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HOME POWER 14

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Home Power

THE HANDS-ON JOURNAL OF HOME-MADE POWER

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Issue Printing by
Valley Web, Medford, OR

Contents

Access

Home Power Magazine
POB 130
Hornbrook, CA 96044-0130

916–475–3179

Think About It

"It is better to know some of the questions than all of the answers."

James Thurber.

Cover

A 1952 Jacobs 2kW. Wind Generator. Built to last, thousands of these 32 VDC units have been used since the 1930s.

Photo by Windy Dankoff

Welcome to Home Power #14

The big news here is that Home Power Magazine is finally going to charge a yearly subscription.

Our circulation has grown too large for HP to be totally supported by advertising. We will charge $6 a year for Home Power starting with issue number 16. This issue (#14) and the next (#15) will still be mailed out free. Starting with issue 16 (April/May 1990), it will cost $6 for a yearly subscription of 6 issues via 3rd class U.S. mail.

Home Power will also be available as single copies on newsstands and at magazine distributors. The selling price of a single issue will be $2 starting April 1990.

We kept Home Power free as long as possible. We feel that $6 a year (that's a buck a copy delivered) is a fair price for the information and access supplied within Home Power's pages. We hope that you feel the same way and that you will subscribe.

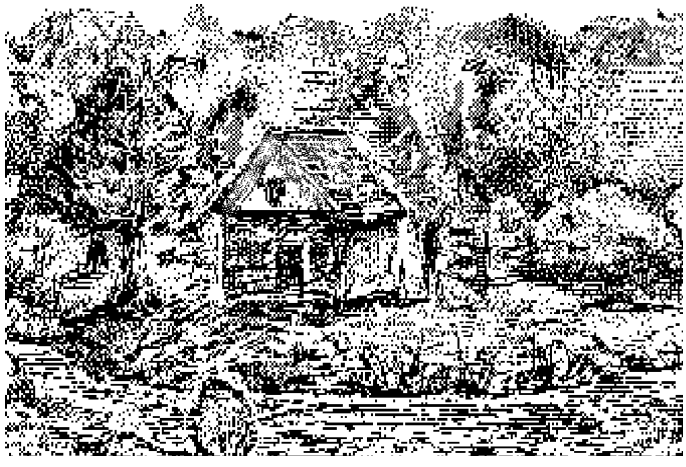
Thanks,
the Home Power Crew

Creations Endless Birth

Daniel K. Statnekov

Beside a brook, clear cold and fast
A flower unseen grew
In shaded light that filled its days
Mid sparkling morning dew

And then it bloomed pale lavender
Beneath the forest wood
Amidst soft ferns and bramble vines
Warm earth encircled roots



Its faint perfume rose to the breeze
Without a care for who
Might see enjoy appreciate
Its subtle fragrant hue

And then without remorse or plea
Each petal fell to earth
Released from form, its purpose served
Creations endless birth

Getting Ready For Winter

Windy Dankoff

Independent power system users and dealers should check their renewable energy systems before Winter sets in. After all, it's easier to do it now- before everything is froze up, iced over and buried in snow.

Photovoltaic Array
Inspect and tighten mounting bolts and wiring, test output, and tilt for winter angle. Pay attention to mechanical connections in the panel's wiring boxes.

Trackers
Oil bearings, check mounting bolts and shock absorbers.

Engine Generators
Give the engine an oil change, replace the air and fuel filters. Low temperatures cause water condensation in the fuel tank. A good water trap & sediment filter is cheap insurance for a gas engine and required on a diesel engine. Check the ignition system and the spark plugs. If the engine uses electric starting, check its battery and clean its connections.

Wind Generators
Make sure that the tower's guys are solidly connected and properly tensioned. Check the propeller, bearings, brushes and slip rings in the wind generator. It's much easier to replace them before the tower is iced over.

Hydro-Electric
Check the trash racks for damage. Winter rains bring debris downstream, so be prepared. Check the thermal insulation on water lines to prevent freeze-ups. Check the brushes and bearings in the Hydro's electrical alternator or generator.

Charge Controller
Check regulator voltage settings, check voltmeter accuracy with digital meter. If your controller doesn't automatically compensate for temperature, then you can set it a few tenths of a volt higher to compensate for cold lead-acid batteries.

Lead-Acid Batteries
Test each cell of each battery with a digital voltmeter or very clean hydrometer to spot potential failures and check the need for equalization. If the cells in your pack differ by 0.05 Volts or more, then equalize! Wash away accumulated moisture and dust from battery tops, use baking soda solution to neutralize acid deposits. WARNING, do not allow any of the baking soda solution to enter the cells. Clean or replace corroded terminals; coat with petroleum jelly. Check water levels and refill with distilled or deionized water. Inspect venting (check for insect nests in vent pipes). Check insulation/shelter from cold.

Wiring
Check for proper wire sizing, tight connections, fusing, safety.

Grounding and Lightning Protection
Install/inspect ground rods and connections, ground wiring (see HP#6).

Loads/Appliances
Check for "phantom loads" and inefficient usages. Example: Does your furnace thermostat hold your inverter on 24 hours a day?

Lights
Look for blackening incandescent bulbs; consider Quartz-Halogen or Fluorescent replacements (see HP#9). Winter days increase the use of all lights. Now is the most cost effective time to install efficient lighting.

Inverters
Check adjustments, settings, connections. Inverters with Battery Charger Option should have the charge voltage set around 14.5 (or 29) volts if a generator is to be used for charging. Most come set lower, assuming utility-line charging at a slower rate. See your manual.

Water Supply
Check freeze-protection, pump maintenance, and pressure tank pre-charge.

Freeze Protection And Heat Tapes
Electric heat tapes are a popular way to prevent water pipes from freezing under mobile homes, on solar water heaters, and in well sheds. Where heat tapes are a necessary evil, here are some tips to MINIMIZE THEIR ENERGY USAGE:

Insulate
Use foam pipe jacketing, fiberglass, ANYTHING that insulates and PLENTY OF IT! Be sure cold air and moisture are sealed out.

Less Is Best
Use less heat tape than recommended, with fewer, wider spaced coils. With extra insulation you won't need much heat.

Frostex And Line Voltage Thermostats
Use "Frostex" round heat tape, it is the most efficient. Add a line voltage thermostat to disconnect it in warm weather. (A Line Voltage Thermostat is one that is designed to handle power directly from 120 vac. A recommended one is Dayton #2E158, available from W.W. Grainger or from any electric or heating supplier. Like most other switches, it will also handle its rated amperage (22A) at 12 or 24 VDC. Its 35-90 degree range makes it appropriate for use with heat tapes and furnaces, and coolers and fans as well. The Dayton 2E158 allows switching power on OR off with temperature rise, so it also works for switching FANS on at high temp for circulation of solar or wood heat. If you use a conventional flat tape, be sure it has a thermostat on it. The thermostat may be tucked into the insulation closer to the pipe so it won't turn on until cold penetrates into the insulation.

ac or DC?
A 100 watt Statpower or any good inverter will power heat tapes, or you can convert heat tapes to 12 or 24 volts!

ac to DC - Here's How
If you're not afraid to cut and splice, here's how to make a low voltage heat tape. 1) Buy a conventional FLAT heat tape with thermostat. 2) For 12V, measure 1/10 of its length from the thermostat end and CUT. For 24V, use 1/5 of its length. 3) Strip the cut end and twist the two inner wires together. Protect the end with silicone sealant and/or tape.

You now have a low voltage tape with thermostat. It will draw the same wattage per foot as the original. The neon indicator light won't work, but an ammeter will indicate current flow. The remaining tape may be cut into more low voltage tapes by splicing lamp cord to one end, and tying the other end together (using crimp connectors). You will need to add a thermostat if desired. One Line Voltage Thermostat can switch many tapes on and off.

Backing Up
Install heat tapes even where you don't expect a freeze. They make it easy to thaw surprise freezes without digging, ripping out insulation, etc. Thermostats are optional on these "back-up" tapes.

Furnaces and Controls - Thermostat Circuits & Power Usage
Most central heating systems use a low voltage circuit through a wall-mounted thermostat to tell the furnace when to turn on and off. The low voltage is derived from a small transformer which is powered constantly. Its usage is only a watt or two, but in an alternative energy system that may be a significant load -- if it is the only ac device that's running, it is adding a constant 6 to 12 watt draw just to keep the inverter "up". That amounts to the wintertime energy output of two 50 watt PV modules, costing over $300 each!

The Answer
If yours is a system where the inverter spends most of its time off, it is worth adding a Line Voltage Thermostat to your furnace circuit. You may order one from a heating supplier and have it installed ON THE ac LINE to the furnace controls. Also bypass the original thermostat. This way when heat is not needed, all power is cut to the furnace transformer. A small "limit switch" thermostat may be also added to sense heat in the furnace and keep the blower on until "left-over" heat is exhausted. Material cost of these modifications is under $30 and the wiring is simple.

Temperature Adjustment
When nobody's home, you only need to prevent your home from freezing, so water pipes, fixtures and bottles won't freeze. Most heating thermostats stop at 50°F, but fuel may be saved if the temperature can be lowered to 40°F or less. Electric power is saved, too.

Windy Dankoff, Flowlight Solar Power, POB 548, Santa Cruz, NM 87567 • 505-753-9699

A sample of Emergency Power System equipment. Pictured are a Sovonics Thin-film photovoltaic panel, a Ovonics nickel-hydride battery, a nickel-cadmium battery, a lead-acid gell cell battery, a Statpower 100 watt inverter, and a PowerStar 200 watt inverter. The 40 watt lightbulb in the photo is powered by the Ovonics battery and Statpower inverter. Photo by Brian Green

Emergency MicroPower Systems

Richard Perez

Earthquakes, hurricanes & tornadoes happen. And when they happen big-time, the power goes out. And when the power goes out so do lights and radios/TVs. When Nature goes nuts, an emergency micropower system (EMPS) provides electricity for essential services like lighting & communications. It can make the difference between sitting in the dark and wondering what will become of us, to sitting under a light and listening to what is actually happening.

Why me?

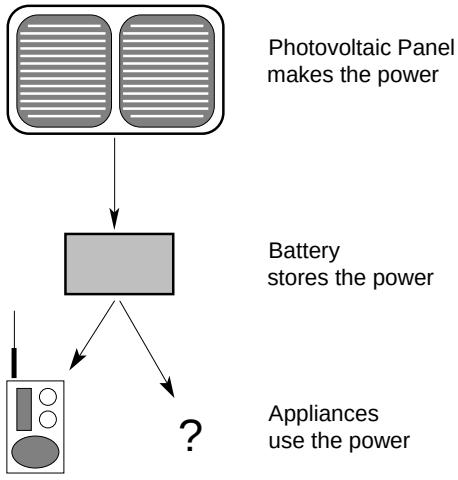
An often heard phrase in disasters is, "Why me?". The recent San Francisco earthquake left many people without power for days. Some of the folks surviving the recent hurricane in South Carolina are still without electricity. The earthquake edition (published on generators) of the San Francisco Chronicle mentioned our humble publication, Home Power, and suddenly we were overrun by folks in the Bay Area wanting information on site-produced electricity. While I have no answer for "Why me?", I do offer information that will allow you to contemplate this question in the light while listening to the latest disaster news on the radio or TV.

The time to get an emergency micropower system (EMPS) is now, before you need it. As you may have noticed, Post Office and UPS deliveries are slow in the middle of natural disasters…

The EMPS

An emergency micropower system is designed to supply essential services. We are **not** talking about running the freezer or the 27" color TV here, we are talking powering up a small light and a radio/TV receiver indefinitely. Emergency power systems come in all sizes to meet all needs. The one we are suggesting here is designed from a minimalist approach. It is small (fits within a 4"X12"X16" box), light in weight (less than 10 pounds) and totally powered by sunlight.

The EMPS consists of three basic components. One, the PV panel which converts sunlight directly into electricity. Two, the battery which stores the electricity. And three, the appliance. A diagram of the system is shown on the next page.



A pictorial schematic of an Emergency MicroPower System.

The PV Panel

The photovoltaic (PV) panel sources the energy for this system. It doesn't matter if the electrical grid has failed, all we need to do is to place the PV panel in the sunshine. The PV panel used in the EMPS should be portable, making it easy to move around to catch the sun.

The Sovonics flexible PV panels are ideal for this purpose since they are small and light in weight. The panel we used as an example is a SunPal Model 105 that is 13.5 inches by 9.9 inches and 3/8 of an inch thick when folded and weighs only 2 pounds. It produces 0.35 Amperes at 15 VDC under full sunlight. Now, this is not a lot of power, but it is enough to source a small light and radio indefinitely. Larger Sovonics flexible modules are available should your EMPS plans include higher powered appliances.

The Battery

The type and capacity battery depends on the amount of electricity you wish to consume and the length of time you wish to run without recharging. In the photo we have shown three types of 12 Volt batteries- a lead acid gel cell, the new Ovonics nickel-hydride battery and a nickel-cadmium battery pack. Twelve volts DC is the best choice of system voltage for EMPSs because all the gear will interface directly with automotive and portable equipment.

The Lead-Acid Gel Cells

The major advantage to the gel cells is capacity. The one pictured in the photo stores 6.5 Ampere-hours at 12 VDC. This gel cell battery (a Panasonic #LCR12V6.5P) weighs 4.85 pounds. Gel cells are available from 1 to over 40 Ampere-hours. They are totally portable and sealed. They will run just fine upside down (don't try this with your car battery).

The Ovonics Nickel Hydride Cells

This is a new battery technology developed by the innovative folks at Sovonics. It is a variation of the nickel-cadmium cell that uses no toxic cadmium. These cells also have about 75% greater electrical capacity than the same sized nicad cell and NONE of the memory effect associated with the small nicads. This pack was composed of ten nickel hydride "C" sized cells in series. The pack shown in the photo stores 3.4 Ampere-hours at a nominal 12 VDC. The battery pack is 1.5 inches by 3.25 inches by 6.5 inches and weighs 2.5 pounds. This pack comes in a plastic box with a female auto cigar lighter receptacle.

Nickel-Cadmium Cells

The nicad battery pack shown in the photo is a shrink wrapped collection of 10 @ series connected "D" sized nicads. The electrical capacity is 4 Ampere-hours at 12 VDC. This pack weighs about 3.5 pounds.

Lighting, Radios and TVs

The effectiveness of your EMPS will greatly depend on the appliances you use. The design criteria here are essential services- a small light and radio/TV receiver. The smallest system uses the Ovonic 3.4 Ampere-hour battery sourced by the small 5 Watt Sovonics flexible PV panel. This system will supply enough power to run a car dash lightbulb (about 0.22 Amperes consumption) and a transistor radio (about 0.10 Amperes consumption) virtually indefinitely. Choose the light for your EMPS carefully. Power consumption should be low, on the order of 3 Watts or less. The same goes for the communications device-either radio or TV. Efficient 12 Volt communications gear is commonly available. For example, here on Agate Flat we use a Panasonic 5 inch, B&W TV that uses 12 VDC directly and consumes only 4 Watts (≈0.3 Amperes at 12 VDC). If you choose your light and comm gear carefully, then this system will power everything as long as you keep the PV panel in the sunshine.

To Invert or not to Invert?

If your EMPS plans include 120 vac appliances, then include a micropower inverter to convert the battery stored 12 VDC into 120 vac. Shown in the photo is the Statpower 100 Watt inverter and the PowerStar 200 Watt inverter. Both work well on small batteries and will provide 120 vac wherever necessary. We've powered all sorts of 120 vac appliances form these microinverters. Don't let their paperback book size fool you, these units will power 120 vac lights, computers, printers, tools, radios, VCRs, and other emergency essentials like the coffee grinder.

Using the EMPS

All the EMPS gear can be stored in a small box in a closet, ready for when it's needed. The battery can be floated on the grid via a battery charger (supplied with the Sovonics setup). This means that the battery is always full and ready for action. The EMPS should have modular plugs to interface with automotive stuff. This is the reason all the gear pictured is equipped with car cigar lighter plugs.

One of the nice features of the EMPS is that you don't need to wait for a disaster to use it. Karen and I use the panel and batteries in the photo to power a light and ham radio gear when we go backpacking or camping. There is nothing like a light in the tent at night and talking to our friends on the 2 meter ham radio transceivers. Just lash the panel to the top of the pack frame during the day, hook it up to the battery within the pack, and have a light and radio at night!

EMPS Cost & Access

An EMPS will cost between $250 to $500 depending on PV panel size and battery capacity/type and whether you use a microinverter or not. This is cheaper, lighter, more portable and infinitely quieter than a generator. And it keeps going when gasoline is a memory.

Emergency MicroPower System equipment is available from just about any Home Power advertiser. I urge you to support your local installing renewable energy dealer!

