HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #64

April / May 1998

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Features

GoPower

Features

Cover: Captain Solar says “If ya can’t beat ’em... at least get net metering!”

Columns

Regulars

Access and Info

Access Data

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Recycled Paper

Recyclable Paper

Photo by Tom Simko, Inkom, Idaho

Small-scale renewable energy systems deserve a far better treatment than America's utilities are giving them. If we really want a million solar roofs, then here are three changes we need to make.

- **America's utilities must value renewable energy equally with their grid power.** Actually the electricity made by home power systems is better than that generated by the utilities. We use sunshine, wind, and falling water. Utilities use nuclear, coal, oil, and natural gas. Our energy is made from nonpolluting and sustainable resources. Utility energy is not. America's utilities need to follow the lead of Ashland, Oregon's municipal utility which offers a 25% premium on the maximum retail rate for solar and wind electricity placed on their grid by home power systems. It's time to pay renewable energy pioneers what they are worth!
- **America's utilities must stop placing unnecessary technical restrictions on small-scale RE systems interconnecting with the grid.** Needless and expensive equipment, masquerading as safety devices, is being required by utilities to discourage us from sharing our energy with our neighbors.
- **America's utilities need to stop requiring multi-million dollar insurance policies on small-scale RE systems.** These expensive insurance policies are far out of proportion with capabilities and liabilities of our systems.

If we can convince America's utilities to change just these three things, then we will have our million solar roofs. Utilities must be made to realize that the way we make electricity is changing. In the past, electricity was only made by large, polluting, power plants, now it can be made on your roof. What was once a monopoly is now as free as sunshine.

It's time to make some changes….

Richard Perez for the Home Power Crew
at Funky Mountain Institute (42°01'02"N • 122°23'19"W) 1 March 1998

People

Mike Brown

Drake Chamberlin

Sam Coleman

Mark Hankins

Kathleen Jarschke-Schultze

Stan Krute

Don Kulha

Don Loweburg

Karen Perez

Richard Perez

Shari Prange

Benjamin Root

Bob-O Schultze

Joe Schwartz

James Udall

Michael Welch

John Whitehead

John Wiles

Myna Wilson

Terry Ziegler

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your burden

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Menuhim

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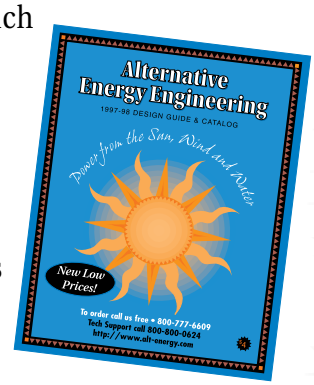

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Grid-Connected PV...

What's It Worth?

James R. Udall

Above: Charlie Wertheim hamming it up with his 1.35 kW, 18 module system in Glenwood Springs, Colorado. This is a heavily treed neighborhood, but the solar window is better than it looks!

For two decades the photovoltaic industry has prospered by meeting the needs of off-grid homesteaders. From New Mexico to California, the backwoods has been the proving ground, where new products were launched, used, and relentlessly refined.

Now, thanks in part to the movement *Home Power* helped spawn, solar is ready for the main event. The time is ripe to transplant PV, and the energy awareness it represents, from the Sierras to the suburbs.

Nations like Indonesia and Mongolia conceivably could use PV to leapfrog from the Stone Age to the Information Age, without weaving a national transmission web. But the grid is a done deal in the U.S. Of the 100 million households in this country, 99.5 million are connected to utility wires. If PV is to achieve its full potential it must make inroads into this vast virgin market, the new frontier.

Solar Jihad

Last June, President Clinton announced a program to install a million solar roofs by 2010. That's right, a million. That means the nation must install 230 solar hot water and PV systems every day for the next twelve years. No rest on Sunday for weary wrenches. This isn't a program, it's a crusade. A solar jihad.

Who are the "early adopters" who will buy these systems? What's the best way to tap the emerging market for grid-connected PV? In this article I take a stab at answering those questions.

I direct the Community Office for Resource Efficiency, a nonprofit energy office in Aspen, Colorado. Last year we sold and installed five grid-connected PV systems, ranging in size from 800 watts to 4.5 kilowatts; in price, from $4,200 to $35,000. Four systems were installed in the service territory of Holy Cross Electric Association, a rural co-op. Four is hardly a down payment on one million, but it's enough to give Holy Cross more grid-connected, residential PV systems than any of the 932 co-ops in the United States. As I said, it's a virgin market.

The Clients

Who'd we sell these systems to? Our clients ran the gamut. They included a millionaire shipping executive who flies his own plane; a Forest Service employee and his preschool teaching wife, who run marathons, drive a Geo Metro, and practice voluntary simplicity; an architect remodeling his house; a former ski patroller; and me. Average age: 45.

We're all homeowners, of course. (The grid-tied renter market is a mirage. Ascension Technologies has, however, begun to sell a 4 by 6 foot, 250 watt module with integral ac inverter that a renter might want to own.) As a group we differ in many ways. What we had in common was a willingness to think outside the box and the means to invest in the future.

Above & below: The author, helping install Brad Larson's 800 Watt system on an asphalt shingle roof in Basalt, Colorado. Brad got a great deal on one of Solarex's PV Value systems, $4 Watt, including an inverter.

Batteries Not Required

Solar advocates delight in bashing utilities. But for all its faults, the industry has strung an amazing amount of wire. Rarely is an American more than 50 feet from an electrical outlet. It's an everyday miracle we take for granted.

From an engineering perspective, the grid is a tremendous resource. A grid-tied PV system will be more efficient, arguably greener, and certainly cheaper than a backwoods one. More efficient because the inverter can track the modules "maximum power curve" rather than the lower voltage needed to recharge batteries. Arguably greener because you don't need batteries, which contain caustic chemicals, emit sulfurous gases, and eventually wear out. And much cheaper because, with the grid as backup, you don't have to buy batteries, charge controller, control panel, or generator. Right there, you've knocked up to $5,000 off a typical stand-alone system.

Getting the price down is critical, because no one on the grid needs PV, at least not in the same way an off-grid homeowner needs it. We've already got juice. It may be from a nuke, it may be from a coal plant, it may be hydro (or "embodied salmon"), but it's there.

To sell grid-connected PV systems you've got to get the price down and then help prospective customers understand that solar is to coal as a croissant is to a Twinkie. On a gut level, many people already grasp the key difference between fossil fuels and renewable energy. One is stealing from our kids, the other isn't.

Dollars and Sense

We lumped our orders together and bargained aggressively for good prices. The 800 watt system, a Solarex prototype subsidized by the U.S. Department of Energy, cost $4,200 installed. The two 1.35 kilowatt systems we installed cost $11,500. My 1.8 kilowatt system cost $13,000. And the 4.5 kilowatt system, the largest residential grid-tied system in Colorado, was $35,000. A contract from Sandia National Laboratory covered our logistical costs. I'll return to economics in a moment, but first a word on hardware.

Above: The author's 1.8 kW pole-mounted system in Carbondale, Colorado. The system was installed by a class of Solar Energy International students supervised by Pat Kiernan of Eco Electric.

Off the Shelf

Here again let's doff our hat to the backwoods bunch and the PV industry. Much of the gear we installed in 1997 was unavailable or unaffordable in 1987. Early PV systems were cobbled up and soldered together. Products were primitive, assembly an adventure. Buying a PV system now is like buying brake pads at NAPA: it's all off-the-shelf, readily available at increasingly reasonable prices.

Four of our systems used Siemens 75 Watt modules and Trace inverters. The fifth featured Solarex' thin-film Millennia modules and an Omnion inverter. The Siemens modules carry a 25 year warranty. This was a big selling point. What other product is guaranteed to last that long? I'm 46, these modules could easily outlive me and become heirlooms.

Trace's familiar SW4048 has been modified for utility-tied applications. It comes with an attractive, powder-white weatherproof outdoor enclosure. Bells and whistles include automatic power tracking, evening shutdown and morning wake up, under/over voltage and frequency shutdown, plus ac and DC disconnects. Ac output is either 120 or 240 volts. We used 120 volts on our smaller systems and 240 on the largest.

The inverter eats 44 to 64 Volts DC. In practice, this means wiring three modules in series, then running the series groups in parallel to the inverter's DC side. After being converted to ac, the electricity flows through a PV meter and then to a breaker in the home's electric panel.

Pat Kiernan, a master electrician and electrical engineer of Eco Electric in Basalt, Colorado supervised the installations. The tidy outcomes reflect his thoughtful and meticulous approach. Heatstroke to hypothermia, Pat endured it all.

We used nonmetallic conduit between modules, ground-fault protection on our roof-mounted systems (a perhaps unnecessary $500 add-on required by code), and fuses for each series of three modules. The Siemens modules have integral bypass diodes, but we added isolation diodes to each series group in two systems that are prone to partial shading. That way shaded panels can't be fried by the rest of a sunlit array.

Pole Mounts, Roof Mounts

Two systems were pole-mounted, three went on a roof. Direct Power and Water Corporation built our sturdy, attractive racks. The pole-mounted racks are supported by 4 or 6 inch, Schedule 40 steel pipe, cemented 3 feet in the ground. The racks are adjustable from 15 to 65˚.

On the roof-mounted systems, Direct Power lengthened the racks' front legs so that the modules would stand 2 feet above the roof and thus out of the snow. We fixed the 4.5 kW roof-mounted system at a 35˚ tilt, steep enough to shed snow, flat enough to maximize year-round production. The other roof-mounted system is seasonally adjustable.

Net Metering

Some utilities object to net metering. Usually the issue isn't money, but control. They don't want your juice on their wires or they don't want to set a precedent that

Above: The author's PVs, inverter, and independent kWh meter for measuring energy produced.

could come back to haunt them. There are some distributed generation technologies coming down the pike that utilities definitely won't want to net meter, including fuel cells and 50 kw microturbines the size of beer kegs.

We were lucky. The two utilities we worked with, Holy Cross Electric and Glenwood Spring Municipal, were open-minded. After some analysis and friendly discussion, they agreed to net meter. At midday when the systems are producing more electricity than the home can use, the meter spins backward. At night or during high usage it spins in the normal direction.

Shocks and Safety

Utility linemen don't want PV systems backfeeding the grid during a power outage when they are working on supposedly dead lines. Both the Trace and Omnion inverters address this with multiple safeguards. Since these sine wave inverters are designed to sense, sync, and dance with the grid, it's impossible for them to operate without it. That means they can't zap a lineman during an outage. It also means that a grid-tied PV system won't provide backup power. If you wanted this feature you could add a battery pack, charge controller, and transfer switch. We didn't because of the expense and because the grid is up 99.7% of the time.

Dollars and Sense, Part Two

PV prices have fallen enough to bring them tantalizingly within reach. For most families, 35 grand for a PV system is out of the question. But 10 grand or 12 grand? Americans routinely pay $3,000 for a four-pound laptop computer and up to $40,000 for a sport utility vehicle that loses thousands of dollars in value the moment it leaves the dealer's lot. Is a PV system more or less "cost effective" than a Suburban? Understanding the emerging market for PVs forces us to re-examine hoary stereotypes about customers' ability and willingness to pay for solar energy.

It's Not Cost-Effective

Gag me with a spoon. If I heard it once, I heard it a dozen times, "What's the payback?" I heard it from an architect, a rancher, an engineer, and an electrical inspector. Dividing my system's price by its production gave my brother in law his bottom line: "It's not earning its keep." The pernicious payback perspective plagues PV people; I heard the now-familiar qualms from module and inverter manufacturers alike. Even our installer Pat Kiernan, as devoted to solar as anyone I know, quizzed me about the economics.

If PV systems get to $2 watt, everyone will do it and won't ask why. Today, though, we've got to wrestle with the economics. "What's the payback?" probably got its start after the first oil crunch, when some builder was

Three shots of a 1.35 kW grid-tied system in Eagle, CO.

Above: The assembled rack plus modules weighs 150 pounds.

Right: Laura, Tom, Andrew, and Pat lift the array to a vertical position and plant it on top of the 4 inch pole. Exciting moment, don't drop it!

Below: Almost beer time.

Left: The completed 1.35 kW grid-tied system in Eagle consists of 18 Siemens 75 Watt modules divided among 3 poles. Shown is homeowner Andrew Shiely with Laura Struempler, the "straw bale queen." In 1997 she built a 7,000 square foot straw bale building for our local Waldorf school, one of the largest straw bales in North America.

trying to figure out whether it made sense to add fiberglass insulation to his next 2 by 4 shell. Duh.

Twenty years later, "what's the payback?" has become a mindless chant. In no other realm does this mentality prevail. Your wife's pregnant!? Jeez, I'm sorry, kids aren't cost effective. Honey, let's buy a new sofa. Have you done a cost-benefit analysis?

We've been brainwashed, infected with bean counter disease. When I began this project a year ago, I knew that PV was not "cost effective," but I ran spreadsheets to prove it. I fiddled with discount rates to figure out how much less cost effective it was with 5% money than with 10% money. As I debated whether to buy a system myself, I chewed my pencil down to a nub trying to justify the investment.

Above: Andrew's Trace inverter being installed, sans its weather proof cover at this point. Socket box for PV meter is at left.

It was impossible. Buying a grid connected PV system is folly. Why pay 25 cents a kWh for solar power when you can buy coal power for 7? Are you brain-dead, a moon rock? PV is cost-effective for cannabis growers, dirt-poor Haitians, Soviet cosmonauts, Everest climbers, Indonesian peasants, and the Mars Rover. As for the rest of you, forget it.

Cheap Power

To understand why grid-tied PV is not cost-effective, look at energy solutions that supposedly are. Building 110 nuclear power plants before figuring out what to do with the waste is cost effective. Drowning the Columbia River and its priceless salmon runs is cost effective. Spending $50 billion a year to defend the Persian Gulf oil fields is prudent. Strip mining pays nice dividends: Wyoming coal is literally cheaper than dirt. Chernobyl was a superb investment. Acid rain, ozone depletion…many happy returns. Burning enough fossil fuel between now and 2100 to warm Earth 4˚ makes fiscal sense: just think, we'll be able to grow wheat in Siberia.

Conventional energy economics is a value system masquerading as mathematics. At its heart is one key assumption: the future is worthless and the environment doesn't matter. Fie on future generations, who needs 'em? What have my grandchildren done for me?

For 80 years, our culture has had cheap power on a pedestal. In most contexts, cheap means "shoddy" or "second-rate." Cheap is schlock, cheap is shunned. Think of your own purchasing behavior. Do you buy the cheapest ice cream, put powdered dairy creamer in your coffee, or drive a Yugo? Of course not, but when it comes to electricity, cheap is best.

If similar thinking prevailed in the underwear industry, Calvin Klein would sell only burlap bras and boxer shorts. Scratchy sure, but cheaper than cotton. A Public

Underwear Commission would ensure that he didn't try to blend some pricey silk garments with the burlap ones. If consumers complained of a rash, the PUC would say, "Quit itching. Americans want cheap undies. Burlap is best."

The cheap power paradigm is bankrupt. It's a fraud. Pathetic. Close to criminal. If you value the future or the environment, PV is cost effective. If you don't, it isn't. It's that simple.

Can The Suburbs Afford Solar?

What would it cost the average family (with an appropriately sloped roof) to get, say, half their juice from the sun? Is that option affordable?

Some historical perspective is useful. When Thomas Edison began selling electricity a century ago, he sold kilowatt hours for $3.20 each, in today's dollars. When my rural electric co-op began service in 1943, ranchers willingly paid about 40 cents a kWh. Electricity rates in Germany are 18 cents, in Japan 20 cents. In other words, many people have in the past paid, and are today paying, close-to-solar prices for electricity.

Relative to cheap coal (and ignoring global warming), solar may appear expensive. But in the context of many budgets, it is quite affordable. Daily production from my system will average 8 kWh. Each kWh costs me 25 cents, compared to the 7 cents I pay for coal. The difference, 18 cents, is my added cost. It works out to $1.44 a day, $42 per month, $518 per year. That's what it's costing me to get 75% of my electricity from the sun.

Break the bank? Hardly. My family of five spends almost fifteen times that much on food, five times that on automobiles, almost twice that on piano lessons. Any family that can afford cable television or the Internet could probably afford to get some power from the sun.

Hurdling Up Front Costs

First cost remains a huge hurdle. When you buy a PV system you are paying up front for 20 years of energy. If my family had to buy 20 years of groceries up front we'd starve. Until we can breach this barrier, grid-tied PV will remain a tough sell.

You can buy a nice PV system for about $12,000 to $15,000. Since that's the cost of a late-model used car, perhaps the auto industry offers some lessons. The first is to forget payback. Cars depreciate rapidly. And yet, 15 million will be sold this year at an average price of almost $20,000. Only 10% are bought with cash, while 60% are leased and 30% are financed. Cash buyers are a market sliver. How does Ford get the rest of us into the showroom? Rebates, cash back!, and cheap financing: 1.9%, 2.9%, and so forth.

Above: This system contains sixty Siemens modules mounted on two adjacent flat roofs at an Aspen home. We believe it is the largest grid-connected system in Colorado. The 4.5 kW system was a big hit during the National Solar Home Tour.

To move PV into the mainstream, we need ready financing. Many homeowners have (or qualify for) 9% home equity loans. But zilch (zero interest) loans would be even better. There's some talk that low interest loans may become available through the Million Solar Roofs program. Let's hope so, for nothing would do more to catalyze that program, and the Feds should put money where mouth is. Installing PV on new homes and rolling the investment into the mortgage is an exciting strategy now being pursued by the Sacramento Municipal Utility District.

Below: Extended legs provide room for snow to shed. The modules are fixed at 35° tilt, a best-guess compromise between steep enough to shed snow and flat enough to maximize annual production.

Left: Master electrician and electrical engineer Pat Kiernan, of Eco Electric, supervised all of our grid-tied installations.

Leasing is another intriguing option, particularly for business customers who could write the costs off as a business expense. Are there people who want to lease a PV system for, say, 10 years? We hope to find out.

Rebates would also jump start the market. The $3 watt buy-down now available in California should unleash a torrent of orders. I can imagine people moving there just to take advantage of this juicy deal.

Beyond Coal

As we were installing my system, a class of students from Solar Energy International arrived to help. One eager beaver, fresh from a lecture on efficiency and renewables, chided me about some incandescent light bulbs in the house. Caught by a frugalista, a compact fluorescent Nazi.

Most grid-connected homes haven't captured all their efficiency opportunities. Does it make sense to add PV until they do? Good question. Our systems will meet between 20% and 90% of their home's energy needs. Not bad, could be better. Wasting energy is our national pastime and in a perfect world we'd do a whole-house energy retrofit first. But to my way of thinking every PV module represents a small victory in the war on carbon.

The Intergovernmental Panel on Climate Change estimates that stabilizing the climate will require 60% reductions in global carbon dioxide emissions. If that's true, by 2050 the world will need 11 terawatts of carbon-free power, as much as we now get from all fossil fuels. Visualize 1 trillion solar panels stretching from Earth to Saturn and you'll grasp why we need to get started today.

An average American home produces 25,000 pounds of CO_2 due to its energy consumption. How much could solar technologies reduce this CO_2 footprint? I was curious to find out, so in addition to installing a PV system, I added a solar hot water heater, replaced an energy inefficient refrigerator, tracked down phantom loads, and improved my lighting.

Before the retrofit my house used approximately 7,000 kWh of coal power per year. After the retrofit, the house is on pace to use just 1,200 kWh, an 83% reduction. Daily CO_2 emissions have been lowered from 38 pounds to 6.5 pounds. Over their 20 year lifetime, the solar water heater and PV system will avoid 230,000 pounds of CO_2.

Performance

So far, all of our grid-connected systems are performing flawlessly. Nary a glitch. With a 25 year module warranty, inverter reliability is the make-or-break maintenance issue. Theoretically, life on the grid should be less arduous for an inverter than life off, since the grid can easily provide the heavy surges of power needed to start a refrigerator, vacuum, table saw, or all three at once. Trace inverters come with a 2 year warranty and we'll buy a 3 year extension. After that, well, we'll hope for the best.

