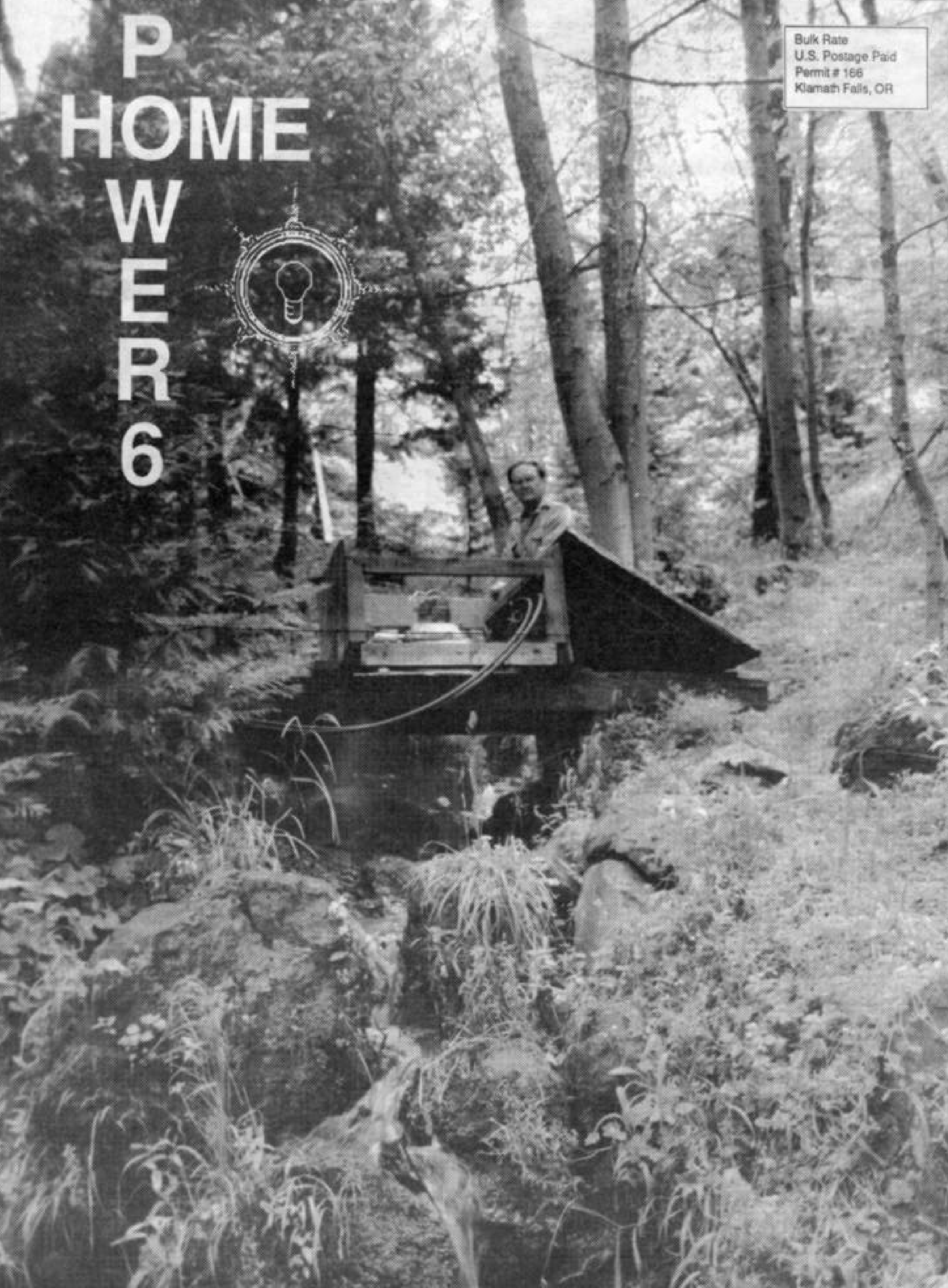
HOME POWER 6



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Contents

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Home Power Magazine
POB 130
Hornbrook, CA 96044-0130

Think About It

"Energy is Eternal Delight."

William Blake

Cover

Harris MicroHydro powers up Journey's End Forest Ranch.
Photo by Brian Green

From Us to **YOU**

Some of you may have been wondering what we do with all the subscription forms. Well, we've been reading their data into the Mac and here is what we've found out. Between November 1987 and June 1988, over 5,000 of you have returned the subscription forms to Home Power. Home Power readers are in every state in the US, its territories and many other countries. Thanks to all who completed the information portions of the form.

We, at Home Power, were getting used to hearing from industry people that there was no real interest in home made electricity. The market was too small, too poor, and/or too disinterested to consider renewable energy products. Well, this survey shows extensive involvement in renewable energy by thousands of Home Power readers. Read ahead for the facts of home style renewable energy use in 1988.

The data below are responses to the various categories on the subs form. The data is raw and not processed in any way other than being totaled. The data includes every sub form, whether the information boxes where checked off or not. It is a picture of what we are all doing now with renewable energy technologies, and our plans for the future. We leave you to draw your own conclusions…

Number of data points in Survey: 5,344

Renewable Energy Usage

	NOW	%	FUTURE	%
Only	1,539	29%	2,381	45%
Primary	482	9%	1,339	25%
Backup	717	13%	755	14%
RV	829	16%	516	10%
No Response	1,777	33%	353	7%

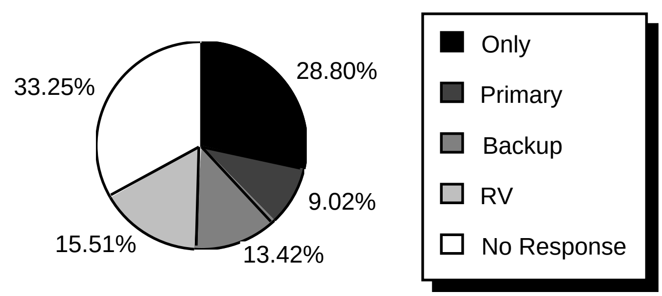
Renewable Resource Potential

	NOW	%
PV Potential	4,154	78%
Water Potential	1,410	26%
Wind Potential	2,494	47%

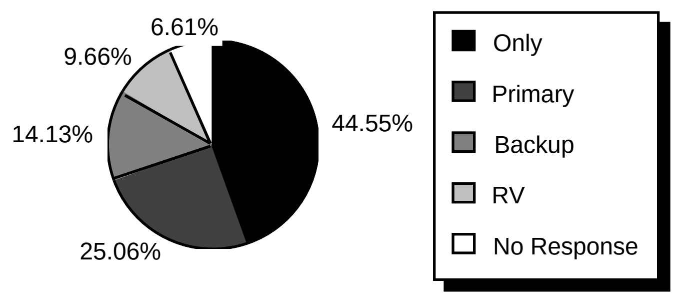
Renewable Energy Equipment Usage

	NOW	%	FUTURE	%
PVs	1,727	32%	2,712	51%
Generator	1,932	36%	1,231	23%
Wind	364	7%	1,720	32%
Batteries	2,379	45%	2,005	38%
Water	202	4%	1,143	21%
Inverter	1,124	21%	2,250	42%
Battery Charger	1,616	30%	1,606	30%
Controls	781	15%	1,691	32%
Instrumentation	851	16%	1,415	26%
PV Tracker	233	4%	1,516	28%

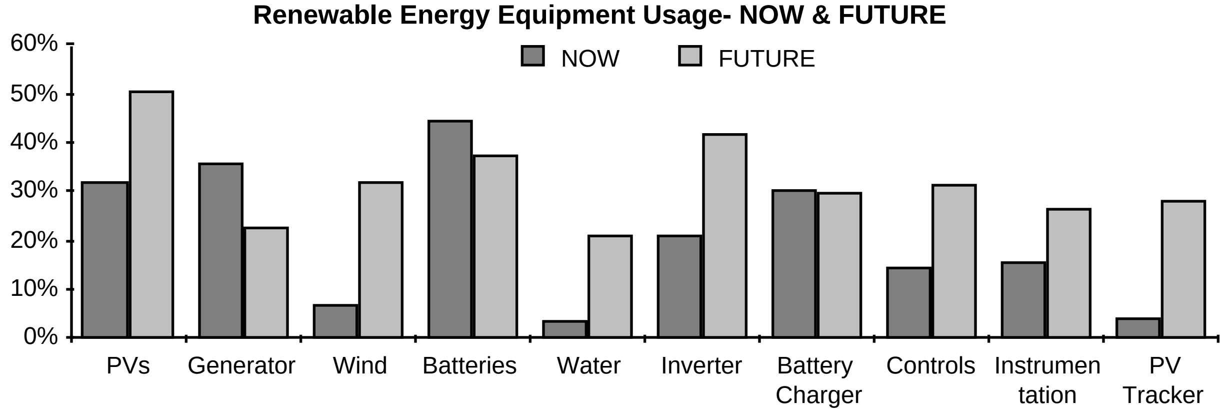
Renewable Energy Usage- NOW



Renewable Energy Usage- FUTURE



Renewable Energy Equipment Usage- NOW & FUTURE



A Working MicroHydro at Journey's End Forest Ranch

Harry O. Rakfeldt

We make our own electricity with a MicroHydro power system. When we were looking for our acreage, our list of requirements contained self-sufficiency. Surface water was a prime ingredient on our list. And we found it. The project to design and install our MicroHydro power system spanned four years. Our goal: to live in a "normal" electrical way, without any commercial power.

Setting the Scene

Our homesite, at 4,300 feet elevation, is located on a corner of a half mile wide, 80 acre, steep mountain property. We are located about 1 mile from commercial electricity. One of the two year round creeks (really a stream) enters our property at the NE corner from the BLM (Bureau of Land Management) land behind us and flows SSW across our land for about 1800 feet. From top to bottom there is a total head of 300 feet. The creek's average seasonal flow varies between about 34 to 50 gallons per minute. But during heavy rains and snow melt, flow will go well above 100 gallons per minute. For practical hydro purposes, it is LOW flow, HIGH head.

Our Considerations

• We like our creature comforts. We wanted our new home to be in all appearances the same as Dick & Jane's in the city.
• Because our maximum output would be low this meant a mixture of electric and propane appliances to reduce electrical needs.
• Our stream flow is heavier in the winter when needed the most.
• To produce a respectable output, the turbine would have to be located at some distance from the homesite. Thus, line loss from transmission of low voltage would be a factor.
• Output from the turbine would not meet PEAK CONSUMPTION (maximum amount of electrical energy needed at any one time). To meet peak consumption, a battery bank and inverter would be required.
• The system should meet our need for TOTAL CONSUMPTION (the number of kiloWatt-hours (KWH) used in a given period of time, most commonly KWH per month).
• And money... How much would a system cost? What compromises did we have to make? There wasn't going to be any money for a second shot if the first try didn't score -- we were going to build a home at the same time. And THIS made me nervous.
• To make a major decision such as this about which I only had "book" exposure put me on the spot with my wife and the few others who knew what was being attempted. With respect to this hydro thing, I felt something like a paraphrased Truman quote, "The flow stops here."

Harry & Marlene on the deck at
Journey's End Forest Ranch

Research and Design

During the four years until our house was built, I had a number of opportunities to observe the creek. Flow was measured a number of times. On this small creek, measuring was simple -- build a small dam and time the overflow into a 5 gallon bucket.

I measured potential head to three different turbine sites on the creek, three times each with two different sighting levels. Starting at the lowest point considered as a potential turbine site, I worked up to the proposed intake site, recording along the way the number of times I sighted through the level and then climbed to that point to sight again. The total figure was multiplied by the 5 foot-6 inch distance from the ground to my eye level to arrive at the total head. Using this method, the final spot decided on for the turbine measured out at 103.5 feet of head. And the site selected offered a fairly straight line for the majority of the penstock's length from intake to turbine and generally followed the creek's SSW direction.

In reading material related to hydro, I came across a number of potential suppliers of hydro equipment and systems. I made contact with one of these firms because the system seemed reasonable in price, was small but looked well made and offered site-selected options. I discussed with Ross Burkhardt of Burkhardt Turbines the variables -- flow and head. Ross and his partner John Takes did much to help me select a system. Ross has a computer program which predicts outputs on the systems he sold. We plugged in my variables and came up with a set of predictions for a 12 Volt system. Then as we fine tuned the variables (different flows and different heads), the 24 Volt system evolved.

What followed at a rapid pace were decisions on an inverter (to match the 24 Volt output), batteries, transmission cable and other related supplies. The size of the penstock -- 3" PVC pipe -- had already been a factor in the discussions with Ross and used in his computer predictions. This size presented a comprise between head loss due to friction over such a long distance --740 feet-- and a nominal size for later expansion if I wanted to extend the penstock further downhill for increased output. I planned for and incorporated this option into the way I laid out the penstock.

The System

Our hydro power system consists of an impulse-driven alternator that produces direct current (DC) to maintain a battery bank. 24 Volts DC is changed by an inverter to 117 volt alternating current (ac) that is passed into the home's electrical circuits through the distribution panel.

For the powerplant, a Harris Turbine system was bought from Burkhardt Turbines. It is a vertical axis, 24 Volt DC Pelton wheel generating setup. A 37 AMP Delco alternator modified for 24 volt output is mounted on an aluminum housing and is direct-coupled through the housing to a silicon bronze Pelton wheel. My setup has two jets (one to four jets can be ordered, depending on your water flow -- a site designed option). These jets hold Rainbird® nozzles which are available in a number of different-sized openings. My system also included a PHOTRON voltage regulator, a 500 watt 24 volt water heating element, a rheostat control to adjust power output at the turbine, a heat sink mounted diode (to control voltage flow direction), a panel with dual meters - VOLTS and AMPS, an extra alternator and detailed instructions.

The battery bank is made up of eight Trojan J-250, 6 Volt, 250 AMP hour units. These batteries are true deep cycle -- listed by Trojan as, "Motive Power-Deep Cycle." The batteries are wired in a series of four to develop 24 Volts and then paralleled to double their Ampere-hour capacity for a total of 500 AMP hours storage.

A model HF24-2500SXW inverter from Heart Interface changes the 24 Volt DC from the batteries to 117 volt ac for use in the home. This inverter is wired directly into the home's electrical panel. The inverter was selected for its high surge capacity -- needed for our induction motors: water pump, refrigerator and washer -- and a built-in 40 AMP battery charger. When connected to an ac generator, the inverter operates as an automatic battery charger while transferring all the loads to the incoming ac power. We keep a 4,000 watt ac gas generator on standby, and we have to use it once in a while.

Getting It Together

The hardest part of putting the system together was the penstock. Not that it was technically difficult, but labor and time intensive. It starts above ground from the intake barrel alongside the the creek. About 40 feet later it enters the ground, a very rocky area that proved somewhat slow and difficult to dig with the backhoe. Shortly after this point, it takes a 45° turn to the right (through an elbow) and continues for some distance underground before exiting to cross above a spring's streambed. On the other side of the streambed, it goes deep underground, up to 6 feet at one location, to maintain grade and follows a straight course for several hundred feet. Then it takes a rapid drop down a 30% grade before relaxing its descent. About 60 feet later it makes a 90° turn to the left through two 45° elbows spaced four feet apart to reduce the sharp transition. The 90° turning point here is intentional. It allows the option to continue the penstock downhill at a later date, giving more head for increased power at a new turbine site. The 90° turn would be eliminated to allow the penstock to continue in a straight line to the new site.

After this turn, the penstock exits the ground again and plunges down an embankment 40 feet toward the creek. At the bottom of the embankment, there's another 45° elbow to level out the penstock before it enters the powerhouse.

Digging the trench took a day and a half in itself. Then the PVC pipe was placed above the trench on crossboards and carefully cemented together and left to dry for a full day before it was gently lowered into the trench and covered.

At the intake end of the penstock is a 55 gallon polyethylene drum. It is connected to the small dam via 4" drain pipe. This barrel is used as the intake because it:

- Filters the debris not trapped behind the dam
- Prevents turbulent water from entering the penstock
- Allows the sediment to settle out
- Can be located as needed with respect to the dam and penstock
- Is easy to work with
- Will last for a very long time

When I put the connections together, I arranged the air vent and gate valve assembly so that it could be removed from the barrel and penstock easily. At the barrel the PVC pipe is threaded into the barrel and a collar is threaded onto the coupling inside the barrel. The short section of pipe on front of the air vent is only slip-fitted into the penstock. Because I only have a low flow stream to work with, building a small dam was straightforward. The end of the drain pipe that extends into the dammed water is also protected with a trash collector made of screening. At the other end of the penstock is the simple powerhouse.