We at Electron Connection Ltd. are offering Emergency MicroPower Systems custom designed to suit your need, as well as individual components. Call or write: Electron Connection Ltd., POB 442, Medford, OR 97501 • 916-475-3179.

Intelligent use of 120 vac Appliances in the Inverter Powered Home

Jerry Fetterman

One of the major developments in renewable energy over the last 5 years is efficient DC to 120 vac inverters. It's no longer necessary to modify appliances to run them on DC or to buy sometimes inferior quality, high-priced DC products. We can now go down to the local discount store and purchase off-the-shelf appliances just like the folks who use commercial power. While most commercial 120 vac products will run on an inverter, some intelligent decisions about what appliances to buy can save you hassles and significant amounts of power.

INVERTER RULE #1: Let your inverter return to standby

In standby mode, your inverter uses minimal power. Using products that are on 24 hours a day, such as clocks or devices with clocks in them, causes your inverter to be "on" all the time. Most inverters use less than 1 watt in the standby mode and upwards of 20-30 watts powering such minimal loads. While 20 to 30 watts isn't much, running such a load 24 hours a day takes 1 to 3 PV panels.

To eliminate or minimize such loads 1) use quartz battery operated clocks, 2) do not use appliances with built-in clocks, 3) use appliances such as battery chargers, cordless telephones, and answering machines with DC inputs, and/or 4) use such appliances on 120 vac only during periods of power surplus.

Some appliances which appear to be turned off still may consume enough power to keep your inverter on. This is generally a result of the manufacturer installing the switch on the secondary of the transformer rather than the primary. It also can be the result of circuitry that stays on all the time such as in instant-on" TV's or remote controlled appliances.

One way to trace a "phantom load" is to monitor the sound of your inverter; know what it sounds like in standby mode and in the "on" mode. If your inverter does not return to standby when all appliances are off, start unplugging appliances until you find the offender. If the inverter powers an extensively wired house, then the inverter may stay "on" because of the wiring. The inverter sees the capacitance of the wiring as a load. If this is the case, adjust the standby level of the inverter.

INVERTER RULE #2: Smaller can be better.

This rule pertains primarily to use of 120 vac water pumps and motors. In general, pump people will recommend pumps/motors that are larger than actually needed. A small pump/motor might take longer to do the job, but will take less surge to start and less power to run. Since inverter capacity is limited, it is often better to save the capacity for other loads and go with a smaller pump/motor.

Special Appliance Recommendations

Color TVs: Many color TVs have either remote control and/or instant-on circuitry. This tricks you into believing that the appliance is off when you push the remote control. In reality, however, it is only partially off and is consuming power as it waits for you to use the remote control. In contrast, a TV set with a switch and an analog dial is off when you switch it off. If the couch potato in you likes to zap commercials from your couch, one way is to install a switch or switched extension before the TV.

Microwaves: Microwaves come with analog and digital controls. The analog type has a rotary timer and is off when not in use and is recommended for use with inverters. The digital types have displays/clocks which are on all day and are not recommended.

Automatic Clothes Washers: Clothes washers are one of the most difficult loads for an inverter. While many will run from a 1200 watt inverter, others require a minimum of 2000 watts. This is due to the surge requirements. The washers requiring the least from your inverter pump the wash/rinse water prior to spinning, like Whirlpool and most Kenmore washers. Spinning with a full load is hard work for the motor and requires large surges.

Gas Stoves and Ovens: A stove/oven with pilot lights requires no inverter power. To eliminate wasting gas by pilot lights, you can turn them off and start the burners with a hand held ignitor. Avoid gas stoves and ovens with built-in clocks. While some stoves/ovens with pilotless ignition work well with inverters, some use a heat element to trigger a solenoid before turning on the burner. These take a considerable amount of energy.

Fluorescent Lights: Compact fluorescent lights with electronic ballasts work well on inverters. In contrast, fluorescent lights with coil ballasts produce a 60 cycle buzz. This buzz is audible on some fixtures and not on others. Find out if you can return the fixture if it is noisy before buying it.

The rare incompatibility problems

While modified sine-wave inverters run most equipment, you might find an appliance which does not operate correctly on inverters. This is usually the result of using edge-triggered power semiconductors. It occurs primarily in electronic equipment with mechanical parts. We have had trouble with a copy machine and a computer printer and have heard of problems with an electronic typewriter. This problem is NOT inherent to all products, just to specific models of machines and inverters. Before buying a high-cost appliance see if you can try it on your inverter.

Access

Jerry Fetterman is co-owner of Yellow Jacket Solar. Yellow Jacket Solar supplies remote home PV systems and water pumping systems to their local SW Colorado neighbors and has a mail-order catalog. The owners have lived with photovoltaic power since 1981.

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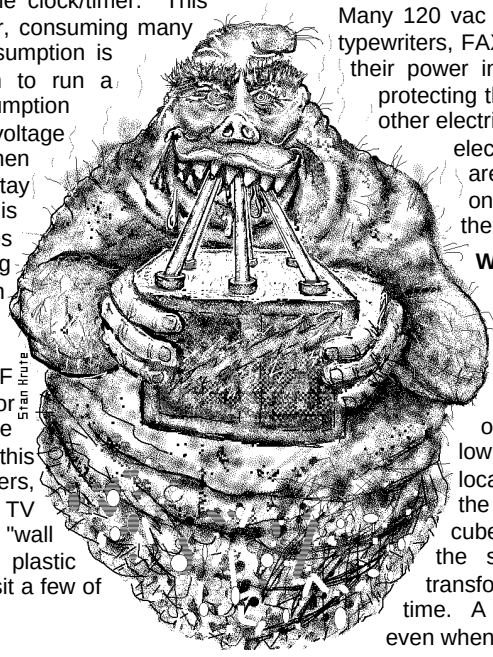
Phantom Loads

Richard Perez

Just because the switch says "OFF" doesn't mean a device is off. Many modern appliances are never really OFF. They contain clocks, memories, remote controls, microprocessors, and instant ON features that consume electricity when plugged in. That's 24 hours a day, 7 days a week… While these Phantom Loads are often small, they add up if several are constantly on line. Some Phantom Loads are easy to spot- things like clocks and timers have displays. Other Phantom Loads are truly hidden- the device seems OFF when switched OFF, but it really isn't.

Obvious Phantom Loads

Consider a clock. Many appliances contain a clock or timer. The electronic clock/timer and its display consume very little (≈0.5 Watts). However, there is a power supply in the appliance that converts120 vac into low voltage DC for the clock/timer. This power supply is very inefficient at low power, consuming many times the power actually needed. This consumption is about 40 to 75 Watt-hours daily- enough to run a lightbulb for TWO hours. Most of this consumption goes to do a job better accomplished by low voltage DC directly from the batteries. At night, when hardly any power is used, the inverter may stay on just to supply small Phantom Loads. This operation is very inefficient. One, these jobs are better done via DC. And two, it's forcing the inverter to operate for extended periods in its least efficient mode.

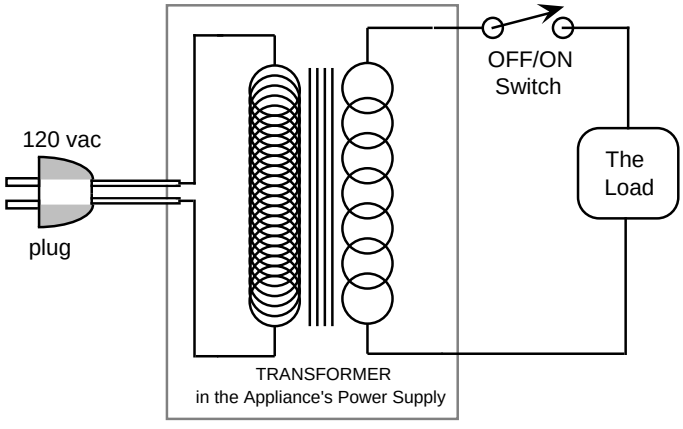


Sneaky Phantom Loads

Some Phantom Loads appear to be truly OFF when switched off. There are no lights or indicators showing power consumption, but the device is still using electricity. Offenders in this category include, stereos, VCRs, computers, calculators, computer printers, satellite TV systems, and any device powered by a "wall cube". Wall cubes are power supplies in plastic boxes that plug into 120 vac outlets. Let's visit a few of these Phantoms where they lurk.

The Primary is Alive!

Many 120 vac appliances contain power supplies. These convert 120 vac, either inverter or grid produced, into low voltage DC for the appliance's electronics. On some appliances the ON & OFF switch is placed on the secondary (low voltage side) of the supply's transformer. The primary is not switched and is always connected to the 120 vac source. See the diagram below.



The inverter or commercial power grid sees the primary of the transformer as a constant load. Power consumption on these devices may run between 50 to over 200 Watt-hours daily.

Filters and Line Conditioners

Many 120 vac business appliances like computers, printers, typewriters, FAX machines, and copy machines use filters on their power input. These filters serve a useful purpose- protecting the device from overvoltage, surges, noise and other electric trash that may wander onto the grid supplied electrical lines. Unfortunately, most of these filters are wired in ahead of the power switch, and are on line all the time. They consume power from the inverter- about 8 to 40 Watt-hours daily.

Wall Cubes

These small black boxes are really Phantom Loads. Wall cubes are actually small power supplies. Consider the case of a telephone answering machine powered by a wall cube. The wall cube is plugged into an electrical outlet and feeds the answering machine via a low voltage power cord. The ON/OFF switch is located on the answering machine itself. Even if the answering machine is turned OFF, the wall cube still consumes electricity. This is electrically the same as having a power switch on the transformer's secondary- the primary is alive all the time. A wall cube uses 20 to 50% of its rated power even when its device is switched off.

How to detect Phantom Loads

We find Phantom Loads by watching for signs of current flow where there should be none. If you are a technician with a meter, then break into the appliance's power circuit and measure consumption when switched OFF. This involves working with live 120 vac wiring and is dangerous if you don't know what you are doing. 120 vac will shock you whether it's produced by the grid or your inverter.

What follows is a very simple circuit for detecting phantom loads. It can be assembled from hardware and Radio Shack parts for under $6. It can be wired before it is connected to 120 vac power, and is as safe to use as a wall socket. The schematic is on the next page

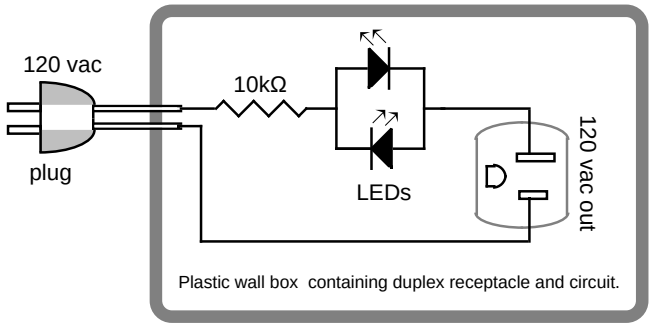
Everything is assembled into a plastic wall box used in 120 vac homes. The two Light Emitting Diodes (LEDs) can be in any color. Use very small gauge lamp cord (≈18 gauge) wired to a male plug.

Use the Phantom Load Detector as follows:

- Turn the appliance to be tested OFF.
- Unplug the appliance from the 120 vac power source.
- Plug the appliance into the Phantom Load Detector.
- Plug the Phantom Load Detector into the 120 vac power source.

• If you are using an inverter as a 120 vac source, then make sure that the inverter is "booted" and operating, not in standby mode.

• If the appliance is a phantom load and consuming power, then the LEDs will light. The more power the appliance is consuming, then the brighter the LEDs. This device is for testing power consumption in appliances when they are switched OFF.



The Phantom Load Detector.

While the Phantom Load Detector will survive switching the appliance ON, the appliance will probably not operate. The entire circuit is current limited by the 10kΩ resistor. With the 10kΩ resistor, we were able to detect Phantom Loads as small as 0.3 watts. If the 10kΩ resistor is replaced with a 3kΩ resistor, then the detector becomes more sensitive (0.1 watts), but the LEDs will not survive operation into an appliance that is turned ON during testing.

The Phantom Load Detector is very easy to build with only three electronic components. One detector should cover a neighborhood. Either a 120 vac appliance is a phantom load or it isn't. Once we have determined this we don't need to test it anymore, and the detector can circulate for others to use.

Dealing with Phantom Loads

Unplug the appliance! This works for sure because it is disconnected from its power source. However, constantly plugging and unplugging is a pain and wears out the hardware quickly. Just about every hardware or discount store sells extension cords with multiple female plugs that are SWITCHED on the plug strip. They sell for $5 to $10. When the plug strip is switched OFF, all the appliances plugged into the strip are disconnected from the 120 vac power source.

A PlugStrip in Action. Photo by Brian Green.

We use these plug strips for all phantom loads. Here on Agate Flat, we have three SL Waber (Model EP7S, costing $7.99 at the local discount house), seven outlet, plug strips with neon indicator lights. The neon indicator glows when the plug strip is turned ON and supplying power to all the phantom loads connected to it. We have two Mac computers, an ImageWriter printer, an HP DeskWriter printer, a wall cube powering a modem, and a hard drive plugged into these strips. I don't mind feeding these appliances when they are actually operating, but I don't want them flattening our batteries when they are supposed to be OFF.

Selecting Appliances that are NOT Phantom Loads

Any appliance with a built-in clock or timer is a constant and obvious phantom load. If you want a clock, then buy a clock, not a microwave or VCR. Avoid appliances with electronic memories **unless** these memories are kept alive by small batteries within the device. As a last resort, take a Phantom Load Detector to the store when you buy your appliance and check it out.

In many cases all appliances of a particular type are phantom loads. VCRs, for example, all contain clocks and timers that are alive even if their displays are not lit. All appliances using wall cubes are phantom loads. Every piece of electronic office equipment is a micro phantom load because of its filtration. Here the switched plug strip comes to our rescue.

The Bounty on Phantom Loads

If you live on the commercial grid, you're paying an average of 7.75¢ per kilowatt-hour for electricity. A small phantom load of 4 watts costs you about $2.70 yearly.

If you make your own electricity, then the savings situation is even better. Site produced power costs much more, about 90.¢ per kilowatt-hour. The 4 watt phantom load costs home power producers about $31. per year. The plug strip pays for itself in less than 3 months. And we get to use our power elsewhere.

The bottom line here tells only part of the story. Sure we can save some money by disconnecting inoperative appliances that still consume power. We can also save resources for use elsewhere. Regardless of the electrical power source, phantom loads waste energy because they don't do anything in return for their consumption. While in the individual sense, these phantom loads are small; in the collective sense, we're wasting enormous amounts of electricity.

Things That Work!
Windseeker™ II Wind-Electric Generator

Windy Dankoff

I am spoiled. I grew up with the wind power revival of the 70's, rebuilding the Cadillac of wind generators, the "Jacobs Wind-Electric Plants" of the 1940's and 50's. The one pictured on the cover ran my shop for years. Jacobs Windplants remain a standard because they work great and last for decades. Most new wind machines have been disasters, so I'm a hardened skeptic. As PV's got cheaper in the early 80's, I "retired" from wind power, phasing out all but maintenance for my old customers. Their rebuilt Jacobs "antiques" were the only ones I'd trust.

New Wind

A year ago, word blew my way that "Windseeker" was cranking out reliable Amps 'round the Northern Arizona mountains. I waited. I heard more good things. I talked to the factory and ordered the instruction manual. It is thorough and easy to follow. It treats tower placement, siting, energy use and other aspects of system design in a streamlined, efficient manner. Could it be that the machine works as gracefully as the manual? At the crusty age of 37, it was going to take SOME CONVINCING to bring me out of wind power retirement! I bought one.

A 20 Pound Hummingbird

The Windseeker II is 1/10 the size of the old Jacobs, but resembles our 1942 Paris-Dunn 200 watt windplant. Made for running radios on the farm, the Paris-Dunn was the most durable of the very small machines made during the old days. Ours survived a second incarnation, blasted by a decade of wild New Mexico winds. The key to its durability is a simple speed-governing system -- wind pressure tips the generator upward in winds over 30 MPH, to spill excess wind and relieve pressure on the structure. In winds over 40 MPH, it resembles a helicopter and sounds like a 20 lb. hummingbird. You can hardly hear its swishing sound above the wind itself.

The Governor

Windseeker's pivoting speed governor is perfect for such a small machine. It is FAR superior to the air brake governor used by the popular "Wincharger". Comparing the Windseeker to the Wincharger is like comparing a Toyota Tercel to a Model T with bad brakes. Windseeker II is one quarter the weight, easier to install and much more resistant to icing, lightning and 90 MPH winds. It is quality-constructed from aluminum castings and looks like it will last for decades. Warranty is two years. No regular maintenance is required. Marine treatment is available.