The Road Ahead

In Japan, 10,000 people are on a waiting list to buy subsidized PV systems. The Japanese government, which is putting $90 million a year into their rooftop program, has identified PV as a strategic technology. Take a memo, Energy Secretary Peña. Ambitious PV programs are also underway in Germany, Switzerland, and other European countries. The U.S. is lagging, but hopefully we'll catch up. Someone once said of Americans, "Count on them to do the right thing after they've tried everything else." We're getting pretty far down the list. Personally, I'm bullish on clean power. Living with PV is instructive, and you soon come to understand that this technology is a gift to the future.

I'm writing this on a crisp, cloudless December day. Though the sun is low and its arc is swift, my array has been bathed in sunlight since dawn. As the sun sets, I go out to check the day's production. It's 10 kWh, enough to lift a pickup truck 5,000 feet into the air. That's also 10 pounds of coal left unburned and 20 pounds of carbon dioxide not spewed into the atmosphere, there to linger a century or more. If that's the payback, I can live with it.

Access

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Siemens PV Modules: Hutton Communications, 5500 N. Havana, Denver, CO 80239 • 800-726-6245

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Web: www.eren.doe.gov/millionroofs

Solar Energy International, Box 715, Carbondale, CO 81623 • 970-963-8855 • E-Mail: sei@solarenergy.org

Holy Cross Electric Association, Drawer 2150, Glenwood Springs, CO 81602 • 970-945-5491

Pat Kiernan, Eco Electric, Box 2389, Basalt, CO 81621 970-927-9270

MORNINGSTAR

four color
on film negatives

3.5 wide
4.5 high

BP SOLAR

Two page spread covering
pages 14 and 15

four color

on negatives
this is page 14

BP SOLAR

Two page spread covering
pages 14 and 15

four color

on negatives
this is page 15

THIS OLD TRAILER

Terry Ziegler

Before & After

Greetings from Clinton, Iowa. The first year I lived here was an adventure. The pipes froze and the fire in the furnace was blown out by the wind several times. I thought there was a better way to keep this from happening again.

The next year I built a 2 by 6 inch framework around the bottom of the trailer then filled it with 6 inches of styrofoam insulation. Well, now that I have all this insulation around the house, how do I go about heating the underside? I remembered seeing solar hot air panels at the MREF solar energy fair in 1993 and I had picked up a copy of the AAA Solar Design Catalog. I researched that catalog night and day and finally figured out what I wanted. At the 1994 fair I was there with checkbook and plastic cash in hand. I went to the hot air solar seminar in one of the tents on the fair grounds and listened to Chuck from AAA Solar. I was convinced that four of these panels would work for me.

Hot Air System

I brought these great solar panels home and started to erect the framing the next week.The two panels on the top section of the house are tilted at 57°, 15° higher than the 42° latitude here in Clinton. Why the extra tilt? Because in the winter months the sun is lower in the sky so you should tilt the panels up to get more output. The two lower hot air panels are set at a compromise. They are only set at a 45° angle so I could still look out my front windows. I notice a 10° difference between them and the panels that are tilted more to the sun, according to my old Independent Energy differential controller. The control circuitry is shot but the temperature meter still works. I can monitor the temperature of both sets of hot air panels, the temperature under my house, plus the temperature of my power shed.

The top set of panels heats the inside of the house, while the lower set heats under the house. The furnace does not come on at all until the sun sets. Then it still takes one to two hours for the house to cool off enough for my furnace to kick on because of the extra insulation. The two sets of hot air panels get their cold air from the rear of the house. The set for the inside draws the cold air through a floor register in the back room then puts the warmed solar air up high through the wall register in the front of the house. Air is pulled through the entire length of the house. The lower hot air collectors are set up the same way under the house. Both are plumbed with 6 inch round furnace air pipe.

Above: Beginning framework with two hot air collectors.

Solar is Social

I only knew my neighbors by names until I started my project. Next thing you know I was the talk of the trailer park. The question was, “What is that guy doing, building a second story or what?” Of course I had already obtained a building permit to do my project beforehand. I stopped in the park office and the manager asked me, “what in the Sam Hell” I was erecting out there. I proceeded to tell him in detail. I also presented my building permits and proof of property insurance. His main question was if this is going to be an eyesore in the park. I had a hard time trying to get any work done because everybody would stop by and ask a lot of questions about what my project was all about. I gladly told them. The main responses were “wow” and blank stares. “Cool, keep going,” they told me. So I did in a big way.

Above: Upper and lower hot air collectors finished. Starting to enclose the rest of the trailer.

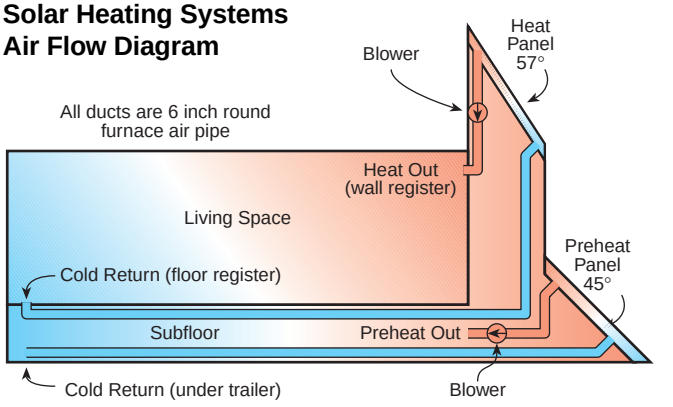
The winter of 1994 came very fast to Iowa. I drive a semi for a living, so I only had weekends to work on my project. It takes a little longer to get things finished. The spring of 1995 seemed a long time off, especially when you want to finish an ongoing project. Spring finally came to Iowa. I had a great thought: since I put up the hot air panels and insulated very well, why not do the rest of the house with an enclosure?

Above: The first day of solar heat in the trailer.

The Framework

The framework consists of 10 foot 2 by 6 boards. They are fastened to the side of the trailer with 9 by 3/8 inch bolts and washers. The bolts were fastened into the frame of the trailer on the top and bottom. I used 2 by 6 framework for the extra insulation space. The walls are insulated with an additional R21 insulation. I am guessing that the insulation in the original 1969 walls was R10 at most. So I now have an equivalent of R31, at best. The roof is sloped at a 4/12 pitch and built out of 2 by 4 lumber. The pitch of the roof was laid out by my dad, a retired iron worker.

Solar Heating Systems
Air Flow Diagram



Above: Completed framework ready for roofing and insulation.

The outside sheathing is 1/2 inch plywood covered with Typar house wrap to keep out air infiltration between the joints of the plywood, making the house more efficient. The final covering is double 5 inch white vinyl siding. All windows are trimmed in brown aluminum bought at the lumber yard and bent on my dad's aluminum break to fit the openings.

The bottom of the new structure is supported with 5/8 inch all-thread rods which go into 4 feet of concrete then into the bottom side of the frame structure with a large washer and nut. There are 20 all-threads around the new structure holding up the massive weight. The size of the cement pillar in the ground is the same as the ice fishing auger which was used to drill the holes helped by a 1/2 inch electric drill.

The insulation added this fall to the new attic is three layers of R30 insulation for a total of R90. Once again guessing the roof R-value in 1969 as R10, I now have R100 in the roof.

The Windows

The original windows were left in the trailer, but modified just a little to make them more efficient by adding a piece of plexiglas to the inside woodwork for a dead air space. I also did this to the outside of the windows, by putting an aluminum angle on the outside of the window for another piece of plexiglas. What do I now have? Window, dead air space, window, dead air space, window. There is a greater efficiency than just one piece of glass.

Solar Hot Water

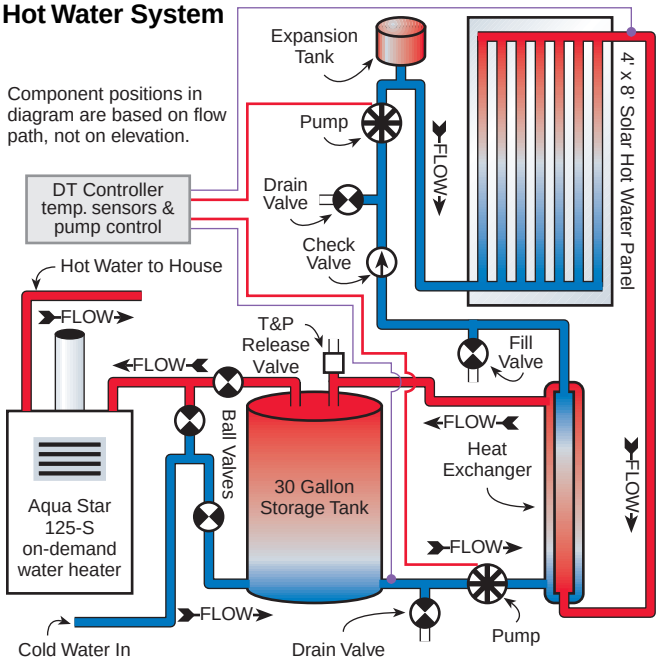
There is also a solar hot water system that I am very happy with. The old tank that was in the trailer house was getting to the point that I could only take a ten minute shower. The tank had limed up as with any hot water tank . It was tough trying to get a 35 gallon tank filled full of lime out the door, even with two helpers and a dolly. We finally got the tank to the door, set it down, and said, "hasta la vista, baby" and gave the old tank a big right foot out the front door. "Ya, ho, get that Aquastar 125S out of the box."

The new Aquastar 125S is mounted in my bedroom closet. Also included is a new 30 gallon storage tank for my solar hot water system. This was the 1995 addition to the solar trailer. The system was a used 4 by 8 foot hot water panel with a new pumping system and controls. The control system and panel were purchased at MREF from AAA Solar for a good price. A once in a lifetime deal, not an everyday occurrence. I just happened to be at the fair at the right time. A nice thing about the 125S is that with it set at the lowest temperature setting, 112° F, the heater will not turn on if my solar hot water is over 112° F. Very neat, I think. The average solar tank temperature on a sunny day is 156° F with the collector running 160 to 175°. The original D. T. controller was replaced with a Heliotrope General DTT74, because of greater control options.

The solar hot water system was extensively thought out before installing. Each component can be isolated with valves I can close to remove the storage tank and still produce hot water via the Aquastar. The Aquastar can be isolated from the rest of the system and flushed down the drain annually with a lime remover to prevent build-up.

Above: Terry with his roof-mounted solar hot water panel, and room for more.

Hot Water System



Above: Domestic hot water controls.

The solar hot water system can also be monitored for performance. Here I also have a used Independent Energy differential controller with the control circuitry shot but the temperature function still working. I can monitor the solar panel temperature, storage tank temperature, the cold domestic water temperature, the final water temperature out of the tankless water heater, plus the temperature of the water coming out of the heat exchanger going into the storage tank.

Hybrid Solar Electric System

I always wanted a wind generator and PV panels. The system started out going backwards. What am I talking about? I invented the wheel then the car. I had a great chance to buy a set of 2 Volt cells, but there were only 18. That meant a 24 Volt battery and some extra cells or a large 12 Volt battery, but I did not want the extra cells just sitting around. To add enough new cells to make a 24 Volt battery meant getting six more new cells for $425 a piece, or $2550. This was out of the question since I had purchased all 18 for $450. Then I had no way to keep them charged so I bought a 75 Amp Todd charger to keep my investment happy until I could get the cash for PV or wind.

Since charging batteries produces hydrogen I needed something to get rid of it. I built a system out of pvc pipe fittings consisting of a cap and coupling to get height to clear the breathers on top of the batteries. A brass nipple in the top of the cap connects them with a clear plastic hose to a main manifold to get the hydrogen safely out of the room.

I wanted more to rely on than just the sloping of the evacuation tube to get rid of the hydrogen, so I added a power vent turned on and off by a voltage controlled switch.

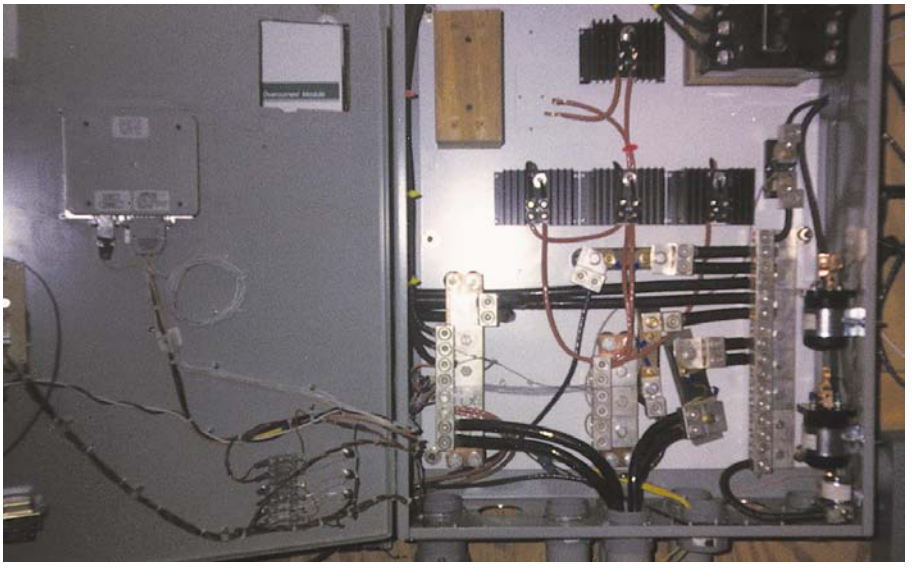
I know that a 12 Volt system has a potential for high current compared to 24 Volts, so I started off correctly by adding 0000 cable with large connectors in between my batteries.

The next thing was the control center. I looked at all the pre-built ones that were available at the time . Most had only some of the things I wanted in a center but not all, so I built my own. I figured out what components I wanted and laid them out on paper to see how I could fit them all in. My enclosure is 30 by 36 by 6 inches with

Right: Homebrew power center with two pull-out three pole fuses.

Emergency beers are a must while trouble-shooting.

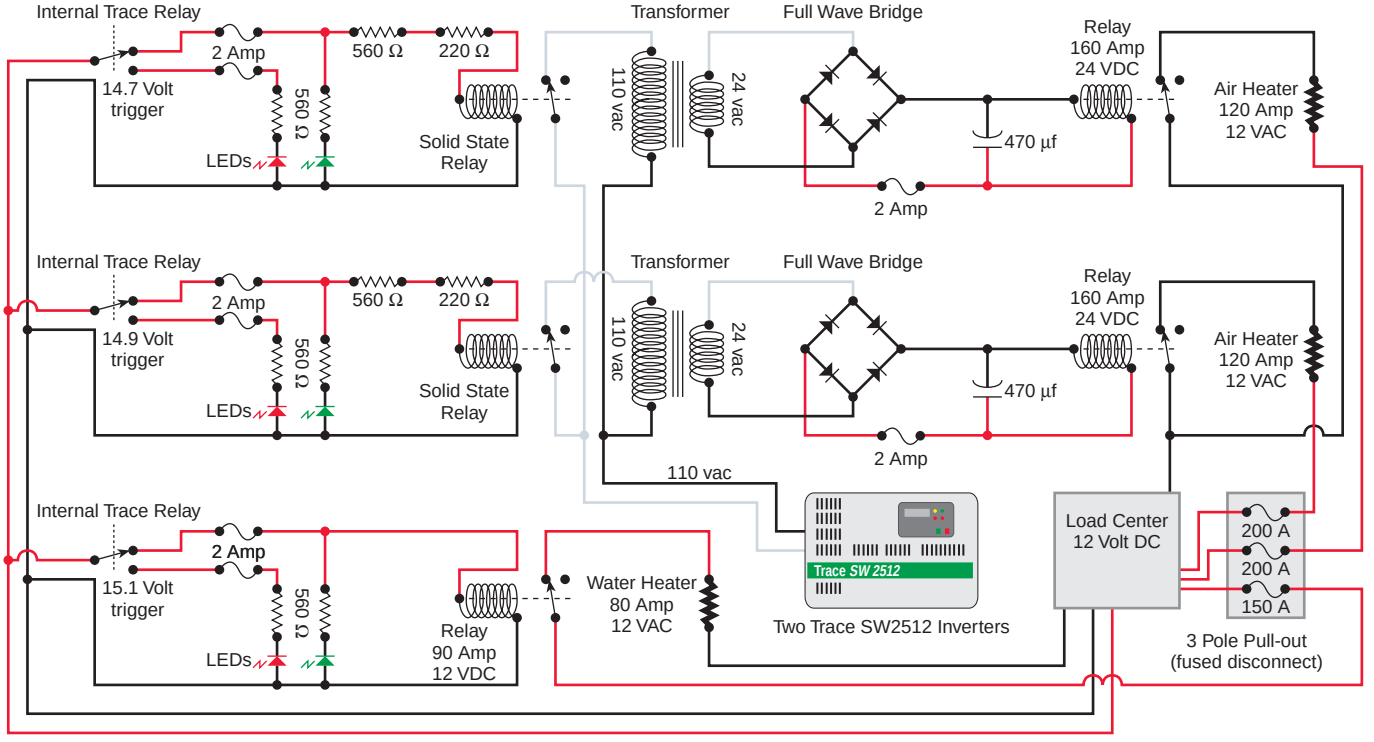
Above: Terry up the tower with his Windseeker 503. He will use this bird and data logging equipment to analyze his wind resource, then might buy a bigger genny.



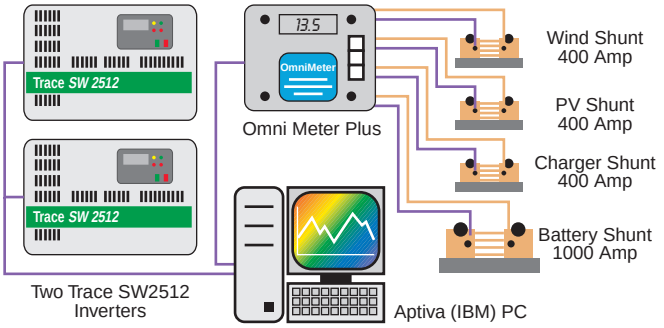
Above: Inside the home made power panel showing four Schottky Diodes.

a back plate that is removable to make things easier to put together. I wanted to build a system that could grow, so my main buss bars must be hefty. I made them out of two pieces of 1/4 by 2 inch copper plate for a total of 1/2 inches by 2 inches wide. I then put dual 250 mcm connectors on the plate with 1/2 inch bolts, using a corrosion inhibitor between all pieces. I needed to stand off the positive buss bars from the back plate which is used for the negative since all metal enclosures are grounded for code and safety reasons. I decided to use 1 inch motor vibration isolators to make it easier to put together. I also made the positive bus bar out of two pieces of 1/4 by 2 inch copper plate.

Load Diversion Schematic



Data Logging System



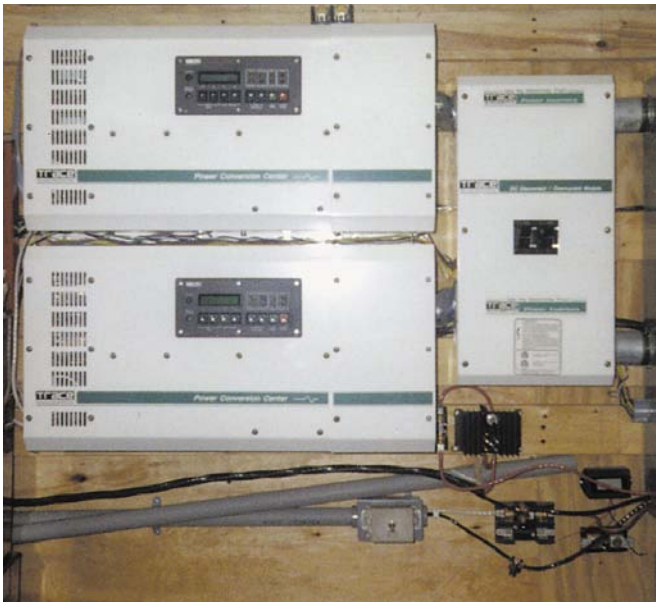
With all this power you need fuse protection. I have opted to use two, three-pole Bolt switch pullouts rated at 200 Amps for each pole. I can expand the system and grow as time and $$$ permit. One of the three pole switches is used for incoming PV and wind power. The other will be used for load diversion of the excess solar power so the batteries do not get cooked.

The main control panel has a lot of PV capacity available. There are four 60 Amp Schottky blocking diodes in parallel so that any single diode will not have to work at rated capacity. They will last longer and will not get as hot.