The powerhouse sits directly over the streambed on railroad ties. There is easy access to the turbine components via a removable roof. It's here I really got a chance to be creative -- I even used a kitchen sink! It makes a great base to mount the

A barrel on the penstock keeps the system free of silt and dirt.

The underside of the turbine & sink showing the turbine's cups

trubine, permitting much easier access to the Pelton wheel and pipe connections.

Laying the transmission cable wasn't difficult but required some "engineering." The terrain from the homesite to the powerhouse falls steeply downhill. The cable was buried from the house to within 45 feet of the powerhouse in a channel dug with the backhoe. The aluminum cable I chose for the transmission line between the powerhouse and homesite is very large -- 4/0 (1/2" diameter plus insulation). It came on a 1,000 foot spool and was heavy.

I placed a long pipe through the cable spool and lifted this combination onto the back of my pickup truck with the backhoe. The pipe rested on the top of the pickup bed sides and was prevented from rolling off. The truck was parked alongside the house, facing uphill. I then grabbed the end of the cable and walked it downhill, unrolling the cable easily from the elevated spool. When I retraced my steps from the powerhouse back to the homesite, I sprayed this section of the cable every 10-15 feet with red spray paint to denote this leg

The Harris turbine at home in the kitchen sink. Note the loading control for the alternator on the left, and the valve to shut off the water to the second jet.

as the POSITIVE side of the line. At the truck I cut the cable and then unrolled the second leg of the pair. The length of each leg is 451 feet.

The final step was to install the components at the homesite. We had planned for the equipment by having our building pad cut into a "stepped" pad with a bulldozer. This resulted in a generous 54" crawlspace across the front half of the home where the inverter, control panel and batteries are kept.

Because of the good instructions, the components went in "by the numbers." One of the items connected was the 500 watt water heating element. It serves to use the "excess" output from the turbine. "Excess" is the electricity not needed when the battery bank is fully charged. The voltage regulator senses the state of charge on the batteries and when the batteries are full, it diverts the continuously incoming power from the turbine to a "dump." In this case, the dump is a water heating element immersed in a 5 gallon bucket filled with water. An air heating element could be substituted for the water heating element.

I didn't think I would have a great deal of excess power to dump, so I chose the 5 gallon bucket initially. While I was getting a "feel" for the way the system performed, I could always go to a larger container of water to hold the heating element. I'm still using the 5 gallon bucket.

It's A Turn On

Finally. After many hours of research, long hours of planning and double and triple-checked installation, the day came to try out the system. The gate valve at the powerhouse was closed. At the intake site, I opened the gate valve to let water into the penstock. It took some minutes to fill and let air inside work its way out through the opened air vent. Then back to the powerhouse. There I slowly opened the gate valve and after some hissing and belching, the water began to flow steadily. As I continued opening the valve the turbine picked up speed and then suddenly dropped off slightly -- but at the same instant the AMP meter began to climb! I continued to open the gate valve and brought the system up to full output. It's working, it's working!

And for me it was a special thrill to know I had just crossed into the world of renewable energy -- from and because of my resources!

That was early October 1985. Except for a period in November 1986, when I purposely shut down the system to have a modification made to our inverter by Heart Interface, our micro-hydro power system has been running continuously.

Our "Normal" Home

It's a modified saltbox design that originally appeared as a cabin style post and beam plan in HOME magazine. It's now a passive home with 1,435 square feet, six inch walls, required insulation, two baths, two bedrooms, woodstove heat, and nine feet high thermal mass (brick) in the woodstove alcove.

Propane is used for the range/oven, hot water heater and clothes dryer. 117 volts single phase electricity is used for: an 18 cubic foot, self-defrosting refrigerator (4.3 amps); 1/3 HP jet pump on the water pressure system (8.3 amps); clothes washer (9.6 amps); 500 watt ignitor on the dryer; ignitors on the range/oven; and electric motor to turn the dryer. We also have or use: AM/FM stereo, AM/FM portable radio, 19" color TV, VCR, typewriter, desktop calculator, 1200 watt hair dryer, small TI computer, vacuum cleaner (3.2 amps), electric broom, Dremel hand tool, electric stapler, 500 watt slide projector, electronic flash unit, small B&W TV (Tube type), electric mixer, 4 cup coffee maker, 30 cup coffee pot, electric griddle, blender, waffle iron, hand iron, electric knife, 3/8" electric drill, tape deck, skilsaw (10 amps), ceiling fan, electric clock, battery charger (portable), range hood, soldering gun, our special radio phone, electric meter and lights.

For lights we have fixtures in the dining room (300 watts), downstairs bath (240 watts) and a 480 watt guzzler in the master bath. Our light inventory is rounded out with: two 2-tube, 4 foot fluorescents, one 2-tube, 2 foot fluorescents, a PL-Type (small twin tube) fluorescent (9 watts + ballast) and various single lamp, varied wattage incandescents.

The Need to Estimate

When I was researching a system design, I kept coming across the statement that in order to develop a properly-sized system, I had to "estimate" my projected usage. Now, for those of us who are coming from a "just-throw-the-switch" type of public power environment, to estimate our usage is difficult, at best. Just how much does a refrigerator run in a 24 hour period? How long do I use lights while shaving on a winter's morn? How long... And the list goes on and on.

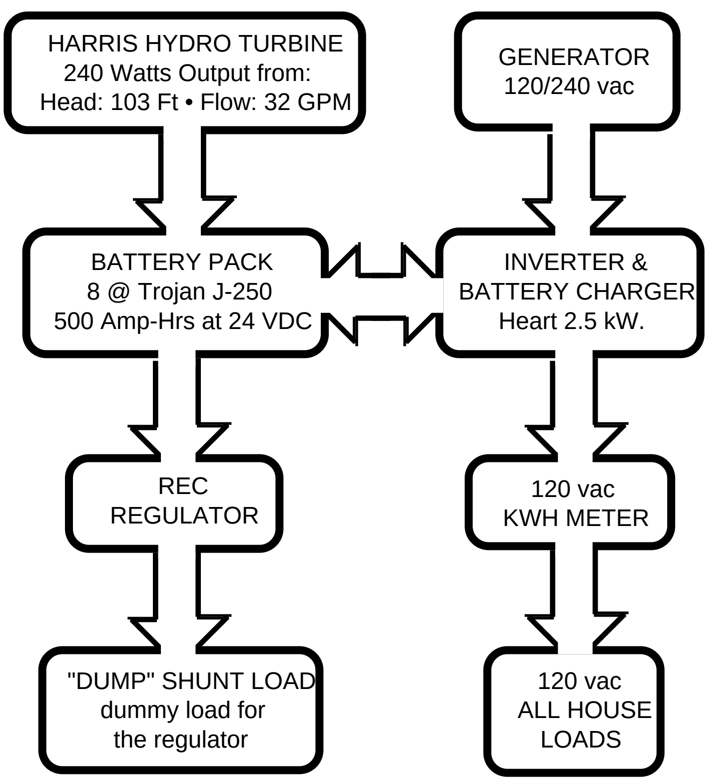
But now I can give you some real help...because I kept track of ACTUAL electrical usage and PATTERNS of usage with a commercial KWH power meter wired to the home's mains panel. But before we look at what has been used, let's look at what I had to work with. Total head is 103.5 feet and dynamic water pressure at the powerhouse is 46 PSI.

In the summer, I use one 3/8" diameter nozzle in the turbine. This nozzle runs about 32 gallons of water through the turbine per minute. This results in 9 Amperes at 24 VDC, or 216 watts turbine output. This amounts to about 5.1 KWH of electricity produced daily. In the winter, increased stream flow allows me to use two nozzles 5/16" in diameter. These nozzles run about 45 GPM of water through the turbine. This ups the turbine's output to 12 Amperes at 24 VDC or about 6.9 KWH daily.

In the 916 days, that the system has been running, we have consumed an average of 4.32 KWH per day as measured by the KWH meter. The system produces a daily average of about 5.0 KWH of usable electricity once inefficiencies in the batteries, inverter, power transmission and other factors are considered. The main thing to be noted from the comparison of output to usage is that there isn't a whole lot of leeway. There isn't much "excess" electricity to worry about.

Even though our turbine output in the summer is lower, so is our average daily consumption. We're not using lights as much, may not be watching TV or using the VCR as often and clothes can now be hung on the line to dry rather than

The interior of the homestead, looking South into the Siskiyous



Block Diagram of the MicroHydro System

tumbled in the dryer. These all help to cut a little off our usage.

In the winter time, or any time for that matter, we have formed the habit of not leaving lights on indiscriminately. When we leave a room, off go the lights. But we don't walk around in a blackout either. We just watch our consumption through closer attention to usage. And we improved over the first months after moving into the house. And now I think we have ourselves trained.

An area that we MUST watch is how much load we put on the inverter at one time. When you compute the watts used by the washer, water pump and refrigerator (117 volts x AMPS = watts), the total EXCEEDS the rated output of the inverter: inverter = 2500 watts; combined usage of item = 2597 watts. When using the washer and water pump, we could turn off the refrigerator. But we don't have to. The inverter surge capacity, so far, covers us when all three of the items happen to be on at the same time. So we do our washing during the day time when lights aren't needed. And we only use the dryer after the washing is done. The surge capacity of our inverter permits it to operate for a period of time even though the normally-rated load has been exceeded. The LENGTH of time that the inverter will continue to operate is directly related to the AMOUNT the load exceeds rating. This may be minutes to only several seconds. The surge capacity for us was a must -- and well worth the few extra dollars.

Standby Power

Yes, we've had to use our gas generator backup. Especially when we have guests who aren't "trained" like we are. Lights left on in the bathrooms; hair dryers going much more often; more flushing of the toilets (our captive air tank has a 36 gallon capacity but reaches its automatic turn-on when 11 gallons have been used) -- just plain more use in a short time frame. Fortunately, our guest stays have not been too long -- but they are noticed with respect to the system.

When our system reaches its low point of 21.9 volts in the batteries, it self-shuts down to prevent damage to the batteries. Even a few minutes wait will sometimes bring the batteries back to a safe limit and the inverter can be reset without resorting to the ac generator. But if the load on the system at the time it shut down is high, I usually choose to start the ac gen and run it for a while to boost the batteries enough to meet the need. As our desire to use more power increases, our next move will be to increase our microHydro's output. The efficiency of my system -- as it operates today -- ranges from 30% to 38%. Not very good. BUT I knew this in advance because the Delco alternator doesn't reach its efficiency in the 24 volt output until it is used at a much higher head. Because of my low stream flow, I have only one way to go -- increase head for more output.

The batteries, inverter, regulator and dummy load are all housed in the crawl space under the house.

I planned for a future increase in head with the manner in which the penstock was installed. I've replaced the first voltage regulator with one much more powerful. The PHOTRON regulator that came with the system had only a 15 AMP capacity. The new regulator has a 40 AMP capacity and the float voltage level can be user adjusted. This new regulator is made by Renewable Energy Controls, owned by Ross Burkhardt. Ross sold out his interest in Burkhardt Turbines to his former partner, John Takes.

What it all Cost

The total cost of the system has been $5,421.37 to date. The expenditures are detailed in the pie chart below. The MicroHydro has been operational for 916 days and during that period has generated 4,671 KWH of electricity. At this point in time, this calculates to an electricity cost of $1.16 per kiloWatt-hour. Over the ten year expected lifetime of this system, the electricity should cost about $0.29 per KWH.

Now, consider that the local commercial utility (PP&L) wanted $5.35 per foot to install 1 mile of line to our homesite. This amounts to over $28,000. for the privilege of paying a monthly power bill. The money we've spent on our MicroHydro system is less than 20% of what the power company wanted just to hook us up!

Some Comments on Components

PVC PIPE - Easiest to use for the penstock. It has a very low head loss due to friction. Take time to cement the sections together -- and to let the cement dry properly. Originally, I tried a 90° PVC CURVED elbow used in electrical conduit. It didn't mate properly and "blew" off quite easily when the system was turned on. Had to shut down for a day to repair with the two 45° elbows.

BATTERIES - The J-250's I'm using don't allow too much storage capacity in my situation. The next sized battery, the L-16, has 40% MORE storage capacity. As I expand my system, and it becomes time for me to replace my present battery bank, I plan to upgrade to the Trojan L-16W.

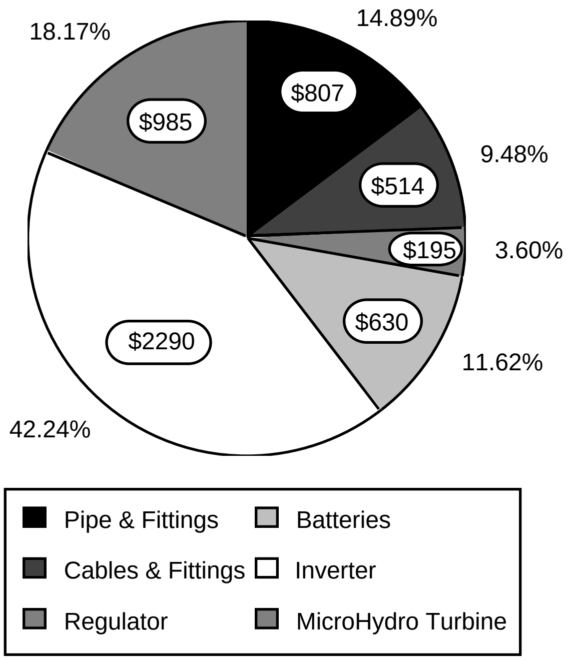
INVERTER - For those who haven't used one before, there is some adjustment necessary. For the most part, forget using the AM portion of your AC-powered radio. The hum from the lines overshadows all but the strongest stations. Stereo and video equipment may also hum depending on make and type.

BATTERY CABLES - Have all connections SOLDERED. My cables came unsoldered. For a while they worked fine. Then deep into the first winter I begin noticing lights blinking especially when a large appliance was on. The blinking disappeared after the cables were soldered.

VOLTAGE REGULATOR - This is an essential piece of equipment in a MicroHydro system. It will sense the correct voltage level needed to properly bring your batteries up to charge and then maintain them there. Without a regulator you'd have to personally monitor the system and then either shut off the turbine when the batteries are full, or flip a switch to shunt off the excess electrical output not needed for the fully

charged batteries.
FAITH - Place faith in a reputable dealer. He has feedback from all sorts of installations. He continues to stay in business by knowing what is happening.

Closing Thoughts
FIRST We feel like a "normal" household. Nothing has drastically changed in the way we live.
SECOND Although the list of electrical items mentioned earlier sounds impressive, we don't use many of these at any given time or the larger ones for any length of time.



THIRD For the two of us, we have what we need. We can curl up in front of the VCR for a double feature, fill our 80 gallon bathtub (meaning, that every 11 gallons the water pump comes on) and other things without the system shutting down. We are careful but not fanatical about our usage.
FOURTH We made some adjustments that are now habits.
FIFTH It's not perfect. The system does work well. And so can yours. Do research, consult with distributors and have faith that you can do it TOO!

EDITOR'S NOTE: When we visited Harry Rakfeldt to take the photos you see here, he had just finished moving his powerhouse some 50 feet lower than described in his article. While this change is too new to give much data yet, turbine performance has increased. The dynamic pressure at the powerhouse is now 76 PSI. The turbine's output has increased some 50% with no increase in water consumption. Harry is now considering a big time electric hot water heater to use his additional energy.

Those wishing to communicate with Harry and Marlene Rakfeldt can write them at 1211 Colestin Rd., Ashland, OR 97520-9732.