A Smart Controller

Windseeker II uses a "smart" controller built onto the machine. The controller allows optimum use of light winds and compensates for wiring loss as it provides the proper taper-charge to your batteries. I was delighted to watch the current interrupting on my ammeter as the voltage reached the perfect 14.3V. Output is 21 Watts at 10 MPH, 75 Watts at 15 MPH, 325 Watts at 25 MPH and 400 Watts at 28 MPH. Windseeker watts add to whatever may be coming from other energy sources. Both 12 and 24 volt models are available.

Blades and Heart

The propellor blade is an efficient taper-twist design that is extremely lightweight to reduce stresses and vibrations. The electrical heart is a modified Ford alternator. Parts and service for it are easily available from automotive sources. Windseeker's special field-control circuit is the key to adapting an automotive alternator to wind power (along with rewinding its stator coils for lower speed operation).

Windseeker II.

Towers

Windseeker can mount on a common antenna tower that may be purchased from (and installed by) your local 2-way radio supplier. A cheaper alternative is a simple mast made of 2" iron pipe with "guy wires". The instruction manual details such an installation for up to 65 feet. Kits are available if you buy the pipe locally. Your tower MUST clear all surrounding obstacles by at least 15 ft. to avoid turbulent wind and airborne debris, or you will not obtain satisfying results (this goes for ALL wind machines). No additional controls are required except for a fuse and optional ammeter. It is easy to shut down by hand with a control cable that tips it upward, out of the wind.

Filling the Gaps

Windseeker II is a very small machine, intended primarily for supplementary power in combination with PVs or other energy sources. Wind power tends to fill in the gaps during storms and at night. So, if you live on a cloudy coast, or the dark wilds of the North or even in the sunny Southwest, consider the Windseeker II to complete your energy system. If you're just curious ("nutty") about wind power, here's your chance to try a low-priced wind system that REALLY WORKS!

Access

Windseeker II is made by Andy Kruse and David Calley at SouthWest Windpower, POB 22178, Flagstaff, AZ 86002 • 602-526-0997.

Windy Dankoff is the Wind Wizard at Flowlight Solar Power, PO Box 548, Santa Cruz, NM 87567 (505) 753-9699. He is a major contributor to The Homebuilt Wind-Generated Electricity Handbook (Hackleman, 1976) and has written 13 previous articles for Home Power. He's worked, lived and slept with wind power since 1974.

Please remember:

As of April 1990 (HP#16) it will cost $6. per year to receive Home Power Magazine via Third Class.

Send in your $6 and don't miss an issue.

We tried to keep HP free, but too many of you want to get it!

Wind Generator Blade Balancing

Mick Sagrillo

Many different ways of balancing wind generator blades and rotors have been used over the years. Some methods work, although often on a hit or miss basis. There is more to rotor balancing than just screwing lead onto the blades. An unbalanced rotor will cause unnecessary vibration and stresses resulting in premature wear on the generator's bearings, governor, blades and tower. A properly balanced rotor will give the wind generator long life and its owners years of problem free power.

Ancient History

An old way of balancing is to mount the blades on their governor and then hang the entire assembly from a wire attached to the ceiling. The wire passes through the generator shaft hole in the governor and acts as a fulcrum or balance point. The entire rotor is then hung horizontally a few feet from the floor. The wire must pass exactly through the center hole of the governor. The point where the wire passes through the rotor becomes the fulcrum about which the rotor teeters. Weights are added to the lighter of the two blades (for a 3 blade rotor) until the entire rotor is horizontal. The primary problem with this system is that the fulcrum is below the rotor's center of gravity. This is because the assembly is supported from beneath by the wire. Balance is best achieved when the fulcrum point is above the center of gravity of the entire rotor/blade assembly. It is virtually impossible to balance the rotor accurately by hanging it from a wire.

Better But Not Perfect

Another old timers method involves mounting the entire rotor on the generator shaft. The generator can be on the tower or preferably on a stub tower on the ground. The rotor is lightly spun and allowed to come to rest. The heaviest blade will always come to rest in the bottom position. On a three blade rotor, weights are added to the lighter of the two and the rotor is spun again. When the blades come to rest randomly, the rotor is considered balanced. This method is tedious and time consuming but with patience a somewhat balanced rotor can be achieved.

Two Blade Balancing

Individual blades can be balanced, one against the other or against a known weight, on a fulcrum. This only works with a two blade system and then only if the governor or hub that the blades are attached to is perfectly balanced. If the governor is not well balanced, the case with most two blade Windchargers, or the rotor has three or four blades, this method doesn't work well.

Balancing with a Fulcrum

A common but ineffective way of balancing blades with a fulcrum is to find the center of gravity of the heaviest blade and transfer this dimension to the lighter blades. These blades are placed, one at a time, on the fulcrum at the marked point & balanced with weights.

Fulcrum Balancing Problems

One major problem with fulcrum balancing is the assumption that the blades are identical in gross weight and in weight distribution or density along their length. We have received blades from manufacturers that have varied by as much as six ounces from the heaviest to the lightest. And these have been considered quality blades. One of our customers bought blades from a well know supplier that varied by three pounds! Even if you've individually balanced all three blades, the rotor assembly will still not be properly balanced if the blades don't all weigh the same. As an exaggerated example, let's say that you used two 2 X 4's and one 2 X 6 instead of blades. Obliviously, the 2 X 6 is going to be the heaviest of the three. If you find the center of balance of the 2 X 6, transfer this center distance to the two 2 X 4's, then balance the two 2 X 4's on your fulcrum, all three will have the same center of balance. You'd have plenty of problems if you tried to use these three pieces of wood to drive your wind generator.

Wood Density

One of the reasons for the large discrepancies in blades is wood density. Trees vary in density, as do parts of individual trees. Ideally, the densest wood should be at the butt of the blade. The butt is the blade end closest to the governor. I know that our blade carver takes these things into consideration. But someone who is buying just one set of blades to finish for his own generator is really stuck with whatever the manufacturer sends. Blade manufacturers sell their wares either prepaid or C.O.D. Once a customer has paid for the blades, he has to be content with what's been shipped.

Blades and Rotor Together

The blades should not be individually balanced using the fulcrum method. Here at Lake Michigan Wind & Sun, we do not balance individual blades. We treat the entire rotor (the blades and governor) as a single unit. The first step in system balancing is to break down all structures to fundamental units. The entire rotor assembly is a fundamental, rotating unit. In theory, the rotor can be balanced by balancing individual blades, then mounting them onto what is supposed to be a balanced governor. In practice, all sorts of assumptions come into play that are givens in theory. These assumptions are not even considered when someone is screwing weights to blades, and therefore become variables. And variables can become vibrations.

The way we balance rotors at Lake Michigan Wind & Sun is very similar to the way tires were balanced before computerized spin balancing. We bubble balance.

Photo1 by Mick Sagrillo

Our balancer (photo 1) consists of a shaft machined to fit the center hole of the governor, in this case a Jacobs or DWS blade-activated governor. Different shafts are machined to fit different styles of governors. The shaft is bored out nearly to the top end. A pivot rod is machined to a point which fits inside the bored shaft. An

Photo 2

Photo 3

Photo 4

Photo 2: Bubble balancer, bored shaft & pivot rod in place.

Photo 3: Blades and hub on the balancing rig.

Photo 4: Bubble blancer at the hub's center.

Photo 5: Governor spring mounting brackets. An ideal place to add weights.

Photo 6: A weight sandwiched between the bracket and the blade.

All photos by Mick Sagrillo.

Photo 5

Photo 6

inexpensive bubble balance, available from any local tool shop, completes the hardware required.

The assembled balancer is shown in photo 2. The governor is placed on the bored shaft and the blades are then mounted onto the governor. At this point, the blades, governor hub, and governor spider are numbered. This is done so the rotor can always be reassembled in exactly the same way that it was balanced. If this is overlooked, the balancing is for naught. It's a good idea to place sawhorses under the first two blades that are mounted onto the governor to keep from placing undue stress on the pivot rod. Once the third blade is installed the sawhorses can be removed because the rotor will, more or less, maintain its own balance.

The rotor mounted on the balancer is shown in photo 3. The primary advantage to this system is that the pivot point of the rod (the fulcrum) is above the center of gravity of the governor and blades, see figure 1.

This makes balancing very accurate as well as very easy. The bubble balancer is placed directly over the center of the top of the bored shaft that is sticking out of the governor (see photo 4).

The Balancing

To balance a Jacobs or DWS blade mounted on a blade-activated governor, place gram weights on the eyebolt brackets of the two lighter blades until the bubble balance reads level (see photo 5). The eyebolt brackets are there to tension the governor springs. They provide a convenient place to attach weights along the blade's center of gravity.

Adding The Weights

Once the rotor is balanced, weigh the gram weights on a beam balance. Measure out the same weight of lead for casting. Add several grams extra to compensate for the mounting bolt holes which must be drilled in the weight. Melt the lead, pour it into a

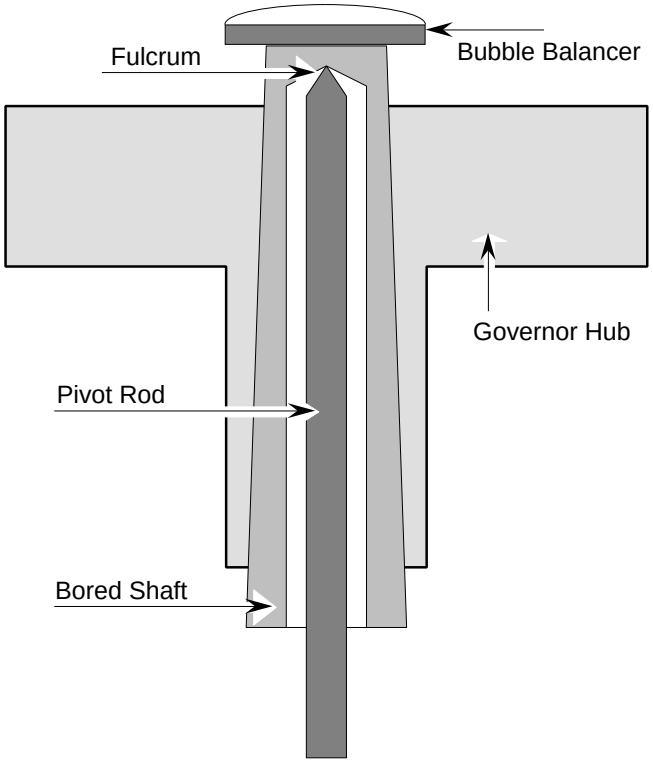


Figure 1- the balancing rig.

mold and set aside to cool. Drill the bolt holes and mount the weight to the blade by sandwiching it between the eyebolt bracket and the blade (see photo 6).

This way, the weight cannot work its way loose from the blade. Now, recheck the balance of the rotor to see how good a job has been done. If you've removed too much or too little lead during the drilling of the bolt holes, make corrections if possible. If not, then do it over. A perfectly balanced rotor is one of the most critical parts of your wind generator. Once you're satisfied with the balancing, move on to finishing the blades, and taping the leading edges.

Finishing Up

Before you balance the rotor, prime and finish sand the blades and mount all the hardware. Don't apply the finish coats of paint before balancing for two reasons. First, several ounces of paint spread more or less evenly over the entire surface will not affect the balance of the rotor. Second, it's very important to attach the weights to the blade before painting so the finished blade is completely protected by the final coats of paint. Then there are no breaks in the paint's skin for moisture to enter. Moisture entering the wood will not only affect balance, but also eventually cause rot.

Inner Workings- Centers

Problems often arise because of where the weights are placed on the blades. As can be seen from the cross section of a blade in figure 2, the thickest part of the blade is near the leading edge of the blade. This is called the aerodynamic center. Also shown in figure 2 is the pivot center. The pivot center is where the blade is attached to the rotor.

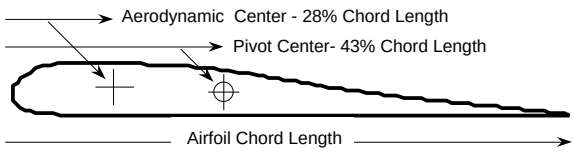


Figure 2- Airfoil Centers & Chord Length

The aerodynamic center is where most people would probably attach weights because it's the thickest and presents the least danger of the screws going all the way through the blade.

The Aerodynamic Center vs. the Pivot Center

In the Modified Clark Y Airfoil used on Jacobs and DWS wind generators, the aerodymanic center is 28% of the chord length measured from the leading edge of the blade. The chord length is the distance from the leading edge to the trailing edge of the airfoil. In the case of a Jacobs or DWS blade used on a blade-activated governor, the hole bored into the blade's butt for the governor blade shaft is the pivot center. The pivot center of the blade is 43% of the chord length from the leading edge. The three blade shafts of the blade-activated governor are 120° apart. The center of gravity of the blade lies along a line that passes through the pivot center of the blade (Figure 3).

Therefore, the center of gravity of each blade is 120° apart. By placing lead weights beneath the eyebolt brackets, you add weight along the center of gravity of the blades. Since each blade's center of gravity remains the same (120° apart), the rotor will balance nicely. If you add weights along the blade's aerodynamic center, then the center of gravity is shifted forward, towards the leading edge. This means that the centers of gravity for the three blades are no longer 120° apart (figure 4 on the next page).

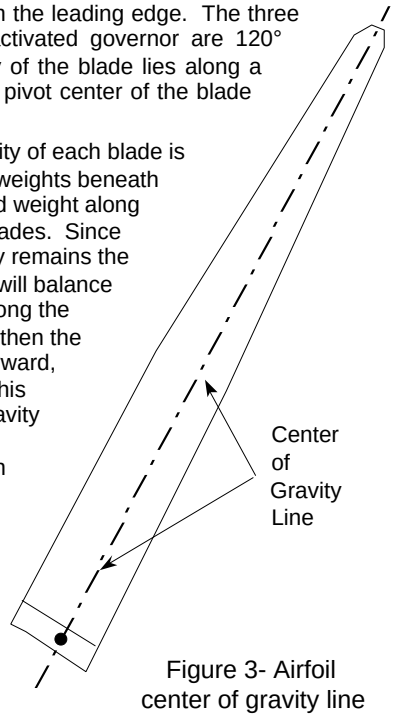


Figure 3- Airfoil center of gravity line

While a rotor assembly whose blades are weighted along the aerodynamic center will balance as a unit on the bubble balancer, it may vibrate in actual use. Care must be taken to locate weights along the center of gravity of the blades (the pivot center if a pivot is used) and not along the aerodynamic center.

Weights On or Within the Airfoil?

Never add weights on the outside of the airfoil. The airfoil of the rotor is a most important part of the entire wind system. The last thing you want to do after painstakingly preparing and finishing a set of blades is bolt some globs of lead to the outside of the airfoil. This creates all sorts of turbulence which will adversely affect the airfoil's performance.

However, some rotors do not have governor hardware attached to them (like the Jacobs or DWS blades) and therefore lack convenient mounting points for weights. There is a method of attaching weights that does not compromise the airfoil. This technique involves countersinking the weights into the blades. We use this method quite often with different airfoils and it works well.

Countersinking Weights INTO the Airfoil

In this technique, weights are placed along the center of gravity line of each blade requiring additional weight. Countersink the weights into the blade with a Forstner bit. A Forstner bit drills a perfectly clean hole in wood and leaves a flat bottom in a blind hole (the hole

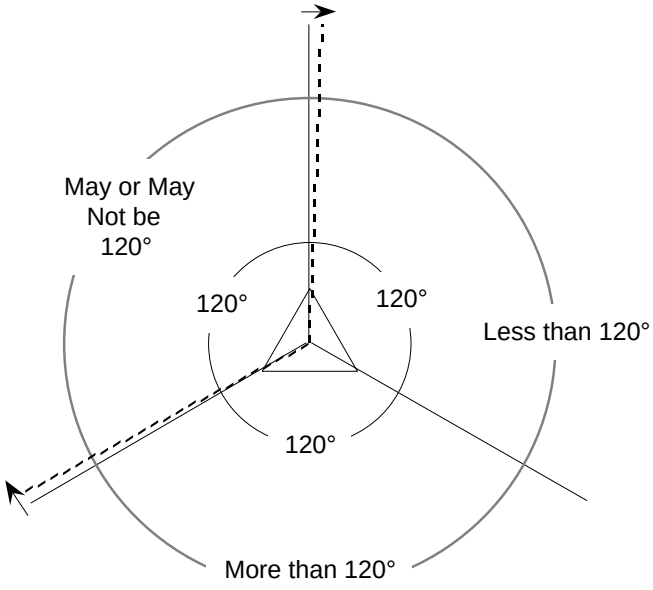


Figure 4- Symmetry of the entire blade/rotor system.

doesn't go all the way through the wood). You'll find an example of a blind hole on chair legs. These blind holes are drilled into the legs and accept crossrails. The best results are achieved with a drill press. I use a 7/8" Forstner bit, although most any size will work. After determining how much weight is needed to balance a blade, the lead is melted and poured into a form. The form I use is a short piece of heavy wall tubing that has been bored to exactly 7/8" to match the holes. The weights are never more than 3/8" high. If more weight is needed for the blade, more holes should be drilled and the lead made into several weights, one weight for each hole. The holes are about 1/2" deep for a weight that is 3/8" high. Epoxy is applied to the bottom of the weight and the weight is pressed into the hole. The hole is then sealed with automotive body putty, such as Bondo or fiberglass. I have found that the 1/8" of body putty or fiberglass that covers the lead weight nearly equals the weight of the wood removed from the hole. No allowances for the additional weight of the body putty or fiberglass are needed. Once the body putty or fiberglass has hardened, it can be sanded to match the contour of the blade. If you have done a good job, it will be very difficult to find the weights once the finish coats of paint have been applied. You have now balanced the blades without destroying the integrity of the airfoil.