Inverters

The inverters of choice were the Trace sine waves with the circuit breaker box that matches the inverters nicely. I found the Trace to be the one with the most options available in any one Inverter available to date.

Above: Eighteen 2 Volt cells make up the 2160 Amp-hour, 12 Volt, battery. Notice the home made hydrogen venting system.



Above: Stacked Trace SW2512 inverters provide 120 and 240 volt ac power. Trace breaker box on right.

Both inverters are SW2512 that are stacked for 240 volts. Trace inverters have the capability to expand. Later on if I decide to sell power to the utility grid I do not have to get a new inverter. The inverters each have three programmable relays and I am using four out of the six available. One controls the power vent for my batteries and the other three control my load diversion to keep my battery voltage at a safe limit. They are set up for a three stage control. The first is set at 14.6 Volts which diverts to 80 Amps of water heating elements that are in my solar hot water storage tank, the second stage turns on 120 Amps of air heating elements at 14.8 Volts, and the third stage turns on another 120 Amps of air heating elements at 15 Volts. The Trace inverter relays are not capable of handling the high amperages, so they operate larger relays that will handle it. The relays in the inverters are user programmable to your liking.

PV and Wind

So far my input for the electric system is small. I currently have only 318 Watts of PV, six Solarex MSX53 panels. The wind generator is a Windseeker 503 rated at only 500 watts. The Windseeker replaced a smaller 300 watt machine that was hard to work on and made too much noise for me and the neighbors. I also had a hard time getting parts for it. The output of the wind generator and PV panels will be data-logged for two years to find out what I can get from both resources. Then I can decide what I need to add to be totally off the grid.

System Costs

#	Description	$ Cost
1	Used trailer house	4,000.00
	Wood, nails, screws, insulation, vinyl siding, metal trim for windows.	4,789.79
4	Hot air solar collectors new	1,200.00
1	Air to Air heat exchanger	908.00
	Pipe for hot air collectors and custom adapters for blowers	452.71
1	Trace SW2512 inverter, conduit box, and 250 Amp breaker	2,300.00
1	Second SW2512 inverter	1,460.00
1	Windseeker 503	745.00
6	MSX53 Solarex PV panels	1,560.00
1	Enclosure for load center	215.75
2	Bolt switch pullouts	210.00
6	Fuses for pull outs	90.00
	5 feet of 2 inch pipe for Windseeker	18.00
2	120 amp air heating elements for load diversion	300.00
4	60 Amp Schottky diodes	100.00
2	Offset nipples for connecting inverters to breaker box	33.10
18	C&D 720 Ah 2 Volt batteries	450.00
	Copper bus bar for load center	90.00
16	1 inch motor vibration isolators for stand off of positive buss bars load center	38.12
1	Todd charger	256.00
1	Wall heater for battery shed	390.00
1	Omni meter for load center	300.00
1	40 foot tower and 3 10 foot tower stubs	706.50
40	Blackburn 250 MCM dual barrel connectors	94.80
	100 feet of 0000 cable	161.07
	Miscellaneous	300.00
	Total Cost to Date	$21,168.84

As of now, if there was a storm that came through this area and knocked out the grid, I can run all my house for two days with no input from the sun or wind, a worst case scenario. Now I do not notice when the power goes out for even five minutes. Would I take on this type of project again? Of course.

Access

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PART 2: How to Build

THE GRAVITY SIPHON SOLAR WATER HEATER

John Whitehead

Last issue we introduced the concept and presented test data. Here the goal is to help self-reliant individuals plan, build, test, debug, operate, and maintain their own system. It is assumed that the reader is familiar with the introductory article and has it handy for reference. In particular, the system schematic is essential. Since there are many types of solar water heaters, the first step is to consider whether the gravity siphon system is right for a given situation.

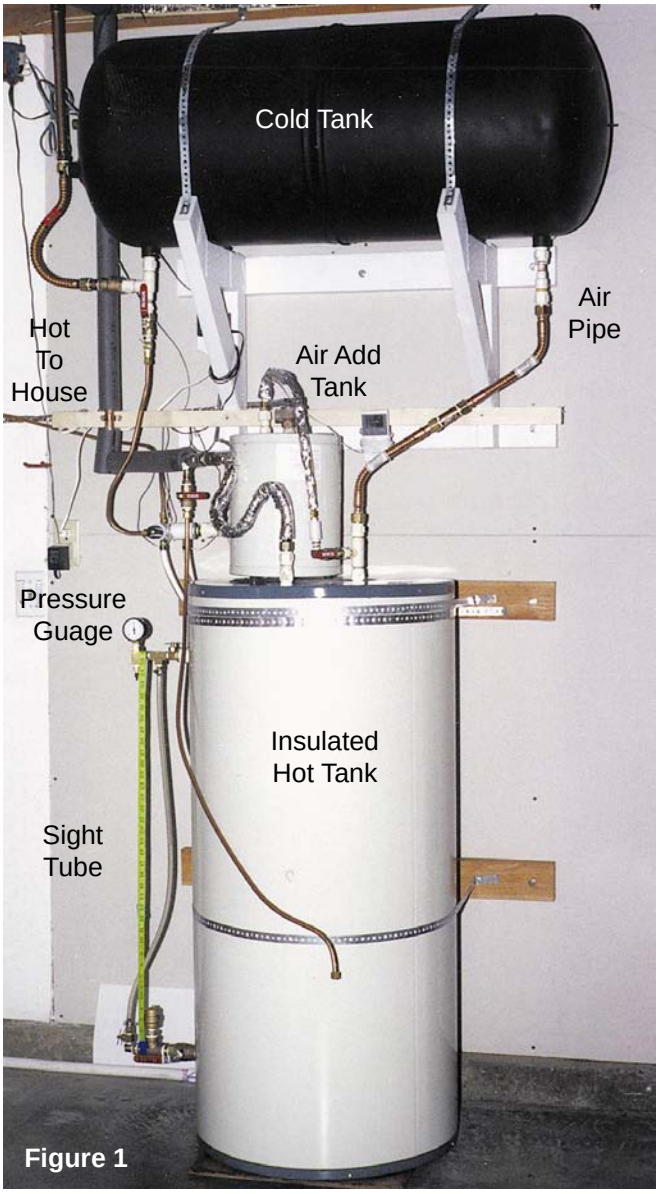


Figure 1

Site evaluation

Floor space is required for the hot storage tank with a higher place for the horizontal cold tank. The cold tank may be offset to the side to simplify replacing anode rods in the lower tank. The bottom of the cold tank must be well above the other two tanks. If ceiling clearance is limited or a taller hot tank is used, the small air tank can be located to the side and lower, instead of being atop the hot tank. A drain pipe connection is needed by the tanks for freeze protection and regular air makeup. The drain can be a pipe out to the garden since the water is clean.

Supply pressure variations greater than 5% will cause the air in the tanks to expand and contract excessively. The ideal situation is to have steady water pressure, as from gravity-fed storage. Many domestic well systems fluctuate between 30 and 50 psi. A regulator set to the lowest pressure should be added if pressure is not reasonably constant. A regulator should also be used to reduce high supply pressures to below 50 psi. Pressure gauges made to fit hose bibs are readily available. Connect one and check it at all hours to spot variations in your water pressure.

The tanks should be near the existing water heater and also in reasonable proximity to the chosen collector location. This could be a south-facing roof or an awning-style mount on a high south wall. A yard mount obviously works if the tanks are installed lower, like in the basement.

The gravity siphon makes an excellent project to rebuild an existing solar water heater having a working collector but a broken pump or controller. In new systems, installing the collector is a major part of the project. There are many books and articles describing do-it-yourself collector designs. Used ones are

available as well. Better features such as selective coatings and extra insulation can always improve performance, especially in colder climates.

Two basic tests are recommended after a collector is installed. These should be done in the middle of a sunny day. Fill the collector from the lower end using a garden hose with a pipe adapter. A collector that is full of stagnant water and vented at the top should become hot enough to emit steam within an hour. The second test is to flow water at 10 gallons per hour (about 10 cc per second) for each 4 by 8 feet of collector area. Measure the outlet temperature with a cooking thermometer in a mug to avoid burning fingers. It should remain steady at 120 to 140˚ F (roughly 50 to 60˚ C). A first experience with solar heated water can really boost motivation to install the tanks and hook up the gravity siphon.

A single 4 by 8 collector and tank volumes of 52 gallons can suffice for a small family. If lots of hot water is used during the day it makes sense to add a second collector. Larger tanks would only be needed if extra hot water is used between 5 pm and 9 am. Doubling the entire system would make the extra hot water needed by large households.

Tank Selection

The next major step is purchasing the two main tanks which must have equal volumes. Electric water heaters are the obvious source for tanks that can withstand pressure and water at elevated temperatures. Plastic tanks are a possibility, but most of those available do not withstand pressure. A length of large PVC pipe with end plugs could be used to make the cold tank (check local codes). The point is, there is nothing “solar” about the tanks. However, the locations of tank connections are important.

Two features shown in the last article’s schematic influence tank selection. First, the cold tank must have two side ports which are vertically in line with one another. This permits both ports to be at the bottom when the tank is turned horizontally. If the T&P valve (temperature and pressure relief) is far from being lined up with the drain valve, then vertically-aligned heating element ports may be used instead. Ports on diametrically opposite sides of the cold tank would also work. The air pipe would simply connect directly to the top of the tank.

The second key feature pertains to the hot tank. The air vent valve must be several inches higher than the end of the dip tube. Otherwise, excess air will occasionally be delivered to hot water faucets. Ideally, the electric water heater should have its drain port six inches or so from the bottom. Such tanks have a convex end as in Figure 2A. If an electric water heater has its drain valve at the very bottom, this indicates a concave lower end as in Figure 2B. In that case a pipe elbow and nipple should be used to raise the air vent valve. Then as the water level falls, any excess air will be vented via the sight tube. Figure 2C indicates another acceptable arrangement. The lower heating element port is used instead of the drain port.

The quality and thickness of insulation is of great interest in selecting the hot tank. The heating elements

Figure 2. Options for locating air vent above dip tube end.

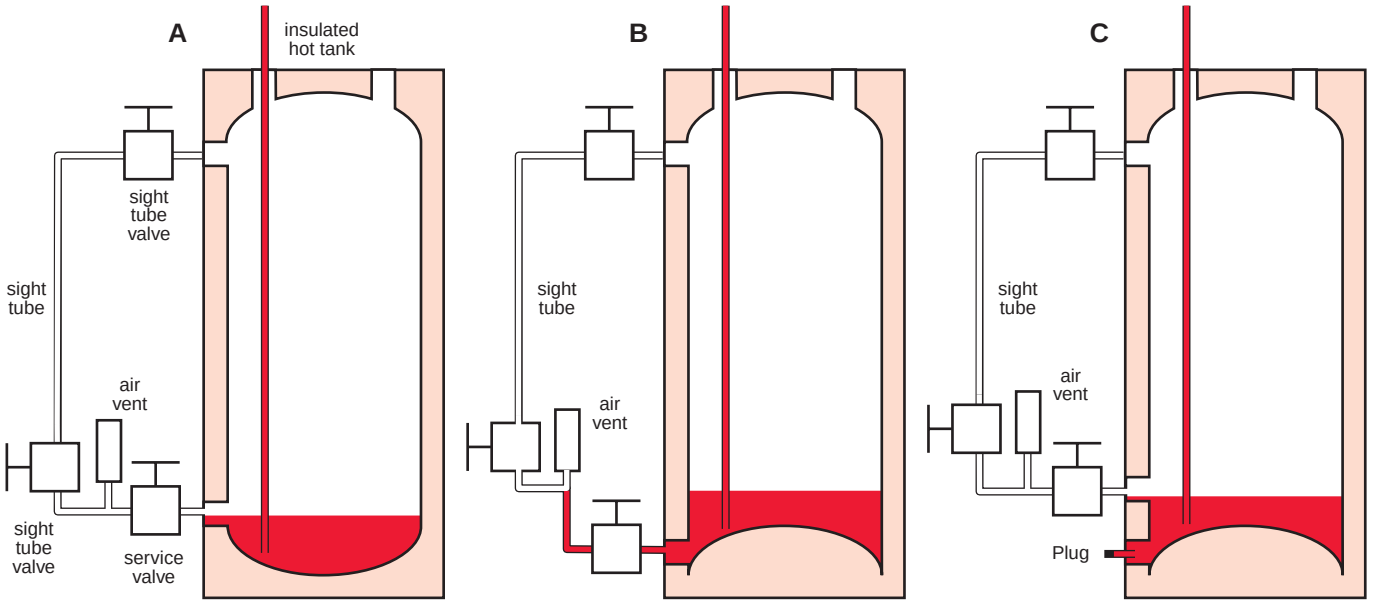
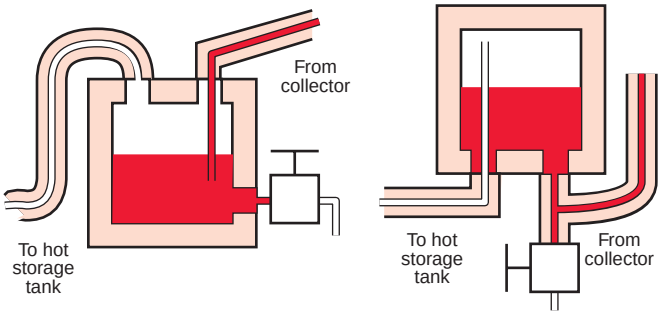


Figure 3. Two options for the air makeup tank.



and control thermostats will remain disconnected or may even be removed, so they are of no importance. Cheap plastic drain valves are ok, since they will not be kept. Anode rods used to protect glass-lined tanks from corrosion should remain in place. Even the cheapest tanks can last long with the gravity siphon system. A significant component of water heater tank failure is extreme temperatures. Gas flames, heating elements, and excessive solar temperatures during vacations are all absent here. One unknown is the long term effect of alternating air and water exposure to tank walls and anode rods.

Tank Installation

Hot tank installation consists of setting it on the floor with the drain port directed so that the air vent and sight tube plumbing will be accessible but out of the way. Cold tank installation requires a very sturdy mounting bracket to support at least 500 pounds total (52 gallons of water weighs 430 lb). The wall mount can be tested with a few friends. It should feel really solid when you apply weight greater than a full tank.

The bracket is made of mitered 2 by 4 wood with galvanized steel plates nailed across both sides of each joint. Lumber without large knots was selected and it was verified that the nails didn't split the wood. Quarter inch lag screws (3 inches long) go through the horizontal wall pieces into the triangular sections. To fit flat on the wall, the heads with washers were countersunk using a 3/4 inch flat wood drill. Pre-drilling sizes were 1/4 inch for screw clearance and 3/16 into the triangles. The completed bracket was finally painted then installed after similar pre-drilling. Lag screws long enough to penetrate 1.5 inches into the wall studs were used in six places.

If time is of the essence a complete water heater may be used for the cold tank. This avoids condensation in humid climates. Alternatively, stripping it down to the bare tank renders it easy for one person to lift, provides more ceiling clearance, and satisfies curiosity about what's inside water heaters. Dark paint helps to absorb heat from the surroundings. This especially makes sense for locations that are hot in the summer, such as a California garage. Of course, tank painting can include creative decoration.

Check whether a heating element interferes with the vertical standpipe to be installed inside the upper tank. The element may be removed and replaced with a one-inch pipe threaded PVC plug. Both tanks should be secured in place with metal strapping, especially in earthquake country. The hot dip tube should be installed prior to this step if the cold tank interferes with this long tube.

Figure 4. Plumbing between the tanks is easy to reach.

The air makeup tank should have 2 to 4 gallons of volume and be insulated. The prototype system uses a 2 gallon electric water heater with the 120 volt cord removed. The tip of the dip tube is slightly above the drain port to permit complete collector draining for freeze protection. Some small water heaters on the market lack a drain valve. Such a tank can be used upside down with a standpipe as illustrated in Figure 3.

Plumbing Details

Figure 4 is a closeup of the area between the tanks. Most of the plumbing is conveniently located here to reduce climbing and

stooping. The tank port connections and branch manifolds appear white in the photographs. They are CPVC plastic rated for 180˚ F at 100 psi. Look for these numbers printed on the pipe. The pipe and fittings are smaller than regular PVC used in gardening, which weakens when hot. Both are nationally approved in the U.S. for potable water, but local plumbing codes may restrict their use.

Copper pipe with soldered fittings may be substituted, but electrogalvanic corrosion reduces tank life. This subject is explained in The Water Heater Workbook. Also included is information about water heater construction and how to reduce heat losses. The gravity siphon system is largely an investment in tanks, so it's certainly worth taking steps to make them last.

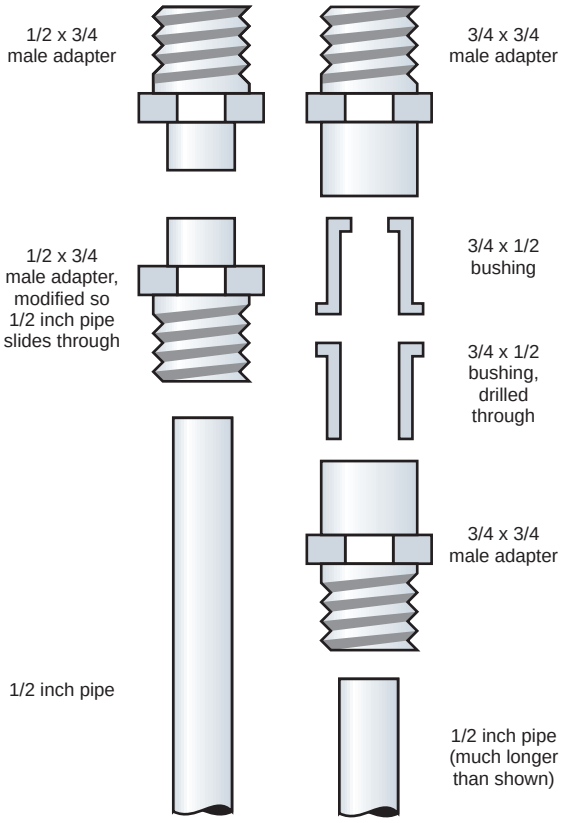
Copper or brass in contact with a steel tank promotes rusting. Damage can be rapid if the copper is inside the tank near a heating element or burner. It helps that solar tanks don't have concentrated heat sources. The prototype gravity siphon used copper tank fittings and dip tubes for the first two years. A small light bulb lowered into the plastic-lined steel tanks showed no signs of corrosion. Nevertheless, CPVC is recommended for direct contact to steel tank ports.

Most dip tubes that come with water heaters are not internally sealed at the fitting. They would permit air loss from the hot storage and air makeup tanks. Fortunately, special ones can readily be made. The cold tank's standpipe must similarly prevent water leakage into the air pipe. Figure 5 shows how to adapt one continuous piece of pipe to both the tank threads and the external plumbing. A wide selection of fittings is available in copper. CPVC may require a few more parts as illustrated. In either case, the trick is to drill through or file down inside the 1/2 inch pipe size adapter. The dip tube then fits completely through the 5/8 inch actual size hole.

Interconnections for the cold water supply, hot delivery pipe, and the air pipe all use 3/4 inch copper flex lines which are standard for water heater hookup. A word of caution: CPVC assemblies should be allowed to dry thoroughly before installation as the solvent in CPVC cement can dissolve gaskets in flex connections.

One advantage of the gravity siphon system is that its low collector flow permits relatively small passageways. Therefore, the two CPVC assemblies which have side branches use 3/4 to 1/2 inch combination tees. Half-inch ball valves to isolate the collector flow path are threaded onto CPVC 1/2 inch male pipe adapters. Manual drain valves should also be 1/2 inch ball valves. Various brass pipe fittings used along the collector passageway have thread sizes from 1/4 to 1/2 inch.

Figure 5. Options for assembling hot dip tubes and cold standpipe.