Access to Equipment Sources

HEART INTERFACE
811 1st Ave South
Kent, WA 98032
206-859-0640
INVERTERS

DON HARRIS
632 Swanton Road
Davenport, CA 95017
Maker of Harris Turbines

BURKHARDT TURBINES
1372 A South State St
Ukiah, CA 95482
707-468-5305
Supplier of Harris Turbines (packaged systems)
RENEWABLE ENERGY CONTROLS
POB 1436
Ukiah, CA 95482
707-462-3734
Voltage Regulators

TROJAN BATTERY COMPANY
12380 Clark St
Santa Fe Springs, CA 90670
800-423-6569 (outside CA) • 213-946-8381 (CA)

PHOTRON, INC.
149 N Main St
Willits, CA 95490
707-459-3211
Voltage Regulator

UNITED STATES PLASTIC CORP.
1390 Nuebrecht Rd
Lima, OH 45801
419-228-2242 (info)
Polyethylene drums (15-55 gal) Comply with FDA regulations for potable water and food storage (pg 110 of 1987 catalog)
and
CONSOLIDATED PLASTICS CO. INC.
1864 Enterprise Pkwy
Twinsburg, OH 44087
Page 18 of 1987 catalog
Both catalogs may be of value to anyone in need of a variety of plastic containers and connectors/hoses.

ELECTRON CONNECTION LTD
POB 442
Medford, OR 97501
916-475-3179
"The Complete Battery Book", a compilation of information about batteries and their upkeep. This firm also designs, sells and installs complete home power systems.

HOMESTEAD ELECTRIC
POB 451
Northport, WA 99157
509-732-6142
Dave Johnson owner/consultant
Hydro and solarpower systems, inverters, radiotelephones

Living in the Mountains has its ups and downs, but when it's water that's up and it's comin' down, Nature smiles…

Linear Current Boosters

Larry Elliott

Several manufacturers are now marketing devices that promise to triple current output from a PV panel. These linear current boosters (LCBs) help eliminate the need for storage batteries or oversized arrays when running electric motors directly from the panels. Is this magic or simply alot of hype? Actually it's neither. In keeping with Home Power's philosophy of delivering accurate and useful information on new renewable energy products, these devices were tested and their performance documented. The following article explains their operation and gives the facts and figures in how well they perform.

Matching Source to Load

When photovoltaic panels are connected to storage batteries, the match between load and source is pretty close to ideal. The panel is able to deliver close to maximum available power over a wide range of solar intensity, current, and voltage. It is only when PV panels are called on to power electric motors directly that a poor match takes place and we find that the panel is unable to deliver full power and operate the motor.

In order to better understand why this occurs, let's take a look at how a photovoltaic panel delivers volts and amps to a load. A photovoltaic panel is essentially a constant current source. It can deliver a fairly constant amount of current even as the voltage falls. We can see this if we connect an ammeter to a panel and short the output. The current may be as high as three Amps even with the Voltage essentially zero. The power output at this point is also zero since Volts x Amps = Watts. (For those who need to brush up on this see Home Power #1 and #4 for R. L. Measures' fine articles on basic electricity). When the panel is connected across a motor that requires close to the maximum power output of the panel, the motor is essentially a dead short and Voltage drops to zero. With no Voltage, there is no power and without power there is nothing to run the motor. A motor that requires as little as eighty Watts to run at full power and speed may require 150 Watts of panel capacity. This leads to inefficiency and higher costs. Now thanks to modern electronics this problem can be eliminated.

How They Work

Without getting overly technical and trying to explain the inner workings of the various current boosters or power trackers, here is an explanation of how they do their job.

Power or Watts is the product of Volts times Amps. Whether we have 40 Volts at one Amp or 40 Amps at one Volt the power is still 40 Watts. The boosters we are talking about do basically two things. First, they "fool" the panel into thinking that the load it is supplying, in this case a motor, is really smaller than it is. This allows the output current and voltage from the panel to remain at maximum, thus delivering full available power to the booster.

The second function, and really the "magic" that these devices perform, is their ability to covert volts to amps. Using high speed switching power supply technology, an input of three Amps at 24 Volts may, depending on load, be output at 6 Amps at 12 Volts. Power out then equals power in (minus 8% efficiency loss approx.) only at a lower voltage and higher amperage. When this higher amperage is input to the motor to overcome internal friction, and reactive loading.

Permanent magnet motors are the only types that these devices work on. The reason for this is that wound field motors need a higher voltage applied to the field to create the magnetism for the field flux. The magnetic field in permanent magnet motors is independent of applied voltage so it is only concerned with input amps to create the torque needed to start. The trade off is in the motor RPM. Lower voltage means lower RPM.

Proof of the Pudding

Because of the units simplicity and low cost, as well as fine technical support from the factory, the LCB or Linear Current Booster from Bobier Electronics, Parkersburg, West Virginia was selected for this article. The device is a small metal can weighing less than 1/2 pound and measuring less than three cubic inches. It is rated at 3 Amps maximum input, 4 Amps continuous output and 8 Amps surge. Connection is via a plus and minus input from panel and plus and minus input to load. Ten inch leads are provided and connections are clearly marked and color coded.

The model tested had what is called by the factory a "Tweeker" adjustment that allows the device to be adjusted to match any load between 12 and 24 Volts. When the device was first taken from the box, the urge to really give it the acid test came over me. I couldn't wait to hook it up. In my shop I have a 24V 1 HP permanent magnet motor that really is stiff and hard to turn over. It seemed much too large for the test, but then I wanted to put the ultimate load to the device. A 36 Watt Solavolt panel was connected to the L.C.B. I then connected the motor leads and nothing happened.

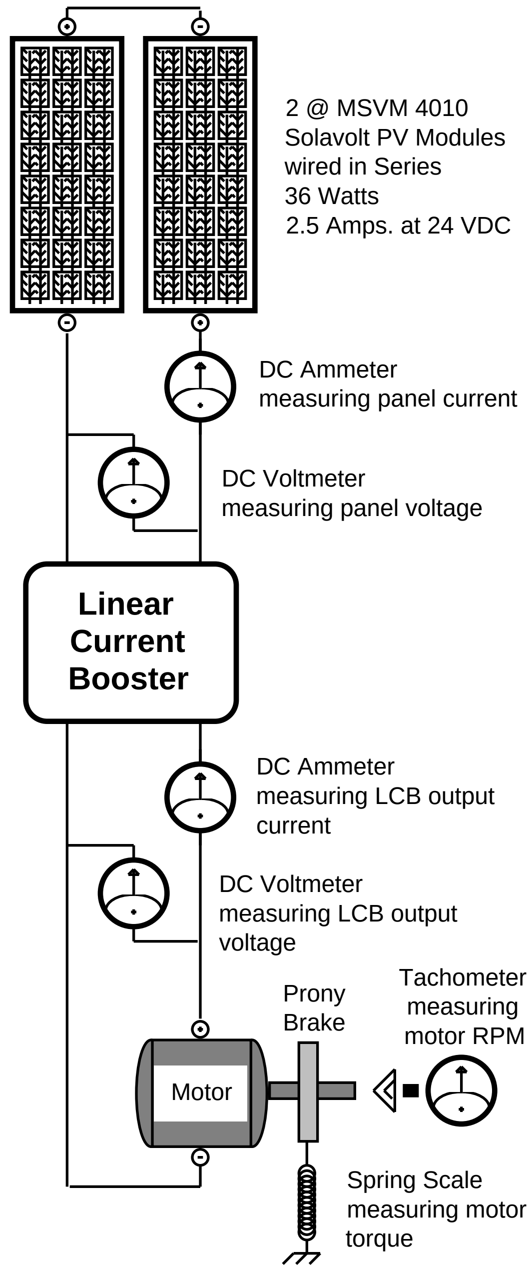
Following the instructions that came with the device I used a jeweler's screwdriver to adjust the "tweeker" on the back side of the case. After a few turns, I heard a high pitched squeal come from the device, and before I knew it the motor had rolled from the deck and on to the ground. The motor was not held in place so the sudden torque of the starting caused it to roll away. Holding the motor in place, I again connected the leads and was very surprised at the sudden torque and quick rise in RPM. I couldn't help being impressed when I realized that this was a one horsepower motor with lots of friction loss, starting and running on less than 40 Watts of power. The booster was putting out over seven Amps to start this motor.

In order to assure myself that the device really worked I connected the panel directly to the motor. I couldn't even get it to hum. I was convinced that the device really did start motors, but accurate lab testing for speed, efficiency, and operating horsepower now had to be run.

Testing Under Load
In order to assure a fair and accurate test of these devices, proper laboratory testing procedures had to be followed. All testing was done at high noon, clear sky conditions at 4,200 feet elevation. Meters and test instruments were calibrated before using. The following diagram shows how connections were made. Input and output current and voltage were monitored simultaneously as motors were tested. Power came from 2 SOLAVOLT 36 Watt panels connected in series to give a nominal 24 Volt 2.5 Amp output. A small prony brake was used to record the output torque from the motor and a hand held tach was used to measure RPM. Using the torque and RPM readings the horsepower was determined. Although five motors in all were tested at 12V-24V-36V, only one was sized to give an accurate picture of performance based on the array size. The motor selected was a 24 Volt 15 Amp 2000 RPM continuous duty unit. The chart on page 14 shows performance figures for loading from no load to approaching full stall when connected to the linear current booster.

From the chart we can see clearly that the booster does indeed supply more current than the panel can by itself. Looking at the input current and voltage, it is obvious that the power is remaining quite stable over the entire range of loads. Close to maximum power is being delivered to the booster. Although we incur some losses (8% average) in the conversion, the power out is still close to power in. The most significant changes we see are in the drop in RPM and the dramatic increase in torque. This increase in torque is the boosters greatest contribution to running motor loads. Not only does this torque boost help in starting a motor, it also allows the motor to power a fluctuating load, or keep a pump operating as a cloud passes. Using this same motor and booster setup, a small rotary vane pump was able to continue pumping even when the sun was hidden behind modest cloud cover. The RPM and delivery rate dropped off, but it kept pumping. On array direct operation, the pump stopped as soon as the clouds rolled in.

Before running the motor on the booster, it was tested on panel direct operation in order to develop a baseline for torque and RPM. With 34V and 1 Amp input, the motor spun to over 2,400 RPM. As soon as the prony brake approached a load of 30 ounce-inches, the voltage dropped very quickly and the motor started to stall. With the booster I was able to load the motor to well over 130 oz.-in. and still not stall the shaft.



The LCB Testing Setup

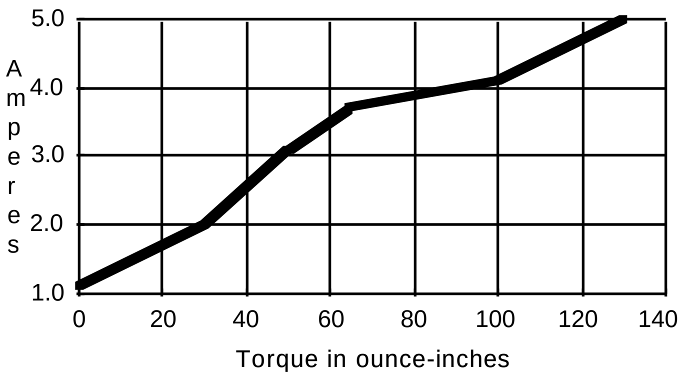
CONCLUSION
Although the Linear Current Booster can't perform magic, or create a free lunch, it certainly can help to reduce the number of panels needed to start and operate motors. The circuitry proved to be rugged and reliable. The device was repeatedly short circuited and forced to deliver far more current on surge than rated for. No failures occurred. At a modest cost of around 50 dollars retail it is well worth the money, when you consider that adding another panel to supply starting current can cost over 300 dollars. The device can be wired in series or parallel for more voltage or current and supply power to large loads. This has the added advantages of redundant connections and reduces down time due to failure. Although

Linear Current Boosters

24 VDC, 15 Amp, 2,000 RPM Permanent Magnet DC Motor
2- 36W. Solavolt PV panels in series- 2.5 Amps. at 24 VDC

PV INPUT		LCB OUTPUT		RPM	TORQUE	H.P.
Volts	Amps	Volts	Amps		oz.-in.	brake
34	1.0	34	1.1	2300	no load	
34	2.0	30	2.0	2000	30	0.060
32	2.4	24	3.1	1770	50	0.088
30	2.8	21	3.7	1400	64	0.089
27	2.8	17	4.1	900	100	0.089
27	2.8	14	5.0	600	130	0.078

LCB Output Current vs. Load Torque



LCD performance in this test.

not advertised as such the current booster can be used to charge a 6V battery at 5 Amps from a 12V panel. Comes in handy when you want to charge just one six Volt battery. For specific applications and engineering information call Bobier Electronics at 1-800-222-3988. Also most of the solar equipment dealers advertising in Home Power stock these devices.

Larry Elliott is the owner/operator of Cascade Engineering and Manufacture, 3611 Hwy. 97N. #50, Klamath Falls, OR 97601, or call 503-844-0817. He is involved with the design and manufacture of PV powered deep well pumps. His "HydraJack™" pump uses hydraulic force to raise water from as deep as 400 feet. The HydraJack™ uses between 150 and 400 watts of PV panels to pump between 400 and 1,000 gallons of water daily.

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to meet your specific water requirements. See pg .27 this issue

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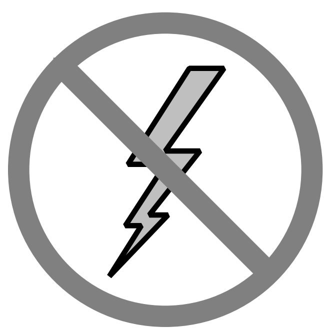
Grounding & Lightning Protection

Windy Dankoff

Lightning and related static discharge is the number one cause of sudden, unexpected failures in PV systems. Lightning does not have to strike directly to cause damage to sensitive electronic equipment, such as inverters, controls and radios. It can be miles away or not even visible, and still induce high voltage surges in wiring, especially, long lines. Fortunately, almost all cases of lightning damage can be prevented by proper system grounding. Our own customers have reported damage to inverters, charging controls, refrigerator compressor controllers, fluorescent ballasts, TV sets (rarely), motors and rarely PV modules. These damages have cost thousands of $, and ALL reports were from systems NOT GROUNDED.

GROUNDING means connecting part of your system structure and/or wiring electrically to the earth. During lightning storms, the clouds build up a strong static electric charge. This causes an accumulation of the opposite charge in objects on the ground. Objects that are INSULATED from the earth tend to ACCUMULATE charge more strongly than the surrounding earth. If the potential difference (voltage) between sky and the object is great enough, lightning will jump the gap.

Grounding your system does four things.
1) It drains off accumulated charge so that lightning is NOT HIGHLY ATTRACTED to your system.
2) If lightning does strike, or if high charge does build up, your ground connection provides a safe path for discharge directly to the earth rather than through your wiring or semiconductors.
3) It reduces shock hazard from the higher voltage (ac) parts of your system.
4) reduces electrical hum and radio noise caused by inverters, motors, fluorescent lights and other devices. To achieve effective grounding FOLLOW THESE GUIDELINES:



INSTALL A PROPER GROUND SYSTEM
Standard practice on any electrical system is to drive a copper-plated steel rod (usually 8 ft. long) into the earth. This is a minimum procedure in an area where the earth is moist and hence more easily conducts electricity. The north side of a building, where the rain falls on the ground from the roof is a good place. Where ground is dry, especially sandy, or where the array is relatively large and high up, more rods should be installed, at least 10 feet apart. Connect all ground rods together via #6 bare copper wire, buried. Use only the proper clamps (not solder) to connect wire to rods. If your array is some distance from the house, drive ground rod(s) near it, and bury bare wire in the trench with the power lines.

Metal water pipes that are buried in the ground are also good grounds. Purchase connectors made for the purpose, and connect ONLY to cold water pipes, NEVER to hot water or gas pipes. Beware of plastic couplings -- bypass them with copper wire. Iron well casings are super ground rods, but you may need to drill and tap a hole to get a good bolted connection. If you connect to more than one grounded object (the more the better) it is essential to electrically "bond" them all together using min. #8 copper wire. Connections made in or near the ground are subject to corrosion, so use proper bronze or copper connectors. Your ground system is only as good as its weakest electrical connection.

If your site is rocky and you cannot drive ground rods deeply, bury (as much as feasible) at least 150 feet of bare copper wire. Several pieces radiating outward is best. Try to bury them in areas that tend to be moist. If you are in a lightning-prone area, bury several hundred feet if you can. You can save money by purchasing used copper wire from a scrap metal dealer. If it's insulated strip off the insulation. Use copper "split bolts" to clamp odd pieces together. The idea is to make as much metallic contact with the earth as you can, over the broadest area feasible, preferably moist. If you need to run any power wiring over any distance of 30 feet or more, and are in a high lightning, dry or rocky area, run the wires in metal conduit and ground the conduit. Any time you cut a trench in the earth, consider expanding your grounding system by throwing in some bare copper wire.