The Bottom Line

As you can see, rotor balancing requires looking at the entire rotor assembly as a unit. Balancing individual blades is approximate at best. If you take time and consideration with the balancing process, you'll have a happy and long lived wind plant.

Access

If anyone has any comments on these ideas or any other ideas concerning rotor balancing, I would appreciate hearing from them. Feedback can be sent to: Mick Sagrillo, Lake Michigan Wind & Sun, E 3971 Bluebird Rd., Forestville, WI 54213, (414) 837-2267.

Lake Michigan Wind & Sun rebuilds, buys, and sells wind

Energy Fairs Update

A fair here, a fair there, a fair everywhere! After filtering through the tremendous masses of mail and numerous phone calls, a clearer picture of the Energy Fairs emerges. And I mean Fairs. Here's a distillation of the information you have been sending us.

The People's Choice

• Multiple Fairs all around the country. Each organized and run by the local folks. Local fairs will allow the development of lasting local infrastructures

• Nonsimultaneity. These Fairs will not be held all at the same time. Many folks and businesses would like to attend several fairs. Holding all fairs at the same time makes this impossible.

• Most everyone shares the same dream of Energy Fairs where renewable sources and alternative power systems are featured in both an educational and commercial setting.

Home Power's Bit

We are trying to act as a clearing house for people, information, and ideas. We encourage anyone wanting to participate in any of these fairs to contact the appropriate folks listed below.

Send Home Power Magazine your local Energy Fair information and we'll see that it's printed. The words and ideas from this point are the work of local fair people.

Solar Energy Exposition and Rally- SEER '90

The Northern California town of Willits will host the first annual Solar Energy Exposition and Rally (SEER '90) on August 11 & 12, 1990. This event is styled after the Energy Fair proposal in Home Power Magazine.

Home Power reader response has been overwhelming and correspondence to all of those who have inquired about SEER '90 is coming.

Touted by a Willits City Councilman as the "Solar Capital of the World", this city of less than 5000 people is welcoming the event with open arms. A steering committee of about a dozen local solar specialists, media and others interested in seeing the project fly has been formed. The steering committee has enlisted the financial and in-kind support of the local City Council and Chamber of Commerce. Within the next six months, preparations will be made to host over 100 exhibitors and vendors, and to attract a minimum or 5000 visitors.

The event will focus on working exhibits of alternative energy in action. Other planned activities include educational sessions and demonstrations and a solar car rally featuring international & local vehicles. Booth space is available for business concessions subscribing to the renewable energy theme, such as PV systems, energy hardware, energy conservation products, solar ovens, and organically produced, solar cooked foods.

As a public show of support for SEER '90, the Willits City Council passed a resolution November 8 designating August 5 through 12 Alternative Energy Awareness Week. Mayor Ed Scott said the city would offer support in the way of land, city personnel, traffic control and park maintenance to help things run smoothly. Organizers of the Willits fair have also asked for financial support, which is being considered in lieu of more detailed plans.

An office has been set up to coordinate planning, and all interested exhibitors, participants and volunteers are urged to call or write

SEER '90
733 S. Main St., Suite 234
Willits, CA 95490
Telephone: 707-459-1256 or
800-669-4786
FAX: 707-459-1256

You can help us finance SEER '90 by sending $25.00 You will not only get 2 days entry to SEER '90, but also a high-quality cotton, full color SEER '90 T-shirt (specify size). SEER '90 is a nonprofit venture. Send $25 to: SEER '90, 733 S. Main St., Ste. 234, Willits, CA 95490.

SEER '90 Solar Car Rally

A most pressing challenge is the organization of the solar car rally. Teams and car builders need as much time as possible to prepare for the rally.

Organizer John Fry has attended Switzerland's 1980 Tour De Sol as well as a recent MIT class in building solar vehicles. The rally rules and course will be available 1 January 1990 from the SEER '90 office. Here is an update on how the rally is panning out:

• There will be four categories of vehicles and the course will include some gravel roads and hills.

• The course will run approximately 50 miles.

• The Solar Car Rally is not a race and all of California's driving laws must be obeyed.

• We are trying to raise $20,000 as prize and travel money for entrants.

• The goal of this rally is to demonstrate the effectiveness of solar powered, non-polluting vehicles.

ATA PV Workshop at SEER '90

A special Photovoltaic Training Workshop will be held in conjunction with the Energy Fair. Scheduled for August 1990. Workshop participants will install several operational PV systems at the SEER '90 site in Willits, CA.

The intensive one or two week workshop is structured for serious PV practitioners who want to learn from professionals. Do-it-yourself homeowners and persons desiring career vocational training are welcome. No prior knowledge of solar or electricity is required.

The Energy Fair Workshop is modeled after the program called "The Nation's Leading PV Design and Installation Course." See HP13 for details about last summer's workshop in Colorado.

The course combines classroom theory and hands on skills training. The first week will focus upon the basics of solar electricity, appropriate applications, system hardware and how to size and specify equipment. Commercially available components will be discussed and evaluated in detail. Teaching is done with full scale demonstration systems and laboratory exercises are taught with working components. The optional second week is devoted exclusively to hands-on installations at the Fair site and will include completely operational residential sized systems. One system will be used to publish Home Power #19 (Oct/Nov 90 issue) from the Fair! DC lighting and appliances, ac systems with inverters and PV gensets will be included.

This unique PV training workshop will enable participants to contribute to THE FAIR while learning how to design and install photovoltaics. So come join us! Workshop sized is limited. The cost per week is $350. This includes a 300 plus page textbook and a product literature supplement guide. Registration opens this spring. For more info contact Johnny Weiss at ATA, 410 Garfield, Carbondale, CO 81623 • 303-963-2682

The Farm, Summertown, Tennessee.

The Farm is planning on a date in Mid-June for an Energy Fair. Also a possibility at this fair is another ATA series of Workshops for PV Practitioners.

Folks into starting and participating in the area surrounding Tennessee should make contact with The Farm now. The Farm is now organizing this Fair, and could use your help and input.

Contact: Mary Ellen Bowen, POB 90, Summertown, TN 38483 • 615-964-3992.

Another Possible Fair in Vermont

David Palumbo of Independent Power & Light, and the folks at ATA are putting together an East Coast PV Workshop at Sterling College, Craftsbury Common, VT. They would like to have a two day Fair at Sterling College in conjunction with the Workshop. Anyone interested should contact David Palumbo, Independent Power & Light, RR1 Box 3054, Hyde Park, VT 05655, 802-888-7194.

Come On Midwest PVers

Central Wisconsin, namely the Stevens Point/Amherst area, would be a good sight for a Midwest Energy Fair. With over 10 PV systems, and a large number of solar air and water heating systems. I think it would be safe to say that this is a major midwestern RE hotspot. There have been several suggestions to a possible site in the area. One PV user has offered to host the fair on his land. Other possibilities include the county fairgrounds and the local University. My wife and I would be willing to direct the organization of the Midwest Energy Fair if it were in this location.

Thoughts we had in regard to content were to focus not only on RE power generation and use, but also on conservative home building materials and practices. Practical workshops including topics such as system sizing, battery maintenance, building design, etc. should be a major focus. Having manufacturers reps at the Fair, with their products, is also very important. We don't want to let down all the Tech-Weenies who need to see, feel and learn all that's new. Of course, it would be wonderful to have a solar car race, and we mustn't forget general socializing, entertainment and the like. As for the Fair's length, I may be wrong, but I think 3 days would be as much as we midwesterners could tolerate before feeling we had to get back to work.

Come on Midwest PVers. Let's show the public that we are here, and that the sun can make electricity here just as well as in California!. BJ Welling, 7934 Hwy 1, Custer, WI 54423 • 715-592-4047. I may also be contacted at: Snowbelt Solar, 286 Wilson St, Amherst, WI 54406 • 715-824-3982.

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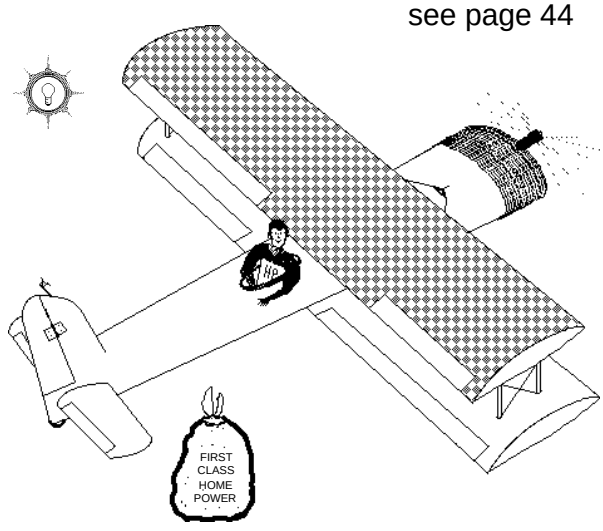

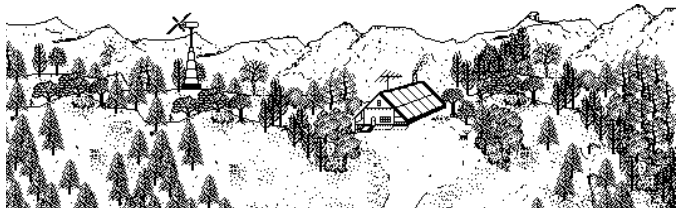

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FOR OUR PURPOSES WE DEFINE ALTERNATIVE ENERGY AS ANY ELECTRICAL POWER NOT PRODUCED BY OR PURCHASED FROM A COMMERCIAL ELECTRIC UTILITY.

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

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

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

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

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

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

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

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

☐ **Wind Power** ☐ **Other** _____

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

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

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The X-Wing was my first attempt at a high speed experimental solar vehicle. This PV powered speedster has been driven at speeds up to 30 MPH. While the X-Wing looks fast, it's real purpose was development of lightweight modular frames and components. The modular frame concept allowed me to recycle all the materials used in the X-Wing into later, better designs.

Photo by John Jensen

Build your own Solar Powered Vehicle NOW!

I am an artist/inventor, inspired by Bucky Fuller's design revolution, "everything needs to be redesigned". We have built ourselves into a technological corner and we must design our way out of our transportation mess. The automobile & its roadways are a very destructive force on this planet. Let's start our own revolution by "Just Saying No" to a car/oil industry and a government who can't or won't build really dependable, non-polluting vehicles.

Building Blocks

We need a vehicle sized in between the bicycle and the car. The solar assisted electric vehicle is the perfect solution with many added benefits.

Being part owner and mechanic in a bike and alternative transportation shop has given me an insight into a radical new idea for creating such vehicles. I am creating a modular framing system with a high degree of part interchangeability. This allows maximum frame design flexibility by designers and builders. This concept is not new. The bike industry has been attempting this for many years. With the advent of the mountain bike, this industry now has a very high degree of interchangeability. This allows the choice of many different quality levels. For instance one can buy a mild steel handlebar for $6. One can also spend $20 or so on a lightweight aluminum bar, or for the ultimate in lightweight performance carbon graphite fiber wound bar for $100. All three bars share the same mounting diameter. Parts standardization by many manufacturers allows frame builders tremendous flexibility for many new designs.

The Big Boys

On another scale entirely we have the auto industry, with almost no parts interchangeability. This industry is presently incapable of any real change. Their inertia is so great that it takes a minimum of six years to produce a new design. The saddest part is the planned obsolescence in their vehicles. We can no longer afford or tolerate this kind of waste.

A Different Approach

My proposal is that we create a new vehicle standard based upon maximum interchangeability of parts. I purpose that a new standard incorporate as much off-the-shelf hardware and technology as possible.

The Matrix™ Framework

Virtually all the frame members in these electric vehicles are aluminum box beam. More complex parts such as front ends and rear axle swing arms are MIG welded steel assemblies which bolt up to the box beam hole pattern. Many vehicle frames can now be assembled in minutes instead of days or weeks of cutting and welding.

I used 1.5 inch by 1.5 inch aluminum square tubing with a 1/8 inch wall thickness for the vehicle's frame. The tubing is structural type 6061P6 and weighs 0.75 pounds per linear foot. This aluminum tubing has 3/8 inch diameter holes drilled at 1.5 inch intervals along all faces. Where 3 members meet at a joint, they triangulate forming an extremely rigid structure.

The Matrix framework at work in the X-Wing chassis.
Photo by John Jensen.

The Vanda with PVs folded for travel.
Photo by John Jensen.

A Matrix framework joint is strong and easy to assemble or disassemble. Photo by John Jensen.

Using the Matrix System

The photo to the upper right shows the X-Wing without it's covering of PV panels and nose piece. Here one can see the modularity of the Matrix framework technique. The X-Wing's frame consumed 60 linear feet of tubing in its construction. Complete with nuts and bolts, the assembled frame weighed in at less than 60 pounds. The X-Wind had two drawbacks, limited hauling capacity and the PV modules were fixed in place.

The Vanda

Vanda is a two-seat, low speed utility vehicle. The Vanda is the current production vehicle of Suntools in Willits, CA. Designed to travel 40 to 60 miles per day, the Vanda's top speed is 30 MPH on level ground. Geared down for the mountains, Vanda's top speed drops to 20 MPH.

Vanda's overall length is 9 feet and overall width is 6 feet. Most of this area is usable interior space. The interior measures 7 feet by

The Vanda with PVs extended for battery recharging.
Photo by John Jensen.

4.5 feet and allows sleeping for two inside. The Vanda will haul 500 pounds of passengers and cargo. The batteries, about half the Vanda's weight, are located low in the framework giving the vehicle a low center of gravity.

The photovoltaic array produces about 240 Watts under full sun. This will totally recharge the Vanda's battery (12 V @240 A.-hrs.) in about three days. Recharging from a home system takes about 5 to 10 hours. The PV panels are mounted on an adjustable rack on Vanda's roof. This allows tilting the PVs to best catch the sun when the Vanda is parked.

The two 24 VDC permanent magnet, electric motors are wired in parallel and connected to the drive axle via chain and sprockets. The motors also operate as regenerative brakes, storing the Vanda's inertia in the batteries. I'm now experimenting with cog timing belts and toothed pulleys for power transmission. Also under development is a Pulse Width Modulator motor control and instrumentation deck.

Vanda is Flexible

Vanda's matrix framework weighs 70 pounds in its current configuration. Being bolted together rather than welded, the Vanda is agreeable to change. Major frame modifications like moving the position of an axle, are just a matter of nuts and bolts. This allows fine tuning of the vehicle's frame geometry without tedious and expensive welding. Vanda is not locked into unchanging welded metal. If you want to improve the design, all it takes is a wrench and some imagination.

Flexibility is built into Vanda's design. For example, Vanda will interface with home power systems. Vanda can recharge from home PV, wind or hydro sources. Vanda's PV array can also charge the home's battery when the vehicle is not being driven. Wherever Vanda goes, it carries its own silent power plant. With the addition of an inverter, the Vanda runs power tools in the field.

Vanda performance is amazing for a vehicle powered by sunshine. It accelerates like a rocket because it is electric. Handling is stable due to the wide track and low center of gravity.

Vanda's Cost

The Vanda will cost less than $9000 to build, complete with batteries and PVs. A builder will spend about 200 hours completing Vanda from a kit. When completed the Vanda is street legal in California as a motorized bicycle.

The Vanda of the Future

I am adding the finishing touches to the Vanda interior, instrumentation and testing of the vehicle for range, hill climbing etc. I will be reporting to Home Power readers on this in the next issue. On January 1, 1990 my matrix parts catalog and work manual will be complete. This will be around 70 pages mainly of parts for building ones own transport systems and other stimulating projects. The price is $20.00, half of which is refundable upon first order and the will be put to good use. If we use our resources wisely the 1990's can be our pivotal years for massive change. The future is now.

Access

Contact Phil Jergenson at Suntools, 271 Franklin Ave., Willits, CA 95490 • 707-459-2453.