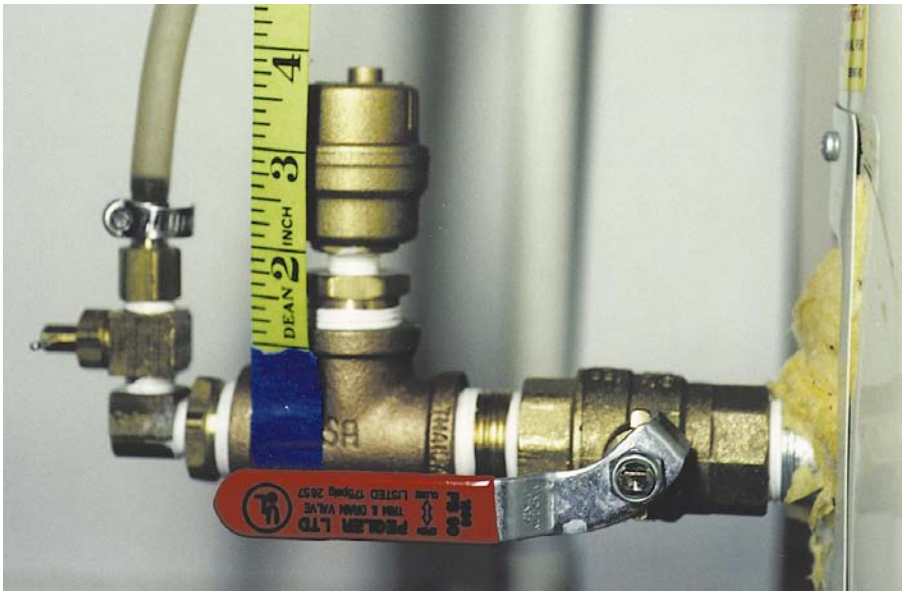


Collector flow is adjusted with a 1/4 inch brass needle valve, for example.

The prototype's collector feed and return tubes are 3/8 inch soft copper tubing which is easy to bend and install. It is connected with compression to pipe thread adapters. If the total length of tubing for collector feed and return is a lot more than 50 feet, 1/2 inch tubing should be used. This larger size is also recommended for more than one 4 by 8 collector, which would at least double the 10 gallon per hour typical flow. Even so, the collector plumbing would be smaller than required for many other solar heaters.

Trapped water in outdoor tubes can cause freeze damage and air trapped at high points may interfere with siphon flow. Therefore, local high or low points along the collector feed and return tubes must be avoided. They should be sloped for draining, except for short horizontal sections through walls. Larger tubes will speed draining, especially if there must be longer horizontal sections or tight bends. Another reason to increase tube size is to reduce the potential for clogging from scaling in hard water areas.

Some experienced solar installers recommend 3/4 inch pipe to guarantee draining. This makes sense if long



Above, Figure 7. Pressure safety ensured by 75 psi relief valve.

Left, Figure 6. At the hot tank lower port.

horizontal runs are unavoidable. The author's 3/8 inch tubes readily drain the collector because they are short and sloped. Draining must be verified for each unique installation. With narrow tubes it can help to locate the drain valves at different elevations to initiate siphoning.

In climates where freezing occurs in the daytime, avoid or minimize outdoor water plumbing. A collector containing glycol could thermosiphon to an attic heat exchanger which is connected to the gravity siphon loop. Insulated gravity siphon pipes could pass through a roof ridge and connect to the top manifold of an evacuated heat pipe solar collector.

The air pipe should be as close to vertical as possible so that any water quickly drains and air may pass freely between the main tanks. Elsewhere, local high and low points can be useful. The S-curved hot delivery pipe, shown in the schematic and photographs, retains heat by keeping hot water from passively rising.

Figure 6 is a closeup at the hot tank's lower port. Large plumbing, including a 3/4 inch ball valve, connects the automatic air vent valve to the hot tank. Thus water readily flows away from the air vent when the level is low. The connection to the tank itself may be a 3/4 inch CPVC assembly or a plastic lined steel nipple, 3 inches long. The vent valve is a very simple device containing a float. An identical valve is used at the highest point along the collector passageway as shown in last article's system diagram. Such valves are used as steam vents and are sold in hardware stores where steam heating systems are common. In warmer climates ask at specialty plumbing stores. Be sure the pressure rating is at least 75 psi in either case.

Small brass needle valves are located at both ends of the 1/4 inch i.d. vinyl sight tube. They should be set about 1/2 turn from closed to minimize flooding in the unlikely event of a sight tube failure. A related critical part visible in Figure 6 is the hose clamp on the sight tube. Never wrap a hose barb with tape to stop leaks. Tape helps the tube slip off under pressure.

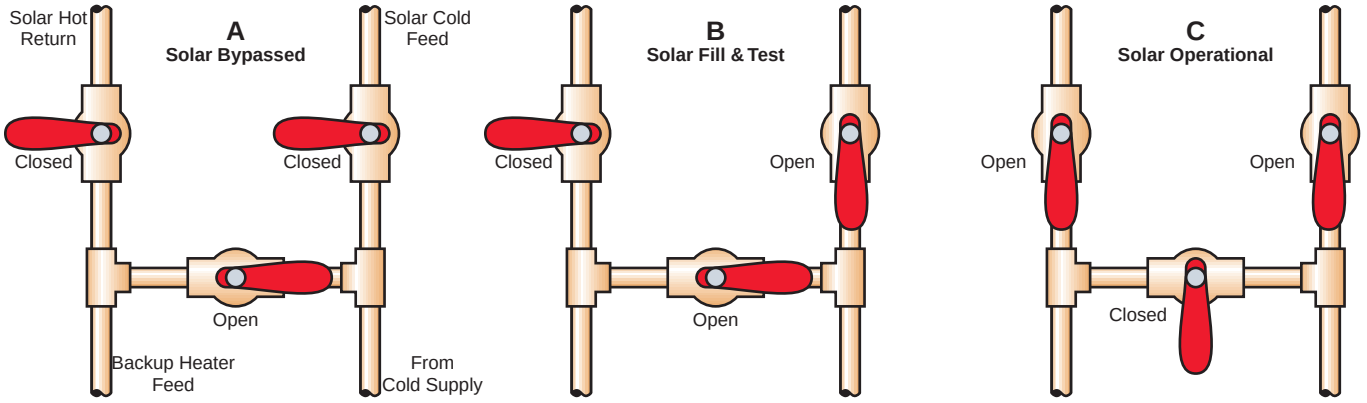
Water heater tanks are factory tested to 300 psi and intended for hot water pressurized as high as 150 psi. However, pressurized air can release more energy than pressurized water. The gravity siphon system uses a 75 psi relief valve to double the safety factor. This also

Figure 8. Three valve manifold above backup heater.

limits system pressure to within the rating of CPVC pipe. Figure 7 is a closeup of this valve which is available through well drillers or specialty plumbing suppliers. The system does not add to the cold water supply pressure. The relief valve just provides a guarantee against the unexpected.

A key step prior to actual operation is to connect the solar water heater to the house plumbing. Figure 8 shows the 3-valve copper manifold located above the existing gas heater. Large 3/4 inch ball valves were used to match the existing plumbing size. As sketched in Figure 9, there are several options for setting these valves. Additional valves could be included for bypassing the backup heater in the summer.

Figure 9. Settings for the three valve manifold.



Initial Operation

Tank filling should be done with the collector passageway valved off. The collector and air tank need not even be connected yet. The latter could be in the way if it turns out there are leaks in the large plumbing joints. All valves associated with the sight tube should be closed, so that air is not wasted out the vent.

Take a deep breath and turn on the cold water as indicated in Figure 9B. As the cold tank begins to fill, look and listen for leaks of either water or air. Also be sure that the cold tank is not shifting under the increasing weight. During this time air from the upper tank is being compressed into the lower tank. If there are leaks at plumbing joints, drain the tanks, tighten fittings, and repeat the initial filling process.

The sound of water overflowing through the air pipe will indicate that the cold tank is full. Wait a minute then open the large air vent connection valve and both sight tube valves. The air vent should emit a puff of air and then shut as it fills with water. The pressure gauge will rise, then the tank level should become visible in the sight tube. If you have an air compressor or patience with a tire pump, shut off the water source temporarily. The ideal thing to do at this point is to add air to match the cold supply pressure. Use the air service valve near the pressure gauge.

If the water is left on, the hot tank and sight tube will initially fill to a higher level. Flow stops when system pressure reaches source pressure. If the cold water supply is at 45 psi, this is a pressure of 4 times atmospheric (45 + 15 = 60 = 4 x 15). The initial air from both tanks will occupy 1/4 of total volume, i.e. the upper half of the hot tank. Air may be added at any time, and excess water may be removed through the hot outlet test valve. Repeated filling and draining of the collector passageway will later add plenty of air to the system.

The final step occurs after completing the collector plumbing. Close both drain valves and open the collector feed and flow adjust valves. The collector will begin to fill with water. During this time the collector return valve must remain closed for several minutes. Finally, the return tube will fill with water while air rises to the outdoor air vent. The flowing sound stops and pressure will equalize with the main tanks. At this point, atmospheric air which was initially in the air add tank has been compressed into the upper part of this small tank. Now the collector return valve may be opened. Siphon flow will begin pushing air from the small tank into the hot storage tank. After several more minutes the sound of collector return water can be heard trickling into the hot tank. If there is a leak or a problem in starting the siphon the collector passageway should be valved off and drained before trying again.

When the sun is shining the collector return plumbing should feel warm or hot. The sight tube will indicate a rising water level. Set the flow adjust valve so the level rises approximately 1/5 of the tank height per hour. Hot water production can be verified using the hot outlet

test valve with a bucket and thermometer. With collector flow shut off, a gallon jug and a permanent ink marker can be used to label the sight tube in one-gallon increments.

If all steps are accomplished successfully up to this point, your gravity siphon solar water heater is operational. Set the 3-valve manifold so that solar heated water feeds the backup heater (Figure 9C). The minimum operating requirement is to close the collector feed valve in the evening before hot water is used. It must be reopened every morning after the sun begins to warm the collector.

Advanced Operating Tips

The author's prototype gravity siphon is automatically started each morning and drained each evening. Custom-designed automatic valves are gradually being refined and may become available for purchase. In any case, it is worthwhile to build the system with manual valves first. This is not like having a circulation pump with a manual switch that needs attention before sundown. You can arrive home as late as you wish since collector flow stops passively. Manual operation fosters familiarity with the system, including verification of hot water production.

The gravity siphon is an ideal solar technology for anyone serious about minimizing backup heating. The sight tube can be used to monitor, plan, and budget the use of hot water. By comparison, other solar water heaters are like independent electric systems having no charge level indicator on the batteries.

Collector draining is necessary if there is the possibility of freezing temperatures. First close both the collector feed and return valves, then open both drain valves. On a new system, drain into a bucket to verify complete draining in a timely manner. To find out if the collector and tubes are empty, blow air into each open drain valve. Note the total draindown volume for future reference.

Draining also adds a little air to the system when the siphon is restarted. Occasionally check the sight tube early in the morning while the last person is showering. If the overflow sound is heard at a water level far from the bottom, then there is not enough air in the tanks. The cure is more frequent collector draining, perhaps daily.

A springless check valve (see HP #58 page 24) may be added just before the collector return valve. An airtight check valve permits the manual return valve to be left open, particularly helpful if daily draining is required. When the siphon is restarted each morning the check valve eliminates the waiting period after opening the collector feed valve. The check valve opens passively to permit siphon flow after the collector passageway reaches full pressure.

Consider having separate weekday and weekend settings for the flow adjust valve. When the house is unoccupied all day, reduce collector flow so the tank fills slowly at higher temperatures. If less than a whole tankful of hot water is used on a regular daily basis, produce only the amount needed. Collector flow may be reduced further or confined to the sunniest hours.

If household members must leave early on a regular basis, significant cold flow can occur before the sun rises sufficiently. This is the greatest potential drawback of the manually operated system, so an automatic collector feed valve would be desirable in this situation.

Collector flow can be increased during the middle of the day when people are home and using hot water. Temperatures are reduced, but this strategy collects more total energy and ensures a full tank by evening. Extra flow during the few sunny hours similarly makes sense in the winter. Low cost collectors may perform poorly during the coldest months. Consider draining the collector and bypassing the system (Figure 9A) until weather warms.

More air dissolves in cold water than in hot. During periods of low solar performance, extra air enters the water and is liberated in the backup heater. Air bursts at hot faucets can therefore occur if the system continues to run when it's cloudy and cold. For example, California's Central Valley is notorious for its weeks without sunshine during December. The author's gravity siphon has operated daily under such conditions, hoping for an occasional sunny day. Happily, the system had a chance to prove itself on the 1997 winter solstice with deliveries reaching 100° F.

When cloudy weather produces luke-warm water that is not used, send it to the garden (through the hot test valve) on the morning of a sunny day. Then a full tank of water will be freshly heated. This also makes sense after arriving home from a trip if the hot tank has had days to cool.

If the hot tank is empty early on laundry day, wait a few hours and check the sight tube until enough solar hot water is produced. This is a unique capability as many solar water heaters yield only a tankful of lukewarm water by mid morning.

The sight tube provides the ultimate feedback about how much hot water is actually used by each activity. Conservation, like using low-flow shower heads, becomes more meaningful when the results are readily apparent. The author's household learned about the old clothes washing machine that didn't automatically

switch to cold rinse. The 4 hour delay timer on the new dishwasher is handy on Monday morning when the solar tank is empty and it's time to leave for work.

Long Term Maintenance

Occasionally check that sounds, temperatures, and tank levels are as expected. Temperature checks can be as easy as feeling the collector return tube during the day or touching the hot outlet pipe after starting a load of laundry.

The rate of hot water production can be verified several times per year by noting tank level and time of day. The sight tube may become opaque after a few years, simply valve it off and replace it.

Collector flow may ultimately decrease over the years. First, attempt to compensate with the flow adjust valve. Checking for mineral deposits requires a little disassembly. It would be inexpensive to replace the collector return tube every 10 years. Periodic flushing (rapid flow) through the collector may be beneficial. For example, a garden hose could be connected to a drain valve, with flow out the other drain valve. Verify complete draining of outdoor plumbing if there is an indication of flow restriction.

If a puddle ever appears from an unobvious leak, the first step is to shut off and drain the collector. If the leak stops, it must be somewhere along the collector passageway. One fact of plastic parts is that temperature changes make them expand and contract more than metal. If leaks appear where plastic pipe fittings thread into metal, tighten while cold and not pressurized. If it ever becomes necessary to empty the main tanks, shut off the water source then let the air pressure expel all water through the hot test valve as well as the collector feed and drain valves.

Conclusion

Although a patent has been applied for, permission is hereby granted for individuals to build their own manual gravity siphon system. The author would be happy to hear from interested do-it-yourselfers.

Erratum

Slight data problems crept into Figure 5 on page 37 of HP #63, the first article. The chart understates the temperatures and delivery, but the text of the article has the correct figures.

Access

Author: John Whitehead, PO Box 73343 • Davis CA, 95617 • 530-758-8115 (Thurs. through Sun. evening).

The Water Heater Workbook, Larry and Suzanne Weingarten, Elemental Enterprises, 1992. PO Box 928 Monterey, CA 93942. See HP #48.

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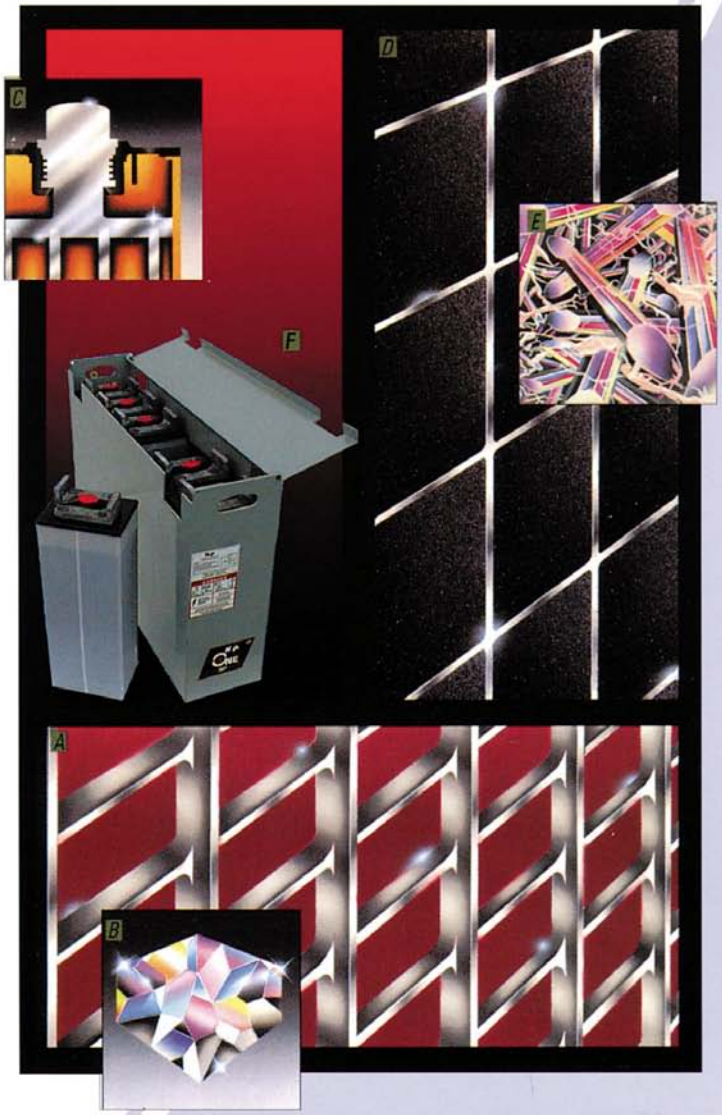

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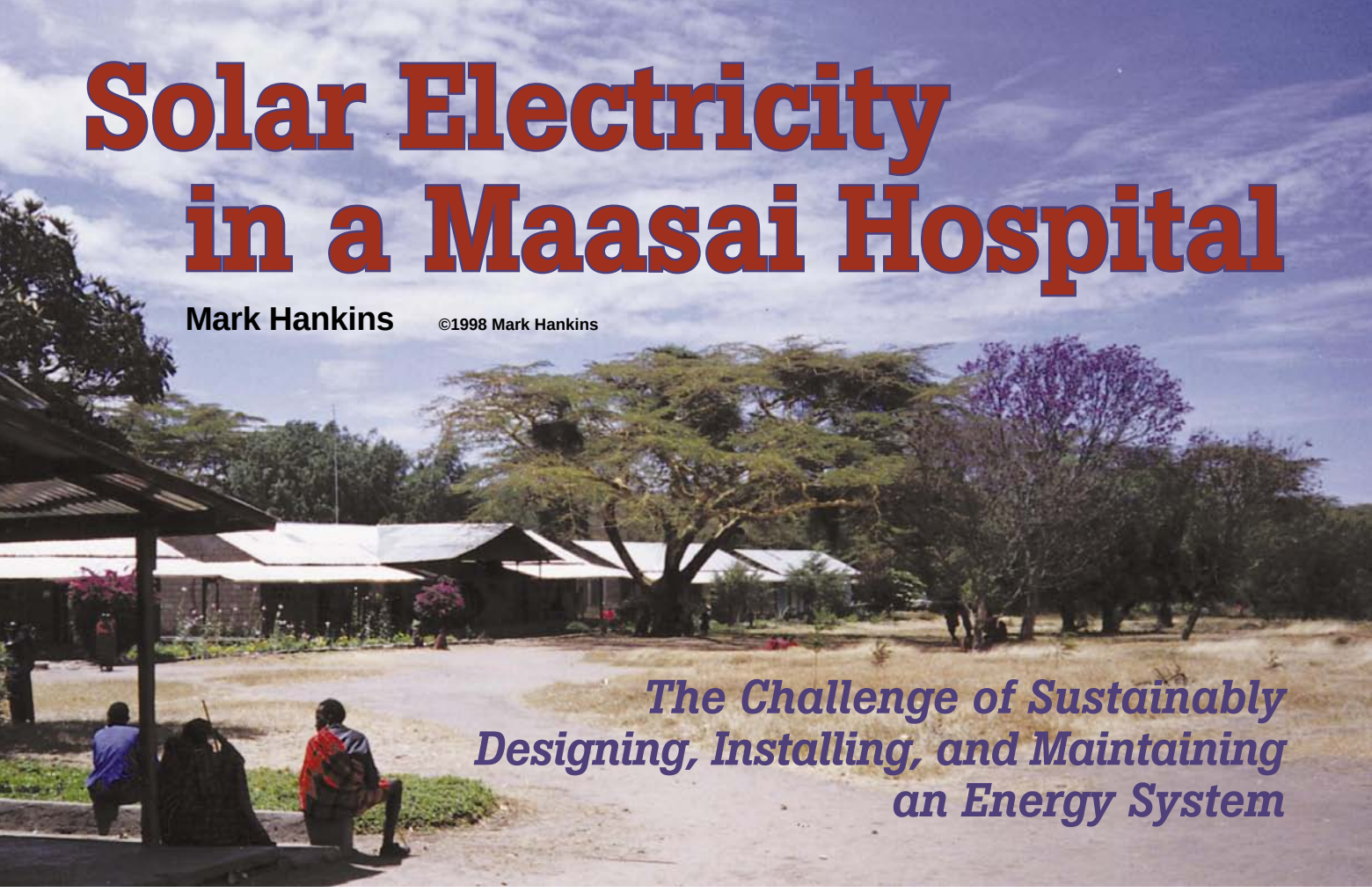
Solar Electricity in a Maasai Hospital

Mark Hankins



The Challenge of Sustainably Designing, Installing, and Maintaining an Energy System

Wasso Hospital is located in the deep bush of Maasailand, nestled along the Tanzania-Kenya border between three spectacular game parks (Serengeti, the Maasai Mara, and Ngorongoro Crater) and the Loita Hills. Hundreds of miles from the nearest tarmac road, it is a mission outpost dreamed into being in Tanzania's early post-independence days by a celebrated Austrian priest, doctor, and hunter named Wassenger.