What To Connect To Your Ground
GROUND THE METALLIC FRAMEWORK of your PV array. (If your framework is wood, metallically bond the module frames together then ground them.) Be sure to bolt your wires solidly to the metal so it will not come loose, and inspect it periodically. Also ground antenna masts and wind generator towers.

GROUND THE NEGATIVE TERMINAL OF YOUR BATTERY BANK, but FIRST make the following test for leakage to ground. Obtain a common "multi-tester". Set it on the highest "milliamp" scale. Place the negative probe on battery neg. and the positive probe on your ground system. No reading? Good. Now switch it down to the lowest milli or microamp scale and try again. If you get only a few microamps, or zero, THEN GROUND YOUR BATTERY NEGATIVE. If you DID read leakage to ground, check your system for something on the positive side that may be contacting earth somehow. (If you read just a few microamps, it is probably just your meter detecting radio signals.) Connect your NEGATIVE POWER to ground ONLY AT THE BATTERY BANK. Do NOT ground the negative line at the array or at any other points.

GROUND YOUR AC GENERATOR AND/OR INVERTER FRAME and AC neutral wires, conduits, and boxes IN THE MANNER CONVENTIONAL FOR ALL AC SYSTEMS. This protects from shock hazard as well as lightning damage. Follow directions for your generator or inverter or consult an electrician.

ARRAY WIRING (and other outdoor wiring) should be done with minimum lengths of wire, tucked into the metal framework then through metal conduit. Positive and negative wires should be run close together wherever possible. Bury long outdoor wire runs instead of running them overhead. Place them in grounded metal conduit if you feel you need maximum protection.

SURGE PROTECTION DEVICES bypass the high voltages induced by lightning. They are recommended for additional protection in lightning-prone areas where good grounding is not feasible (such as on dry mountain tops) especially if long lines are being run to an array, pump, antenna, or between buildings. To be reliable these devices must be capable of conducting thousands of amps (for a short time!) and must have an indicator to show internal damage. They must be special for low voltage systems, so contact your PV dealer.

SAFETY FIRST!!!! If you are clumsy with wiring, or uncertain how to wire properly HIRE AN ELECTRICIAN!

Windy Dankoff is Owner/Operator of Flowlight Solar Power, POB 548, Santa Cruz, NM 87567
or call 505-753-9699.

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(formerly Windlight Workshop, since 1977)

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RETSIE: A Strange Visit to the Energy Dream

Richard Perez

Every year the renewable energy industry has a convention, RETSIE (Renewable Energy Technologies Symposium and International Exposition). A mouthful in any language… This convention displays the latest developments in renewable energy sources, and allows industry executives to meet & eat on company expense accounts. Home Power Magazine attended last year's RETSIE as a dream (which few believed…); this year we attended as a reality, back issues firmly tucked beneath our arms. Our objective was to cover the convention so that you can be informed of the very latest energy policies and technologies. And maybe sell a few ads so we can keep Home Power coming your way free. Read ahead for the strange saga of the Home Power Crew in the big city.

A Short History of RETSIE

Back in the days of energy tax credits and high oil prices, RETSIE was quite an affair. Hundreds of companies attended, displaying their energy wares. Thousands of people, from all over the World, came to see the hardware on display and to attend the seminars.

During the last three conventions, attendance has greatly declined. Partly due to cheap energy and partly due to the high price of renting a booth at RETSIE. Companies like Westinghouse, ARCO, and other biggies have no trouble affording the $2,000+ needed to rent a booth, while Mom&Pop Solar can't afford it. We attended without a booth, as walkers on the floor, as did many of the smaller companies whose equipment graces your systems. This year's attendance was down about 60% from last year, which was reportedly over 50% down from 1986. There were less than 50 companies exhibiting their wares at this year's RETSIE, compared with over 150 companies renting booths for RETSIE 1987.

This year's RETSIE was held in Santa Clara, California on June 7th through 10th. While Home Power's crew is not at home in urban type settings, we decided to attend and report to you on what's new.

Keynote Address

The keynote speaker at RETSIE this year was Donna Fitzpatrick, Assistant Secretary, Office of Conservation and Renewable Energy, U.S. Dept. of Energy. Ms. Fitzpatrick discussed the role of renewable energy within the US government's energy plans. We enjoyed Ms. Fitzpatrick's speech. Her clear explanation of what the federal government is doing informed us not to expect much help from the feds in the future. According to Ms. Fitzpatrick, "Among all the energy sectors, the renewables industry is at a disadvantage in the federal budget game, and for several reasons. First, there is no longer a sense of crisis about energy. Secondly, the industry is relatively small and it does not have the political clout which is enjoyed by industries like oil and gas and coal and many other interests. Third, renewables are not geographically concentrated… Fourth, we are not proposing any superprojects which total billions of dollars. This is the kind of thing that captures the politicians attention and gets his juices flowing. Fifth and last, there are too many promises which were made in the '70s about plentiful and cheap energy from the sun."

Ms. Fitzpatrick then discussed how the renewable energy industry could turn its disadvantages to its gain. First, the lack of a crisis atmosphere allows the industry enough time to do the R&D necessary to make products that work well and last. Secondly, the small size and miniscule political power of the industry means that renewables are not perceived by other energy technologies as competitors. Ms. Fitzpatrick stressed cooperation with nonrenewable forms of energy. She stated that renewables, like PVs, are problem solvers now finding success in niche markets such as telecommunications. Third, on the lack of geographic concentration and thereby political clout, renewable energy sources exist in every state of the Union. Ms. Fitzpatrick stated that the renewable energy industry needed to organize itself into a broadbased coalition of local, state and federal resources. Fourth, on the lack of big projects to attract governments attention. Ms. Fitzpatrick mentioned that this was just as well as the federal government isn't funding many big energy projects these days. Fifth, that there was not much that the industry could do with it's creditability problem other than deliver as promised in the future.

Ms. Fitzpatrick spoke of little federal support for home power producers. Federal involvement in renewable energy will remain in research, development, and international marketing. We home power folks are on our own as usual. So what else is new?

New Hardware

Since the government had little interesting to occupy us we went down to the convention floor to tour the hardware displays. It was gratifying to meet friends face to face after only telephone acquaintances. Every facet of renewable energy was represented, from multimillion dollar cogen projects for factories, to the latest in home sized power inverters, and of course, PVs.

It would be impossible in an entire issue of Home Power to tell you all we saw and heard. We've decided to concentrate on equipment that fits into home power systems. If you don't see access info for the companies below it is because they are advertising in this issue, so look up their ad in the Advertiser's Index on page 47. Companies not advertising in this issue have their addresses and phone numbers listed in the comments below.

Trace Engineering

Steve Johnson and Bob Summers from Trace were on hand showing off their new line of DC to ac power inverters. The big news here is an increase in power output from 1,500 watts to 2,000 watts on Trace's 12 VDC inverter, with the battery charger's increase from 75 to 110 Amps. All this some 33% power increase and the price of the new Trace 2012 inverter is the same as the older, less powerful, 1512 model. Congratulations Trace- Good Work! See Trace ad in this issue for more details.

Kyocera America

Kyocera displayed their new photovoltaic powered street lamp. Al Panton of Kyocera told us that their multicrystal PV panels are now warranteed by Kyocera not to lose more than 10% of their rated output in a TWELVE year period. This is two years longer than any other company in the home PV market. Kyocera also has increased panel efficiencies by using a new, anti-reflective, PV cell coating. Kyocera is holding the line on the price of their panels, eventhough the shrinking dollar to yen exchange rate should really raise their panels' prices.

Steve Johnson and Bob Summers of Trace Engineering do the "More Watts for the Same Bucks Boogie" at the Trace booth, 1988 RETSIE. These folks deserve a big hand for making an inverter you can't kill with a shotgun, and at a reasonable price!

Brute Power in Action. Two 2kW. Trace inverters, each with TurboCharger, coprocess to make up to 4,000 Watts of 120 vac in tandem.

Ramona Works

Lee Talbot and the Ramona Works' crew demonstrated their new "POWrPAK™". The POWrPAK™ contains a Trace 2.O kW. inverter/charger (tricked out with all the options like metering and Turbo!), and a 460 Ampere-hour at 12 VDC Exide battery pack. Both are mounted in a very ingenious metal housing and wiring nexus. The POWrPAK™ handles all the following interconnections within its steel frame: battery to inverter, ac output, DC output, DC input (from PVs, etc.), ac input from generator or grid. The unit is highly modular, with plugs to fit just about any situation. The units are available in larger sizes, with up to 4.0 kW. inverter output

Al Panton of Kyocera America was on hand to show off Kyocera's PV panels. Kyocera now offers a 12 year warranty on its PVs- the best warranty in the business.

and twice the battery capacity of the model mentioned above.

POWrPAK™ offers a flexible, money saving, alternative to continuous generator operation. Run the generator only periodically and store the energy in the batteries. Later use the energy as 120 vac produced by the inverter. Inverter/Battery setups like the POWrPAK™ can save generator only users between 50% and 75% on their electricity costs.

Ramona Works "POWrPAK"

Heart Interface
Warren Stokes of Heart showed us their new Universal Power Interface. This synchronous, pure sine wave, power inverter can interface DC renewable energy sources like PVs with the commercial utilities' electrical grid. With this machine and enough PVs, a fellow could turn the power company's meter backwards! The HZ12-1500S is rated at 1,500 watts and contains a sophisticated 80 Ampere battery charger. This synchronous inverter can coprocess (provide synchronous power in parallel) with ac generators or even the grid. Heart offers a one year warranty with this inverter, and at additional cost, a five year warranty is available. This inverter offers an efficient (80% to 90%) uninterruptable ac power backup to those on the grid. To home power folks, this inverter provides a pure sine wave output for noise sensitive applications like video and audio equipment. Contact Heart Interface, 811 1st Ave. S., Kent, WA 98032 or call 206-859-0640 or 1-800-732-3201. And tell'em ya saw it in Home Power!

Photoelectric, Inc.
SolarInverter® is a 3.0kW., 48VDC to 120/240 vac 60 cycle, synchronous, sine wave inverter. It is designed with one purpose in mind-- running your commercial electric meter backwards! The SolarInverter® allows the user to sell power to his commercial utility whenever his PVs are making more energy than he is using. While this inverter can be used with batteries, it is primary intended to run without batteries, directly from PV produced energy.

The design of the SolarInverter® is unique; it uses a large toroidial (donut shaped) transformer rather than the rectangular laminated transformers used in almost all other inverters. The toroidial transformer contributes to the high (93% to 95%) efficiency of the sine wave SolarInverter®.

The Heart Interface Model HZ12-1500S. A pure sine wave inverter that can operate synchronously with other ac power sources.

This inverter also has the most developed digital metering system of any inverter I've ever seen. Quantities measured are input voltage, input amperage, output voltage, output amperage, output kiloWatts, output kilovars, and output kiloWatt-hours. Contact Photoelectric, Inc., 9191 Towne Centre Dr., Suite 220, San Diego, CA 92122, or call 619-587-2015 or 1-800-233-3411 (nationwide) or 1-800-542-6188 (in CA). Please remember to tell them that you heard about their inverter in Home Power.

Seminars
One of the problems with RETSIE is that everything is happening at once. Eventhough there were three of us (Karen, Brian, and I), we had to choose from a list of very interesting seminars, many of which were running at the same time. And in addition to the seminars, there is the action on the floor, where much of the business of the convention is conducted. RETSIE is a classic example of too much to do and too little time to do it in.

We attended the Photovoltaics sessions to find out the latest developments in PVs. ARCO has developed a thin-film PV cell that is semi-transparent. ARCO is considering marketing this "see through" PV as a car sunroof and building glass. Imagine having your windows make electricity directly from the sun! The model I saw gave a bronze tint to the light that passed through it. A major advantage of thin-film PVs is that they are less expensive and easier to make, hence lower in cost. ARCO is also doing research into using copper indium diselenide (CIS) PV cells. The CIS junction, sandwiched with a cadmium/zinc sulfide layer, widens the spectral response of the resulting PV cell from the mid-visual range of light into the near-infrared region. The result is potentially much higher efficiencies and greater power output.

ARCO is working on getting the CIS junction together with the transparent thin-film junction. Sort of a PV sandwich. When this is perfected, the result will be a two layer (tandem) PV cell with sunlight conversion efficiencies around 20%. The sunlight shines through the upper transparent PV layer making electricity, then the light strikes the lower CIS layer and makes still more electricity. Working, prototype, tandem PVs now offer efficiencies around 15.5%. Conventional silicon PVs are now about 13% to 14% efficient.

A very interesting opinion came up during the Marketing portion of the PV seminars. Experts now consider that the home energy market will be the fastest expanding and largest market segment in the near future. This surprised us. At last year's RETSIE, all the experts told us that there was NO home market for PVs. Maybe these folks have been reading Home Power…

People
The best part about RETSIE is not the seminars, speeches, and foo foo rah on the floor, but meeting folks. It's the people making the products you use who are really responsible for your lights at night. The renewable energy industry is blessed with a very wide cross section of excited and involved people. We met everyone from three-piece suit types to sandal & jeans types, everyone of them high on renewable energy and excited about its role in a future we can all live with.

I've been reading Joel Davidson's writings on PV energy for years and it was a pleasure to finally meet this astute and farseeing person. I can strongly recommend his THE NEW SOLAR ELECTRIC HOME book (ISBN 0-937948-09-8 and available from Aatec, a Mercantile advertiser in this issue). This book very effectively communicates Joel's many years of hands-on PV experience. Joel is now working as Western Regional Sales Manager with Heliopower, a PV manufacturer currently not in the home power market. Joel told us that Heliopower is considering marketing its PVs to US home power users. He is now involved in setting up a dealer network to assure home power customers the service they deserve. You can contact Joel Davidson at POB 5089, Culver City, CA 90231 or call 213-202-7882. Those of you wanting info about Heliopower's PVs, or wishing to encourage them to market their PVs, please contact Heliopower Inc., One Centennial Plaza 3F, Piscataway, NJ 08854 or call 1-800-34-HELIO. Don't forget to tell them you heard about it in Home Power!

We started Home Power magazine last November on nothing but hope. None of the crew here has ever published a magazine before. If we'd have realized how ignorant we were, I don't believe we'd have even started. Anyway, we're in it now and are learning as quickly as possible. While at this years RETSIE, we met Mark Fitzgerald. Mark publishes PV International Magazine (PVI), and has been doing this for six years. No small feat in the small magazine business… PVI is the official magazine of the Photovoltaic Information and Education Association (PVEIA). PVI covers the cutting edge of PV technology in a more technical fashion than you will find in Home Power. If our PV articles leave you thirsting for more detailed technical data then contact, PVI Magazine, POB 4168, Highlands Ranch, CO 80126 or call 303-791-2322. Mark Fitzgerald was kind enough to spend several hours with us sharing his years of publishing experience in this field. We learned more about magazine publishing from him in an hour, than we had in months of trial and error. We, and all Home Power readers, are indebted to Mark for his generous help. Home Power will be a better, more efficient, publication because of Mark's assistance. Thanks, Mark!
The Home Power Crew were not the only "back woodsies" to go to the city to meet big time energy. We met Steve and Elizabeth Willey of Backwoods Solar Electric while they attended RETSIE. Steve and I exchanged info on running a home power company. Of particular notice is Steve and Elizabeth's mobile office. Running a renewable energy business in the boonies requires flexibility and adaptability. Steve's 4WD van is equipped with two ARCO PV modules to power the van's computer, numerous two-way radios, lights, and refrigerator. The Backwoods Solar Electric van is a mobile demonstration of solar power in action, and gets Steve to his customers' remote systems.

Joel Davidson of Heliopower talks
PVs with RETSIE goers

The Scene
RETSIE held no major breakthroughs this year, no 25¢ PVs or forever batteries. Instead we found an industry that is working overtime to make tomorrow's reality affordable for us today. Home Power extends its compliments and congratulations to renewable energy people for their efforts and useful products. Without their work, many of us would be sitting in the dark.

