortunately, we have a poor location for solar: the annual insolation is about a third or so of the national average, and there is only one place in the lower forty-eight that has a lower level of sunlight (it's in the Pacific Northwest). We're buying a Zomeworks tracker with 12 Solarex 60-Watt modules, and we'll see what El Sol gives us in the way of photons to drive it. We expect to expand the array in the future when we've saved up again.

We have been grid-power pigs by home power standards: over many years we have averaged about 25 kilowatt hours per day, drawn from the grid. Admittedly, much of this is electric heat, supplementing an old natural gas furnace in a leaky 140-year old farmhouse, and has been decreasing as we become more energy conservative; we're averaging under 20 now. But even that's absurdly high for a solar-powered residence in this area, unless we smother the place with photovoltaic panels.

Part of the problem we face in the new house is that we are both computer professionals, and Roy has a private consulting business at home that often has the computers running 18 hours a day. The business helps support the house, so clearly, our everyday habits of electrical usage have to change radically if he is to continue to work at home, which we both desire.

We figure with efficient appliances and lighting, and woodstove/solar instead of gas/electric heat, we can wean ourselves down to about 3 or 4 kilowatt hours per day (groan -- all things are relative). Even with 15 kilowatt hours of useable (50%) battery capacity, we'll need generator backup to get us through the regular 6-day and occasional 20-day cloudy stretches that characterize this area.

Nevertheless we have good solid reason to believe the system will work, thanks to you folks, Jon Hill, and the other Home Power People.

We really appreciate your interest in our project and the excellent phone advice last Saturday. We offer the enclosed check as a contribution to the Home Power Magazine "press" in thanks for that advice, and we'll let you know how it all comes together this Spring. THANKS AGAIN and KEEP 'EM ROLLIN'!

Kate Mink & Roy Flacco, 629 Valley Rd., Brooktondale, NY 14817

Congratulations, Kate & Roy, this all sounds wondrous.

By the way, usage levels of 3 to 4 kilowatt hours per day are pretty common among Home Power People. Funny how when you pay 10 or 20 times the bucks per kilowatt hour you quickly drop to using 10 or 20 times less kilowatt hours. SK.

Electronic Home Power

Home Power Crew,

Right on! Each issue in the mail makes my face smile and my hands rush to tear open the envelope. Enclosed is dough for my own renewal and two new subscriptions I'd like to give to friends. Keep up the great work.

I also wanted to share some ideas on other means to distribute Home Power. Specifically, have you thought about using computer networks like EcoNet, PeaceNet, or the Whole Earth Electronic Library? I'd be curious to know how many of your readers might have access to a computer and a modem along with the inclination to download articles via telephone. More and more folks are using telecommunications now. Moving electrons is the cheapest and most resource efficient way to transfer information. Seems a perfect match for Home Power.

One of the great benefits of on-line publication is that the information becomes easily available overseas. I'm currently working as a consultant to a renewable energy office in Cairo, Egypt. I know they would love to have the hands-on, practical information in Home Power. And they have modems and computers as well. I know that Econet (a computer network run by the Institute for Global Communications) is used by folks like us in many areas, including Scandanavia, Europe, Asia, USSR South America, and Canada.

Another advantage of on-line publication is that a dialogue can be established. This dialogue is called a "conference" in telecommunications talk. Conferences allow readers to make comments about articles, chip in their experience, flag information sources or good buys, and answer questions. Its like an ongoing conversation that gets recorded. The articles from Home Power get the discussion going, then the readers keep it going. A great way to learn from each other, regardless of the city, county, state or even country the readers are in.

I've talked to the people who run Econet and Peacenet and they are very interested in putting Home Power on-line. In the area of energy, they already have a general conference and one highlighting wind energy news. "Home Power On-Line" would be an excellent and welcome addition.

What do think? Maybe you could print this letter and people could express their thoughts on the idea. How many Home Power readers would like to see and/or could use "Home Power On-Line?" Send letters with comments and ideas to me at the address below.

Best regards to the whole Home Power Crew. Your effort is much appreciated.

Eric Heitz, 823 Oxford Street, Berkeley, California 94707

Thanks, Eric. A bunch of you have been reading our minds. We are now up and running on EcoNet. Richard will give you more info in a moment.

The kinds of conversations made possible via electronic conferencing are an inspirational guidepost for working the HP letter column. (Along with all the comic book and science fiction magazine letter columns of my youth.) SK.