The hospital was established in wilder days, when a mzungu (white) doctor could shoot game and swig sundowners in between bloody sessions in the operating room and when the Catholic sisters and volunteer orderlies would trek for picnics on nearby hills. Today, the head doctor doesn't carry an elephant gun and much of the old bush romance is gone, but Wasso is still one of the best hospitals in the region, providing primary health care services and front line treatment against the most common local ailments—tuberculosis and sexually transmitted diseases.

To get to Wasso one drives over savannah plains and through acacia woodland populated by wildebeest, zebra, gazelle, and giraffe; and the ubiquitous Maasai with their vast herds of long-horn cattle. Driving into the compound in the morning through a forest of riverine fever trees, one sees the buildings of the hospital compound with their tin roofs and neat flower gardens. On one side of the compound dozens of shuka-clad moran (Maasai warriors) sit in the shade of acacias and, on the other side, bangled women sit with babies awaiting post-natal check-ups.

Over the years, supplying power to the hospital has become a nightmare. As Wasso has grown, so have its energy requirements and, what with all of the other daily crises, there has been precious little time to think about energy systems. I was flown in last December to do an energy audit with a view to solving as many problems as possible with solar. At the time, the energy systems were inefficiently, and somewhat hazardously, ramshackled together. The genset was regularly run three hours a night and was switched on irregularly when needed. The energy situation is truly out of hand when one must fire up a 25 kVA generator to run a bubble-jet printer.

Our report recommended a reorganization of the hospital's energy system. Six months later, the Energy Alternatives AFRICA team was hired to do the job with

support from several donors. There were a number of ambitious tasks:

- Replace the lighting loads in the maternity, operation, and OPD wards with a battery buffer/ inverter system. This uses an inverter and a bank of batteries which charges from the genset when it is running.
- Replace the generator wiring in the TB Ward and Male Ward with stand-alone solar lighting systems.
- Install stand-alone solar lighting systems in the seven staff houses.
- Install stand-alone solar lighting and 240 vac power systems in two doctors' houses.
- Install a PV-powered deep freeze in the doctor's house.
- Install a stand-alone PV-powered lighting and HF radio system in a distant clinic.
- Install solar water heating systems in the doctor's house, the patient ward, and in the laundry (this was subcontracted to a Nairobi solar water company).

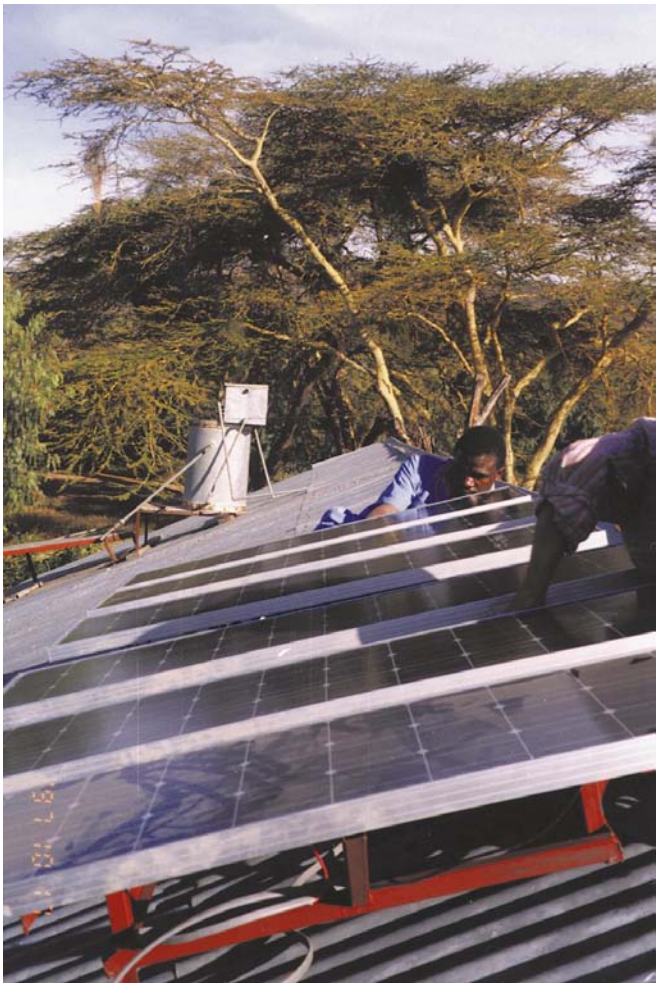
Above: Energy Alternatives AFRICA students and instructors. Mark Hankins wears the blue hat.

There is a huge difference between simply recommending an energy package and putting one in place. We of the West tend to be like Tarzan when it comes to technology dissemination in Africa. We swing in, take pretty pictures, thump our chests, and we make a lot of noise. But too often we simply parachute equipment in or we come in and do the installation ourselves while bemused locals watch. Then we dust ourselves off and swing out. Even when intentions are good, work without a long term maintenance plan is doomed. Europeans and Americans have left graveyards of renewable energy equipment in Africa. The real task of teaching locals to install, design, choose, maintain, and sell renewable energy equipment is far more daunting and time consuming than supplying equipment. In this project our team was spending several person-months on site to train 14 Maasai community members and hospital staff to install and maintain the systems.

Left: Most students had never used tools before.

Reworking of the hospital's energy system proved to be more of a learning exercise and adventure than a profitable venture. Just arranging the enterprise took weeks. Systems had to be designed and equipment had to be ordered from various countries. A qualified team had to be put together. A preliminary site visit had to be made. We had to deliver equipment from Norway, Nairobi, and Arusha to one of the most remote parts of East Africa. All this happened before the installation work began in early October, before November rains washed away the roads.

The team included myself (leader and chief instructor), Frank Jackson (consultant solar electrician provided by



Above: Gaspar Makale wiring PV modules on the Doctor's house.

the Irish aid organization, APSO), Daniel Kithokoi (EAA solar technician), Gaspar Makale (KARADEA solar technician), and Hans Gelly (German volunteer). After purchasing batteries, lamps, cables, conduit, and various spares in Nairobi, Frank rode with the lorry load of equipment across the border post in Namanga. He picked up the imported equipment (NAPS modules, charge regulators, and inverters) from Kilimanjaro airport outside Arusha. Then he followed a long circuitous route around Ngorongoro Crater and through the Serengeti to Wasso. Daniel, Hans, and I, in the EAA Land Cruiser, took the more direct route through Narok and a hundred or so kilometers of rough tracks through the Loita Hills, somewhat illegally crossing the border on the unposted frontier. Gaspar, meanwhile, had to take a 24 hour bus ride from Mwanza across the Serengeti to Arusha, then back, to get to Wasso.

Installation work was integrated with a training course for community members. The idea fits with Energy Alternatives AFRICA's strategy of building a base of knowledge in the community where the technology is used. Each morning the student technicians, including staff members from two hospitals and four local development NGOs, had theory sessions in the classroom. After tea they completed long practical sessions on site where they were able to apply the theory. Things were a bit crazy as we were trying to complete professional work with limited means, and trainers often had to re-do student mistakes. The Maasai—God's own ecologically sound people—inhabit cow dung bomas, live off milk, meat, blood, honey, and hardship; and are as proud and beautiful as a people can be. Elegance and beadwork, yes, but the Maasai are not known for building or wiring skills. Half of our students had never before picked up a hammer. Work proceeded slowly. In the process we enthusiastically smashed walls, shattered roofing tiles, hacked away at battery boxes, laid miles of wire, and mis-drilled holes on mount angle iron.

There were delays. Key battery interconnects were accidentally left out of the NAPS package meaning that work on the battery buffer system was paralyzed. We had to use the head doctor's satellite phone to make a call to NAPS in Norway. They promptly DHL'd the equipment to Arusha, where it sat for days awaiting a flight by Flying Doctors to the hospital. The solar water heaters got stuck in Mombasa customs. There wasn't enough battery acid, we forgot armoured cabling for the underground wire run, and one of the RCD's was defective; so we had to send a pickup to Nairobi.

Then there was the problem with generator wiring. The existing wiring in wards and staff houses was in horrible shape, brittle and coiled dangerously like snakes in the super-heated filthy attic spaces. Some PV systems had been installed previously by untrained people, we had to tear these out and rewire them. Finally, at the time of our work, the hospital was a busy building site. It was difficult to get time in the workshop for making the battery boxes, mounts, and peripherals we needed.

Excess work wasn't the only cause of delay. Three of five of the training staff were hit by tropical ailments. Daniel was struck down by malaria and Frank had tropical stomach problems. I lost two days due to infected insect bites on my legs that turned into deep, fever-inducing abscesses cured with a tandem treatment of antibiotics. It's lucky that we were in a well-run hospital.

The Systems

In all, we were to install more than ten systems and more than a kilowatt of PV. For most of the systems we concentrated on low-tech, easily maintained solutions that reduced or ended the need for generator back-up. On the seven stand-alone staff houses we installed

basic 55 Wp modules, 100 Ah Kenyan modified SLI "solar" batteries, NAPS charge regulators, and Sollatek (UK) fluorescent lights. Student technicians completed these 12 VDC systems under the supervision of Daniel, Gaspar, and myself.

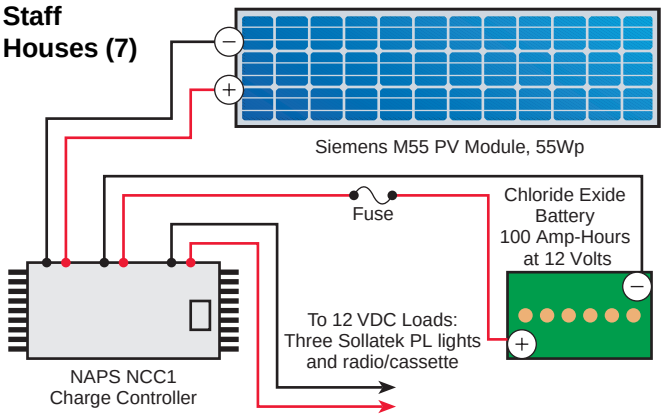
The TB Ward and Male Ward each used 110 Wp arrays connected to 200 Ah battery sets through NAPS regulators. In addition to Sollatek PL-type lamps, we installed Jade Mountain yellow ultra-low consumption LED lights as night lights in the rooms of each ward.

For the above systems, all of the batteries and regulators were mounted in lockable wooden boxes which prevent end users (the hospital owns the systems) from bypassing the regulator. The Siemens modules were mounted at 15° facing North on fixed pole mounts. EAA always mounts modules well off tin roofs, as African heat significantly reduces output of modules mounted on metal.

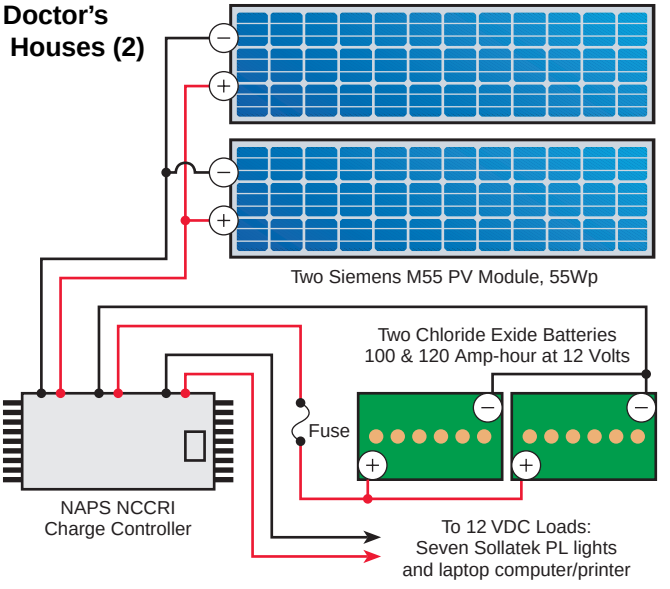
In the head doctor's house we installed two independent systems after straightening out the generator wiring and tearing out the previous poorly installed PV system. One 165 Wp system powers eight lights, a rather powerful stereo, a laptop computer, and, through a 400 watt inverter, a TV and video set. The second 220 Wp NAPS freezer system is used to keep blood plasma frozen and to freeze meat for guests in a separate compartment. In the second doctors' house a 12 V 110 Wp system is used for lighting, powering laptops, and bubble-jet printers.

The most complicated and vulnerable part of the system is the inverter battery buffer which uses excess generator power to charge Tudor deep discharge batteries. The batteries are used to run compact fluorescent lighting and low power loads in the Female Ward and delivery room (and eventually in the operating theatre). It is less costly to charge batteries with excess generator power than with expensive modules. For equivalent power supply we would have needed ten or more modules. The 25 kVA genset is routinely run each day, usually at well below 25% of rated capacity, to power workshop tools (i.e. the compressor and welding tools) and the X-ray machine. The generator is a permanent, necessary part of the hospital energy system and should be used as efficiently as possible.

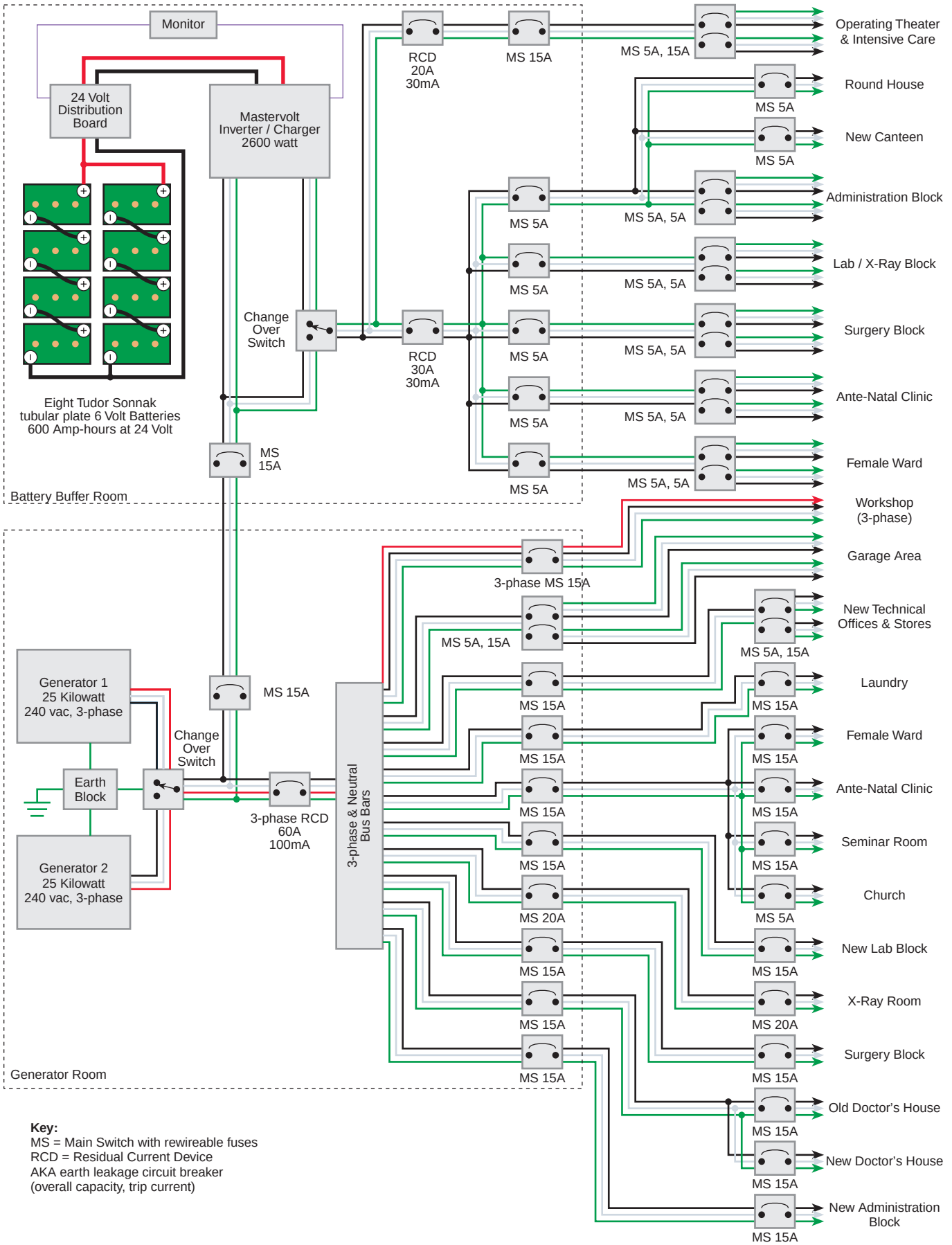
We were reluctant to install a 2,600 watt inverter-battery charger in such a remote hospital for the simple reason that repairing or replacing the unit, should it break down, would be a logistical nightmare. We know of many failed inverters in remote East Africa as lightning knocks out even properly grounded units. If the inverter goes down on a 240 vac battery powered system, everything goes down. Nevertheless, the alternatives were continued reliance on the generator (which would limit light availability to a few hours each night) or use of a direct-wired 24 VDC lighting system (which would not be able to power 240 vac hospital appliances). We discussed the possible alternatives with the hospital and donors, and they agreed that it would be worthwhile to take the risk and to get experience with inverter/battery chargers at Wasso. This installation would be a carefully monitored pilot project and the lessons learned could assist other hospitals in the future.