It's easy to get tired of the big city. All the conveniences don't make up for no trees and animals around. Karen even got tired of the unlimited hot water in the hotel room's shower (eventually). Three days of city air is about our limit. It wuz fun, but it twern't home.

RETSIE

Mark Fitzgerald of Photovoltaics International

Well, I'm not sure that the big city is the best place to display home style, renewable energy. At RETSIE we all gathered in a large, grid connected, air conditioned megastructure. We met many people from companies actively participating in the industry that couldn't afford a booth. We searched the floor, peering at each other's miniscule name tags & hoping to make contact.

Maybe we home style energy folks need our own convention. One not encapsulated in air conditioned concrete, but outside under the trees where the wind blows. I can see PVs, batteries, inverters, and maybe a few computers setup in the country to aid our discussions and info exchange. I see more than professional industry types attending, I see everyone interested in home power. I see it being FREE to all. What do you think? Would you attend? Please communicate your ideas for a home power synergy with us. We are making plans…

Steve & Elizabeth Willey (and Shadow) of

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- ☐ **As my primary power source**
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- ☐ **Photovoltaic power**
- ☐ **Water power**
- ☐ **Wind Power**
- ☐ **Other** ______________________________

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☐	☐	**Wind generator**	☐	☐	**Batteries**
☐	☐	**Water power generator**	☐	☐	**Inverter**
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☐ **Wind Power** ☐ **Other** ____________________

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Using PVs to Pump Deep Wells

Richard Perez

What can we do when the water lies deep down the well and all we have for power is sunshine? Well, thanks to the folks at SolarJack™ and Kyocera, we can get along quite nicely. Read ahead and see how this family pumps their water from 400 feet down using sunshine.

Eight Kyocera PV modules & the SolarJack pumps water from this 400+ foot deep well--- 1,000 gallons per day.

The Situation

Don & Carly White live on a mountainside near Jacksonville, Oregon. Their homestead requires a water system that could pump water from a deep well and do it without commercial power. The Whites estimated that they needed about 1,000 gallons of water daily to support their homestead and garden. They sought the aid of Electron Connection Ltd. in solving their water pumping problems. Here are the facts of Don & Carly's water situation.

The Well

The well was already in place so this factor was given (wells being difficult to move). It was drilled, with a 6 inch steel casing, 512 feet deep. The static water level in the well is 120 feet down from the top of the casing. According to the records of the well drillers, the main flow of the well is 9 gallons per minute (GPM) and is located at approximately 480 feet down from the top of the well casing.

The Site

The site surrounding the well has excellent solar insolation. Wind is minimal at this location and no microHydro potential is present. The water from the well has to be pumped an additional 75 vertical feet from the well head to the 3,600 gallon water storage tanks. The only renewable energy source at the well site was solar. In order to use the solar, however, we were forced (sadly) to remove a large madrone tree directly south of the well head.

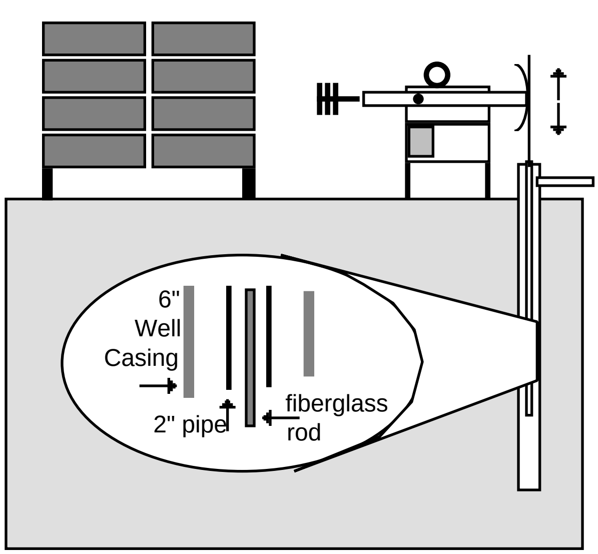
Possible Solutions

We considered many options. Bringing water up from wells as deep as 500 feet is a difficult enough task with commercial electricity available, but without? Wind powered jack pump, submersible deep well pump powered by either 120 or 240 vac from either a generator or inverter, and a PV powered solar jack pump were considered. The Whites selected the PV powered SolarJack™ pump because it is quiet, ultrareliable, and does not require the use of generators, inverters, batteries, or commercial power.

The SolarJack Pump

SolarJack pumps work in much the same manner as the jack pumps used for years on wind mills. The pump itself is a piston type and is located deep down the well. In the White's case, 399 feet down from the top of the well casing. The piston and cylinder are attached to the 2 inch diameter steel pipe that extends down the well. In the Whites case we used 19 sections of steel pipe each 21 feet long. The pump piston is mechanically activated by a fiberglass rod that connects the piston to a power source at the well head. This rod rides within the 2 inch galvanized pipe which brings the water to the surface. The power source at the well head lifts the fiberglass rod and all the water in the 2" pipe from the piston to the well head and beyond. The cylinder on the SolarJack we installed is 1 and 7/8 inches in internal diameter, and the finished setup had a piston stroke of 7 inches.

The advantage of the jack pump design is its ability to lift water from very deep wells without having to install an electrical motor deep within the well casing. The power source for lifting the rod is at the well head. The motion of the pump is very slow in comparison with other types. Slow motion means reliability. In this case, the fiberglass rod was being lifted about 30 times per minute.



An electrical motor on the well head portion of the SolarJack provides the basic motive power for the pump. The motor used on this particular SolarJack installation is a 90 VDC,1750 RPM, Honeywell unit rated at 3/4 horsepower. The motor is bieng run on about 64 VDC nominal from the PV array. This motor is geared down via a toothed belt & pulleys, and then through a gear case. The motion is translated into reciprocating up and down from rotary by a mechanical setup that closely resembles an oil pumping rig. The working head of the SolarJack is coupled to the fiberglass rod via steel cables attached to a polished stainless shaft that passes through the well head seals.

The electricity to power the DC motor is provided by eight Kyocera 48 Watt photovoltaic modules. The modules are series/parallel wired in a 4X2 matrix to produce an array with a nominal output of about 6 Amperes at 64 Volts DC or 380 Watts. The system uses NO batteries, which contributes to its reliability. When the sun shines, then the pump operates. The SolarJack uses a Linear Current Booster (LCB) to make the DC power from the PV array more compatible to the motor (see Larry Elliott's article on LCBs in this issue). This LCB is especially made just for the SolarJack pump.

The Installation

This turned into a real saga. Things did not start well when the trucking company lost 19 pieces of 21 foot long fiberglass rod. "The rods are somewhere between Oklahoma and Portland, Oregon. We just can't find them.", we were told by the trucking company. Well, three weeks later (and after a duplicate shipment) we finally got the rods and could begin the project. Getting the parts here turned out to be a bigger job than installing them…

The first detail to consider was a base for the pump to stand on. The SolarJack is a big puppy- weighing in at some 400+ pounds or so. We opted to pour a concrete slab that surrounded the well casing. This slab would allow us to position the SolarJack precisely over the mouth of the well casing. Alignment between the polished stainless steel rod sticking up from the well seals, and the working head of the SolarJack must be within 1/16 of an inch. The slab we poured was 4 feet wide, 6 feet long, and 16 inches thick. We used two layers of steel wire mesh as reinforcement.

We, at Electron Connection, enlisted the aid of Gene and Pat of Gene's Pump Service in Medford, Oregon to install the pump down the well. We needed to lower the pump piston/cylinder assembly, the 399 feet of 2" pipe and the 399 feet of fiberglass rod into the well. The weight of this assembly required a truck with a boom and a gas operated pony engine.

Once the pump, pipe and rod were properly fitted and lowered down the well, the seals and polished rod were installed at the well head. Next, the pump was positioned properly and secured to the concrete slab with eight 3/4 inch in dia. by 3.5 inch long lead anchors and lag screws. The job of drilling the holes in cement precisely was difficult and redrilling was necessary on the pump base to get everything to line up. Use a heavy drill for this job and drill the holes one at a time. Install each mounting bolt before drilling the hole for the next.

After the pump was secured to the slab, we attached the polished rod to the working head with the steel cable harness. The pump was now ready to operate.

We racked the PVs using slotted steel angle and cement piers. This arrangement is strictly temporary. The PV are to be moved to the roof of the pump house as soon as Don White gets it constructed. Once the PVs were racked and wired we hooked it up and took it for a ride. We flipped the ON switch on the SolarJack's LCB and the motor immediately started and the pump came up to speed. About 30 strokes per minute. We waited until the pipes filled to the holding tanks, and adjusted the counterweights as per SolarJack's instructions.

Pump Performance

The sun shines, the pump pumps… all day long. The output of the system is some 1,170 gallons per day. The pump is not very noisy, we couldn't hear it from about 100 feet away. It runs without human attention. The White's don't even have to be home to pump their water. The sun shines and the pump pumps… All day long…

Due to the weight of the some 400 ft. of 2" pipe, it was necessary to use a boom truck to install the whole works down the well. Those installing SolarJacks should consider hiring a crew with the equipment for this job. Shown here are the crew from Gene's Pump in Medford, Oregon.

After hours of operation outside in the direct sun we felt the motor for signs of heat. The motor was only slightly warm, as it has a very good internal cooling fan. The motor will last in very hot environments.

System Cost

The cost of the SolarJack pump, complete with fiberglass rods, seals, counterweights and all other pump parts necessary for this system, was $6,451. This includes the concrete base and all shipping. Labor and small parts to install the pump down the well cost $658. The PV panels and their rack cost $3,088., installed and wired. The total cost of the entire system was $10,197., installed and working.

Conclusion

The SolarJack pump, and the Kyocera PV panels that power it, offer a real alternative for deep well pumping. The reliability of this system is supreme and justifies its additional expense over other options. Beyond the commercial power grid, all other alternatives involve using generators or inverters. These reduce reliability and efficiency. This water pumping system, using SolarJack and PVs, is quiet, ultra reliable, and should last for many years. This system provides dependable water anywhere the sun shines and the water lies deep.

SolarJack makes all kinds of pumps for just about any application. You can contact Jim Allen at SolarJack Solar Pumping Products, 102 West 8th St., Safford, Arizona 85546 or call 602-428-1092. Kyocera America, the supplier of the PV panels, can be reached at 8611 Balboa Ave., San Diego, CA 92123 or call 1-800-537-0294 or in CA 619-576-2647. The system's

The crew (from left to right), Richard Perez & John Pryor of Electron Connection, Gene Coggins & Pat Coggins of Gene's Pump, and the system's owner Don White, are all smiling. After all, we've done our work and now its time for the Sun to do its' job…

specifier and installer is Electron Connection Ltd., POB 442, Medford, OR 97501 or call 916-475-3179. We are pleased to answer questions or supply information about this system.

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Charging Batteries Can Be A Gas!

Gerald Ames

In an article in Home Power #4, I discussed a working Wind/PV system. There have been numerous requests for additional information on the Hydrogen Gas disposal system that I made to vent my lead acid battery pack. So here's how to make your own venting system out of off the shelf materials. And here's how it works!

Gerald Ames's battery pack complete with venting system

Hydrogen Gas Problem

Before explaining how the system is put together, some background on Hydrogen gas is necessary to understand where it comes from and why it is dangerous. Hydrogen is the lightest and simplest atom known. The term comes from the Greek words meaning water former. Each molecule of water (H2O) contains two atoms of Hydrogen and one atom Oxygen. Hydrogen and Oxygen gas is formed by electrolysis of water. In electrolysis, an electrical current (such as battery charging) breaks down water into its two elements. Hydrogen in the presence of Oxygen forms an extremely explosive mixture, which needs only a spark, to cause a violent explosion. A good example of what can happen was recorded on film with the explosion of the airship Hindenburg in Lakehurst, New Jersey on May 6,1937. Had the gases in that burning airship been confined, as they are in a battery, the loss of life and property would surely have been much greater.

Hydrogen and oxygen gas are produced within the lead-acid cells during recharging when the cells are approaching full charge. The amount of gas produced depends on the size of the battery pack, its state of charge, and the rate of charge that the cells are undergoing. The higher the state of charge and the higher the charge rate, the more the cell gasses. Such are the facts of life on lead-acid batteries…

Options For Gas Disposal
In a home power system, there are several options for dealing with the Hydrogen gas produced during lead-acid battery recharging. Here is each briefly, along with its disadvantages for use in my particular system.

Ignore The Gas
This may work for a small battery bank provided it is not confined in a small enclosure. This is not a viable option for a system with 20 or more batteries.

Canopy System
A canopy is constructed over the battery bank as a collector, with a vent pipe attached to carry away gasses. There is no assurance that all of the gasses will be vented to the outside, so this was not secure enough in my mind.

Air Circulation System
This system requires that air within the battery room be exchanged 3 to 4 times per hour. In a closed system, where temperatures are closely controlled, it would be impossible to circulate fresh air in and keep it at 70°F without great expense. Also the blowers required consume electical power, another disadvantage.

Hydrocap System
This system utilizes catalytic battery caps which recombine Hydrogen and Oxygen gasses into water. Essentially it is a good system in theory, and may work very well. My main problem was the expense of purchasing enough caps to replace 66 original cell caps at a cost of $4.75 each plus shipping and handling. Since this type may be of interest to many home power users, I am including the address of Hydrocap Corp. at the end of this article.

An Explanation of my System
With the limitations of the other systems in mind, I set out to design a closed system that would dispose of the gasses safely and at a reasonable cost. This closed system was

Closeup of individual vent tubes joining the main vent pipe.

made by using a 3 inch PVC pipe as the main transmission vent, and then connecting it to each individual battery cell via a clear vinyl tube. The main vent line is sloped at 2/3 inch per foot of horizontal length to encourage the gasses to exit rapidly. Hydrogen gas is much lighter than air and rises rapidly in our atmosphere. This slope was arbitrary, but worked with the dimensions that I had. The main vent line features a threaded cap at the lower end which can be taken off to remove water that is formed by the recombination of gasses and condensation. The outside end of the main vent is cut on a bevel to reduce the chances of rain dripping in, prevents birds from making deposits in the outlet and lastly, it provides a larger end area, which encourages gas dispersal.

The space between the main vent line and outside wall was filled with silicone caulk which remains flexible when dry, and allows for differential expansion without cracking or creating air leaks. The main vent line is held solidly in place by the hole in the wall and U-bolts attached to the angle iron stands on the rear of each battery rack.

In preparation for drilling the holes in the main vent, the line was marked off proportionally, according to each battery location, and the vent holes were located within these marked areas based on good visual symmetry. The holes were drilled approximately 1/3 radius from the top center, on each side of the pipe. These holes, as well as those in the cell caps, were drilled slightly smaller than the outside diameter of the tubing, to assure a tight, leak free fit. The cell caps were drilled on dead center and the original vent holes were glued shut.

The tube was then cut to proper length, both ends were sprayed with polyurethane clear gloss finish to seal off minor leaks, and then put in place. The tubing used on the 6 volt batteries is 1/8" ID, clear vinyl and the 2 volt batteries utilize 3/16" ID, clear vinyl tubing.

This system has worked flawlessly for 3 years now and other than possible replacement of the vinyl tubing at some future date, the maintenance requirements are virtually zero. Electrolyte loss through this system has not been a problem.

Venting System Cost

3" PVC pipe fittings and glue =	$13.90
100 ft. 1/8" ID vinyl tubing =	$9.00
6 ft. 3/16" ID vinyl tubing =	$0.72
U-bolts, angle iron & misc. =	$9.27
Total Cost =	$32.89

The vinyl tubing costs from $0.07 to $0.12 per foot, depending on the quantity purchased. I have not included the cost of $4.99 for the can of Polyurethane clear gloss spray finish since so little was used. I normally keep a can on hand to maintain the battery tops, so no additional expense was incurred. All of the products listed can be purchased at hardware stores, so the system should be easy and economical for anyone wishing to build their own.

Windup

I hope this article, along with the photos will explain how the system was put together. If you have further questions or comments, please feel free to contact me at any time.