The text of Home Power is indeed now on line at EcoNet. As for the graphics and other nontext info quìen sabè. We are also checking into EnviroNet (the Greenpeace BB) as often as we can. We'd sure like to see the info in HP go out without dead trees. RP

From A Home Powered Ski Lodge In The Cascades

Dear Rich & the crew:

I can relate to your statement in HP#16 (Letters, page 59) that you "have found what you're meant to do in life". I think that some people (other people) start and build up businesses just so they can sell them. The idea is to make a pile of money so they won't have to work. For the rest of us, our business is what we enjoy doing in life. I t makes us feel productive and fulfilled, and allows us to live in accordance with our dreams and our principles. I don't see any reason to ever stop working, short of rigor mortis. Do you ?

I run a cross-country ski lodge way back in the hills, 5 miles off the power grid. I'm dreaming about my next addition to the lodge, which will be a reading room. When I do that (in the nebulous future: other projects come ahead in line), I want to wire it for lights. My current photovoltaic system is one Kyocera 48 watt solar panel and a 105 amp hour battery. It powers a 12 volt DC fluorescent over my desk, my radio-phone, and my boom box (when I have extra power). After your note about it being more efficient to wire for 120 volt AC than for 12 volt DC, and to use an inverter, I came up with the idea of wiring for 120 volt lights in the reading room, and hooking this wiring into the panels and into the 4 receptacle system that comes from my Honda generator. I will be adding two more panels and increasing battery storage to about 350 amp hours.

My questions are as follows:

Electricity flows both ways, right? I can use the generator to charge the battery bank through the system, right ? Currently I haul the battery to the generator if necessary, but the panel does a great job. Are the inverters also charge controllers ? *No, inverters are not charge controllers. Some inverters have battery chargers which regulaste themselves. Inverters however do not regulate PVs or hydros. RP*

When the generator is running, do I have to disconnect the PVs?*No, you can leave the PVs on line. RP* Can I connect the generator to the inverter through all the 110 outlets, or does the inverter/charge controller have to come first in line off the generator? *NO NO NO Never let the inverter produce 120 vac into the same line that the generator is also powering at the same time. This is disaterous- it will KILL the inverter. RP* They are on opposite ends of the house, so you can see why I ask. *See HP#11, page 23 for details on how to wire your inverter into your house grid. RP.*

These may sound like dumb questions, but I'm a total novice. Everything that I know about 12 volt (which is to say, virtually everything I know about electricity), I learned from Home Power.

Thankyouthankyouthankyou.

Jennifer Stein, Garrison Springs Lodge, P.O. Box 1191, Ellensburg, Washington 98926

Some Beginners' Questions

As a beginner, having received seven issues, I would like to see more simple explanation of various alternative energy systems. And more basic living questions addressed, such as: (1) Is it possible to run any typical oven/range on alternative energy ? (2) What about electric heating and water heaters ? (3) Can a battery system through an inverter handle anything like that ? (4) Or what about if you have potential for hydro power all year? (5) How would that differ from a photovoltaic system in its capability with or without batteries? (6) Can a typically wired home (using 12 gauge wire) be transferred to alternative energy without rewiring? I believe there are a lot of people who want to change, but are afraid of the unknown. Remember, some of us out here need to start from zero knowledge.

Leo Schreven, P.O. Box 680, Frederick, Maryland 21701

(1) It is possible. The difficulty is that ovens and ranges use A WHOLE LOT of energy. Most home power systems don't have that much energy available. And that energy typically costs a dollar or more per kilowatt hour, versus under 10¢ per kilowatt hour when bought from an electric utility. Cooking is most economically done via gas or wood or solar. (2) Same answer as to (1): heating electrically uses A WHOLE LOT of energy. (3) You'd need lots of batteries and a high-capacity inverter. These are available if you have enough money to spend. (4) Medium and large-scale hydro systems can produce A WHOLE LOT of power. They can take care of things like electric cooking and heating. In fact, the only home power systems I know of that provide those capabilities are hydro systems. (5) The batteries in a home power system act like a flywheel in a rotating mechanical system or a capacitor in an electrical system: they store energy in order to even out a fluctuating supply. During a sunny day, photovoltaics provide lots of energy; during the night, they provide nothing. That's a pretty severe fluctuation. It's batteries that let you use the energy produced by photovoltaics day OR night. Hydro power system fluctuations are much less severe than photovoltaic systems, and thus, as you may have intuited, require less battery flywheeling. (6) Yes, if the alternative energy you're distributing over the existing wiring is 120 volts AC, as comes from a power company or an inverter. Your inverter just feeds your breaker box. SK.