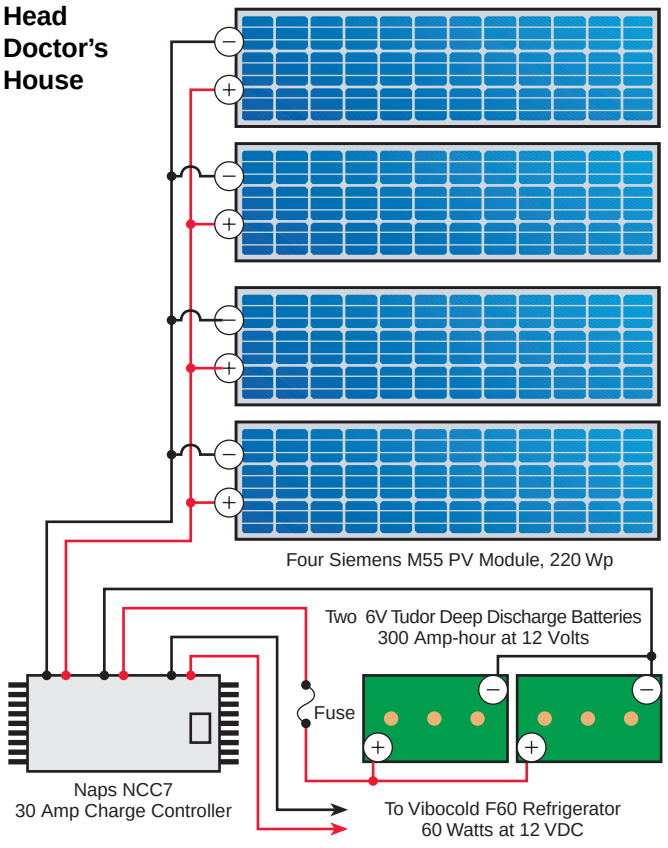
Frank Jackson installed the Mastervolt inverter/battery charger in the specially designated battery buffer room in the back of the Female Ward. First, the ward's wiring had to be isolated from the rest of the hospital wiring and upgraded. Given the poor state of the existing wiring (and its confusing and twisted arrangement), this took time. Then all of the 30 light fixtures in the ward were replaced with compact fluorescents. A 600 Ah 24 V Tudor battery bank was installed in the buffer room

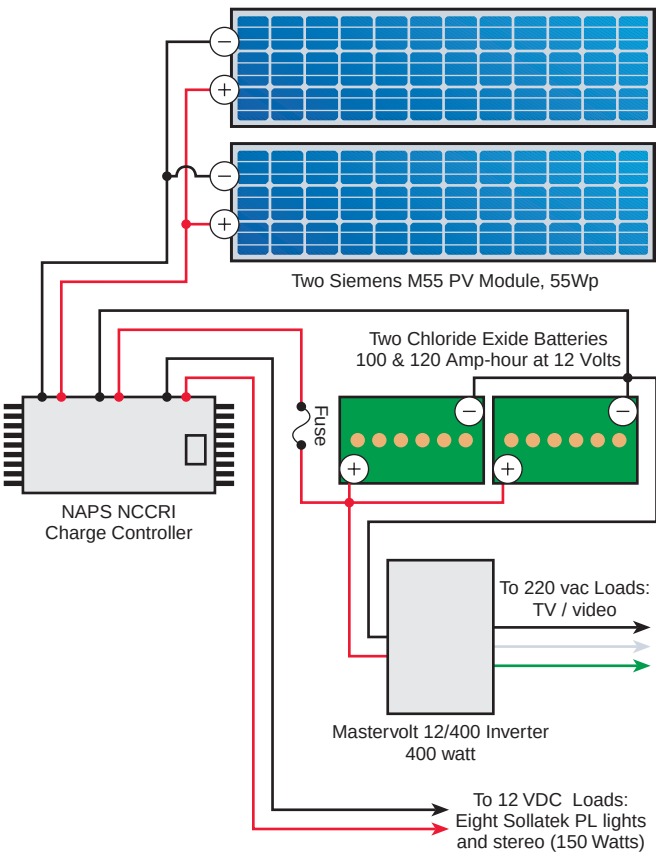


Hospital Generator / Battery System



Key:
MS = Main Switch with rewireable fuses
RCD = Residual Current Device
AKA earth leakage circuit breaker
(overall capacity, trip current)





and the Mastervolt inverter/charger was wall-mounted nearby. When they arrived, the battery interconnects, 250 A fuses, and DC switches were assembled with the shunt and remote monitor between the battery bank and the inverter. A change-over switch was installed to enable the hospital staff to switch between the inverter and genset in the event of inverter failure (the inverter switches automatically in normal mode). Appropriate RCDs were also put in place.

Follow-up

As mentioned, EAA works as a training and infrastructure development body and does work that is non-commercial in nature. This project involved many more person-days of time than an ordinary company would be able to offer. But the after-service and training was a crucial element of the work.

After the scheduled training and installation work was completed, Frank Jackson remained behind for an additional three weeks to tie up loose ends, monitor system performance, and assist in the establishment of a maintenance and operation routine. Hans Gelly also remained behind as a volunteer at the hospital for several months, working with the hospital electrician, Estomih John, to maintain the systems and to sort out some of the generator wiring problems. From Nairobi, I made sure that the solar water heaters made the journey to the hospital. They are being installed as I write this.

Two of the NGOs involved in the course received 55 Wp demonstration solar lighting systems for use in their projects. The purpose of the demonstrations is to give the NGOs' technicians installation and operational

Above: The battery / inverter system.

Above: Daniel Kithokoi and students installing a radio call system.

experience with PV. One course is never enough, technicians must do a number of installations before gaining proficiency. Hans and Frank assisted the trained technicians in installing the systems in areas near Loliando.

Six weeks after the installations were completed, things were still functioning smoothly. Staff now has light all night long (instead of only three hours per night), the doctor can work all night (or watch videos with staff), and babies can be delivered any time in the Female Block without having to fire up the generators. Although we found that the Mastervolt charger was delivering slightly less power than we anticipated, the records kept over the first six weeks indicated that there is plenty for the lights. Most importantly, there is a base of knowledge on site which can maintain the power systems and handle basic problems as they come up.

Above: Frank Jackson wiring the doctor's system.

As Energy Alternatives AFRICA continues to build solar energy infrastructure in the region through demonstration and training, we realize that there is more to remote system installation in Africa than good equipment. First, design and planning must be rigorous. Second, the team must be able to cope with all manner of unforeseen and unavoidable crises which range from missing parts to malaria attacks and washed out roads. Third, local skills and knowledge must be raised to acceptable levels for long term upkeep of systems. On this project, EAA didn't get a perfect score in all categories, but the team did install all the systems to a high standard and we did address the sustainability issues.

The energy problems of the hospital are not over. The generators need to be serviced and much of the wiring still needs to be redone. An energy plan and maintenance programme needs to be put in place. But this needs to be done in a manner that slowly improves the existing skills, services, and structures and which taps into the lively spirit of the Wasso Hospital staff.

Access

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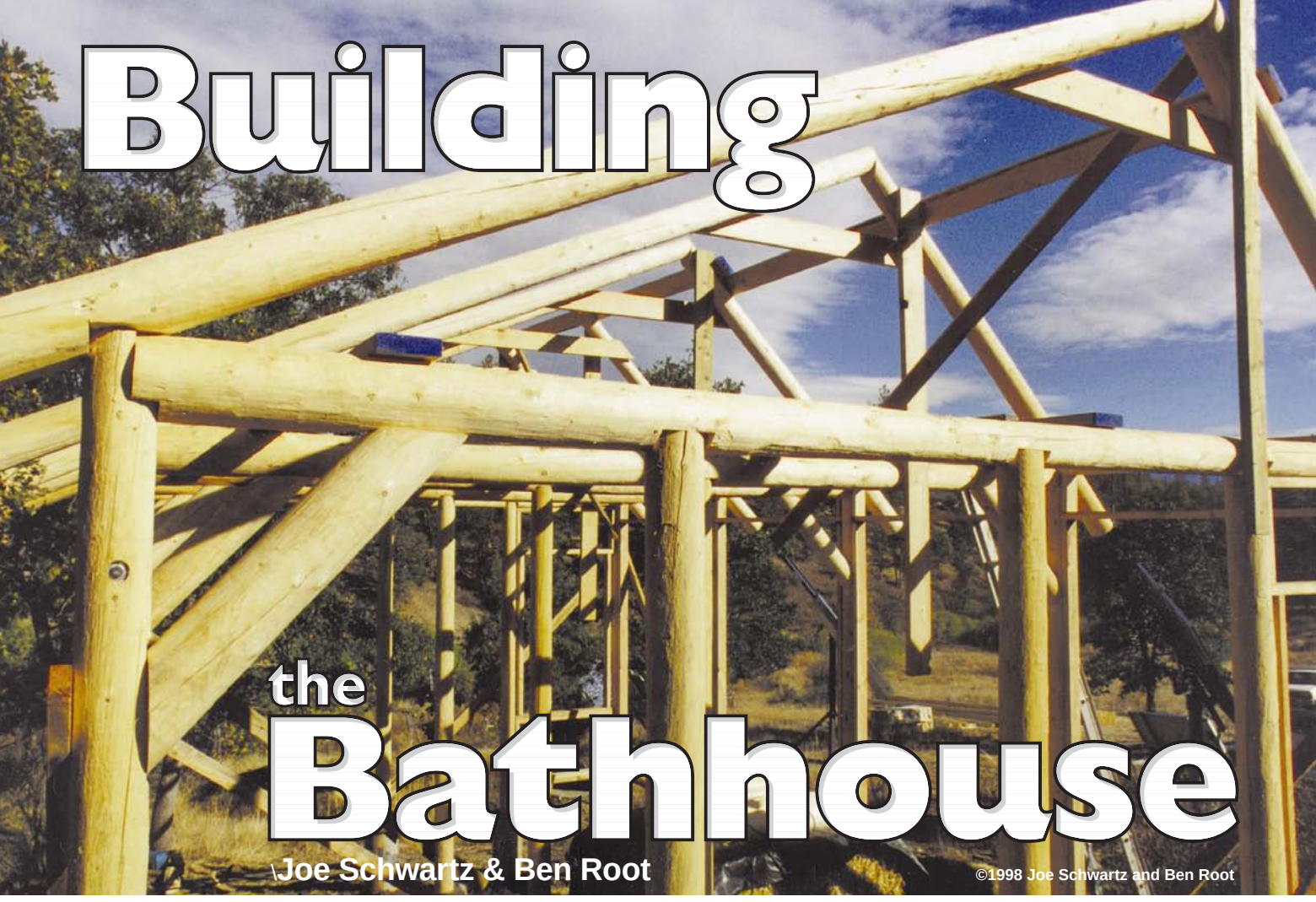
Building the Bathhouse



Joe Schwartz & Ben Root

For over twenty years Home Power has served as a test bed for renewable energy (RE) system hardware. The sheer volume of RE components living up on Agate Flat is a testament to this. Ancient PVs are still contributing to daily power production, worn out wind generators and electronics inhabit scrap piles and are up for grabs as spare parts, and untested gear waits its turn in outbuildings or under numerous blue tarps. While this scene would be expected by *Home Power* readers, another look around the property reveals experimentation in a wholly different direction.

In 1970, Richard, Karen, and friends built a 26 foot diameter wooden, two frequency, octahedral dome based on designs from Stewart Brand's original *Dome Book*. It was built with hand tools and took only thirteen days to complete. The dome had a dirt floor, no foundation, no insulation, and a roof that kept the rain out more often than not. It was also the first structure on the Flat where hay bales were used for something other than livestock feed–furniture! In 1973, The Pod, a 15 foot 8 inch diameter, twelve-sided stressed plywood structure on a six foot high platform was built. The dome became the hay barn, which isn't the most efficient space in which to buck and stack hay! An old tipi platform in the pine grove is now a nice place to sit and stretch. Currently, Home Power Central is housed in the Plywood Palace, which utilizes rough sawn fir in its more conventional construction.

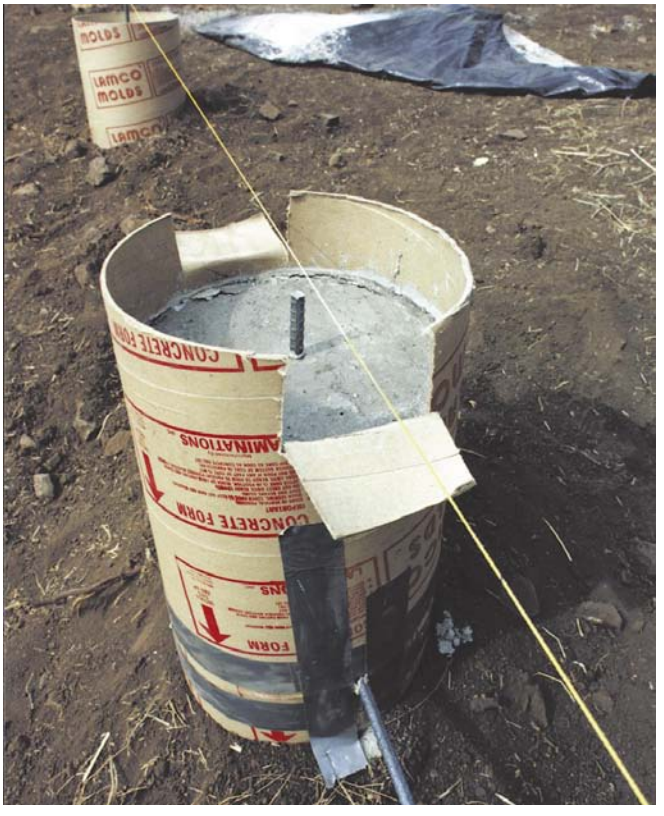
When word came 'round that Richard and Karen were ready to build a bathing facility, we were stoked to try some low-impact building systems including straw bale wall construction, now experiencing a revival. Since we weren't the ones dropping the cash on the project, we approached them somewhat tentatively with our ideas. Richard was grinning when he said, "Take a look at this place! It's always been experimental."

Right off the bat we'd like to share two insights after working on the bath house project for a little over a

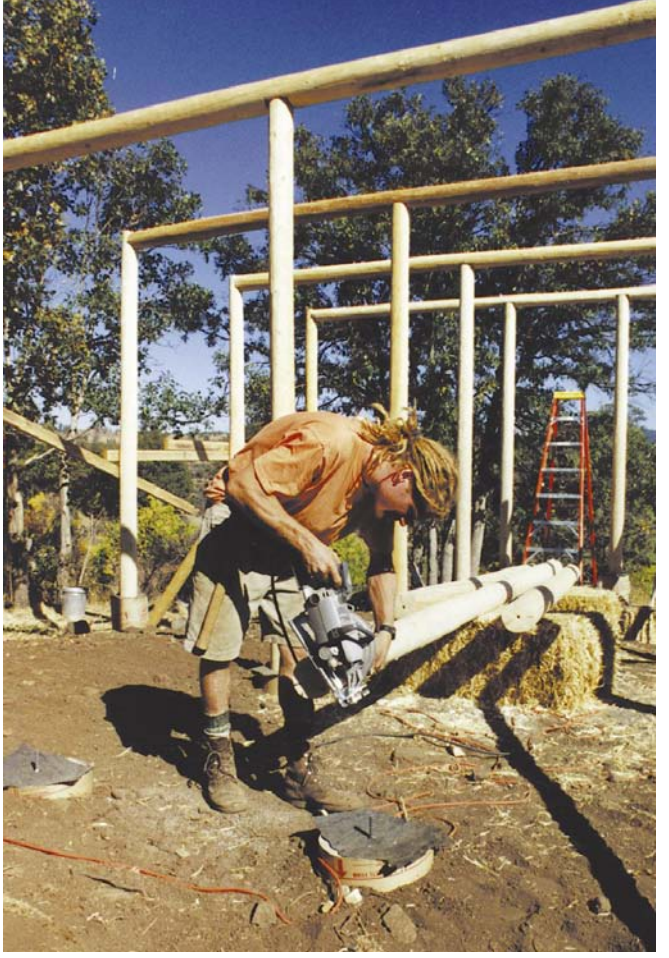
year. First, straw bale construction is a somewhat less technical building method for the inexperienced owner/builder. But construction experience is still required, especially when the roof and finish details come into play. Second, ecological implications aside, don't plan on saving piles of money by building with bales. Wall construction typically accounts for only about 10% of a structure's overall cost. Even if we assume that we can complete straw bale walls for half the cost of a standard 2 by 6 stick frame, the materials and labor expenses saved is still only 5% of the total building cost. This isn't to say that construction costs can't be brought way down on a given structure, but utilizing straw bales only accounts for a portion of these savings.

Off the Ground

In the U.S. one of the least expensive and most commonly used methods of outbuilding construction utilizes posts set on independent pier footings rather than a continuous footing. Concrete foundations have a monstrous embodied energy value and aren't cheap. If built right, pole structures can save you a substantial amount of money before the project is even off the ground, so to speak. For the bathhouse project we opted to utilize this post and pier technique to support



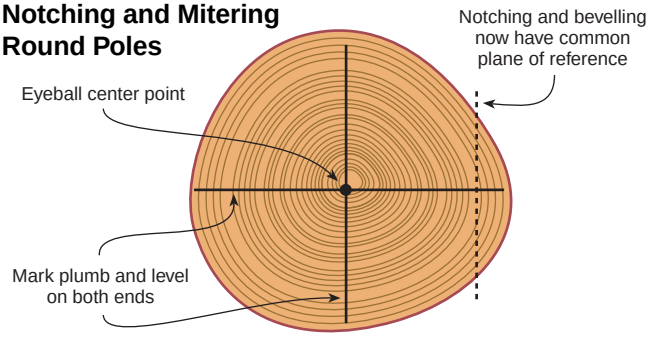
Above: Twelve inch concrete piers extend below frost line. Rebar prevents lateral movement of posts.

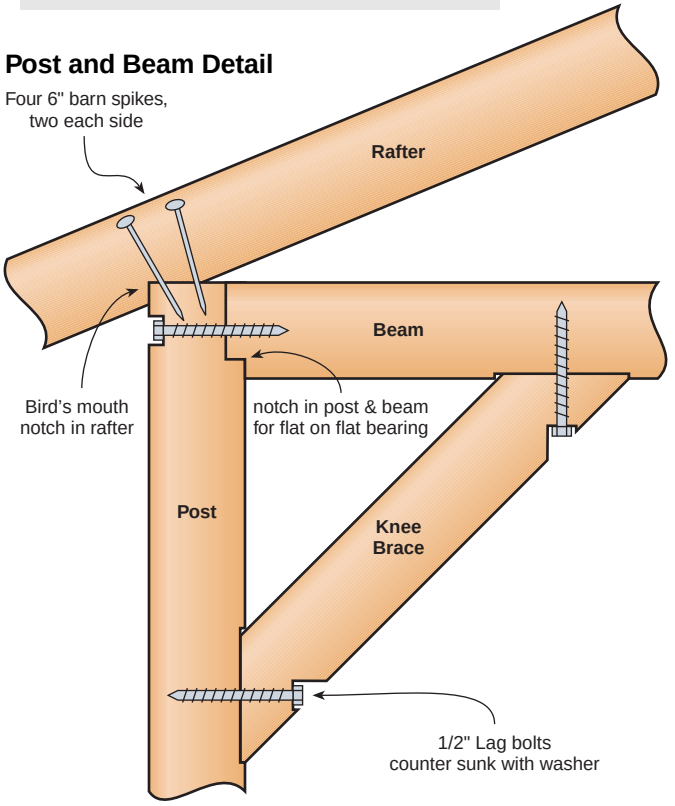


Above: Joe notches beams.

the roof load, keeping the straw bale walls non-load bearing. The building was laid out and post holes were hand dug 2 feet deep and 18 inches wide. Agate Flat has a very stable clay based soil and a frost depth of 12 to 18 inches, so these specifications were appropriate. Make sure to research frost depths and soil types in your region prior to pouring footings as requirements will vary. Case in point: when we utilized the same footing method in northern Vermont, post holes needed to be a full 4 feet deep to get safely below frost level. Needless to say we were happy to be digging in southern Oregon. To get the piers above grade we used 12 inch diameter cardboard forms often referred to as Sona tubes, the trade name of one form manufacturer. The tubes were suspended approximately 8 inches above the bottom of the holes. This allowed the hand mixed cement to flow out the bottom of the tubes to

Notching and Mitering Round Poles





Above: Posts and beams still spotted with stucco.

create an 18 wide by 8 inch deep footing for the 12 inch diameter concrete columns to bear on, distributing the building's weight. Rebar was used to reinforce each individual footing as well as to tie the piers together above grade, forming a rigid foundation grid.

Framing

The frame of the bathhouse rests on these piers. We recycled asphalt roofing from the original dome to use as a moisture barrier between the posts and concrete, which can wick water. The poles were 6 to 8 inch diameter peeled Lodgepole pine which generally grow straight-as-straight. However, compared to working with dimensional lumber, pole work is more labor intensive. The frame of the building still went up in about a week, or 80 hours of total labor.

Post heights were calculated by shooting the relative height of each individual pier and correcting for the total wall height. Posts were squared off with a chainsaw and dialed in with a hand held Makita power planer and a framing square. Since our skill with a chainsaw was limited to cutting firewood, the planer proved to be an indispensable tool for squaring up our cuts. The bottom of the posts were drilled out and tightly fit over 4 inch, #4 rebar anchors that had been set in the concrete piers during the pour. These anchors protect the posts against lateral movement with the weight of the building doing the rest.

No sophisticated scribing was used in the frame joinery. Our technique was very similar to building a really tall post and rail fence. Notches were cut into the posts and connecting beams with a Skil saw and evened up with sharp chisels. The notching allowed for the bearing of

Below: Ben cleans up a notch in a beam.

each beam to be directly over corresponding posts and therefore directly over the concrete footings. The five individual bents were plumbed up and then held square with 3 foot knee braces angle cut to 45 degrees.