Gerald L. Ames, POB 749, Okanogan, WA 98840

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Amateur Radio for Home Power People

Windy Dankoff KE5HV &
Brian Green N6HWY

Recent issues of Home Power have mentioned ham radio and its practicality for independently-powered folks. When I was in high school in the late 60's, you couldn't keep me away from radios. I got my ham license and was thrilled to discover how easily I could talk with people all over the world. Then, just as I was shifting interest to environmental concerns and independent living, I happened to tune into the New Directions Roundtable (NDR). NDR was a nationwide network of hams with information to share about energy systems, self-reliance, economics and environment.

In the late 70s, the West Coast NDR was active enough to be a practical forum for useful info exchange among about 30 active members. We had an established frequency at which we would meet three evenings per week, like friends at the corner bar. A typical session would include about 10 people with various guests and family members chiming in. One person would moderate the discussion to keep it on track and see that no one was left out while we would concentrate on specific, pre-scheduled topics of discussion. Occasionally a guest speaker was brought in to address a special subject, which might be anything from alternators to zucchini recipes. I gave several talks on wind power, batteries etc., and obtained answers to countless questions of my own from the pool of expertise available. I also made some lasting friendships.

Some of the members of the old NDR have formed the West Coast HOME POWER NET, and we are proposing a schedule of frequencies to help other nets from around the country. Not all these nets are established, so if you are able and willing to participate, please HELP START THEM by calling "CQ HOME POWER" at these times and frequencies:

7.230 to 7.250 MHz at 16:30 Local on Sundays

3.900 MHz at 19:30, 20:30, 21:30, & 22:30 Local on Tues, Thurs, & Sun

7.240 MHz at 18:30, 20:00, & 21:00 Central Time on Fri & Sun

14.290 MHz at 17:00, 19:00, & 20:30 Local on Sat & Sun

7.110 MHz (Novice CW) at 22:00 Local on Weds & Sat. Listen for CQHP from KE5MI

If you don't get any action, please keep trying! Future issues will re-list schedules as Home Power Nets crystallize. If you DO get a regular schedule established, let us know so we can publish it! If you are NOT a ham radio operator, you might contact one who has the equipment to operate on these frequencies. Look for wires in the air, or a tower in your neighborhood with an antenna that looks like a TV or CB antenna on steroids. It might be a ham who can help you communicate with us! Remember hams provide a service, and do it for fun. Most will be happy to involve a friend or neighbor. We encourage Home Power people to become licensed amateur radio operators. See HP#5 for inspiration. Licensing involves learning morse code, some radio theory and laws, and passing an exam. Used equipment can be had for under $500 that will put you in touch with our net AND with other hams worldwide! The transistorized 12 Volt equipment uses no more power than a car stereo (10 Watts or less) to receive. While transmitting, it's typically about 100 Watts average. Not much electric power for the potential you can tap!

Windy Dankoff

Home Power Net News

On 19 June 1988, home power hams got together on 40 meters. It was like old home week, most of us had been active on the New Directions Roundtable (NDR). NDR was a local version of the international net started by Copethorne MacDonald of Mother Earth News. We all agree that the time is right for renewable energy (RE) to grow; there have been many changes since the NDR was running.

I received an informative letter from Gary Peterson of Breckenridge, CO. As a SWL, he passed signal reports for everyone on the net's first session. Gary just passed his Novice exam and is waiting for his ticket. Gary's station and homestead is powered up with PVs and microHydro. We're looking forward to hearing Gary on the air.

I have it on good authority that Ann Taylor Jones N7LFM has been reading "The How To Do It!" manual by Mary Duffield WA6KFA. Ann and 149 senior citizen's club members built a trailer park for retired seniors near Yuma, AZ. Knowing the importance of emergency communications, Ann started studying the ARRL novice exam material (see Home Power #5). On 22 March 1988, she passed her Novice exam. On 16 April 1988 she passed her Technician exam, on 14 May 1988 she passed the General exam. The icing on the cake is that on 18 June 1988 Ann passed her Advanced Amateur exam. That's four grades of license in 4 months! Outstanding! Ah, you folks that have been putting off upgrading your license take note…

I agree with Windy KE5HV about getting local area nets started. We will print any time, frequencies and call signs that are sent us. This is a good way to hook up for local 2 meter work. Tomorrow its back to stacking pallets in the warehouses of Tri-Valley Growers with my good friend Jim Cook, ole' number 4. 73s, Brian

The following are making the Home Power net happen:

Windy KE5HV, Santa Cruz, NM
Johnny K7JK, Grants Pass, OR
Len WA6 ZXZ, Tuscon, AZ
Richard KE5MI, Arlington, TX
Buffy W6PSC, San Juan Capistrano, CA
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Shunts: Using wire & a DMM to measure current

Richard Perez

Use the wire that's already in your system to make current measurements. All you need is a tape measure, a meter, and the information right here. It's easy and will answer the perennial question, "How much does it draw, anyway?"

In Theory

Ohm's law informs us that any electrical current flowing through a material (like a piece of wire) suffers a loss in voltage. This voltage drop across the material is due to its resistance and the movement of the electrons (current) through that material. The amount of current flowing through the material can be determined if we know two things. One, the voltage loss across the material, and Two, the resistance of the material. Or in algebraic terms using Ohm's Law:

$$I=E/R \quad \text{(Equation1)}$$

where:
I= the amount of current in Amperes
E= the voltage drop in Volts
R= the material's resistance in Ohms

Well, every appliance, power converter, power source and whatever is wired into the system with copper wire. The wiring in necessary to move electrical current from place to place, from source to load, etc. If we consider these bits of wire as resistors, then we can use the amount of voltage loss across a wire to determine the amount of current flowing through the wire. Wire used in such a fashion is called a "shunt" in electronics jargon.

How it Works

All we need to perform current measurements on our PV panels, inverters, refrigerators, or any other device that consumes, stores, produces, or converts electricity is a Digital MultiMeter (DMM) and the already existing wire in our systems. And a little help from Ohm's Law.

The DMM is used to measure the voltage drop across a piece of wire carrying current. The DMM should be capable of making measurements in the millivolt DC range. For example, the Fluke 77 we use at Home Power can measure down to 000.1 millivolts (mV or thousandths of a Volt). Such resolution is necessary as this technique involves using lengths of wire with resistances from 0.1Ω to 0.0001Ω. The resultant voltage drops across such small resistances will be very low, and we'll need a DMM that can make accurate measurements in the milliVolt range. At about $140, the Fluke is a good deal for a 0.03% accuracy, very rugged, DMM. Radio Shack also offers DMMs that will measure in the mV. range for around $60.

We also need to know, as accurately as possible, the resistance of the piece of copper wire we are using. To find this resistance first determine the wire's size or gauge. Most wire has its gauge number printed on its insulation. Or the wire's gauge can be determined by using a wire gauge measuring tool. Once the gauge number is known, then measure the length of the wire. Copper wire has its resistance, in Ohms per foot, specified by gauge number. Once we know the gauge, we can look up the resistance (Ω/ft) in the Copper Wire Table (See BasicElectric • Home Power #2). This value is multiplied by the number of feet of wire we are using to make the measurement. And the result is the resistance of that particular piece of copper wire or shunt.

This technique can be used on wire of any size, and of any length. There are certain resistance values for shunts that have distinct advantages. Consider the following resistances: 0.1Ω, 0.01Ω, 0.001Ω, and 0.0001Ω. If these values are used for R in Equation 1, then we are performing division by a decimal fraction of 1. This means that the measurement taken by the DMM can be read directly and a calculator is not needed to perform the math. Only the decimal point of the reading of the DMM need be shifted to obtain the amperage measurement.

What follows below is a Copper Wire Table that is optimized to display the lengths of various gauges that have resistances from 0.1Ω to 0.0001Ω. Find the wire gauge size of the wire you are using, and the lengths necessary to produce the shunts are shown across the table. Measure the indicated length along your wire and you have a shunt with a resistance that is a decimal fraction of 1. Attach the leads of the DMM across this length and you're ready to make current measurements.

At the head of each shunt column on the table, there is a reminder to shift the decimal point on the mV. reading taken from the DMM. For example, let's consider a 12 VDC light hooked up with 12 gauge wire. From the shunt table, we see that 0.63 feet of this 12 gauge wire will give us a shunt of 0.001Ω. The heading of the column tells us that the milliVolt (mV.) reading on the meter will equal the amperes of current through the shunt. If we measure 4.2 mV. across this 0.001Ω shunt, then the current flowing the shunt (and the light) the light is 4.2 Amperes. If the shunt had a resistance of 0.01 Ω (as in 6.3 feet of 12 ga.), the the milliVolt reading on the DMM would be 42.0 mV. and would have to be divided by 10 to produce the correct amperage measurement of 4.2 Amperes.

The schematic shown below shows the electrical setup for using copper wire shunts to measure current. The measurement can be taken in the positive or negative wire, it doesn't make any difference. The wire need not be cut at the ends of the shunt. Simply strip back the insulation and make the measurement. In places where you don't need to make measurements all the time, use needle probes on the DMM to pierce the insulation without stripping. A piece of string is useful to transfer length measurements from a tape to stiff

Copper Wire Shunt Table

	mV / 100 = Amperes		mV. / 10 = Amperes		mV = Amperes		mV X 10 = Amperes	
	0.1Ω		0.01Ω		0.001 Ω		0.0001 Ω	
Gauge Size	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters
OOOO	2039.51	621.644	203.95	62.164	20.40	6.216	2.04	0.622
OOO	1617.44	492.995	161.74	49.299	16.17	4.930	1.62	0.493
OO	1282.71	390.969	128.27	39.097	12.83	3.910	1.28	0.391
O	1017.25	310.058	101.73	31.006	10.17	3.101	1.02	0.310
2	639.78	195.004	63.98	19.500	6.40	1.950	0.64	0.195
4	402.37	122.644	40.24	12.264	4.02	1.226	0.40	0.123
6	253.06	77.134	25.31	7.713	2.53	0.771	0.25	0.077
8	159.16	48.512	15.92	4.851	1.59	0.485	0.16	0.049
10	100.10	30.510	10.01	3.051	1.00	0.305	0.10	0.031
12	62.96	19.189	6.30	1.919	0.63	0.192	0.06	0.019
14	39.59	12.068	3.96	1.207	0.40	0.121	0.04	0.012
16	24.90	7.590	2.49	0.759	0.25	0.076	0.02	0.008
18	15.66	4.774	1.57	0.477	0.16	0.048	0.02	0.005
20	9.85	3.002	0.99	0.300	0.10	0.030	0.01	0.003
22	6.19	1.888	0.62	0.189	0.06	0.019	0.01	0.002
24	3.90	1.188	0.39	0.119	0.04	0.012	0.00	0.001
26	2.45	0.747	0.25	0.075	0.02	0.007	0.00	0.001
28	1.54	0.470	0.15	0.047	0.02	0.005	0.00	0.000

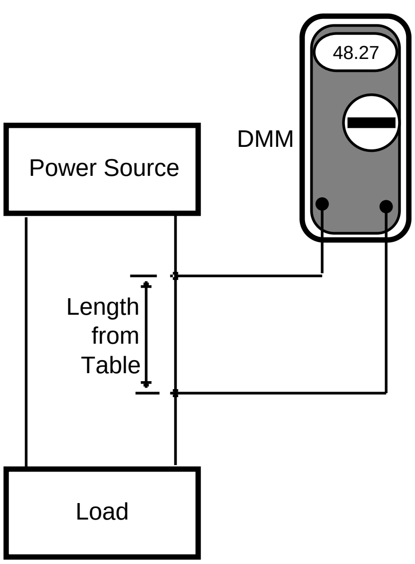
pieces of nonstraight wire and cable.

Where to Use Shunts

Use this technique any place you wish to measure current. Here are some suggestions. On the main wires delivering current from PV arrays to the batteries. On the wires that supply current to an inverter (this is a great place for a 0.0001Ω shunt made out of 2.04 feet of 0000 gauge copper cable). On the wires that connect the battery pack to the bus. And on any appliance whose current consumption needs to be measured.

Advantages

There are all kinds of advantages in using this technique. The wiring that we are using to make the measurement already exists to move the power to or from the device. The measurement process doesn't introduce any new losses as the shunt wiring is already there. The wiring need not be cut as in the insertion of an in-line meter. Shunts have very low resistances, thus enabling high current measurements with minimum loss. The technique can be used with minimum trouble for occasional measurements than don't require a dedicated ammeter.



Disadvantages

The big disadvantage is inaccuracy due to the copper wire changing resistance as it heats or cools. The information on the Copper Wire Shunt Table is correct for copper wire at 68°F. (20°C.). For copper wire at 32°F. (0°C.), this method will yield amperage measurements that are low by about 10%. At a wire temperature of 122°F. (50°C.), this method yields amperage measurements that are high by 10%. If you compensate for the temperature, this technique can be made more accurate.

Nerd Stuff-- Equation City

The data on the Shunt Table was calculated from an equation written by the Wizard. While browsing through the Copper Wire Table one afternoon, he noticed this simple exponential relationship between wire gauge size number and the resistance of that sized wire. What follows here is a specialized equation that yields amperage through a shunt of any length and gauge of copper wire. This equation is also compensated for temperature.

where:

I= current through the copper wire shunt in Amperes (A.)

Lm= length of the shunt in meters (m.)

mV= voltage drop across the shunt in milliVolts (mV.)

Tc= temperature of the shunt wire in degrees Centigrade (°C.)

N= the wire gauge size number (B&S). Note: use the following integers for these gauge sizes: for 0000 use -3, for 000 use -2, for 00 use -1, and for 0 use 0. In all other cases use the wire gauge number directly. This equation works for gauge numbers between 0000 and 40, even fractional gauges.

$$I = \frac{(0.3051)(\text{ mV.})\left[0.79305^{(N-10)}\right]}{(\text{Lm})\,(0.9214 + 0.00393\text{Tc})}$$

Things that Work!
Home Power tests the Drag-A-Mouse

Karen Perez

Being the "low techie" around here, I decided it was time to get away from bits, bytes and PVs for awhile. We've had lots of requests for critter power and people power info. Here's both for a low tech, lots of fun, "Things that Work!"

The Drag-A-Mouse is a suede cat toy that is made of high quality materials. The toy really looks like a mouse. Attached to the grey mouse's nose is a strong nylon cord. It's simple to operate, just drag it along and watch the fun.

The Drag-A-Mouse has been extensively field tested by 57 cats that the Home Power Crew knows personally. They've found that the more it's used the more mousie it gets and the better they like it. The Drag-A-Mouse can be people powered or cat powered. It provides many hours of cat fun and people smiles and is well worth the small cost.

The Drag-A-Mouse is made using renewable microHydro electricity. The actual system used is featured in this issue on page 5. Support renewable energy powered Home industries.

Three Terminal, Adjustable, Regulators

J. Michael Mooney

The LM317 has a 1.5 Amperes maximum output, while the LM350 can handle 3 Amps. and the LM338- 5 Amps. All are wired as in the schematic. Be sure to use a heatsink as these regulators will get hot if run near their maximum output.

You can pick up the LM317($2), a heat sink, and resistors at Radio Shack. When you have the circuit put together, give it the following workout;

1. Using a well charged 12 Volt battery for input, and a good digital voltmeter - set the output to 11.00 Volts.
2. Load the output with a 1 Amp load and watch the voltmeter as you apply and remove the load. Isn't that nice?
3. Now, leaving the circuit JUST AS IT IS, series a second 12 Volt battery into the input circuit raising the input to 27.5 Volts. Cycle your load on and off again. THAT'S LINE/LOAD REGULATION!

In a project box, this regulator is a terrific voltage source. In a circuit, with a fixed resistor in place of the pot it's a rock solid regulator.

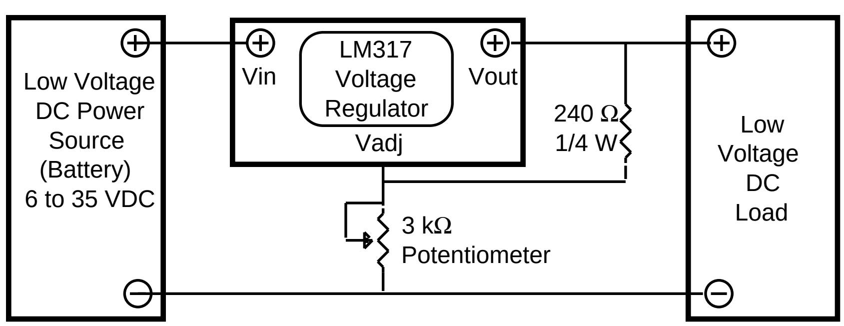
Internal protection effects a shutdown if thermal overload and/or current overload occurs, operation resumes afterward. It's almost indestructible.