The Solar Apprentice- a PV Powered Vehicle

Christopher Dymond

This project is a joint operation of SolTerra and The Global Walk. In the first phase, an ultralight photovoltaic powered, electric vehicle will be built in Olympia Washington by SolTerra and local solar energy enthusiasts. In the second phase, the vehicle, "The Solar Apprentice", will cross the country in conjunction with the Global Walk. It will be an operations vehicle for solar energy displays and information, as well as a dramatic demonstration of PV power.

Why This Project?

The primary purpose of this project is to increase awareness and education of the value of solar energy. In order to develop energy sources which are compatible with our environment, we must make a conscious decision to do so. Sustainable energy technologies are not currently profitable enough to excel via the free market system. Instead, we must make a personal investment today, through conservation and renewable energy sources such as solar energy, wind, hydroelectric & geothermal. In return, this investment will leave the Earth in as good a condition as we found it.

The Global Walk

The Global Walk is a grass roots non-profit organization working to make the world more "livable." They have organized a grand project, to send several hundred people on a walk around the world. Representatives from Denmark, England, France, Australia, New Zealand, Japan, the Soviet Union, and the United States will participate in the first part of the walk across the US. Through this experience these people will meet tens of thousands of people and develop a better understanding of our world, both as individuals and as a whole Earth.

"The goal of the Global walk is to raise awareness about the environmental crisis and demonstrate what can be done about it." Joan Bokaer, Global Walk director

The walkers will teach people "how-to" be more globally responsible and politically active, by networking already existing organizations and setting up fairs. One of the most valuable elements of the fairs will be the Solar Energy Display. The display will consist of a demonstration of photovoltaic power, passive solar energy (water and space heating), how to demonstrations, and information packets on available solar energy technologies and services.

It is in the solar energy display which the Solar Apprentice will be of its greatest use. Joining the Global Walk in Arizona on April 15,1990, the Solar Apprentice will travel to New York. The vehicle will provide eye catching attraction to draw people to the solar energy display and demonstrate effective photovoltaic power. For more information on the Global Walk please contact: The Global Walk,1431 Ocean Ave., Suite B, Santa Monica, CA 90401 • 213-458-3911 or 213-395-4123.

WHO IS BUILDING THE SOLAR APPRENTICE

The majority of the work will be done by Team Solar, a group which consists of members of the Capital Bicycling Club (Olympia, WA), mechanics, machinists, local solar energy enthusiasts, and science students of the Evergreen State College and South Puget Sound Community College.

Materials selection and assembly is directed by Dan Kneelands, Student Shops Instructor at The Evergreen State College. Dan has had a wide variety of experience in alternative energy systems and appropriate technology in developing countries, and has years of experience in ultralight aircraft design and construction. The director of the design and building is myself, Christopher Dymond.

The facilities which have been made available for the project include:

•The Evergreen State College student shops & science department

•South Puget Sound Community College electronics lab

•Western Washington State College wind tunnel

Additional support and resources which must be acknowledged include: Dr. Mike Seal (WWSC), Dr Robert Cole (TESC), Bill Tourtilott (SPSCC), Richard Rau (Bow Wow Cycleworks), Dr Don Middendorf (TESC), Richard Apple (Apple and Assoc.), and Kurt Knutson, Larry Eisner (Solar Engineering inc.), & Richard and Karen Perez (The Electron Connection, Ltd.).

THE SOLAR APPRENTICE

Physical Requirements

Power source	= The Sun
Range per day	= 80 km.
Vehicle Capacity	= 110 kg.

Vehicle Physical Dimensions

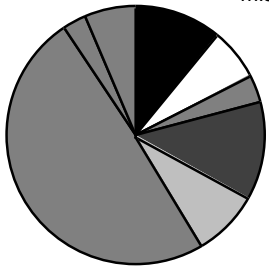
length	= 560 cm.
width	= 172 cm.
height	= 110 cm.
mass loaded	= 270 kg.
mass unloaded	= 160 kg.

Vehicle Specifications

Motor	= 1 kW. series DC
Solar Array	= 5.0 sq. meters, 600 W.
Batteries	= Nickel-cadmium, 60 kg.
Chassis	= 4130 steel tubing
Suspension	= 4 wheel independent
Wheels	= 20 inch bicycle, 90 psi tires
Brakes	= Drum type, front & rear
Body	= fiberglass, PVC, & Aluminum
Drag Coefficient	= 0.26 to 0.28
Max. Speed	= 45 km/hr under full sun
Max. Speed	= 70 km./hr. with battery assist

Cost Breakdown

Item	Cost
Steel tubing for frame	$790
Fiberglass and PVC	$480
Batteries	$250
Hubs, wheels, tires, & suspension	$892
Motor	$624
Solar Array	$3,580
Office Supplies	$225
Miscellaneous	$450
TOTAL	$7,291



What We Need

Time, energy and expertise have all been donated by SolTerra, the Global Walk, Home Power Magazine and Team Solar. We have the skills, facilities and people power to make this project work. We need the material components necessary to make this project to work. Join us though your contributions, be it in the form of information, contacts, time, money, or the donation or loaning of materials,. All will be well appreciated.

Contributions are tax deductible. In addition, large donations can reserve you a space for advertisement on the side of the vehicle, which will traverse the nation, stopping at hundreds of small towns and cities.

JOIN US TODAY!

For more information contact: Christopher Dymond, c/o SolTerra, 720 S Adams #3, Olympia, WA 98501 • 206-352-2652.

Christopher Dymond is the owner of SolTerra and has a B.S. in Physics and a B.S. in Engineering Physics from Oregon State University. His vehicle design experience includes an apprenticeship with Richard Rau, (Member of the Board of Directors of the Oregon HPV Association, and a renowned recumbent bicycle designer/builder), and being the primary designer/builder of the "Red Shift", for the gravity powered vehicle competition at Oregon State University. RP

Wire Sizing and Voltage Drop in Low Voltage Power Systems

John Davey & Windy Dankoff

Properly sized wire can make the difference between inadequate and full charging of your energy system, between dim and bright lights, and between feeble and full blast performance of your tools and appliances. Even wiring that is slightly undersized can cheat you out of a major portion of your system's energy.

Designers of low voltage systems are often confused by the implications of voltage drop and wire size. In conventional home electrical systems (120/240 volts ac), wire is sized according to its safe amperage carrying capacity know as "ampacity". The overriding concern here is fire safety. However in low voltage (12/24/48 volts DC) systems, sizing for larger wire is usually necessary to minimize power loss due to voltage drop before increased wire size is required for amperage safety.

Typically, low voltage systems are seen in Alternative Energy (AE) home systems and Recreational Vehicle (RV) systems. The heart of these systems is DC power because DC electrical power can be stored in batteries. With photovoltaic systems, the electrical power produced is also DC. DC systems are primarily low voltage because most of the DC lights and appliances have traditionally been built for the vehicular market, which is typically 12 or 24 volts. There is also increased fire danger with high voltage DC because of the high potential for arcing in switches and poor electrical connections. High voltage DC also has a high shock hazard (more than at an equivalent ac voltage).

Voltage Drop is caused by a conductor's electrical resistance (Ohms) and may be calculated according to Ohm's Law--
(1) Voltage Drop (Volts) = Electrical Resistance (Ohms) X Current (Amps)

Power Loss is calculated by--
(2) Power Loss (Watts) = Voltage Drop (Volts) X Current(Amps)

By substituting the Voltage Drop Equivalence from equation (1) into equation (2), we find--

Power Loss (Watts) = Ohms X $Amps^2$

If we have a 12V system with a 100 ft. wire run of 12 gauge wire (0.33 Ohms) and a 72 watt load, there will be a 6 amp current (Amps = Watts/Volts) and a power loss of 12 watts (0.33 Ohms X $[6\ Amps]^2$). If we converted this system to 24V, we would have a current of 3 amps and a power loss of 3 watts. The significance here is that by DOUBLING the system voltage, power loss is reduced by a FACTOR OF FOUR. Or for no increase in power loss, we can use ONE FOURTH the wire size by doubling the voltage. This is why the trend in AE full home systems with DC circuits is towards 24V instead 12V systems. It is also why it is important to reduce the current by using efficient loads and putting fewer loads on the same circuit. Likewise, reducing wire resistance by using large wire and shorter wire runs is important. All of these are particularly critical with AE systems, where cost per kilowatt of electrical power may be several times that of "Grid" supplied electrical power.

Wire Size Chart

Because of the significance of voltage drop in low voltage electrical systems, we have developed an easy-to-use wire sizing chart. Most previous charts published assume a 2 or 5% voltage drop for 12 and 24 volt systems and result in pages of numbers. This new chart works for any voltage and accommodates your choice of % voltage drop. You'll find it the handiest chart available. The chart applies to typical DC circuits and simple ac circuits (refer to footnote on Wire Size Chart). We recommend sizing for a 2-3% voltage drop where efficiency is important.

ac/DC Wire Size Chart

① Calculate Voltage Drop Index (VDI)

$$VDI = \frac{AMPS \ X \ FEET}{\%\ VOLT\ DROP \ X \ VOLTAGE}$$

where:
AMPS = Watts/Volts
FEET = One-way wire distance
%VOLT DROP = Percentage Volatage Drop
e.g. use 2. for 2%

② Determine Appropriate Wire Size from Chart

a. Compare the "calculated VDI" with the VDIvalues for the American Wire Gauge (AWG) sizes in the chart to determine the appropriate wire size to use.
b. Circuit amperage must not exceed the indicated fire harzard AMPACITY rating for the wire gauge set by the National Electric Code.

Wire Size	Copper Wire		Aluminum Wire	
AWG	VDI	Ampacity	VDI	Ampacity
OOOO	99	260	62	205
OOO	78	225	49	175
OO	62	195	39	150
O	49	170	31	135
2	31	130	20	100
4	20	95	12	75
6	12	75	•	•
8	8	55	•	•
10	5	30	•	•
12	3	20	•	•
14	2	15	•	•
16	1	•	•	•

- Size for a 2% to 3% Voltage Drop where efficiency is important.
- Information here applies to DC and ac circuits where the Power Factor = 1.0 and the line reactance is negligible.
- For 2-wire circuits. For more complex circuits refer to an electrical engineering handbook.

Sizing Example
We have a 12 volt system with a total one-way wire run of 40 ft. servicing three 13 watt fluorescent lights and one 20 watt quartz halogen light. Sizing for a 2% voltage drop, what wire size is needed for this circuit?

$$\text{AMPS} = \frac{\text{TOTAL WATTS ALL LOADS}}{\text{VOLTS}}$$

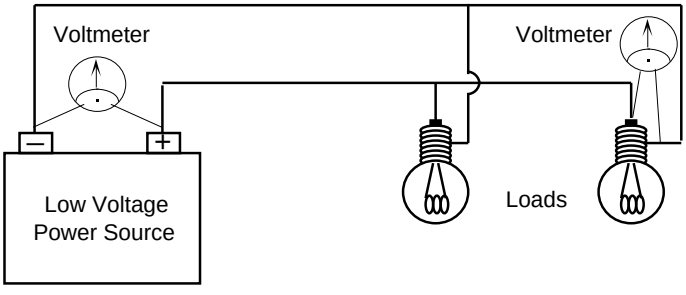
$$\text{AMPS} = \frac{(3 \text{ X } 13) + 20}{12} = 4.9 \text{ AMPS}$$

$$\text{VDI} = \frac{\text{AMPS X FEET}}{\text{\% VOLT DROP X VOLTAGE}}$$

$$\text{VDI} = \frac{4.9 \text{ X } 40}{2 \text{ X } 12} = 8.2$$

The "calculated VDI" 8.2 is between VDI values 8 and 12 on the Chart. This calls for #8 gauge wire (#12 gauge wire could be used in a 24V system). Since the "calculated VDI" is not much greater than 8, we may consider sizing-down and accepting a slightly greater voltage drop. This would be sensible because #8 gauge wire is expensive and difficult to work with. Or we might consider putting these loads on two circuits--compare wire and labor costs. If typically only one of the fluorescents and the quartz halogen are operating at the same time, we could size for this typical load, being sure not to exceed the wire ampacity for the total of all loads. In this case #12 gauge wire could be used. This is an example of some of the considerations and tradeoffs that will be discussed later in this article.

Determining Voltage Drop In Existing Circuits
You may wish to know how efficient an already existing circuit is in terms of voltage drop. There is an easy way to measure this. With a "multi-tester" or voltmeter, measure the "source voltage" for the circuit and the "load Voltage" at the end of the line, then compare the difference. Do this while the circuit is powered and all the loads are on:



Now calculate the % voltage drop with the following equation--

$$\text{\% VOLT DROP} = \frac{(\text{SOURCE VOLTS} - \text{LOAD VOLTS}) \text{ X } 100}{\text{SOURCE VOLTS}}$$

This method will total ALL voltage drops in the circuit caused by wire, connections, and switches. Because the amperage is less beyond each load in the circuit, the true % voltage drop will be somewhat less than that calculated in the above equation.

An easy way to calculate the wire voltage drop WITHOUT any measurements, if you have the information needed about the circuit, is to solve for % Voltage Drop using the VDI equation--

$$\text{\% VOLTAGE DROP} = \frac{\text{AMPS X FEET}}{\text{VDI X VOLTAGE}}$$

where:

$$\text{AMPS} = \frac{\text{TOTAL WATTS ALL LOADS}}{\text{VOLTS}}$$

FEET = one-way wire length of the circuit.

VDI = VDI value, from Wire Size Chart for the gauge of wire in the circuit.

VOLTAGE = System Voltage.

Practical Applications and Considerations

Here, we will consider voltage drop and wire sizing for different types of electrical loads, alternatives to the use of large wire and long wire runs, and some recommended wiring techniques. Different electrical loads (power-consuming devices) have different tolerances for voltage drop. These guidelines will help you determine how much drop is acceptable.

Lighting Circuits

Incandescent and Quartz Halogen
A voltage drop below appropriate levels results in a disproportionate loss in performance. A 10% voltage drop causes an approximate 25% loss in light output. This is because the bulb not only receives less power, but the cooler filament drops from white-hot towards red-hot, emitting far less visible light.

Fluorescent
Voltage drop here is less critical, causing a proportional drop in light output. A 10% voltage drop results in an approximate 10% loss in light output. Because fluorescents are more efficient, they use 1/2 to 1/3 the current of incandescent or QH bulbs and therefore many be used with smaller wire (including most pre-existing ac wiring). We strongly advocate use of fluorescent lights. The unpleasant qualities of flicker and poor color rendition may be eliminated by using the more advanced 12, 24, and 120 volt fluorescents now available. See our "Efficient Lighting" article in HP#9 for details. We suggest using a 2-3% voltage drop for sizing wire in lighting circuits. If several lights are on the same circuit but are rarely all on at once, see the Part-Time Loads section for an economical approach.

Motor Circuits

DC Motors
DC motors operate at 10-15% higher efficiencies than ac motors and eliminate the costs and losses associated with DC/ac inverters. DC motors have minimal surge demands when starting, unlike ac induction motors. Voltage drop results in the motor running at a proportionally slower speed and starting more gradually. We suggest using a 2-5% voltage drop under normal operating conditions for DC wire sizing.

DC motors used for hard-starting loads, particularly deep-well piston pump jacks and compressors, may have high surge demands when starting. High power demands are also seen in DC power tools when overloaded. DC refrigerators (e.g. Sun Frost) with electronically controlled (brushless) motors will fail to start if the voltage drops to 10.5 volts, in a 12V system, during the starting surge. This is due to a low voltage shut-down device in the refrigerator intended to protect your batteries from damage. We suggest sizing wire here for a 5% voltage drop at surge current (use 3X operating current).

ac Motors
Alternating Current (ac) induction motors are commonly found in large power tools, appliances and well pumps. They exhibit very high surge when starting. Significant voltage drop in these circuits may cause failure to start and possible motor damage.

Universal Motors
Brush type ac motors ("Universal Motors") are found in smaller appliances and portable tools. As with DC motors, they do not have large surge demands when staring. However, wire should still be generously sized to allow for overload and hard-starting conditions. Consult an electrician or the *National Electrical Code* for wiring standards in ac tool and appliance circuits.

Photovoltaic Battery-Charging Circuits
In PV battery charging a voltage drop can cause a disproportionately higher loss in power transfer. To charge a battery, a generating device must apply a higher voltage than exists in the battery. That's why most PV modules are designed for 16 volts or more. A voltage drop of 1 or 2 volts in wiring will negate this necessary voltage difference, and greatly reduce charge current to the battery. A 10% voltage drop in a wire run may cause a power loss of as much as 50% in extreme cases. Our general recommendation here is to size for a 2-3% voltage drop.