Things got much more complicated when we began roof framing. The roundness of the building material added to the complexity and construction time. The trick was getting the plumb cut at the top of the rafters on the same plane as the birds mouth on the bottom. We secured each framing member to a set of saw horses and drew corresponding plumb and level reference lines on both ends of the pole. Now we could rotate or spin the poles in any direction, as required to make cuts, and still come back to a definite position to mark out the next cut. We devised an elaborate series of jigs that allowed us to make our initial chainsaw cuts which were then cleaned up with the power planer and hand chisels.

Above: The east end shows dirt bag, stone, and straw bale techniques.

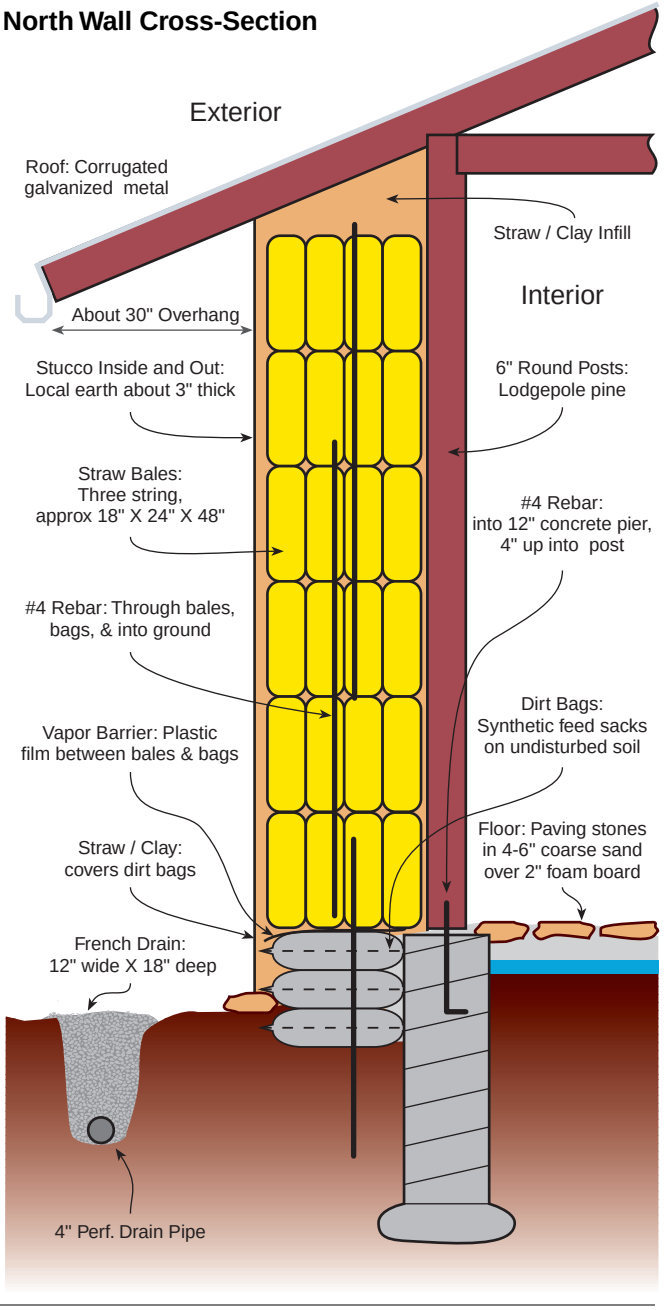
We became meticulous when making these measurements and cuts since positioning the 18 foot rafters on the roof was an effort that necessitated much gruntin' and groanin'. We sure didn't want to do it twice! The north roof pitch was set at 5/12 to match the neighboring framed building. The south roof was set at 12/12, or 45°, which on Agate Flat is close to the optimal angle for solar thermal collectors. Dimensional 2 by 4 inch purlins were notched in place which was also a trick considering the variations in rafter diameter. New galvanized metal roofing was applied because of its low price and durability, creating a full-on straight roof line.

Dirt Bags

With the building's frame and roof load supported, we began building a footing to carry the weight of the bale walls. The grade at our site dropped off 4 feet over the building's length and we wanted to build up the footing level. As a result there would be no need to step the bale wall and deal with the vagaries of bale dimensions. Hinterland Llama Ranch in Sisters, Oregon hooked us up with 200 plastic feed sacks for the construction of the wall footing. From then on we began, and continue proudly, to refer to ourselves as "Dirt Bags."

To control water runoff around the building perimeter, we laid 4 inch perforated pipe and gravel in a French drain that was hand dug around the north, west, and south walls. The grain sacks were filled with dirt from this perimeter drain, laid in a running bond, and compacted by much jumping-up-and-down on each

North Wall Cross-Section



Above: Driving the rebar which pins bales together.

course. They were finally pinned to each other and the ground with lengths of rebar. These flexible bags of dirt were amazingly self leveling. We also found that we could easily correct the level of each course by adding or removing dirt from individual sacks. The open ends were merely tucked under before the next bag was snugged in place. The dirt bags proved to be an inexpensive, fast, and forgiving construction material and created a bomber base for the bales.

A word of caution. When we picked up the grain sacks our friend Danny at the ranch warned us to keep the bags out of the sun. After the footing was built, covering it somehow got put on the 'round-to-it list and never happened. We experienced significant photo-degradation on the east footing within six months, and now must do some repairs. So keep the sacks out of the sun!

The wall footings were completed by building the south and southeast retaining wall with local stone. Basalt gathered from a nearby cut along the creek bed was built in to a rustic but beautiful front wall. Only the cap stones were mortared to prevent weathering.

Straw Bale

Straw bale walls go up fast. We had them up and secured in a day. We still laugh about how little the bales actually have to do with a straw bale building. Building with bales requires few tools and the bales themselves are a relatively intuitive material to build with. The speed the walls went up was due to where we chose to use straw bales. All building materials display characteristics which make them more efficient under certain circumstances than others, and straw bales are no exception. Ben's building design specified bales only where their dimensions seemed appropriate.

To capture solar gain for space heating and plant growth, the building's south wall is mainly glass with posts to support the roof load. Entrance doors and a pair of small windows are located along the south eight feet of both the east and west walls. This layout eliminated the variables inherent in floating window casings in bale walls, as well as the time consuming job of cutting and retying bales to custom dimensions. In addition, the dirt bag footing was laid along the outside of the building posts, so there was no time spent fitting the bales, or the footing for that matter, around the posts. Bales enclose the entire north wall of the building and wrap around half of the east and west walls. These wall segments have no windows or obstacles to work

Below: Dave sifts the good stuff.

around. The bales were laid in a running bond just like the dirt bags and pinned with overlapping lengths of rebar. To keep them from bowing out from the frame, each course was tied to the posts as the wall was built. This technique created a structural tie between the bales and the building's frame while still allowing the bale walls to settle. We were working with 10 foot pieces of rebar so the roofing needed to be left off until the bale walls were built, allowing adequate clearance for driving the rebar.

The bale walls remained without stucco through the winter of 1996/97 while we completed a mud room and pantry project for the current Home Power cabin. We watched the straw bale walls closely over the winter. As the rain fell and the snow piled up, the large overhangs kept the bales dry. The dirt bag footing and French drain kept the base of the bales well above grade and away from any water runoff. If you're building in a climate where precipitation is moderate to heavy, make sure to give ample thought to these elements of building design. Our bale walls never got wet except in seriously driving rain. Remember, straw bales are not a forgiving building material when excessive moisture is an issue.

Stucco and Cob

We began applying stucco last fall after giving the bale walls nine months to settle. For 200 bucks we found an old cement mixer with a 4.2 amp, 117 vac motor from a junked washing machine. It worked flawlessly, cut down the time involved in the stucco process by an easy 50%, saved all our backs, and gave Mix Master Dave time to flip CDs every couple of batches. It's an enlightening sight to watch a cement mixer hard at work, running off nothing but sunshine!

We began applying stucco just in time for the cold weather to start creeping in. The nights were still above freezing but we took to heating pots of water on the woodstove, adding it to the mix to make the mud temperature tolerable on our hands.

We heard that chicken wire wasn't necessary unless synthetic stucco was used over foam board. After a bunch of back and forth we decided to use chicken wire as a stucco mesh anyway, figuring the more strength the better. After the first batch of mud our hands were thoroughly shredded by the chicken wire. Trowels didn't work either as the corners constantly got hung up in the wire. So, off with the chicken wire and on with the mud, which stuck wonderfully to the rough bale surface!

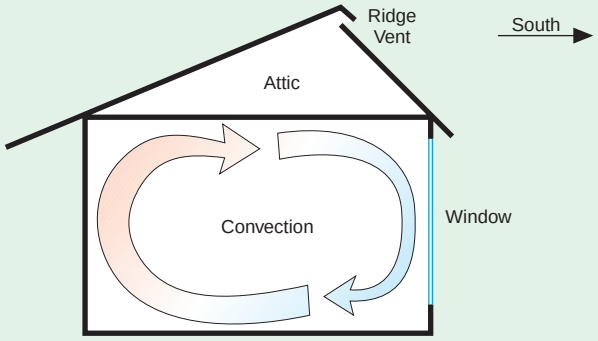
Above: Mix-Master Dave spins the hits
The solar-powered mud machine saved much labor.

Our interior and exterior stucco finishes have four distinct layers, each with a different earth-sand-water ratio. The soil on Agate Flat has a high clay content, so our different mixes were always based on adding varying amounts of sand. Our stucco seemed to work out like this: more sand = less cracking = harder to apply. No sand was added to our first layer as we

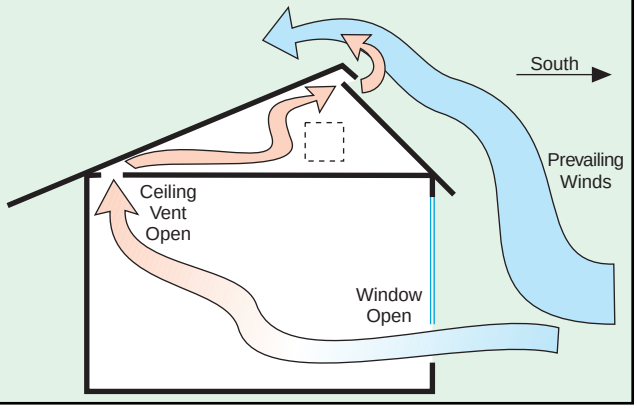
Below: Joe and Doug spread the first thin layer of stucco.

Bath House Ventilation

As mentioned in the previous article, this building is not a living space. The excessive glass necessary for the garden bed makes larger temperature fluctuations possible. While the southern roof overhang will help prevent overheating in the summer, we designed a ventilation system to help fine tune interior temperatures. The top diagram shows air movement during a typical heating cycle. Sun shining through the south windows heats the air and floor mass of the building. Rising hot air would tend to stratify, but cooling along the glass face causes a convection cycle as shown.



In the second diagram the lower portion of the south windows are opened to catch the prevailing winds. Also, vents in the ceiling along the north wall are opened. A chimney effect is created with air flow travelling through the building and into the attic space. There, the air can either escape through the ridge vent or out two vents in the gable ends. Adding vents on the north side of the ridge could have taken advantage of the low pressure on the leeward side of the roof by drawing air from the attic, but we felt that the current design is adequate. The west end vent is merely louvered while the east end contains a Sol-Aire 24 Volt DC fan. Except for experimentation during the stucco drying process, we have not yet had to open the ceiling vents…but summer is coming.



wanted it to be as sticky as possible to create a positive bond between the straw and the successive stucco layers. Water was added until it was the consistency of a cream soup enabling us to work the mix deep into the bales with our hands. For the second coat about 25% sand was added to the mix along with several large handfuls of chopped straw to add tensile strength to the stucco. Thanks to Bob-O for loaning us his chipper to chop straw. It was mixed thick like pudding and we were able to get a 1 to 1 1/2 inch layer on the walls. Between the second and third layers, clay with cob and straw was used to fill low spots and gaps between bales and along the gable ends. The third layer consisted of the same earth-sand ratio without the straw, adding another 1 inch to the walls. The finish layer was a mix of 50% sand and 50% earth and was the only layer we ran a trowel over for a rough finish. The multiple layering system gave us about 3 inches each of interior and exterior stucco that set up nearly as hard as cement.

Initially, we had been concerned about the perfect stucco mix. We found, however, that trial and error quickly led us to the right recipes. Thicker was easier to spread though harder to get out of the mixer. Sandier prevented cracking but didn't stick as easily to the layer beneath, and was rougher on the hands. We suggest that you just experiment. Besides, it's fun…really!

Using earth stucco on straw bale walls is a dynamic process as both temperature and humidity radically affect the building material during application and drying. As our second layer set up, we began to notice some surface mold growing on the straw we had added to the mix. None of us had any experience working with stucco, synthetic or otherwise, and none of the books we read or people we spoke to mentioned anything about mold during the drying process. Admittedly, we freaked a little. The more we thought about it the more we were convinced that mold spores were likely to be present in straw and that water was going to wake 'em up like a strong cup of coffee. Barring rampant herbicide application, this was accepted as part of the process.

Close inspection revealed that the mold only occurred where the straw was exposed to air and as soon as the layer dried the mold died off. In addition, the bales themselves were completely dry so outside water infiltration was eliminated from the figurin'. We also found that the walls inside were experiencing more mold than the outside, presumably due to higher humidity, higher temperatures, and less air circulation than outside. The humidity inside the building was as high as 90% from all the moisture introduced by the wet stucco. Our first reaction was to dry the walls out and

Materials Costs

Location	*Material*	*Cost*	*%*
Foundation	Drain pipe	$35.00	1%
	Feed bags	$0.00	0%
	Sona tubes	$125.00	2%
	Redi mix	$221.00	4%
	Rebar	$68.00	1%
	Rigid insulation	$131.00	2%
	Mortar mix	$25.00	1%
	6 Mil. plastic	$38.00	1%
Framing	Lodgepole	$576.00	10%
	Dimentional	$574.00	10%
Decking	Cedar	$163.00	3%
Siding	Pine	$931.00	16%
	Straw bales	$590.00	10%
Stain	Pine	$144.00	2%
Roofing	Galv metal	$640.00	11%
	Felt paper	$59.00	1%
Doors	Salvage	$135.00	2%
Windows	Salvage	$348.00	6%
Hardware	Misc.	$550.00	9%
Insulation	Fiberglass	$252.00	4%
Truck Rental		$223.00	4%
	Total	$5,828.00	
	Cost / Sq. Foot	$16.00	

deprive the mold of all necessary moisture. So we fired up the woodstove good and hot to force dry the walls. They cracked rather severely! Oh geez…

For the next layer we opened up the building to full ventilation mode. While this increased circulation for drying, it also made for one cold work space. We finally dialed in our climate control by closing the building, keeping the stove temperature down, and regulating the temperature to 65°. Humidity dropped to around 60% and we were in business.

The other wall areas of the building, above and below windows and doors, were framed with conventional lumber and insulated with fiberglass. They were sided with 1 by 12 pine board and batten. The natural materials; straw, stone, and wood; while rustic, play off each other in a beautiful way. Metal roofing, steel cable railings, and glass add just a touch of tech.

For What It's Worth

Our monetary goal was to keep the materials cost of the bathhouse under $20 a sq. ft and we came in at a respectable $16. We trimmed money off the project by not using excavation equipment (other than shovels),

Above: The Turd Tower with obligatory moon window. The small PV powers the toilet's vent fan.

tons of concrete, or too much milled lumber. We saved some money by using straw bales, dirt bags, and recycled lumber. We saved piles of money by using salvaged windows and doors.

See the Letters section for some interesting feedback from readers about the bath house project.

Access

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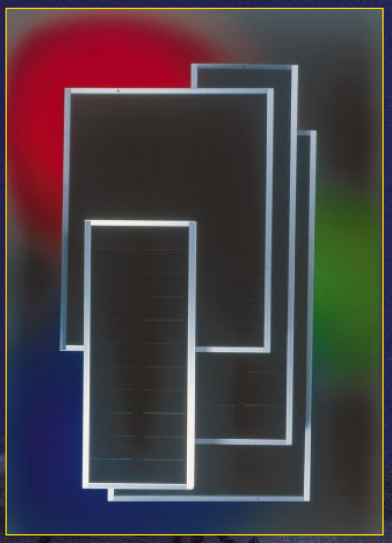

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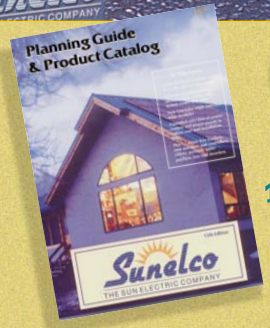

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Make It Easy On Yourself

Shari Prange

Some people love a challenge. Like my cat when she purposefully bats a ping pong ball under a bookcase so she can spend the next hour trying to extract it again, some people seem to enjoy making things complicated, then solving the puzzle they've invented. The rest of us like to make it easy on ourselves whenever possible. This is never more true than in electric car conversions.

Above: Reserving the central area under the hood for batteries will make your conversion easier.

If your goal is to build an automotive Rubik's cube, you can skip this article. If, however, you would like to have a life outside your garage, then let's look at ways to make the process of building and working on an electric car as easy as possible.

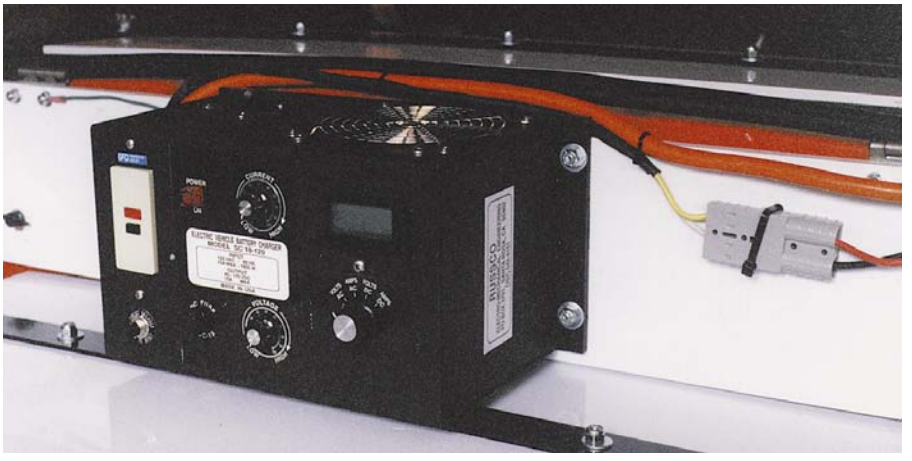
But It Came Apart So Easy!

Some of the things you take apart have to be put back together later. Make notes, take photos, and take videos. A few weeks or months from now, you won't remember how it was supposed to go. You will probably take the hood off for the duration of the project. It's important to get it perfectly re-aligned when you put it back so that your latch will work properly. To make this easier take a scribe or felt marker and trace the hinges on the underside of the hood before removing it. When you re-install the hood later you will have a perfect outline on which to line up the hinges. Don't throw anything away (space and significant other permitting) until the project is finished. Keep all the hardware carefully bagged and labelled with its original use. There are many times when you can save yourself hours of design and fabrication by adapting bits of original brackets to new purposes, and fastening into existing threaded blind holes in the chassis.

Location, Location, Location

One of Murphy's military laws states "No battle plan survives first contact with the enemy." In a conversion, a lot of plans may seem wonderful, clean, and easy in your head, on paper, or on your computer screen. They may not survive first contact with the chassis. If they do you may come to regret them when you have to live with them. One common mistake is to group all the components into one big, pretty box under the hood. This makes it very hard to fit any batteries up front, so they all end up in the back which results in a car that handles like a pig on ice. When planning layout, locate the bulkiest item first. This will be your battery pack. The big open area under the hood is prime real estate for batteries. Note the components, such as the motor or power brake system that have functional needs to occupy specific

Below: A quick-disconnect is much preferred to hard-wiring the charger.



locations. After that, work on grouping your batteries in the space available in the least complicated arrangement possible. The ideal is a simple cube, making rack and box design simpler. The peripherals; controller, contactor, DC to DC converter, etc.; belong around the periphery.