The basic regulator circuit above merely scratches the surface for this amazing IC. Contact your nearest NATIONAL SEMICONDUCTOR Branch Office for the following application notes on the products;

1. LM338 POWER REGULATOR FAMILY
2. AN-178 ADJUSTABLE IC POWER REG.
3. LB-35 3-TERMINAL REG. FOR BATTERY CHARGING.
4. LB-46 REGULATOR TRIMMING.

No doubt, these ICs will be incorporated into low voltage and cordless appliances so that they operate from any DC or ac power source in the 1.25 to 35 Volt range. A single 35 Volt design will emerge for all "ac Adaptors".

J. Michael Mooney is a PV consultant with B&M Distributing, POB 667, Heavener, OK 74937 or call 501-441-7098.



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Letters to Home Power

Letters printed unedited. We'll print your name & address if you say it's OK.
Compiled by Karen Perez

Dear Home Power Crew,

First of all I want to complement you for the fine magazine.

The reason for this letter is to share some of my lighting experience with your readers. The THINGS THAT WORK! article in issue 4 concerns fluorescent lamps. I am not familiar with Solar Retrofit Consortium, Inc. products, but the description given is consistent with the technology. PV systems need cost effective, reliable and efficient light sources. Many of the available DC fluorescent lights leave something to be desired.

Several years ago I managed a large village power project for a photovoltaic manufacturer. The systems used a total of 64, 40-watt 12-volt fixtures and were installed in schools and dispensaries in a tropic area. There were severe problems with the initial light fixtures that were manufactured by REC Specialties (now know as Thin-lite). Almost all of the inverter/ballasts burnt out during the first year of service. Those that did last a few months suffered from lamp failure after about 2,000 hours of operation. Lamps should last 15,000 hours. We reproduced the problems in the lab. The short life of the inverter ballast was due to improper operation of the power transistor (excessive base current spikes). The short lamp life was due to improper waveform (Current Crest Factor [CCF] above 2.5, more about this latter). At that time we purchased samples of all commercially available 12-volt 40-watt inverter/ballasts and complete fixtures and determined that only one manufacturer (IOTA) made an acceptable inverter/ballast. All the fixtures were replaced with fixtures using IOTA inverter/ballast and both problems disappeared. We had the same problems with 18-watt Low Pressure Sodium street lights but were unable to locate any better inverter/ballasts.

Because of these problems we paid more attention to the different types of fluorescent lamps available and the ballasting requirements. There are major differences in fluorescent lamps, the OCTRON™ series by Sylvania is far more efficient than normal lamps. The 48 inch long size fits into standard 40-watt fixtures but requires only 32 watts at 60 cycles per second (hertz) and an even lower 28 watts at 25,000 hertz and provides up to 103 initial lumens per watt (L/W). In comparison the F40SSP30/WW/RS mentioned in your article provides 91.4 L/W. Standard 40-watt fluorescent lamps provide only about 78 L/W. There are some disadvantages that must be considered; special 32 or 28-watt ballasts are required (standard 40-watt ballasts result in a very short life), higher lamp cost (about $6 wholesale), and low temperature starting difficulties. General Electric and Phillips also make equivalent lamps. I have used these lamps with a special IOTA 28-watt ballast (2D12-1-28) with good results. At present IOTA does not make higher voltage versions of this ballast.

I have recently become aware of some PV powered highway signs using IOTA inverter/ballasts that have operated all night for 3 years in a hot climate with very few lamp or inverter/ballast failures. We should insist on this level of performance.

Any type of light can be powered from PV, but the more efficient types are generally used. The efficiency of a lamp is expressed in terms of lumens per watt. The following table indicates the relative efficiency of the major lighting technologies:

TYPE	LUMENS PER WATT
Incandescent	4-35
Fluorescent	
Standard	35-80
Miniature	50-70
High Efficiency	80-104
Mercury Vapor	57-65
High Pressure Sodium (HPS)	58-126
Multivapor	68-140
Low Pressure Sodium (LPS)	100-198

The above LUMENS PER WATT are for the lamp only; with the exception of incandescent, the lamps require ballasts to control the power. Normal ac ballasts are only 50 to 80% efficient (using normal utility power). For PV applications the ballast function is provided by an inverter/ballast with an efficiency of 90% to 98%. The higher frequencies (20-30,000 cycles per second), increase the light out of the lamp and allow economic design of the inverter/ballast due to smaller components.

A few companies make good inverter/ballasts for the larger arc lamps (HPS, LPS, Multivapor, and Mercury vapor). The same concerns about inverter/ballast reliability and lamp life mentioned above for fluorescent apply to these lamps.

The higher efficiency lamp technologies have several drawbacks that may eliminate them from many applications. These lamps are not suitable for flashing applications, do not render colors accurately, and with the exception of fluorescent, require warm-up times of several minutes. These drawbacks have limited their applications in PV systems.

Accurate measurements of lighting performance and parameters such as CCF is very difficult. Some fixtures that appear to be very efficient because DC input power is close to the nominal lamp wattage are actually operating at lower efficiency because lamp output (lumens) is well below specification. Measurement of total lamp lumens requires very special equipment and costs about $350 per measurement. Few fixture or inverter/ballast manufacturers actually measure the output of their lamps, instead they cite the lamp manufacturers nominal rating for the lamp. Comparison of light levels produced by operating the same lamp with a standard ac ballast using utility power is the only practical method for home users to judge the relative efficiency of the available DC lighting fixtures.

I hope that this information is of help to you and your readers.

Very truly yours,

William J. Kaszeta, President, Photovoltaic Resources International, 144 W. Meseto Ave, Mesa, AZ 85202

Dear Friends,

Thank you for another informative issue of Home Power.

We live about as far back in the woods as you can get in South Carolina - two miles from the nearest public road.

We have no electricity in the house (yet). We have kerosene lamps for light, including two Aladdin Mantle lamps. We have a gas stove and water heater and a kerosene refrigerator (Sibir). We heat with wood. The refrigerator averages about a gallon a week and we use about $10 a month in gas for the stove and water heater. We plan to put 12VDC lights in the house (powered by PV and batteries) in the Very near future. We use a gasoline engine generator for power tools.

The main thing I want to report on is our water pumping system. We get our water from a spring, pumping with a FLO-JET Model 2000-732. It is powered by a pair of 6 volt, 220 amp-hour golf cart batteries. The batteries are charged by one ARCO M65 self-regulating module. This pump has to be no more than 10 feet above the source of water BUT it is pumping water 600 FEET from the spring to our house and maintaining VERY GOOD pressure (the pressure switch is set for 60 pounds). The only time we had to charge the batteries with the generator and battery charger was during November, December, and January. The only problems we've had with the pump is having to replace the pressure switch twice (if anyone purchases a system like this, it might be a good idea to order a couple of extra pressure switches - they only cost a few dollars and are very easy to replace).

I would like to mention that we bought our pump and PV modules from Backwoods Solar Electric Systems. They publish their phone number in their advertisements and I have called several times with questions which were clearly explained. Their regular prices are lower than SALE prices I have seen advertised from other distributors. They will help you plan a system that will meet your needs and work in your budget. Since the initial investment is the hard part to come up with in any AE system. it helps to know that what you're getting WILL WORK. I hope this information will help the "skeptics" out there to go ahead and take the plunge.

Now that I've seen PV pumping water 600 feet - I know it will light my house and I have no more second thoughts about spending the money on a system.

Deborah Sullivan, Jefferson, SC

Dear Richard and Karen,

I just want to comment on Windy Dankoff's article in HP 5. He failed to mention the concrete tank. I've recently been researching this and here are the facts. The completely buriable poly tank sold locally is 1100 gallons and the manufacturer limits the earth fill over it to 30 inches. Where this should be plenty to keep it from freezing, it makes me wonder if it could bear the weight of, say, 4 feet of snow on top of that. The concrete tanks sold locally by the Transit Mix Company are 1400 gallons and are made in the same forms as the septic tanks. However, they add more steel and use an FDA approved form release agent. The fittings cast in the concrete are steel with a bar welded to them to keep them from rotating under tightening torque. I was told you can get a custom lid made at no extra charge but the regular one should suffice for almost any installation. There is even a 6 inch hole for a "float type" switch or valve. These units are about 10,000 pounds empty, but I can get one delivered and set in the hole for less money than the poly tank!

Of course, one would need an adequate road for the delivery truck but beyond this limitation it looks like a better deal.

Steve Borgatti, Hornbrook, CA

Editors Note: This spring Steve, Master of the Backhoe, dug us a much needed well, which is doing GREAT! Thanks Steve.

Dear Home Power,

Each issue is a gem packed with information and inspiration. We recently spent $1500. on equipment from some of your advertisers: two 48 watt Kyocera panels and a Zomeworks TrackRack from Alternative Energy Engineering, a 600 watt Trace inverter from Backwoods Cabin Solar Electric, and a hydrogen-oxygen gas generator from Hydrogen Wind Inc. We are satisfied with our purchases and wish to thank Home Power for providing access.

The cover photo of Mary Duffield's Aqua Alegre caught our eye. We also live on a small sailboat where we enjoy living simply and and lightly on this overburdened earth. Even in our relatively cool cloudy Pacific Northwest climate the 2 PV panels have no trouble keeping a single 12VDC marine battery charged. Direct from the battery we operate cabin lights, blender, vacuum cleaner, depth sounder, various radios, ni-cad battery charger, and a nifty heating pad that pre-warms the bed on cool nights. Marge is a seamstress and musician so the Trace inverter powers her sewing machine and a full 88-key electronic piano.

During winter a wood stove does the cooking and heating, while a propane stove does the cooking in the summer. But we are hoping to replace the wood and propane with less polluting renewable home-produced fuels. So we purchased a hydrogen-oxygen generator to soak up our excess PV electricity. When the battery is charged the power is switched to the gas generator. The results are encouraging, producing bladders (air mattresses) of hydrogen and oxygen that can be ignited in a regular propane burner. The flame is truly colorless and the gases are odorless, requiring care in handling. It remains to be seen whether we can produce a useable amount of cooking fuel. We would appreciate seeing more information on hydrogen in Home Power. Keep up the good work. Enclosed is a contribution.

Pacifically, Larry Warmberg & Marge Welling, Nahcotta, WA

Editors Note: Thanks for the flowers and the help, both are appreciated. How about it folks, anyone out there have more info on using hydrogen-oxygen generators to store energy?

Howdy Folks;

Just received my first issue of HOME POWER, Right on!

I am a HAM radio operator and very involved in emergency communications, and as such, very interested in alternative energy sources, so will be looking to your magazine for information and resources.

I am now using a 30 watt panel (cut in half and hinged to fold up and close for portability) to keep a deep cycle battery charged while running a Kenwood 7950 2 Meter radio during emergency and other related events. This set-up works real well except that I have to keep an eye on the attached voltmeter to keep from over charging the battery (I am in the process of building a charge controller to relieve me of this task).

If any of your reader's have any knowledge in Edison batteries (older type in metal casings, EXIDE XL-4, C6E) I could sure use some help in: 1) Finding a source of small quantities of Potassium Hydroxide and Lithium Hydrate. 2) Finding the correct formula for mixing the above chemicals. 3) Finding the amp/hour ratings for the above mentioned batteries.

I congratulate you on your fine magazine and hope it (and you) have a long and happy life.

Sincerely, Garry Palmer N6ONZ, 333 E. Robles Ave., Santa Rosa, CA 95407-7971

Dear Home Power,

It was a pleasant surprise to find HP#4 on the "Periodicals to be Shared" shelf at our local Co-Op. We are presently only at the exploration stage of our plan to become energy independent and it was encouraging to read examples of what other people have done. Please send us HP #s 1, 2, & 3. Payment is enclosed. Keep the change.

As long as I'm writing, perhaps you can answer one of our most pressing questions in our search for PV panels. Can it possibly be true that ARCO panels (the cheapest, most readily available, as far as I can tell) are produced by the Atlantic Richfield Company? The following quote from an article on the oil industry's plan to drill in the Arctic National Wildlife (Amicus Journal, Spring '88, pg.16) will explain our concerns.

"With little or no monitoring, oversight, or enforcement from federal and state environmental-protection agencies, what have the oil companies that profit from Prudoe Bay done to safeguard or restore public assets? Not nearly enough, especially in light of recent corporate profits.

For example, Atlantic Richfield Company (ARCO), which depends on Prudoe Bay for more than 40% of its worldwide oil production, rang up a $1.22 billion profit in 1987. Yet, even with such massive revenues, ARCO and other Prudoe Bay operators have done far too little environmental monitoring and few, if any, studies on cumulative ecological impacts. Likewise, they have given no assurances that adequate monies have been set aside for mandated habitat restoration...

ARCO, for example, has attempted to refute the highly researched "Oil in the Artic" by claiming that 'selective and outdated' information was used. Yet ARCO, which obviously disagrees with the conclusions of the report, has failed to cite a single error in it..."

I am hoping that you will inform me that these two ARCO's are not one and the same. However, if ARCO the PV panel manufacturer is in fact ARCO the Prudoe Bay polluter, perhaps this information should be shared with your readers. For markets to work, even alternative markets, buyers need as much information as possible. Maybe one of your market-wise associates could address the environmental sensitivities of PV panel producers in a future edition of HP.

Thanks for putting us on your mailing list. Keep up the good work.

Sincerely, Tom Bik & Family, Carbondale, IL

Editors Note: Yes, Arco Solar is mostly owned by Atlantic Richfield Company. Of course if you go back far enough many, but not all, PV manufacturers are owned by oil companies (or so we've been told).

Hello Folks,

Thank you for my subscription to Home Power. It's a most informative and interesting magazine.

I have been happily using water power for six years as my primary power source. (Tnx to Steve Willey)

Yesterday I constructed the "Pulsar" nicad battery charger, (Home Power 5), and it appears to be a real winner.

In Home Power #4 I noted that Fred Richardson of Waldron, WA was looking for a high powered 12 volt soldering iron. I see Dick Smith Electronics, PO Box 468, Greenwood, IN 46142 (tel. 317-887-3425), has what looks like a good one for $29.95. It is 12 volts, 30 to 150 watts - their cat. # T-1650. It features a carbon element and the wattage is said to be adjustable as you solder and to heat up in just 3 seconds. The brand name is Superscope.

My subscription started with Home Power #4, so enclosed please find my check and send issues number 1, 2, 3.

Thanks again for a fine magazine and Keep them coming.

Sincerely Yours, Gerald L. Brown, Porthill, ID

Dear Home Power,

Glad to see your theory articles. As an engineer, I am amazed to see how few people understand their light switches in our totally electric society.

It is my experience that 100% of the people I have seen using gas generators GIVE UP and connect to their public utility.

Donald F. Scott, Goldendale, WA

Editor's Note: I don't know about 100%, Donald. We've seen quite a few folks start out with gas generators who've *moved to PVs as prime power source. The generator fades quietly (the only time it's quiet is when it's NOT running) in to the background. It's used only for periods of extended cloudy weather or unusually intense power consumption.*

Howdy,

I enjoy; letters to Home Power. Home Power is a useful way to educate the consumer (me). It must be challenging sometimes. But someones got to do it. Uncle Sam would if he could but he can't so he won't. Sometimes I'm ashamed to be related to him. But he may see the LIGHTbulb and have a change of heart soon. Let us pray he does.

Thanks, J. J., Western, NC

Home Power,

Another letter to tell you that Home Power is very informative with lots of valuable information.

I really believe that AE has a future in the US if the energy tax credits are brought back. Everyone should write their legislators urging them to support alternative energy and federal tax credits.

Dave Maugans, Cherryvale, KS

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Q&A

We try our best to directly answer all your questions. Please remember that we are limited by our own experiences. If we don't have the direct personal experience to answer your question, we won't. We'll print the question anyway and hope that a Home Power Reader will have the experience to answer it. So this column is not only for questions to Home Power, but also for answers and comments from its readers. We try to answer as many questions as we can. Fact of the matter is that for every one we print, there are about 10 we don't. It's a matter of space. Hopefully, we will be larger soon and can deliver all the fine material that forlks have sent in. Thanks for your patience-- Rich

---

In response to the inquiry about financing a Solar Electric Home. As a distributor and designer for the first FHA-HUD accepted design for a Stand-Alone Photovoltaic Passive Solar Home let me take the question Susan Mistico of Camden, NY had on financing.