PV array voltage also drops in response to high temperatures. Use high voltage modules (over 17 volts peak power) in very hot climates (where module temperatures commonly exceed 117°F./47°C.). In moderate climates, high voltage modules allow for more line voltage drop, but they cost more per Amp delivered to the battery bank. Therefore, size wire for a somewhat larger voltage drop, e.g. 5%, when high voltage modules in a moderate climate.

If you think you might expand your array in the future, install wire appropriately sized for your future needs NOW, while it is easier and less costly. It never does any harm to oversize your wire.

Number Of Circuits
If circuits are designed with numerous loads requiring large wire, overall wire cost may be adding additional circuits and putting fewer loads on each circuit. Fewer loads per circuit reduces circuit current which in turn allows for the use of smaller wire.

More Than One Size Of Wire In A DC Circuit
If you size wire for the loads on "End Branches" of a circuit, smaller wire may be used. For instance, voltage drop sizing may specify 10 gauge wire for a circuit but a light on an "End Branch" of the circuit, when sized separately, may allow for the use of 12 gauge wire from the switch to the light. Using smaller wire for "End Branches", may also make your electrical connections faster and easier because it is physically difficult to make connections to standard household switches, receptacles, and fixtures with wire larger than 12 gauge.

BE SURE THAT THE AMPACITY RATING OF ALL WIRE IN A CIRCUIT MEETS OR EXCEEDS THE FUSE PROTECTION RATING OF THE CIRCUIT.

Part-Time Loads
If a number of loads are on the same circuit but are rarely all operating at the same time, you can size the wire for voltage drop according to the TYPICAL load demand. AGAIN, BE CERTAIN THAT THE AMPACITY RATING OF ALL WIRE IN THE CIRCUIT MEETS OR EXCEEDS THE FUSE PROTECTION RATING OF THE CIRCUIT.

System Voltage
Consider 24 volt DC instead of 12 volt where feasible. Use 120 volt ac from inverter to loads where 10-20% conversion loss is not a major comprise. See our article "Selecting System Voltage" in HP#4.

Location Of System Components
Locate batteries, inverter, ac battery charger, and distribution panel near each other. Also, locate the distribution panel as close as possible to very large loads and as central as possible to all other loads. This will shorten wire runs and for some circuits, reduce the wire size required.

Water Well Pumps
Consider a slow-pumping, low power system with a storage tank to accumulate water. This reduces both wire and pipe sizes where long lifts or runs are involved. An ARRAY-DIRECT pumping system may eliminate a long wire run by using a separate PV array located close to the pump. (For more about water system design, see our article "Solar Powered Pumping", HP#11.)

Soldering vs. Mechanical Connections
Soldering is recommended around battery and inverter terminals (see "Build Your Own Battery/Inverter Cables" in HP#7) and in other corrosive, high-current environments OR at the discretion of the installer. Soldering requires skill and has numerous pitfalls--too much or too little heat, oxidized or dirty metal, the wrong solder or flux, or just lack of experience will GUARANTEE poor solder joints. Do not attempt to solder connections in your system unless you have learned do it properly. A tight mechanical joint is far safer than a questionable solder joint.

Grounding And Lightning Protection
We've seen thousands of dollars of damage to electrical equipment from lightning. In one PV home a lightning bolt entered the house via the PV wiring and exited the other side of the house, popping plaster and light bulbs, and burning wire along the way. Proper grounding PREVENTS nearly all such occurrences. For a more thorough discussion, see our article "Grounding and Lightning Protection", HP#6.

Audio Signal Wires
Wires that carry audio signals (telephones, intercom, speakers) may pick up buzzing noise if run alongside ac wiring. This is especially true when the ac power is from an inverter. Avoid this problem by running audio wires along a separate path (or in a separate trench) from the ac wires. Keep then as far apart as possible, especially on long runs. Proper grounding also helps. Audio wires will NOT pick up noise from DC lines.

Wiring Design And Installation Book
We recommend *The Solar Electrical Independent Home Book* to familiarize you and your PV installer/electrician with safe up-to-code installation procedure (available from Flowlight Solar Power).

About the Authors
Windy Dankoff is owner of Flowlight Solar Power. Flowlight supplies remote home PV systems and manufactures "Flowlight Solar Pumps". Windy began working with wind generators in 1975 and PV in 1979. He has contributed 12 articles to *Home Power* since issue #2.

Dr. John Davey is a professor of ecology and (thus) jack-of-all-trades at Flowlight Solar Power. He is a graduate of the Colorado Mountain College Solar/PV program.

Contact the authors at Flowlight Solar Power, POB 548, Santa Cruz, NM 87567 • 505-753-9699.

***Editor's Note**: I have reprinted the first section of this article which appeared in HP#13. This is because I introduced serious errors when typesetting the equations in this article for HP#13. My sincere apologies to John, Windy & any reader who tried to make sense of the hash I made of the data. This version contains the straight info. Richard Perez*

Nerd's Corner

We try hard to keep the info in Home Power accessible to anyone who managed to stay awake during high school science. And all of you techies cuss us out for not getting down with some heavy nerding on high tech stuff. Well, here it is: a column that assumes that you are experienced. This column is for electronic and computer techies to get as complicated as necessary without providing basic access for non-electronic types. Damn the transistors, full speed ahead!

The Hewlett-Packard DeskWriter Printer-
a high res printer that loves inverters!

We use Macintosh™ computers to publish Home Power Magazine. We've never been flush enough to afford our own LaserPrinter. In order to print the masters for an issue of Home Power, we bundled up all our computer gear and went to town where we rented a LaserPrinter and hoped everything came out right (which it never did…). We've dreamed of having our own printer and were alarmed to hear of a LaserPrinter frying and dying instantly on inverter power. Something to do with the essential incompatibility of thyristor power control and non-sinusoidal ac electricity… Is there anyone out there successfully running a laser printer powered by an inverter? Now a laser printer consumes almost 900 watts when operating. We went looking for alternatives.

We discovered a 300 dpi ink jet printer made by Hewlett-Packard that is specifically designed to work with Mac computers. We paid our bucks ($885) and held our breath. The HP DeskWriter is powered via an oversized wall cube. The printer functions well, with no heat buildup, from inverter power. It consumes 26 watts while printing and less than 4 watts in standby. We were impressed. Quite a difference from the kilowatt consumed by laser printers. But the proof of the pudding is in the printing.

We were astounded to see printed output from the DeskWriter that is comparable with laser printers. Graphics done at 300 dpi reproduce faithfully on the DeskWriter. The pixels are squarer than laser pixels and dimensions are truer to life. The DeskWriter is not a Postscript™ printer, but speaks QuickDraw™, the heart of the Mac graphics system. As a QuickDraw native, the DeskWriter prints more faithfully what is shown on the screen. And it does it faster. We decided to give it a tough task printing Stan Krute's illustration on page 4 of HP13. This illustration is full of 300 dpi dots and choaked the laser printer. Our page layout program refused repeatedly to print the image on the laser while giving cryptic screen messages like "Unknown Postscript Printing Error". The DeskWriter consumed the image and printed it in less than a minute. It took the laser over 3 minutes to decide that it wasn't going to print the image at all. The DeskWriter performs glitchlessly with all our software (RSG4.5, SuperPaint2.0., Excel2.0, Word4.0, and MacDrawII).

The DeskWriter printer is very quiet when printing. It is cheaper to use (in terms of electricity, paper and ink) than our 72 dpi dot matrix ImageWriter. The DeskWriter costs about 1/2 to 1/4 of a laser printer and consumes about 97% less power.

And how does it look? Well, you've been reading its output reproduced on this newsprint. We used the DeskWriter to make the masters for this issue. No trip to town, no massive power consumption, and no gastric ulcers because everything printed properly the very first time! Richard Perez

More on Inverters and Electronics

This is in response to the HP13 letter about TV interference. I'm running an RCA portable VCR docked into its 120 vac tuner/timer unit, feeding video (not modulated RF) directly to a Mitsubishi 1371A computer monitor (I can't imagine why anyone would want HDTV after seeing the beautiful picture this gives!). Watching broadcast stations on generator power always worked fine, but running on my Heart HF24-2500X inverter I would always get more and more noise (short horizontal lines) in the picture as the battery voltage increased. By midday, the PVs raised the battery voltage to the point where the picture was totally overloaded with noise and the screen would go black. Running the antenna rotor also caused this kind of interference. Running either the VCR or the monitor on a separate inverter would cure the problem. Finally, I found that a big EMI filter, with four 3mH chokes and some capacitors inside, installed between the inverter and the VCR tuner/timer, and a smaller filter installed on the power cord to the rotor, solved all interference problems. EMI filters are commonly used in computer equipment (the monitor already has one, but not big enough to deal with the inverter power) and are available at many surplus outlets. You must connect the ground wire as well as the power wires to get full effect. You may have to try several filters before finding the right size, and one which does not buzz obtrusively. The one which solved my problems is about 1.5" X 2" X 2.5 - bigger than most. While playing with this filter, I discovered that a smaller 4 @ 1.6 mH filter left on the inverter almost eliminates the nasty audible buzz on idle, and adds on 30mA. to the inverter's idle current.

AND- a report on the Telenexus phone line extender

I have a 1.5 mile clear path for the radiotelephone link, which is very easy for the 2 Watt Telenexus units. The phone line end is on a pole in the middle of a field, with its own PV panel and battery. I brought the units home, wired them up, and everything worked the first time! Then I tried using a computer and modem… Neither Apple's "Personal Modem" nor a U.S. Robotics "Password" would work at 1200 baud. After reading an InfoWorld test of modems, I bought their highest rated Multitech "MultiModem 244EH" and was immediately able to run 1200 or 2400 baud and connect MNP error correction! When you are out on the raggedy end of the phone network, there are VERY significant differences between different brands of modems.

Also connected to my end of the Telenexus is an AT&T HT-5500 cordless phone. It comes with a wall transformer marked 14 VDC, which actually puts our a measured 17+ VDC, but the phone works fine connected directly to a 12 Volt battery. No polarity problems, no interference, and no noticeable reduction in range. As always, it is wise to add reverse voltage protection diodes when hacking on devices not intended for 12 Volt use. There is (wouldn't you know) one flaw- the phone uses "short tones", meaning that no matter how long you hold down the push buttons, the "touch-tones" are only 1/1000 second in duration. Sometimes my central office doesn't hear them properly, and I can't be sure if it is because they are short, or not loud enough, or off frequency. I have been comparing various phones and find a wide variation in the pitches of the tones they make! I'm sure there are standards and tolerances for such things- does anyone know where to find them?

The hardest part of installing the Telenexus was convincing the phone company they had connected me to a defective wireline! It took almost two months of complaining and listening to them say my intermittent noises were in the radio system, before they sent out a top techie and solved the problem of stray voltage in **their** wireline. Pac Bell's tech finally admitted my Telenexus provided a cleaner connection than the best wireline he could hook it to out here in Northwest Nowhere! Loren Amelang, Box 24, Philo, CA 95466-0024 • 707-895-3837.

Wiring for Reliability and Performance

John Wiles

PV Modules will last more than 25 years and the rest of the system should be designed and assembled to provide equal reliability.

Good Interconnections - A Must

Good module interconnections are a must. Stranded 10 gauge USE wire is a good start. On older modules which have terminal screws and junction blocks, it is suggested that crimped and soldered ring terminals be used. Uninsulated terminals crimped with a crimping tool specifically designed for that style are best. Although solder has a higher resistivity than copper, it fills all of the remaining air voids and provides numerous parallel current paths to improve the connection. Insulated terminals can be used as a second choice, and they should also be soldered. If the screws are captive, then use spade terminals with hooked ends. With newer modules, be sure to torque the terminal screw and clamp to the manufacturer's specification. Hardware, auto supply stores and electrical supply houses usually carry ring and spade terminals. A mail order source is: Marlin P. Jones & Assoc., Lake Park, FL 407-848-8236.

Wire

Since stranded USE wire is not cheap, it is frequently spliced to a more reasonably priced wire or cable a short distance from the modules. Enough stranded wire should be used to allow for tracker motion and module servicing. Number 10-2 with ground type UF cable is a good low-cost choice to run from the area of the modules to the PV disconnect switch. A black or dark grey outer jacket is preferred for maximum sunlight resistance. On larger arrays, the wire gauge must be increased to handle the higher current and keep the losses to a minimum. Grey PVC conduit could also be used.

Splicing

The wires in this cable should be firmly twisted, soldered and then taped to the module interconnect wiring. Pressure connectors could be used for convenience in servicing, but the possibility of losses increases. The splices must be installed in an improved rainproof box which can be obtained at electrical supply houses for less than $20.00. Ask for a NEMA 3R box in the size needed. This junction box should be equipped with the proper bushings and cable clamps to prevent physical abuse to the wires and cables as they enter the knockouts on the box.

More next issue from John Wiles at the SWRES.

Dear Home Power Readers,

Yes, experimenting in photovoltaics is fun--fun for both the amateur and beginner and fun for the experienced electrical engineer. But we must all keep firmly fixed in our minds that when we start implementing real HOME POWER (electricity for our homes), SAFETY is the first and last word. The ability to do work--POWER-- also means the ability to do HARM and electricity can certainly accomplish much destruction and even death if used improperly and/or unwisely.

A single twelve volt PV module cannot do much harm, but several modules connected to even a modest battery pose a significant hazard. The regional and national building codes and the National Electrical Codes were developed for our safety. As more and more areas of the country become civilized, greater areas will come under code jurisdiction. Although the codes and sometimes the inspectors are a little slow to respond to the latest technology, they in general do provide safe guidelines for building and wiring our homes.

Many of us who are shade tree mechanics and back yard do it yourselfers feel that moving up to a PV powered home is second nature - as easy as falling off a log and not much more difficult than an afternoon tune up on an old truck. Although some of the principles are the same, the IMPLEMENTATION IS FAR DIFFERENT. PV systems can and have caused serious fires. Insurance companies may not insure a PV powered house unless wired by a competent person. Death can result from improper design, under rated components and improper installation. Wire may burn, batteries may explode, inverters may catch on fire, and other equally nasty events can ruin you and your families day unless your PV system is safely installed.

THE BOTTOM LINE-- None of us can afford to experience property damage, injury, or loss, of life from a PV related accident. The PV industry cannot afford a string of such accidents. If such accidents started to become common place as our industry grows, then both the insurance companies and the building inspectors would shut us down. BE SAFE--GET HELP FROM A QUALIFIED PERSON IF YOU ARE UNSURE ABOUT WHAT YOU ARE DOING.

John Wiles 505-646-6105

the Wizard Speaks…

SOMETHING FOR NOTHING

It has been repeatedly said that you can't get something for nothing. This, however, is in danger of being overthrown. In this case the something is energy and the nothing is the empty space between the particles of matter. It has been theorized (by physicist John Wheeler at U of Texas- Austin) that a cubic centimeter of so-called "empty space" contains more energy than all the matter in the universe. This energy may exist in the form of non-directional random fields at all vibrational frequencies. A way to use this energy needs to be found.

Approach

It appears that material particles and their associated fields can have an effect on the energy fields of space. This effect is essentially one of applying order and direction to the random fields. Order from disorder. The approach is to create static and dynamic patterns of matter and its fields which will cause the random fields of space to become ordered. These ordered fields would then appear as forcefields which could be used for energy generation. Another use may be for anti-gravitic propulsion.

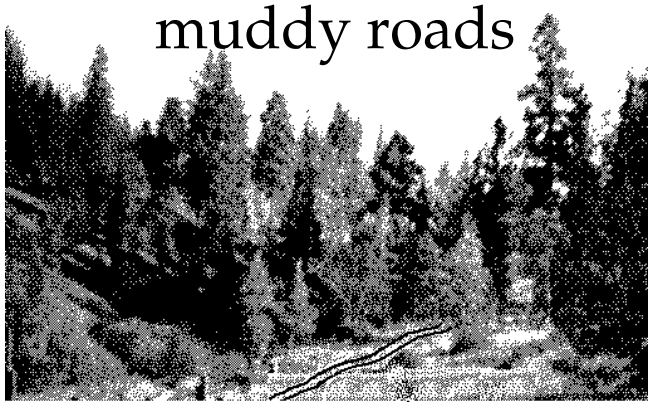
Theory

In reference to my article in Home Power #8, these space-energy fields could be seen as a randomly distributed, zero level, tachyon field capable of being brought into a higher level of manifestation by a set of geometric operators. These operators would be created by patterns of existent matter and its related fields.

What Now?

Advancement in this arena, both theoretical and practical, has been slow but steady. It is hoped that further developments will enable anti-entropic energy production without any heavy environmental consequences. A new order may be arising from the emptiness; a new Tao emerging from the void. Climb on board!

muddy roads



by Woody Legg
as told to Kathleen Jarschke-Schultze

We had moved into a cabin by the River whose water line ran up the mountain side. We had been told, vaguely, that if the water stopped "there are a few places up the line that you can clean out.". But we had no idea where. It immediately became imperative to find these 'few places' as the water stopped.