More Things To Do For Futurists And Battery Nerds

Here's a question to put out to all the futurist thinkers out there. How about a practical design hybrid combining a solar water heater with photovoltaics -- (either underneath as the black absorbing surface, or integrated inside using the new Solvonics marine panels).

Also, batteries: smaller and lighter: where are they ?

Paul Prelitz, Seacrest Builders, POB 5024, Laguna Beach, California 92652

Combining PV panels and hot water panels might be practical in some very space limited applications, but there are two important things to consider before combining these sun technologies. First PVs are more efficient at cooler temperatures. Second, no electrical devices like wet environments. Solar hot water panels are by design hot and wet.

Some types of solar cells are specifically designed to be used in concentrators. Water is often used to cool these special PV cells. Every manufacturer I know of will void the warranty on panels used in concentrator service unless specifically designed for such service.

See page 34 in this issue for a comparison of current battery technologies. As to future batteries, who knows? The techies are working on all sorts of stuff- from liquid sodium (ugh) to lithium rechargeables. Whoever invents a long lasting, high density, rechargeable battery stands to make a lot of folks very happy, and probably a large pile of money. CG & RP.

Something Useful In Schools

I enjoyed very much your articles about teaching children about photovoltaics. (*HPs 15 and 16. SK.)* We hope to use the course at our school next year. I'm looking forward to the article about building a battery charger. It will be great for the kids to come away from the course with something they can really use.

Jim Agee, 14618 Tyler Foote Road, Nevada City, California 95959

It's always nice to hear of schools being smart. SK

Simple Load Center

Since my AC loads are kept to a minimum I decided to use two outlet strips as a load center out of my inverter. The strips are fused, have a master on/off switch, have LED (light-emitting diode) indicator lights, and protection up to 15 amps. Two of them gives 30 amps of coverage. A whole lot less trouble and easier than a full scale AC load center. Maybe your readers could benefit. Thanks Home Power for every minute of input.

Sincerely, Kenneth Gillaspie, PO Box 218, Coosa, Georgia 30129

My own plywood palace sports several of these strips. Thanks for *bringing them to our readers' attention, Kenneth. SK.*

Large Flows, Low Heads, Ram Pumps, & Cloudy Winters

What we need to know is about a hydropower system that could be used at our creek, which has an excellent flow but little observable head. Tell me about ram pumps -- we want to supply our house (only 60 feet from the creek) with creek water for wash uses, plus try to get hydro-electric power from it. I'd like to know more about photovoltaic units. We have a 55 watt unit bought 6 years ago for $500. Works great to charge our batteries in full sun. Have they come down in price ? Who are the most reputable dealers ? In order for us to invest in more units, we need to know if our cloudy Washington weather here by Mount Rainier will allow our panels to produce much juice in winter, especially.

Leslie Rousos, P.O. Box 204, Ashford, Washington 98304

Hydro is far to site specific to specify from incomplete data. Do a real site survey, see Bob-O's article in HP#15, page 17. Ram pumps do work well if applied properly, but to consider using them to not only pump water, but also to make electricity via hydro is decidely optomistic.

PV modules have indeed come down in price. Prices are around 5 to 7 bucks a watt, and performance is definitely up. You can reliably order your stuff from any HP advertiser (we try to weed out the weasels). PVs can be a applied in cloudy neighborhoods, see Ed & Meg's system on page 13 of this issue. RP

Domestic Reverberations

I am a wife who doesn't read your magazine but is left to write checks like this one for $6. Consequently I find myself having to fill out your subscription form to the best of my meager ability with the knowledge I absorb from an enthusiastic husband who babbles incoherently at the mere sight of the Home Power Magazine. I have even had to hide the magazine if it comes on a day we are planning to go out or get something done because once he has it in his hands I can't budge him to do anything. Aside from this slight drawback he is a very good guy.

Margaret Odhner, P.O. Box 96, Stony Run, Pennsylvania 19557

And thou art one fine good woman, Margaret. Salute !!! SK.

How Do They Do It ???