1) The home you mentioned must first be shown to meet all other standard codes for dwellings and occupancies.

2) The home must have a detailed, architects approved, heating and/or cooling fraction calculation completed with a justification of the heating and cooling plant sizes.

3) The home must then have a detailed set of calculations justifying the entire home electrical system sizing for a standard home occupancy for one of its size. (i.e. a two bedroom, 1200 square foot house would at maximum have two adults and one child.) These calculations, plans and the specifications of all the equipment must be included. Any undersized wiring or connections that would not meet code will toss the system from consideration. These calculations and specifications must be approved by a professional electrical engineer and should also contain a letter from your local electrical inspector stating that if the system is installed according to code that the home will, as designed by the electrical engineer, be approved for the electrical portion.

4) The home must have an appraisal (I am a licensed real estate agent as well and found an appraiser who could make the necessary adjustments in the appraisal process).

5) The whole package, including system and product brochures and warranties, life cycle and Operations and Maintenance Costs should then be submitted to both your local FHA/HUD office for review and to your local FHA/HUD lender to find out if there are any other requirements either one may have.

Approval process may take you up to a year until more submissions take place since the paperwork will be shuffled to and fro, mostly to Washington D.C.

Of course, be prepared to receive the FHA/HUD acceptance and still have problems receiving a loan. These problems may come from location and the perceived marketability of your home should you default. A higher down payment may be required or additional security. A typical item that may keep you from getting the loan may be the ability to receive hazard insurance (typically fire insurance) on the home or lack of reasonable vehicular access year around.

You may also not be able to qualify if you cannot make up the difference between the FHA approved loan limit for your area and the cost of your home with the system if it exceeds the FHA limit and the mortgage lender is unwilling to assume the additional risk. (Each area of the US has different FHA/HUD limits.)

If this sounds like a lot to do, it is. Expect to spend 2-5% of the value of the home in getting this work done. Of course, if your financial picture is rosy the banker/lender may not require you to get FHA/HUD acceptance for insuring your mortgage. Such was the case with John Murray of Cudjoe Key, Key West, Florida, as I understand. His loan was processed thru Southeast Bank, Judy Peace was his personal banker (305) 294-4601.

FMHA-Farmers Home Administration found that passive solar homes in our area had delinquent rates of 1% or less versus 11-13% for conventional homes. They have an experimental Home program for lower cost housing your readers might want to check out.

Touch the Earth-Lightly, "More Power To You"

Steve Verchinski, Solar Electric Systems, Inc., 2700 Espanola NE, Albuquerque, NM 87110, 505-888-1370.

A Question and another Answer

Congratulations on your timing: You started your publication just when I needed it. Wish I could help you in some other way than just being an avid reader.

I have a tip and a query or two. The tip: Most major lending institutions know nothing about solar power and don't want to know anything. I recently wasted months trying to educate the people at Great Western. I'm surprised that the PV industry has not mounted an effective campaign in this area. I finally was able to refinance my place through Butte Savings in Chico, CA. They had already had experience with solar power and were willing to learn more about it. My advice: Ask your loan officer whether he/she is willing to lend on solar power before you fill out the applications.

My query: Even when the voltmeter on my battery pack (four Trojan L-16s) reads 27 or 28 volts, the individual cells register in the red (discharge) zone of my hydrometer. How come? And if my batteries are in a discharged state (readings of 1200 on the hydrometer), why does my Trace C30 controller switch on and off (more off than on)? Why doesn't it feed the power from my six ARCO 75s into the batteries continuously until they are fully charged?

If you have any PV readers in the Marysville-Oroville area I'd love to hear from them. Maybe we could have some information-trading sessions.

Charles Johnson, 8038 La Porte Rd, Marysville, CA 95901

The voltage you mentioned is too low for the L-16s to be really full. Our experience with this battery shows us that a voltage of 2.50 volts per cell (under a C/20 charge rate) indicates the cell's being full. If your regulator is adjustable, then turn it up to about 30 VDC for your battery pack. Please remember that temperature as a very great effect on lead-acid cells. Cells that are below 50°F. will have to have their voltage raised to about 2.70 (at C/20 charge rate) per cell in order to be totally refilled. Also check all wiring and connections for voltage loss in the battery/PV/regulator network. It only takes one bad, resistive connection to bring the voltage up and cause the regulator to function prematurely.

Enclosed you will find my form to receive your magazine. I am considering putting in a solar system to replace my present gas-powered water pump. In addition, of course, we hope to get some fluorescent lights to raise plants in our dark springs, three reading lights at night, re-charges on our ni-cad batteries, and depending on relative cost, possibly even refrigeration. However, an important consideration would be whether a solar-driven pump could start and stop Automatically, actuated by the cast-iron weight which indicates water level in the 1,000 gal. tank near the house. As the water source is relatively thin, it would also be important that the pump deliver only a small volume per minute so as not to exceed inflow in our sandpoints.

I am having some difficulty knowing how much to stress certain procedures you recommend as extending battery life. I gather some of my neighbors are not discharging down to 50% all summer long. Does one leave lights on or shut panels off to bring about the 50% discharge? Further, the 7-hour overcharge would represent a greater use of my gas-powered welder-generator than at present. Seven hours listening to it is itself costly, suggesting a spreading out of overcharge times as much as feasible. Lastly, my system would not be in use from October to March. In 6 months in constant "topped-up" state so hard on batteries that I should intentionally discharge them during that period, even though I have no use for the power?

Are you able to recommend someone here locally who might make a site visit and help answer the question whether my ambitions for solar power are realistic? William B. Cook, Waldron, WA

Lead-acid batteries don't require exercise. It is NOT necessary, or desirable, to cycle the batteries any lower than your consumption requires. In fact, the shallower the lead-acid battery's cycle, the longer their lifetime. PV systems left unused to long periods (over 1 month) should have regulators to prevent overcharging the batteries. Equalization charges, using your mechanical generator, may be spaced out as convenient for you. The essence of equalization is to bring all cells within the lead-acid battery pack to the same state of charge. If the individual cell voltages are within 0.05 VDC of each other, then everything is fine. If there is a cell, or cells, that differ from the others by more than 0.05 VDC, then its time to equalize until ALL cell's voltages are within the 0.05 VDC of each other. The equalizing charge is carried out at a C/20 rate (or any rate less than C/20) on an already full battery pack. It can be accomplished over several days, but be sure not to include the time it takes to bring the pack up to 100% state of charge in the equalizing charge. The seven hour time period (at C/20) is strictly ballpark, some packs require more and some less. Use the voltage differences between cells to determine when equalization is necessary and when the equalization charge is completed. At equalization rates less than C/20, the charge takes proportionally more time, i.e. at a C/40 rate it may take 14 hours to do what it took 7 hours to accomplish at the C/20 rate.

So glad you are in business, Love your "Home Power".

We need some information & help. We have a 1957, large size, Servel gas refrigerator. It works beautifully, but when we have high heat (over 85°) and high humidity it defrosts in the refrigerator, the freezer works OK. We are mature adults and don't open the refrigerator very much. We also keep the refrigerator and freezer fairly full. Keep up the good work. We are interested in everything. Gloria Baublit, Almond, WI

Consider the ventilation around the refrigerator/freezer. Is hot air collecting around the unit? If so, then provide the ventilation necessary for the unit to work properly. Also consider applying additional insulation (the foil backed, foam boards work well) to the sides and top of the unit. When it gets hot, refrigerators have to work much harder to keep the box cool. What were small inefficiencies in the system become big ones. So do all you can to provide your reefer with a cool place to work and to keep the heat pumped from the box from getting back in.

I have PV panels and 6 -2016 AH cells - surplus telephone equipment. I would like very much to utilize the DMM method of determining the state of charge, but there are some drawbacks. First of all, in a PV, or any AE system, it is a rare day when one can allow the batteries to rest for 24 hours with no charging. Secondly, since the charge rate is not constant, there is no fixed C-rate, so the rate of charge is variable. QUESTION #1: How can I, or any AE user, determine the state of charge, under these circumstances? QUESTION #2: You stated 2 or three times in the Battery Book that the charger should be capable of C/20, but I don't think you said why. Since fast charging can damage plates, how would ultra-slow charge rates affect batteries? In my case, with the 2000 AH cells, I would have to use a 100 Amp charger. I currently have a 40 Amp charger that I use on "High", so I can obtain as much as 60 Amps, but this is still only a C/30 rate, which mostly represents the beginning charge, quickly reducing to about 50 Amps - a C/40 rate. QUESTION #3: I'm not certain if I should equalize each month, REGARDLESS of the cell voltages. My cells run within 0.02V of each other. The manufacturers label on the cells say to equalize at 2.33V for 8-24 hours, but they don't say how often. What is your advice on this? Thanks, Orin Bridges, Sandpoint, ID

Question1: While under charge the voltage on a lead-acid system is elevated. Letting the pack rest for 24 hours before using the voltage measurement to determine state of charge represents an ideal situation. Letting the pack rest for as little as 2 hours can be effective, however the voltage will indicate a little high and cause the corresponding state of charge determination to also be a little high. Also not every battery has the same voltage to state of charge (SOC) relationship. The best information can be obtained by watching the voltmeter in your system; eventually you will know the relationship between voltage and SOC for your particular system.

Question2: A charge rate of C/20 is ideal for equalization and is NOT a fast recharge rate for lead-acid cells. At room temperature and in the middle of their cycle (between 20% and 80% SOC), lead-acid batteries happily accept charge rates as high as C/5 without damage. There is no problem with recharge rates less than C/20, other than it takes more time to complete the recharging process or equalizing charge. In general, slower recharge rates are more efficient and give longer battery life. However, if a generator is used for recharging there are other economic considerations. The C/20 rate is a compromise between what the battery wants and the cost of running the generator for extended periods.

Question3: Equalization is only necessary when there are cells within the battery whose voltage differs by more than 0.05 VDC for the other cells. If all cells' voltages measures within 0.05 VDC of each other, then everything is OK and equalization is not necessary. See the previous question in this column for more info on equalization of lead-acid cells.

the Wizard Speaks…

Horizon Promises: Entrepreneurial Edge Inventors & Tinkerers

John Bedini of Bedini Electronics Inc., POB 769, San Fernando, CA 91341 has developed a few devices in in the field of Free Energy. One of these is a battery, DC motor & control system which, it is claimed, produces useable power during the off times of the motor's duty cycle while keeping the battery fully charged. Another, called the G-Field Generator, is alleged to produce its power by using electromagnetic energy in a pseudo antigravity manner. Further information can be obtained from Mr. Bedini or from the Telsa Book Co., 1580 Magnolia St., Milbrae, CA 94030. Also available from the bookstore are works by T. K. Beardon which explain some of the principles involved.

Another example is provided by Mr. Joseph Newman, Route 1 Box 52, Lucedale, MS 39457. By using advanced materials processing techniques Mr. Newman claims to have created a quasi superconducting material. When this material is used in his Energy machine, the resulting output power is professed to be greater than the input power. Contact Mr. Newman for further details.

The third example comes from Howard Johnson of Blacksburg, VA. Using only permanent magnets Mr. Johnson says he has developed a mechanism which might be used to drive alternators or generators. If it works, first there is a circular arrangement of bar magnets like the stones at STONEHENGE. Each segment consists of bar magnets, back to back, separated by a magnetically permeable material. The inner magnet has the north pole at the top while the outer has the south. Each segment is anchored to a base which can spin. Another magnet, elliptical in shape and about 3 1/8 inches long is placed within the circle about 3/8 of an inch from the perimeter. The outer circle of bar magnets then begins to turn. A patent (US Patent #4,151,431) has been issued to Mr. Johnson. Contact the patent office for more info.

With new processes, topologies and geometries, the Free Lunch may become more than a dream.

Home Power #6 is dedicated to Dave Winslett.

Dave was part of the StartUp Crew here at Home Power. We miss his sage advice, humor, and encyclopedic knowledge of everything under the Sun. Dave died suddenly of a heart attack on 25 June 1988. He was our friend and we miss him. Time will allow the void to be filled and fond memories to remain…
Thanks, Dave…

The Old Windmill

Daniel K. Statnekov

I never see a windmill
That I don't stop to think
About my early days of youth
That flew by in just a blink

We had an old mill standing
'Tween the house and the barn
Set high up on a wooden frame
The sentinel of our farm

Like an old-fashioned rocker
Keepin' time to bended knee
That windmill turned its circle
While the breeze was blown' free

You could hear its rusty creak
When the wind turned around
Sort of made a punctuation
To its normal spinnin' sound

I can hear 'em yet those wind-songs
Played on fan blades made of steel
Accompanied to the clatter of
Those turnin' gears and wheels

Set a rhythm to my childhood
Gave me notice of the breeze
Whether gusts before a summer storm
Or silent winter freeze

So in lookin' back with hindsight
On the mem'ry of that mill
I'd say it gave a pulse beat
To the place that's with me still.

Daniel K. Statnekov has a book "Animated Earth" published in 1987 by North Atlantic Books, Berkeley, CA.

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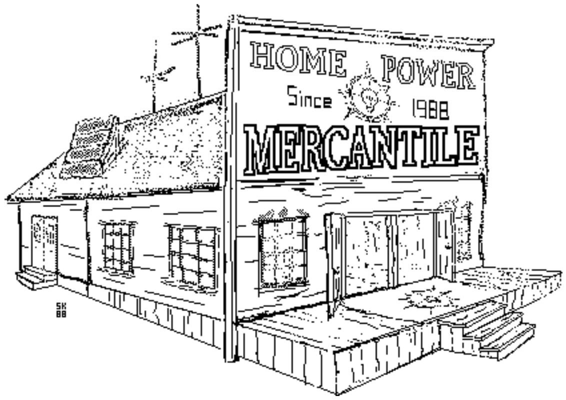

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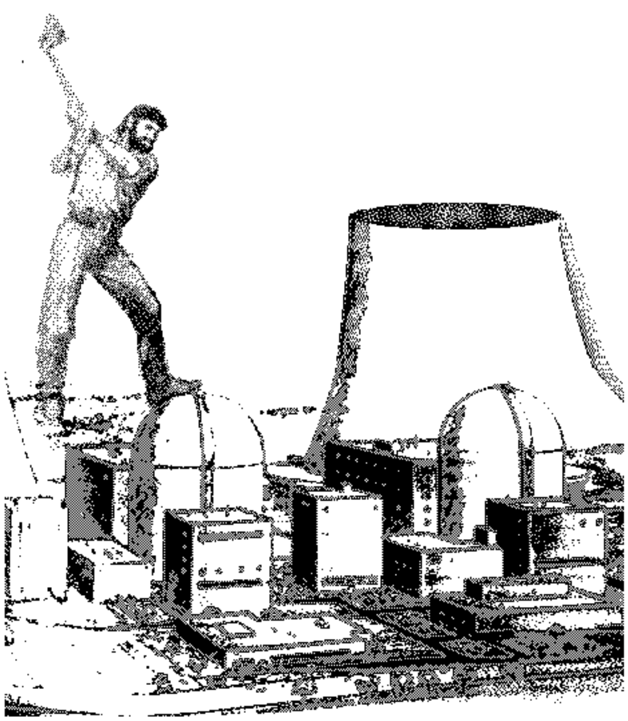

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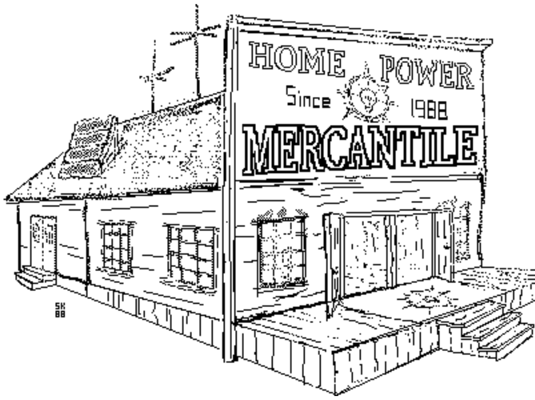

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