So we started up the line, following it through the brush up the mountain, through the poison oak, up, up, and through until we came to a blackberry patch four feet high and I don't know how wide. Unable to face the prospect of beating our way through it Carol and I made our way around the patch and picked up the trail of the line on the far side and continued up. We traced the line a mile up and started back down cleaning out as we went.

We came to an old wooden penstock that had rotted and blown out on one side. We knew it would have to be replaced. Down at the cabin we had found a fiberglass fish box, the kind they use on fishing boats. It fulfilled all the penstock qualities we needed. It was here, free, light, held about 70 gals. and was graded food safe. We moved it and cleaned the ditch at that point so that the water would run down the hill over the rocks and into the box.

The problem was how to get the water out of the box and into the existing pipe without the water just spilling out of the box. The hole had to be far enough above the bottom of the box to let the sludge settle , but low enough from the top to still be covered with water in the summer. We had brought the fish box to the penstock area before we came up against how to get the right sized hole in the side. We didn't have a hole saw or electricity, even at the cabin.

We did have a .22 rifle and Carol is a crack shot. She stood up hill to shoot down into the box and out the side, eight feet away, using shorts. She shot out the outline of a two inch hole in about 9 shots which we then connected the dots with a hacksaw blade. After applying sink gaskets and fittings it connected beautifully to the existing pipe. We went down the mountain triumphantly to wait for our water.

We waited, and waited and waited some more. Finally we knew some thing was wrong so we went up to the penstock again. It was working beautifully. It was so full it was running over, plenty of water going into the pipe. We went down and waited some more. A small trickle of water started from the faucet. Knowing something else was needed we tracked the line through the dreaded blackberry patch and found our line was not the one we had followed and cleaned before. We traced our line and cleaned out the 3 traps and miracle of miracles, when we got home we had water.

About 2 months later a man knocked on the door. He lived up the mountain a ways and had seen what we had done to his waterline. He was livid. He accused us of trying to stealing his water. Carol apologized and tried to explain but he would have none of it. He left in a huff.

Then a week later another knock on the door brought the other man hooked into the erroneous waterline.

"I see you've made some changes in my water system," he started out. Carol jumped in with an apology and explanation and promise to never touch his line again.

"Whoa," He said, " I followed the line and I know you're not stealing the water. I just want to thank you for the new penstock and the work you did. In fact, I'd like to pay you for it." He pulled a fifty dollar bill from his wallet.

"No, no ," we said, "It's all done now, no reason to pay us." He wanted to pay for the penstock-fishbox then. We explained that we had found the box at the cabin and thought we were repairing the cabin's water system with it. We went back and forth, him wanting to pay us and us not wanting to accept, being relieved he wasn't yelling at us.

He told us he had followed the overflow from his penstock and found that it wended it's way down the hill to actually tie into our system. That was where the trickle of water had come from. He told us we were welcome to it, we had earned it.

After he left we found the fifty dollar bill in the cabin where he had left it. We have been friends these many years since.

CQ HOME POWER HAMS

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7.230 MHz on Sundays at 1330 Pacific, Central & Eastern.
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7.107 to 7.110 MHz. Listen for Dave KB6HLR
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CQ Novices and technicians, work on your code and up grade to general. Check into **"Home Power CW Net"** on Wednesday nites at 8 P.M. California time, 40 meters 7.107.00-7.110.00 ± QRM. No speed too slow. Don't be restricted to 2 meters. Get on HF and share your knowledge of alternative energy systems. Want to set up other times or frequency schedules?
Write or call me Dave Roy KB6HLR, 100 Harbor Blvd. Space 16, Belmont, CA 94002, 415-595-4528

Please remember:

As of the April/May issue, Home Power Magazine will be going to a subscription of $6. per year (6 issues) via Third Class US Mail.

Send in yer six bucks and don't miss an issue!

We tried to keep HP free, but all of you just love us

HAPPENINGS

ATA Summer Photovoltaic Workshops

The dates and locations of SUMMER PHOTOVOLTAIC WORKSHOPS taught by Appropriate Technology Assoc. (ATA) will be announced later this winter. Three intensive two week workshops are planned (see HP#13). There will be an East Coast, a West Coast and a Colorado workshop. If you want to be mailed detail info later this winter write Johnny Weiss, ATA, 410 Garfield, Carbondale, CO 81623 • 303-963-2682. Thanks HP readers for your patience!

Sunnyside Solar

Sunnyside Solar will present several one day Workshops in Brattleboro, VT. The program will be an introduction to independent electric systems and includes a hands-on assembly of a four module system. The 1990 schedule is March 31, May 5, June 9, July 14, August 18, September 22, and October 27. Each is on a Saturday from 9 A.M. to 4 P.M. The workshops cost $85. An advance registration deposit of $25 is required. Each Workshop is limited to the first eight deposits received. The day's program includes lunch, a packet of product info & related articles, & Komp and Davidson's "The New Solar Home". The principle presenter will be Richard Gottlieb whose experience spans 20 years.

For more information contact Carol Levin, Sunnyside Solar, RD4 Box 808, Green River RD., Brattleboro, VT 05301, 802-257-1482.

Florida Solar Energy Center

Photovoltaic System Design Workshops. Dates for 1990: March 27-29, May 1-3, September 11-13, December 4-6. Location: All sessions will be held at the Florida Solar Energy Center in Cape Canaveral, FL.

Contact JoAnn Stirling at the Florida Solar Energy Center, 300 State Rd. 401, Cape Canaveral, FL 32920, 407-783-0300. Cost: $150 for Florida residents, $300 for out-of-state residents.

PVs Power Boat!

The Good Ship Esther Foundation was organized this summer by Bruce Herron and Richard Orawiec of Michigan. Their immediate goal is to restore & rebuild the 93 year old/new "Esther" into a PV powered boat. Long term goals include educational projects about solar power.

They plan to launch the SPS (Solar Powered Ship) Esther at S. Haven port of Lake MI on April 22, 1990, the 20th anniversary of Earth Day. In July, Esther's maiden voyage from South Haven, MI to Chicago will be the first solar powered crossing of Lake Michigan or any major body of water.

The SPS Esther is 36 feet long with a 7.5 foot beam and will powered by 300 square feet of PV panels. Esther began life as US Navy captain's gig in 1896. The group plans refit her to exclusively PV power and use her as a solar demonstrator. Bruce and Richard plan water borne educational tours with the boat over the next six years.

The Good Ship Esther Foundation is nonprofit and needs help for this amazing project. If you want to participate, help out financially, or just get their newsletter, then contact: Good Ship Esther Foundation, POB 265, Pullman, MI 49450, or call 616-236-6179 • 616-543-4591

21st IEEE Photovoltaic Specialists Conference

The 21st IEEE PV Specialist Conference has been slated for May 21-25, 1990, at the Hyatt Orlando Hotel in Kissimmee, FL. Technical sessions during the five day conference will cover photovoltaic technologies for both space and terrestrial applications. Specific topics will range from solar cell design, technology and measurements to system technology and experience.

For more information call John Meakin, 302/451-1672.

ARCO Solar Training Program

Arco's PV Technology & System Design training program has a new two part format. The first is a home study course for $175. It consists of a training manual (text, review questions, suggestions for lab & measurements), newsletters, a set of audio tapes and the videotape "The World Of Solar Electricity". Upon successful completion of the review questions and exam, the person will be eligible to attend the 1 week hands-on, in depth training class for an additional $175. The 1990 courses will be held in Camarillo (Jan 29- Feb 2; Mar 26-30; May 14-18; July 23-27; Nov 23-30), in Baltimore, Feb 26-Mar 2 and in the southeast U.S., Oct 15-19.

Contact: Training Manager, ARCO Solar Inc., POB 6032,

Letters to Home Power

We Print 'em Unedited

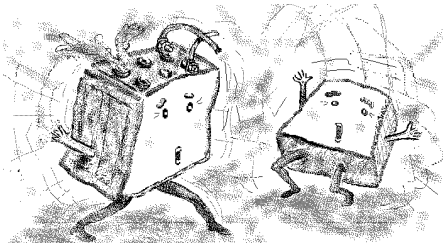
Selected, Entered, & Illustrated by Stan Krute

Quake News From Davenport

Dear Home Power

The last 2 weeks have been a real testament to "Home Power" in the Santa Cruz Mts. For the second time this decade us back wood-sers have had relatively uninterrupted power while the Grid-connected folk have been down for days at a time. A society tied together by tubes and wires is hard to maintain when the earth relieves itself.

One thing important when mounting batteries is to think not just of their tipping, but of their being tossed, and where the fluids will go if they get out. This was the only problem I have heard about on A.E. homes in the Quake.



Incidentaly I would like to add one observation to Bob-O Schultze's informative article "Controlling HydroElectric Systems" (HP #13). Alternator life seems to be the longest on systems where its temperature is kept above the dew point, i.e. dry. This varies greatly with climate and season. Generally the self-discharge load of a large battery bank is sufficient to keep the alternator adequately loaded, but in very moist conditions it may require more.

Looking forward to the Energy Fair.

Sincerely,

Dan Harris, Harris HydroElectric, 632 Swanton Road, Davenport, California 95017

Environmental and Economic Aspects of PVs

This letter is in response to Mitch Lansky's query in HP #13 about the environmental impacts of PV production and their cost effectiveness.

The largest part of the downside of PV use comes in its production. By production I mean the mining of raw materials, the refining and processing of these materials, and finally the use of these materials in a manufacturing process that results in the final product: a PV.

Silicon-based PV manufacture is a very energy intensive process. I have seen estimates that the energy needed to manufacture a silicon cell PV is as high as 50% of what that PV will produce over the course of its lifetime. This includes the mining and transportation of the raw materials as well as the actual manufacturing process. And you can bet that this energy is derived from either fossil fuels or nuclear power (although it can be justly argued that the use of non-renewables to produce renewables is an appropriate technology).

However, silicon-based PV's pose minor health risks compared to the manufacture of the thin-film or amorphous PV's. The processes used to manufacture thin-film, non-silicon PV's employ many toxic compounds. A partial listing of these compounds includes the following gases: arsine, diborne, cadmium telluride, chlorosilane, hydrogen selenide, phosphine, silane, silicone telluride, trimethyl, copper indium diselenide, trimethyl zinc, gallium arsenide, and zinc phosphate. We can assume that the responsible PV manufacturers protect their employees and the environment from exposure to these toxins. However, this may become another story when these compounds are disposed of. Waste gases and those released during manufacture are "caught" by wet scrubbers or thermal incinerators. The sludge or ash that is collected

eventually becomes solid waste. Disposal of virtually all categories of toxins has come back to haunt us, showing up most often as groundwater problems (as have most mining ventures). To my way of thinking, this is the most serious threat posed by the manufacture of PV's.

Another potential problem associated with PV manufacture is the use of RF (radio frequency) plasma systems and laser beams needed for their fabrication. While these are not hazards to you nor I as end users, they certainly pose a health threat to the person earning a living by working in a PV manufacturing facility.

While many might think that this is all very picky, remember: there ain't no free lunch! PV's don't just appear out of thin air, or sunshine. There is an environmental price to pay for any energy system that we use. On the up side, though, it has been estimated that, when all factors have been considered, the manufacture of photovoltaics causes no greater environmental problems than the construction of conventional energy systems. And while conventional energy systems do pose environmental problems throughout their life cycles of energy production, the use of PV's (and most other renewables, for that matter), is harmless.

For anyone interested, this information was gleaned from:

Power Surge-The Status and Near-term Potential of Renewable Energy Technologies, by Nancy Rader, published by Public Citizen, May, 1989, and available from Public Citizen, 215 Pennsylvania Ave, SE, Washington, DC, 20003, for $10; and

Environmental Impacts of Renewable Energy, by the Organization For Economic Cooperation and Development, published by the OECD, Paris, France, 1988.

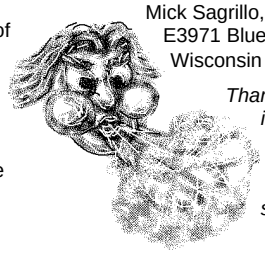
The economics of PV's is a little harder to justify. As Richard replied, Mitch's 50-watt panel will produce 2,190,000 watt-hours of electricity during its 20-year lifetime. To those more accustomed to conventional units, that's 2,190 kilowatt-hours.

At the national averge rate of 7.5 cents per kilowatt hour, this panel will produce $164.25 worth of electricity over its 20 years. This amount will vary throughout the country based on local prices. While California's average cost for electricity is 10.7 cents per kilowatt-hour, resulting in a total of $234.33 wotth of electricity produced in 20 years, Oregon's average cost for electricity is only 4.8 cents per kilowatt hour, yeielding only $105.12 worth of electricity in 20 years.

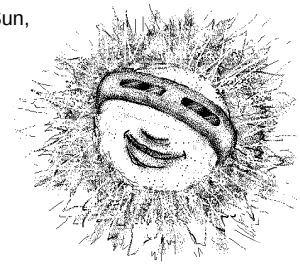
If you paid $7.50 per watt, about the going retail price for PV's, the 50-watt panel would have set you back $375 + tax. Not a good investment for a 20-year return of $164.25! That is, if you're competing with a heavily subsidized utility that has the ability to socialize many of its costs. Actually, if PV's had to compete directly with the utility selling electricity for 7.5 cents per kilowatt hour, the calculator says that the most we should pay for that 50-watt panel is $113.48, tax included (based on an inflation rate of 5% per year and an interest rate of 9% per year).

But then, most of us are not into alternate energy to compete with the utilities. I would assume that most of us are into alternate energy either because the utility is not a cost-effective option, or out of principle, or both.

Mick Sagrillo, Lake Michigan Wind & Sun, E3971 Bluebird Road, Forestville, Wisconsin 54213



Thanks for the detailed information, Mick. Looks like conservation remains the cheapest lowest-polluting power source.SK.



Quake News From South of Hollister

Hi!

Just last week I wrote saying how I had hoped to read about PV in the "Hugo disaster". Well this letter is right from the Quake!

We live south of Hollister, which is now on its 2nd day without "power". We never were without power! Our PV system and propane refrigerator kept us "online", and I'm only sorry we weren't closer to help others immediately after, and also for them to see, for themselves, how PV does work, even after and during a disaster. Luckily, our house (in construction) is AOK, and the "living-experiment" setup of PV, which we

will soon put onto the house, worked like a charm, even in its "crude" setup (only 10 amps now).

PV is the future - NOW. Too bad the "rebuilding" doesn't include it now.

Katcha Sanderson, 20295 Panoche Road, Paicines, California 95043

Retired Hero Seeks 12 Volt Cool

I would like to know how (if possible) to build a 12 volt air conditioner (want to air condition a 28' long by 14.5' room).

Also would like to know how to build a 12 volt fan (about 20" fan). Can I rewire my present AC 20" box fan for my 12 volt system ? If yes, how ? Thank you.

I am a retired school teacher, living in the beautiful Ozark Mountains - deep in the woods and love it ! (Live in Pruitt, Arkansas).

Dr. Mary Welch, P.O. Box 118, Jasper, Arkansas 72641

Enjoy Everything You Have

Dear Folks,

Your stand alone survey was enough to finally get me motivated to take the time to send you the letter of thanks I've always meant to. Your publication was a delight and surprise to discover. It continues to inform, entertain, and reassure me that there really are a lot of people who care about clean, sane, and responsible energy solutions to mankind's electrical habit.

Using "home power" as a tutor and reference tool has saved me hundreds of dollars and countless hours of work and research. Also the confidence to approach energy production "hands on".

Generating "home power" has given me a sense of well being and pride in living independently and in harmony with our planet. A more responsible outlook and sense of priority in my "consumer self".

Not to have everything you enjoy.
But to enjoy everything you have.

Continue your valuable work educating the source of power requirements, the consumers of power. Your belief in what you are doing shines through in every issue. I'm proud to be a part of the "off grid revolution". Thanks again.

Doug Yuskia, Russel Valley, California 95734

P.S. Where the Hell is Hornbrook ?

You're welcome, Doug. When the readers get revved up so do we. And Hornbrook is on the Klamath River, in California, right next to Oregon, about 90 miles inland from the coast, and fifteen miles from the Home Power offices. SK.

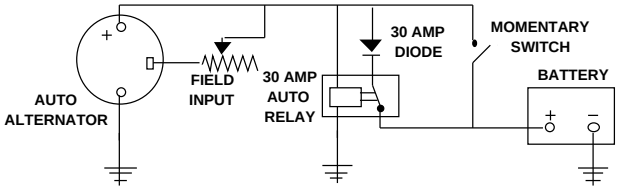
Tweaking The Simple Field Controller

Dear Home Power People,

In HP #2 (page 23) Richard Perez gave us plans for a simple and useful generator utilizing an automotive alternator, powered by a lawnmower engine.