We recently moved from a 100% solar/wind powered homestead near Tomah, Wisconsin, including a house we built off the grid in 1975-76, to an old farm house at Menomonie, Wisconsicn, which is in the city limits and of course is grid connected. The Jacobs 32 volt wind generators are temporarily in the shed, but the 6 photovoltaic panels are keeping 60 2-volt cells charged and running our Sunfrost refrigerator. We find that we now use less than 200 kilowatt hours per month (usually under 150) even with furnace fan, water pump, regular refrigerator, plant lights, and all the other household items & appliances. How can "ordinary" people use 600 to 1000 and more kilowatt hours per month ???

At 7 or 8 cents per kilowatt hour the monthly financial pain is generally not great enough to awaken conservative thoughts. At $1.00 or more per kilowatt hour, typical home power system figures, the pain of sloppy usage becomes acute rather quickly. SK.

Carefully Gather Data And Think For Yourself

Dear Home Power,

Regarding the reference (Letters, HP #16, page 56) to Paul Brodeur's recent book, **Currents of Death: Power Lines, Computer Terminals, and the Attempt to Cover Up Their Threat to Your Health**, I wouldn't be so quick to call his story "information". Scientific American, which has for some 145 years been highly respected, in a review of his book in the April, 1990 issue concluded that Brodeur, in using a journalistic style more geared toward selling books tha presenting hard facts, "has done a disservice to the public interest he presumes to champion."

I only mention this because I, for one, have little patience with those who jump at the chance to embrace alarmist attitudes solely because they "feel right." A little knowledge can be a dangerous thing. I encourage anyone concerned with the possible hazards of low-level electromagnetic fields to at least chase down the April issue of SciAm and read the review. Now more than ever, we need facts, and the objectivity to gather them.

Looking forward to the next 16 issues,

Steve Cabito, P.O. Box 677, Chama, New Mexico 87520

Thanks, Steve, for the pointer. I read the Scientific American book review you mentioned, and it seemed reasonable. I have not yet read Brodeur's book. One point: as much as I respect SciAm (I've subscribed since 1967), on issues that touch closely upon public policy debates their record is not always totally pure and cosmic. Some examples (not based on whether I agree with their biases): animal rights, nuclear power and weaponry, and the green revolution. So, as usual, I recommend all interested parties read as many different views as possible, then make use of their own synaptic set to build a personal working opinion. Objectivity is a myth, albeit gradated. SK.

Wind And Draft Animal Hybrid Tech

Dear HP Staff,

My hat is off to you for the excellent job you're doing.

My question is not simple. Is it possible to use the intermediate windmill technology with the all but forgotten draft animal ? Consider my needs to pump water and grind grain. Both are low speed applications using a windmill style piston pump and a burr mill. By using a draft animal pulling a lever attached to an up ended 3/4 ton truck differential and attaching a steel plate to the pinion drive, simple off center drilling of holes produces the eccentric for the up and down action needed to drive the water pump. And the addition of a V-belt pulley of course would drive the grain grinder.

I would appreciate hearing from anyone with ideas or experience using animal power. Does anyone know of a practical plan to make a refrigeration system that does not require electricity, either the absorption system or a windmill mounted compressor ? I would like to be able to make ice cubes or ice chips. All I can find is the simple encyclopedia schematic.

Thank you for your help and especially your magazine.

LeRoy D. Bohna, POB #9, Santa Maria Del Oro, Nayarit, C.P. 63830, Mexico

We have no direct experience with using real horsepower as you mentioned. We do, however, have a horse and a mule who would be only tooooo pleased to try out any ideas. How about it readers, anyone got any ideas on how to get the hay back? RP & KP

Run For Your Lives! It's A Landslide !!!

What you have accomplished is great. Keep up the good work and more of us will be able to get off of the power grid. What you have started will turn into a landslide! Have no doubt that there are countless thousands of us common people who are concerned about the rapid degeneration of our planet and would like to do something about it. You are leading the way.