We use such a generator, and would like to offer an improvement. When wired with Perez's basic resistive field controller, the field input will draw down the batteries when the generator is idle, unless disconnected. This means the machine must be attended and switched manually.

To avoid irritating noise, we prefer to run the engine while away from home. With the circuit shown below, it is possible to simple let the generator run until it is out of gas, since the power will be automatically disconnected when charging stops.



A common auto relay (such as used for auxiliary lights), is held closed by the alternator output. The diode prevents current from the batteries operating the relay. A momentary switch is needed to bypass the diode for an instant, to energize the alternator field, and thus initiate charging (after the engine is running).

Also, for high output alternators, check into emergency vehicles. Fire, police, ambulance units are often 100 amps plus. Military vehicles of the "M" series (Fifties thru Seventies Jeeps and trucks) used high quality 24 volt alternators of 25 to 100 amps, and are easily available from surplus dealers.

Yours for No Nukes,
Peter Ladd, RFD #2, Newmarket Road, Warner, New Hampshire 03278

Cheap Water Tricks & Three Dot Journalism

Dear Friends at Home Power

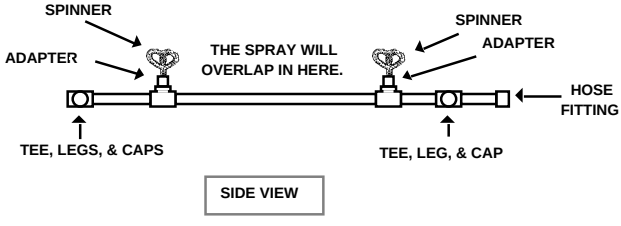
We have a combination of PG&E and solar panels. Bit by bit … we are increasing our solar capacity. I have four panels … two 47-watt panels on the pump … & 37-watt and 23-watt panels for lights … My friend has ten 23-watt panels … & both of us have batteries …

We are at the bottom of a bowl. We live in Rackerby Valley … between Bangor & Rackerby, California, & are surrounded on all sides by mountains. (We live in the foothills of the Sierras…) & windpower is not sufficient for a wind generator. … & the water in Honcut Creek is not sufficient for hydroelectric power … so solar is our only alternative at present.

I have not put PG & E power in at my place … so in the future … solar & kerosene will be my lights … & I have a propane stove for cooking & a wood stove for heat. I have a 47-foot mobile home. … & I have invented a way to keep food cold using the inside basket of a washing machine. … will not keep cooked foods for long but works well, even in the heat of the summer, for raw fruits & vegetables … & will keep water comfortably cool … even in 110° weather.

What I wanted to tell you about is our 'sprinkler system' … I have a Flowlight pump in a well pumping with 24 volts from 70 feet. It gives us a bit under a gallon a minute of water. But it takes 3 gallons a minute to run a 'rainbird'. So this is well below the amount we need for watering the garden with a 'rainbird' sprinkler.

At the hardware store we found a small plastic whirl-i-ma-gig whizzer which is called a 'full circle spinner'. It does not take much water pressure & will water an 8 foot circle … & more if there is more pressure … (I have a solar 24-volt pump with a half-inch hose on it so there isn't much water.) I can run 3 of these at a time. They have a 3/8 inch base … so we had to get an adapter to fit into the 1/2 inch pipe. I put 2 on one sprinkler & one on the other. I made them out of 1/2 inch PVC pipe. I put the adapter into a threaded tee and ran the pipe about four or five feet away & putting the second one in. this will water two ten foot rows at a time. … & if it is put up on a small stand … where it is above the foliage



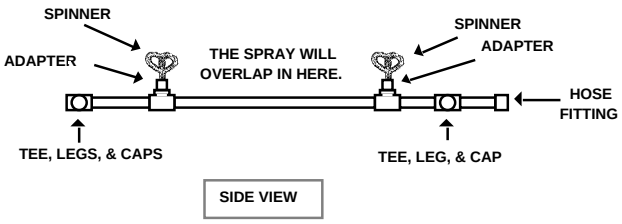
of the plants it will reach farther.

It is necessary to put legs on the pipe or it will turn over. … Then on the hose end … I put a hose coupling so I could attach it to a hose. … & I put a metal Y on the hose with turn off's on it so I could turn the water from one spot to another without having to move the whole thing.

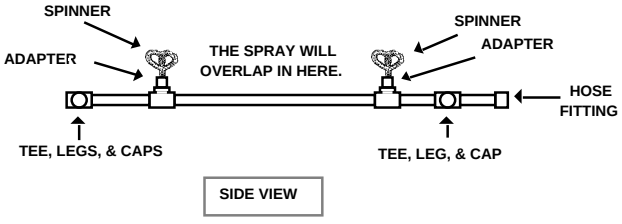
I just use one leg in the front to balance this … if you don't use these legs the sprinkler will have a tendency to turn sideways & it doesn't work nice. …with the legs … it stays upright & does it's work … Using just one leg in the front makes it easier to adjust it to the plants. With a small output from the pump … it is not wise to use a larger pipe on this.

I have another solar adaptation. … Every summer … there is not enough water for everyone here & the gardens. … There are five of us on two wells & a spring. We are on the top of the hill so when the water table drops … & water pressure does too … we run out of water in the pipes … & in our area … in the summer … it gets hot …

We have another solar adaptation … Every summer … there is not



enough water for everyone here & the gardens … There are five of us on two wells & a spring. We are on the top of the hill so when the water table drops … & water pressure does too … we run out of water in the



pipes … & in our area … in the summer … it gets hot …

We have a swamp-type air-conditioning unit. But although the PG&E current will run the motor & the pump for the cooler … we don't have a constant water supply for the cooler basin will run the motor & the pump for the cooler … we don't have a constant water supply for the cooler basin. … so the cooler can't cool the air.

In order to meet this problem … I have a poney pump … 12 volts … hitched up to my panels with batteries … which keeps the batteries charged up even when we are using them.

For water for the poney pump … I have a 50 gallon barrel at the corner of the house … & I fill it every morning early … before the rest get up & the water gets low. … I have a short hose in the barrel for the pump to suck up its water supply & I run a garden hose up to the cooler … & I have a turn-off switch on the poney pump … which keeps itself primed … & when I feel warm air coming from the cooler … I go out & run the poney pump for as long as I need to … (until I see water run off the roof) … & then shut it off. Thus we are not without our cooler even though we are out of water … the 50 gallons lasts a couple of days so when I fill it I am assured of at least two day^^s of water for the cooler.

Before I got my panels … I used my battery chargers on a car battery to run the pump … They kept the battery charged nicely … & the car would start alright if I wanted to move it … I don't run the pump constantly … Just when the cooler runs out of water.

Before we got our water supply properly set up … I used the poney pump to get water from a spring that was below the house. I put a garden hose in the spring & filled 5 gallon jugs in the car … I couldn't get my car close enough to the spring to use a shorter hose to the pump … so I used two 25-foot hoses. … one into the pump … & the other out. … later as I advanced inknowledge & equipment … I ran the pump on a 23-volt panel … which I put out in the sun. …

My present project is a 1/4 horsepower motor & a bilge pump on the cooler so we can run the cooler on 24 volts for the motor & 12 volts for the pump … for our air-conditioning next summer.

I am also planning on converting a washing machine for home use. … that will take more time …

Sincerely,
Catherine G. Curtis D.C., P.O. Box 138, Bangor, California 95914

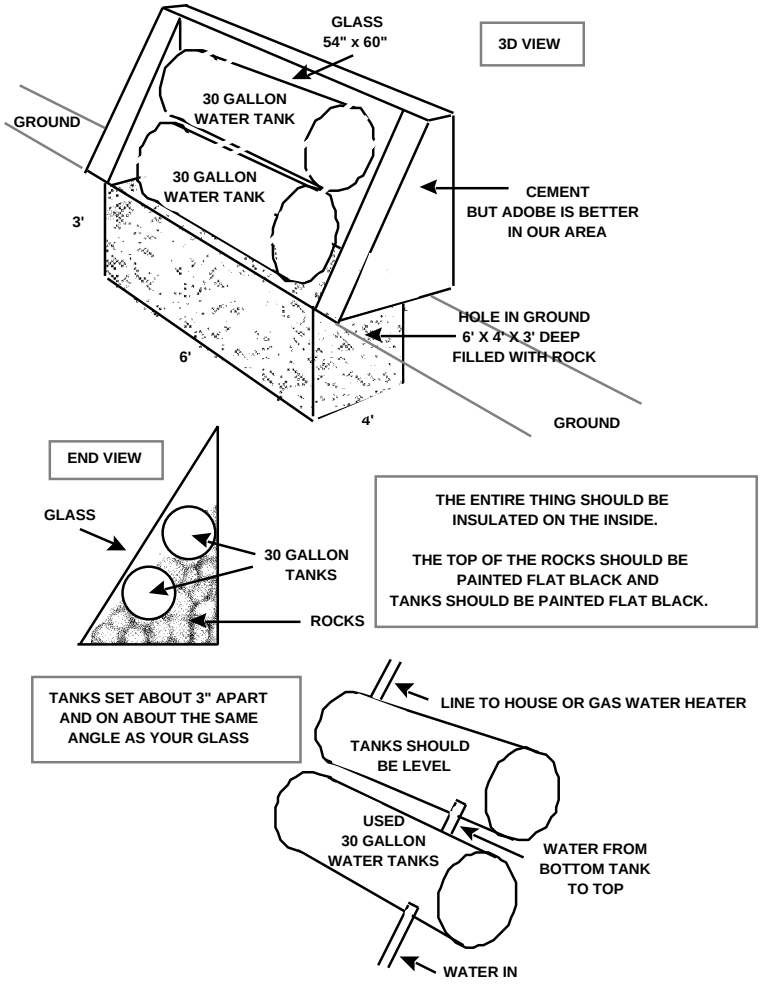
Another Simple Solar Water Heater

Dear Home Power

I am glad that a friend of mine gave me a subscription form to send to you folks, I only expected to get one issue and it is still coming. Thanks a bunch.

I am building a house now. I plan to go for PV electricity. I have power only 150 feet from the house but am going for no light bill.

Enclosed find a drawing of a solar water heater that I made three years ago that sure works. We don't get down too cold here but (it is too cold for me and water) I have a heat gauge on my water (top tank) and the coldest my water has been in the solar tanks is 68° and it usually starts out in the morning between 70° and 90° and gets to 120° to 130° most days. Winter and summer. So you can't go wrong when you can use all used stuff.



Even if it won't give 100% if it gives 50% you are ahead 50%. In this area I feel I get between 70 and 80%.

I would like to see lots of these installed. I have doors on mine and close them at night and on cloudy days.

Thanks
Loyd Berlier, Star Route 2, Box 17, Deming, New Mexico 88030^^

Of Pools and Ponds & Cheap Refrigerator Tricks

Home Power

I'm glad to see that interest is growing in areas such as swimming pool filters. Pool filtration is a perfect example of how a change in lifestyle can lower energy requirements to a level easily handled by solar power.

While it is important to remember that such terrors as the polio epidemic of the 1950's were associated with public swimming pools, the sanitation requirements of public swimming pools should not be rigidly applied to the average home pond.

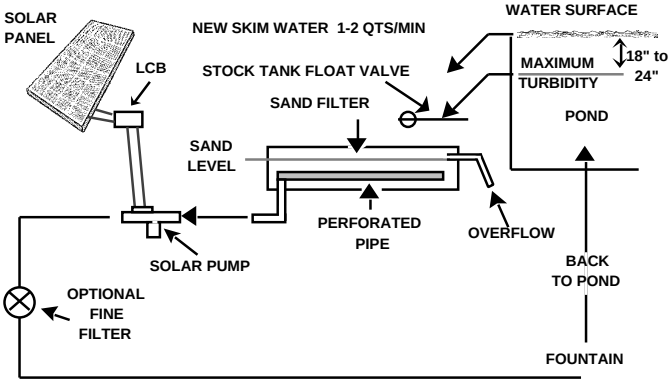
For example: the algae that grows on the walls of a home pond is a resource which can be directly deposited on the home orchard during a combination pool cleaning/irrigation. Brush the pond in the evening. Let it settle overnight, and vacuum it in the morning. A standard 1.25" inch pool vacuum hose needs only two feet of sipon fall, bleow the pool surface, in order to operator very well. More fall simple gives more vacuum power. You will find that you would like your pond to produce

more algae thatn it does. The energy and chemicals employed to stop algae production in home ponds are anti-environment.

The idea is to work with the environment rather than fight it. Notice that natural streams have clear water and mossy rocks and logs. And that such water is good to drink. Utilize this knowledge for greater enjoyment of the home pond.

A very small flow of new water will go a long way toward keeping the water clear. Cloudy water is referred to as turbid. An important fact is that the zone of maximum turbidity is 18" to 24" below the surface. Seasons are also important to pond maiuntenance. Filtration in summer, when the water is warm, is far more important than winter. If your water turns bright green in summer, and you have nothing to irrigate with it, you will need a fine particle filter such as diatomaceous earth.

A very small flow of new water into the pond will skim surface debris from the pond before it settles and creates a mess. One to two quarts per minute is enough. Let this water run over a collection spot and use it in the garden. If your land is flat, and you cannot direct this continuous overflow without piping, then let the overflow store in a small tank for later use. The overflow spot should be perfectly level and about one foot wide.



If you are short on water or cannot utilize extra water, the entire system can go through a sand filter and diatomaceous earth. Sand filters are easy to make. They are simply a leach field operating in reverse. Perforated pipe wrapped with a brass screen, which has holes smaller than the sand particles, is buried in sand. This pipe leads to the intake of your solar pump. An old bathtub is a perfect sand filter box, anything will do.

One 48-watt solar panel, one linear current booster, and one small pump, such as a Floject diaphragm pump model #4300-732, will take care of an average home pond. Your water will not be as clear as a public pool, but, on the other hand, it won't be chemicalized water, either.

There is one last point to make this system complete. Plumbing must be set up so that high-pressure water can be run backwards through the sand filter. This water cleans the muck out of the sand by flowing out of the screened pipe, overflowing the filter tank, and proceeding through your highly imaginative plumbing system, to the garden. Another source of great fertilizer ! I suggest a fountain-like return to the pond so that there is a constant visual reminder of what one or two solar panels are doing. If you can afford it, use two panels. Make a show of it.

One last point is important here, that is, the pond itself. The letter which motivated me to write this referred to a plastic pond, which was going to be replaced. The energy and resource use to make a plastic ond is not much less than concrete and steel. Ferro cement technology, utilized in boat building, but much less technical for ponds, is great. If interest is expressed I will be happy to write an article about ferro-cement for the next issue of Home Power.

Sincerely,

Garrett Connelly, Environmental Economics, 300 West Mountain Drive, Santa Barbara, California 93103

P.S. -- RE: Pool Filtration systems

Sighting of the home pond is very important for turbidity management. Put your pond in the afternoon shade. The cooler water, just enough be refreshing, will also inhibit algae growth. A pond in full sun is more work, even considering leaf fall. Also, a few mosquito fish will keep your pond from being a breeding ground of that pest, the mosquito.

P.P.S. -- It's time to turn off refrigerators and move them to a cool place. (A few extra steps won't hurt).

If it's too much trouble to move the fridge, and you see the logic of turning it off for the winter,

Do this:

1) The sides are pretty much plastic and insulation.

2) Buy a 3.5" hole saw. Cut through the outer fridge plastic (maybe sheet metal).

3) Gouge out the insulation by hand, make sure no tubes or wires are in the way.

4) Finish the hole through the inner plastic liner.

5) Do the same thing through the wall of your house.

6) Stick a pipe down from fridge to the cold air outside. Screen the piep.

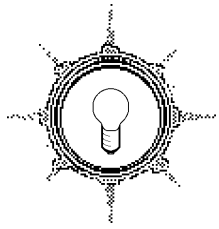
7) Insulate the pipe.

8) Turn fridge off till it's too hot for natural cold.

9) Store the 3" black ABS or white PVC 'til the next winter. (3" pipe needs 3.5" hole).

10) Patch the holes for summer.

Home Power's Business



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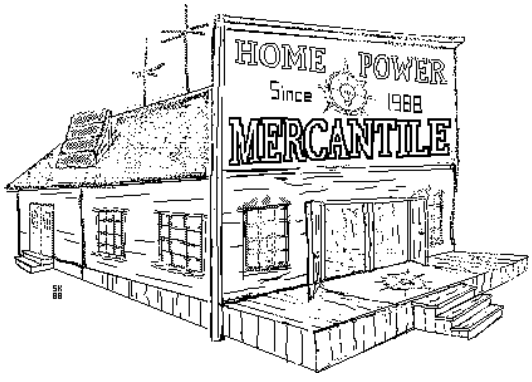

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