A.L. Spangenberg, 4661 Rocky Gorge Road, Newport, Washington 99156

Thanks, A.L. We surf our readers' tsunami. SK

Converting A Sewing Machine To Hand Power

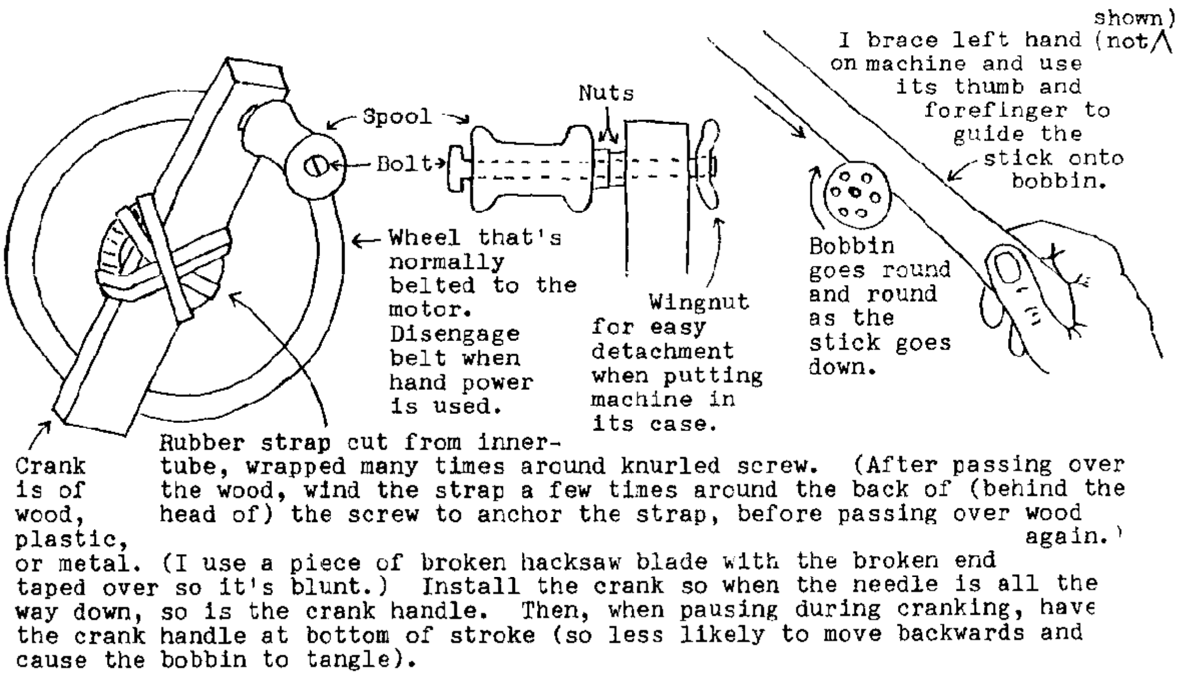
Julie Summers

Lightweight Portable Sewing

As one who doesn't always live where there's electricity, I find a lightweight portable sewing machine (such as the Singer model Featherweight) that I can power by hand a great convenience. (The bulk and weight of a treadle model are probably too great for most portable dwellers.)

From Junk For Free

I was told at a sewing machine store that there is a simple-to-install, inexpensive (+- $5) handle for hand powering that fits some machines -- but mine wasn't among them. It's just as well -- I was able to make my handle from junk for free. Here's an illustration:



Experiential Notes

I've been hand powering for over six years now. My sewing machine remains one of my favorite tools. My sewing has included two rain suits, a knapsack, a one-person mosquito tent, a leather holster for pruning shears, plus much mending and alterations. On jobs with short seams the additional time required is negligible. Longer seams do take considerably more time, and I've consequently had to learn to accept the smaller output per unit of time. I've also had to get used to guiding the material with only one hand, since the other is cranking. And I have to stop more frequently so I can adjust the material with both hands. (I used to enlist a family member to crank for me, but now I usually do it all myself.) I find the slower pace encourages neater work. For me the utility of having a machine operable independent of electric power far outweighs any of the drawbacks. (However, if I had to sew many extremely long seams at one time, e.g., a mammoth mosquito tent, I'd try to arrange for electric power.)

Useful Techniques

At first, winding the bobbin by spinning it with my finger was extremely tedious. However, it goes much faster since I hit upon spinning it with a 20 inch long by 3/4 inch diameter stick (which happens to be my backscratcher). I put the bobbin on the bobbin winding holder of the machine, attach thread, place the handle end of the stick on top of the bobbin, then stroke down. (See the illustration above.) I lift the stick off the bobbin at the end of the stroke and return to the starting position. Then repeat. I wind a whole bunch of bobbins at one time, so I'm not interrupted during sewing jobs.

Image Remembered

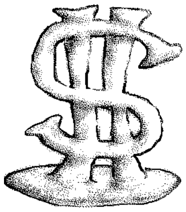
I recall a photo of an Eskimo family, showing the woman sitting with legs outstretched, hand cranking a machine perched atop her thighs. I often work sitting on the floor too, but cross legged in front of the machine, which rests on its case, which sets on its side.

Access

You can write to Julie Summers at PO Box 190, Philomath, Oregon 97370. Other hints on better living thru improvising by Julie appear often in the portable dwelling info-letter Message Post. Sample copies of it are available for $1 from PO Box 190-sr, Philomath, Oregon 97370.

Letters To Home Power
Departmental Policies And Practices

1. We print 'em 99.9% unedited.
2. We DO change any extremely obfusucatory/painful errors of grammar, spelling, and/or usage.
3. For publication, we like 'em short, sweet, practical, inventive, and positive.
4. We print full addresses, so folks can get in touch with you, unless otherwise specifically requested not to.
5. We get lots of great stuff, and everyone reads it all, but can neither print nor respond to each piece due to space/time crunches.
6. Thank you thank you thank you for the wondrous letters you all send. You are us.



Home Power's Business

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

Display Advertising

Full Page	$1,200	67.5 sq. in.
Half Page	$672	33.8 sq. in.
Third Page	$480	22.5 sq. in.
Quarter Page	$377	16.9 sq. in.
Sixth Page	$267	11.3 sq. in.
Eighth Page	$214	8.5 sq. in.

Maximimum Vertical Ad size is 9 inches
Maximum Horizontal Ad size is 7.5 inches

We can set up and lay out your display ad. Camera ready advertising is also accepted. For current, detailed reader demographics, call us.

Long term display advertising is discounted, so buy ahead and save 10% on 3 insertions and 15% on six.

Home Power is published bi-monthly. Ad Deadline for the Aug/Sept 90 issue (HP#18) is 15 July 1990.

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Energy Conversion Devices, Inc, (ECD- the makers of Sovonics panels and Ovonics NiH batteries) announced in mid-April a joint venture with a U.S.S.R. energy organization to manufacture ECD's PV solar products and sell them world wide (except for Japan and India).

These folks aren't starting out cold: ECD has been rapidly spreading from its home in Troy MI to other parts of the globe. They have licensed technology to Japan and have recently set up a joint venture in India for PV manufacture and sales. In the United States manufacture of ECD's photovoltaics will soon begin by a US corporation combining the manufacturing expertise and resources of Canon, Inc. of Japan with the technology developed by ECD.

The Soviet-American joint venture will begin with Soviet purchase of a fully integrated "triple cell" deposition and module assembly plant for $8.5 million (US). This plant should produce 2 Megawatts a year. Pending success, the second phase of the joint venture is a large volume fully automated plant to be constructed in the U.S.S.R. ECD has already received over $2 million from the Soviet Union and further payments will be made as the U.S.S.R. receives ECD manufactured equipment. ECD has licensed its Soviet partner the technology to exclusively manufacture and sell in the U.S.S.R. Manufacture will become nonexclusive if the second phase of the joint venture does not occur.

ECD's photovoltaic and battery products are environmentally safe and they address problems like atmospheric pollution, ozone layer depletion, hazardous waste and the greenhouse effect.

Energy Conversion Devices, Inc., 1675 West Maple Road, Troy, MI 48084 • 313-280-1900.

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Business does GOOD! is a new column for Home Power. We steadfastly refuse to publish inside industry info like Joe Blow is promoted to Vice-President of Whatever (usually accompanied by 8X10 glossy photos only a mother could love…).

But there are companies out there that deserve a pat on the back for the good work they are doing to make renewable energy more useful and less expensive. Business does GOOD! is our place for honoring renewable energy companies that are working for us all, not just next quarter's profits.

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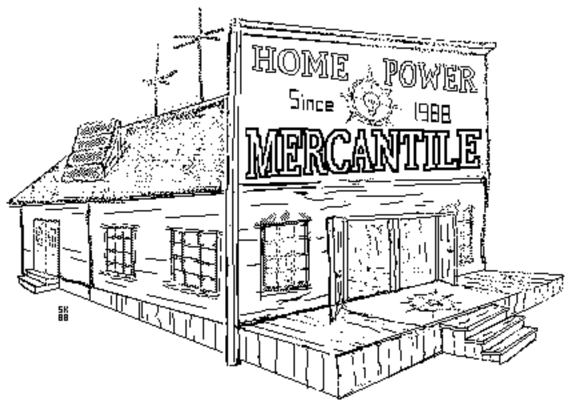

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