Using Stunt Doubles

With all the subtle angles and protuberances under the hood, it can be difficult to figure out whether your batteries will fit. Since batteries are rather heavy it's not easy to use them to test the fit. Instead, build yourself some dummy batteries out of poster board or foamcore. Foamcore is great stuff and available at art supply stores. It's a sheet of rigid foam sandwiched between paper. It's light, can be cut easily and precisely with a razor knife, and can be glued easily with a hot glue gun. You can also use foamcore to build dummies and test fit on motor mounts or a full battery box.

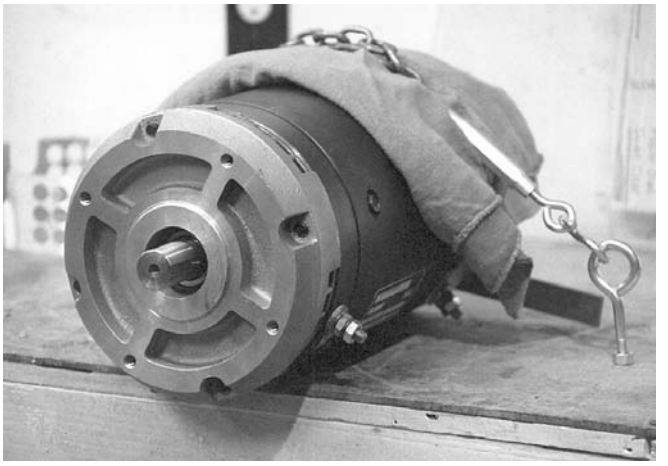
When sizing your battery box, be sure to account for the thickness of the material and the interference between the inside radius of your welded rack and the square corners of the box. Also, add 1/16 inch to each dimension on each battery. As batteries age they swell. One EV pioneer passed away and his car was sold by his widow. When the new owner went to replace the dead batteries, they wouldn't budge. He finally had to pump as much acid as possible out of a couple and cut them apart to free up the pack. No fun.

Plan Ahead

Remember that your batteries need and deserve minor but regular service. If this is hard to do odds are you won't do it, so make it easy. Make sure you have reasonable access to your battery tops. Can you see the electrolyte level to check it? Can you add water or use a hydrometer? Can you clean or tighten terminal connections? One fellow wanted to keep his Porsche 914 as close to visually original as possible. When he decided to add two more batteries to raise his system voltage, he installed them on each side of the motor below the rear trunk. They were invisible, kept the weight low, but it took two hours and a floor jack to lower each one to check the fluid level. Bad design. Components may also need to come out some day for service or modification. Don't weld or rivet on a belly pan, make it removable. Instead of hard wiring your charger into the car, use a quick disconnect Anderson connector on the wires.

Professional Motor Wrestling

Motors are big, heavy, and don't have convenient handles. Moving them and working on them can be difficult, and dropping one is painful. In order to hoist that motor onto the work bench, make some instant handles. Get a couple of 3 1/2 inch bolts that match the



Above: Two eyebolts, a chain and turnbuckle, and a steel strap (right rear) hold the motor securely.

mounting holes on the end of the motor. Thread them in a half inch. Presto, handles! Once on the workbench, you'll need to immobilize the motor while you attach your adaptor and clutch. Install a couple of hefty eye bolts in the workbench, one on each side of the motor. (Don't fret about making holes in your bench, these may come in handy for other projects, too.) Drape a towel over the motor to protect the surface. Then fasten it down with a short chain between the eye bolts, tightened with a turnbuckle. Of course, you need to keep the motor from rotating, too. A short, flat piece of steel with two holes in it can be bolted to the mount holes on the back of the motor so that it braces against the bench to resist rotation.

Now, With Your Other Hand…

Components will end up in awkward places. It can't be helped, but there are ways to minimize the pain of installation. Components with related interconnections, such as the controller, main contactor, and ammeter shunt, can be grouped together on a common component plate. This allows you to wire them in comfort on a workbench instead of pretzeled under the car. Sometimes it is difficult to hold components in place while getting the threads started on the mounting bolts. With a component plate you can install a couple of permanent studs on the chassis, matched to holes on the plate. Slip the plate over the studs and let them support the assembly, leaving both your hands free to deal with nuts, bolts, and washers.

Cable Cooperation

A 2/0 cable can be very obstinate, not wanting to bend the way you want it to. Sometimes this happens because you need the cable to twist in order for the flat of the lug to line up properly with a component terminal. The shorter the cable, the worse the resistance. To avoid this problem, cut your cable to length and fit both lugs in place, but only crimp one of them. Go to the car and bolt the crimped lug into position. Then route the cable to its destination and rotate the lug on the other end of the cable for the best fit. When you're satisfied,

use a felt pen to make a mark across the cable insulation and lug barrel. Also mark the lug (not where it will be covered by shrink tubing) with a "+" or "-" to indicate which end of the connection this is. Now you can take the cable back to the workbench, make sure the line on the cable matches up to the line on the lug, and crimp it permanently. Back at the car, your polarity mark on the lug will tell you which end to attach where.

Color Coordinated

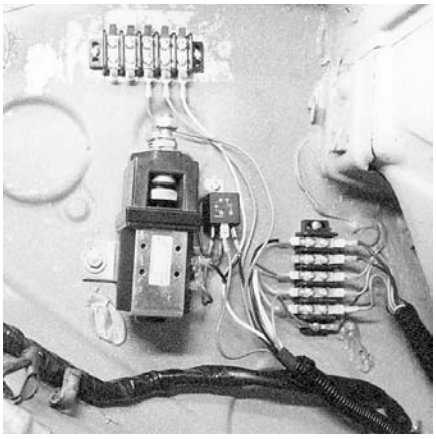
Your wiring needs a consistent color code, unrelated to the color of the paint job or upholstery. This makes it easier for you to work on the wiring months and years down the road. The easiest course is to follow the car's original codes as much as possible. If you have to make an extension of an original wire use the same color wire. If grounds are always brown make yours brown too. Some original wires have a base color and a contrasting stripe. Very chic, but hard to match with off-the-shelf wire. In this situation, match the base color and use bottles of touch-up paint or model paint to band it every few inches with the contrasting color. Electronics hobbyists sometimes use little numbered tape strips to identify wires. These don't work as well under the hood where road splash and temperatures may make them unreadable or cause them to fall off.

Looms

The shortest distance between two points is a straight line, but that's not always the best route. Don't run each wire individually from source to destination. This effect is known as "explosion in a spaghetti factory." It seems easy at the time but makes life harder later by making the car difficult to work on and increasing the chance of a pinched wire and a short circuit. If your 12 Volt system gets accidentally crossed with your traction pack voltage, things could get really exciting. Instead, gather your wires into looms and run them around the perimeter, peeling out individual wires as their destinations go by. You can often follow and fasten to the car's original wiring loom. An easy "instant loom" is four-in-one trailer wire. This is a ribbon of four different colored 16 gauge wires bonded together. As the ribbon reaches a component along its route, you can easily peel off one of the four wires and cut it to length.

Get It In Writing

When you're building your car it may seem like a pain and an interruption to stop and document everything you do. However, it will be much more painful some day in the future if you don't. You are building the owner's manual for your car. If you do it right, one day three years from now when you are troubleshooting a problem or installing a new gizmo, you will thank yourself for your foresight. The most important thing to document is your wiring. Get a set of colored pencils or pens and draw a wiring diagram matching the color codes of the wires. Be sure to include wires that are in place but not currently in use, and label them as such for possible future use.



Right: Color-coded wires gathered into looms make it easier to work on the car later.

Honey, Could You Hold This?

There are times in both building and troubleshooting an electric car when you need to check for full pack voltage with your handheld voltmeter. Unfortunately, sometimes your most positive terminal is here and the most negative is way over there. Or perhaps you want to check it from the driver's seat. You don't, of course, need to take your reading directly off the battery terminals. It might be more convenient to pick up the most positive leg from the positive terminal of the main contactor, and the most negative from the battery negative terminal of the controller. These will give you pack voltage. You can also solve this problem by building in a test point. This can be done easily under the hood with two 16 gauge wires (black and red, respectively) from the most negative and most positive terminals to a common, easily accessible point. It's best to connect these to the contactor and controller as described above, rather than installing small gauge wires on battery terminals. Terminate the wires in fully insulated female connectors and tie wrap them together. Your voltmeter probes will fit nicely into the connectors and the insulation will keep them safe when they are tucked out of the way between uses. In the cab you can build a similar test point from the terminals of your dash voltmeter and mount it in an inconspicuous but handy place. This would be useful if you wanted a more precise reading than the dash gauge provides for diagnostic purposes.

Do Yourself A Favor

These are just a few suggestions to save you some time, effort, and grief when you are building or working on your electric car. Next time, we'll talk about things you can do to make the car easier to use in daily life.

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Mike Brown

"What is the difference between battery Amps and controller Amps? Is the voltage steady out of the controller and this is why there's a difference in Amps?"

I got an e-mail last week with several interesting questions, including this one. I'm going to e-mail answers back to the gentleman, but I have picked this question for this month's column.

We are talking about the most widely used electric car speed controller, the Curtis/PMC, although this information would apply to any pulse width modulation (PWM) controller. The average voltage out of the controller varies as well as the Amps. What accounts for the motor/controller Amps being higher than the Amps coming out of the battery pack is the "chopping" action of the controller.

The PWM controller is basically an electrically operated switch that switches the electricity from the battery pack to the motor off and on very quickly (15 kHz). This controls the speed of the motor. The amount of "time on" versus "time off"—the width of the energy pulse—averages out to determine the voltage the motor sees. For example, if you have a 120 Volt battery pack and the controller is pulsing "on" half the time and "off" half the time, the motor will respond as if it were getting a continuous 60 Volts. At 15,000 pulses per second, this happens so quickly that there is no jerky sensation in the motor operation.

A by-product of the PWM control system is current multiplication during acceleration and low-speed operation. In this situation, you need torque more than rpm. Torque is determined by Amps and rpm by Volts. When the EV is in this mode the PWM controller allows more current to flow into the motor than flows out of the battery pack. This happens because the controller acts like a DC transformer which takes in low current and high voltage and puts out high current and low voltage. Thus, during these times, the battery pack has to supply only a portion of the current needed to operate the car. This effect continues at a diminishing ratio of Amps out of the battery pack to Amps into the motor until the motor hits full speed. My first EV had a series/parallel voltage switching control system, and the ammeter seemed to live pegged at the 800 Amp mark. After I installed a PWM controller, the car accelerated faster, was at the 400 Amp current limit for only seconds before the current demand started to fall off, and the range was increased significantly.

This difference in battery Amps versus motor Amps leads to a lively debate over where to put the shunt for your ammeter. Do you want to read what you are taking out of the batteries or what you are putting into the motor? My policy has always been to put the shunt between the controller and the motor to read motor Amps, since this will show me how much current is actually circulating through the motor. As I mentioned above, depending on the operating mode we are in, there may be a difference between battery Amps out and motor Amps in. One reason for knowing motor Amps is troubleshooting performance problems. An increase in amperage draw over what you are used to seeing at a certain place in your daily trip might indicate a mechanical problem like a low tire or a dragging brake. The controller company's tech support people will also want to know motor Amps when attempting to diagnose a controller problem. I hope the above discussion shed some light on the benefits and operation of the PWM controller.

Thanks to those of you who have sent in questions I'll try to find answers for you and get back to you. Keep them coming.

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Grounding

John Wiles

Sponsored By The Photovoltaic Systems Assistance Center Sandia National Laboratories

In my last Code Corner Article, I mistakenly stated that Drake Chamberlin, in his Code Counterpoint letter in HP 62, thought there wasn't much reason to use 90°C wiring on PV modules. I am sorry that I misunderstood what Drake was trying to say. As a practicing electrician in Colorado, he is installing PV systems and knows the requirements of the NEC® and local codes. We both know that most listed PV modules are marked with a requirement to use 90°C conductors.

Grounding

I get more calls each month on grounding PV systems than any other subject. The NEC covers this subject in Article 250, Article 690, and in several other locations including definitions in Article 100. For those who want to achieve a good understanding of the subject of grounding, I recommend the National Electrical Code Handbook and the International Association of Electrical Inspectors (IAEI) Soares Book on Grounding. See Access. The Soares book even gives some of the 100-year history on the grounding requirements in the United States.

Definitions

Electrical systems (including PV systems) are solidly grounded to limit the voltage with reference to ground during normal operation and to prevent excessive voltages due to surges from lightning or unintentional cross connections with higher voltage lines. In PV systems, the modules are usually mounted in high, exposed locations where they are prone to picking up surges from nearby lighting strikes. Utility-interactive inverters are subjected to surges on the power line. Systems using PV power to run computers with hardwired modems are subject to surges from the telephone line. Proper grounding effectively deals with these potential problems and more.

The term "grounded" indicates that one or more parts of the electrical system are connected to the earth, which is considered to have zero voltage or potential. Unfortunately, the earth isn't always at zero potential, and that complicates the grounding requirements. To better understand the grounding requirements, it is necessary to examine several terms used in conjunction with grounding.

The grounded conductor is a conductor that normally carries current and is connected to the earth. Examples are the neutral conductor in an ac wiring and the negative conductor in many DC systems. Note that some DC systems such as telephone systems connect the positive conductor to ground rather than the negative conductor.

An equipment grounding conductor is a conductor that does not normally carry current (except under fault conditions) and is also connected to earth. It is used to connect the exposed metal surfaces of electrical equipment together and then to ground. An example of an equipment grounding conductor is the bare conductor in non-metallic sheathed cable (Romex®). The green-insulated conductor in power cords for ac-operated portable equipment is another example of an equipment grounding conductor. These equipment grounding conductors help to prevent electrical shocks and allow overcurrent devices to operate properly when ground faults occur.

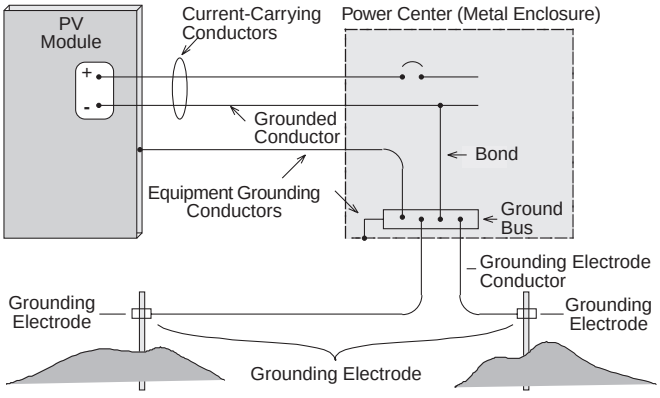
A grounding electrode conductor is a conductor between a common single grounding point in the system and the grounding electrode. Splices in this conductor must be made with special devices or welded.

A grounding electrode can refer to the common 5/8 inch diameter, 8-foot long ground rod or other metallic device that is used to make actual contact with the earth. There are "made" grounding electrodes (ground rods) and other types of grounding electrodes such as metal water pipes, metal building frames, and concrete-encased cables (known as UFERs after their inventor). Specific requirements for each of these grounding electrodes can be found in Article 250 of the NEC. Local codes and practices vary greatly and should be investigated to determine which types of electrodes are being used.

Bond is a term that, as a verb, means to connect two or more points together. In common usage as a noun, it usually refers to the connection (bond) between the grounded conductor, the equipment grounding conductors, and the grounding electrode conductor. Bonding is also used to describe connecting all of the exposed metal surfaces together to complete the equipment grounding conductors.

A grounding electrode system is a system where two or more grounding electrodes are connected together. These systems are common in PV installations where there are two grounds such as an existing one for the ac system and a new grounding electrode that has been installed for the DC system. See NEC Sections 250-81 through 250-86.

Figure 1 shows how these conductors are related in a PV system.



NEC Requirements

The NEC covers nearly all field-installed electrical systems that are not owned and operated by a utility on utility property. For example, it covers PV systems (Article 690), Cranes and Hoists (Article 610), EV charging stations (Article 625), electric welders (Article 630), computers (Article 645), communications systems (commercial and amateur) (Chapter 8) and most other electrical installations.

The NEC covers low-voltage systems (less than 50 volts in Article 720) and high-voltage systems (up to 230 kilovolts in Article 710). It covers systems with zero frequency (direct currents) through radio frequency (RF) systems.

With respect to grounding, the NEC requires that all PV systems (those that have field-installed wiring) have an equipment grounding system connected to a grounding electrode (690-43). Those systems with a rated voltage over 50 volts are required to be grounded by having one of the current-carrying conductors connected to the grounding electrode. The rated voltage is the maximum open-circuit voltage of the system after any UL requirements have been met. UL-listed PV modules come with instructions that require that the module rated open-circuit voltage (measured at 25°C and marked on the back of the module) be multiplied by 125% (UL Standard 1703) before any NEC requirements are addressed. This multiplier is used to ensure that modules used in cold temperatures (below 25°C -77°F) have connected components rated for adequate voltage. The output voltage of crystalline PV modules increases as temperature decreases.

This calculation indicates that a nominal 12-volt PV system has a rated voltage of about 27 volts (22 volts open circuit voltage at 25°C times 125%). A nominal 24-volt system has a rated voltage of about 55 volts which means that, in addition to the equipment grounding conductors, one of the current-carrying conductors must be connected to the grounding electrode.

The 1999 NEC will have a change that allows the maximum system voltage to be calculated based on the lowest temperature in the installation area. The 125% factor, presently a requirement UL Standard 1703 for listed modules, will be moved to the NEC and will apply only when low temperatures get to -40°C. In areas where low temperatures are more moderate, factors less than 125% (listed in a table) may be used when the 1999 NEC is adopted in those areas.

On 12-volt PV systems, the grounding of one of the current-carrying conductors is optional (NEC Section 690-41). However, the NEC, in Articles 240, 230, and 690, requires that each ungrounded conductor in any electrical system have overcurrent protection and disconnects. Since a 12-volt PV system must already have equipment grounding conductors, grounding electrode conductor, and a grounding electrode, there is a significant cost advantage and sometimes a performance advantage to grounding the system. With the addition of one wire (the bond shown in Figure 1), the number of disconnect poles and overcurrent devices can be cut in half since these devices are not required in the now grounded current-carrying conductor. Furthermore, low-voltage fluorescent lamps start more reliably when installed in a grounded system and inverters and other electronic devices can be installed so that they radiate less noise when one conductor is grounded.

Hows and Whys

Equipment Grounding Table 250-95 in the NEC specifies the size of the equipment grounding conductors for each circuit. The size is based on the rating of the overcurrent device protecting the circuit and ranges from number 14 AWG conductor in a 15-amp circuit to a number 3 AWG equipment grounding conductor in a 400-amp circuit.

Of particular interest to PV installers is Section 250-95 of the NEC that states that if the current-carrying conductors have been oversized to minimize voltage drop, then the equipment grounding conductors must also be oversized in the same proportion. Oversized conductors (above minimum ampacity requirements) are frequently used between the PV array and the charge controller to reduce voltage drops in these lines. Table 8 in Chapter 9 of the NEC shows the cross sectional area of different sized conductors, and the calculation is straight forward. Oversizing the equipment grounding conductors is required by the NEC to ensure that overcurrent devices function properly during ground faults.

Equipment that must be connected to the equipment grounding system includes the exterior metal surfaces of PV modules, power centers, charge controllers, inverters, and switchgear and overcurrent devices. Equipment listed to UL standards will have properly marked connections and instructions for connection of the equipment grounding conductors.

The equipment grounding requirement in renewable energy systems is usually met by using a separate conductor. If the system uses metal conduit (and many commercial systems do), then the conduit can serve as the equipment grounding conductor when used with listed fittings.

The connection of the equipment grounding conductor can run from module frame to module frame and then to switch gear and then the power center. The order of the connections is not critical and multiple connections or parallel connections do not cause problems. Each equipment grounding conductor may also be run from the metal surface being grounded to a central point like the power center. The connections and wiring for the equipment grounding conductor must be continuous to allow fault currents to properly operated overcurrent devices. Removal of a piece of equipment for service must not interrupt the equipment grounding system for other equipment.

Generally, module frames are made of aluminum which is anodized. The anodized coating or aluminum oxide that forms on aluminum surfaces is a relatively good insulator. This is why listed PV modules have a special point marked for connecting the equipment grounding conductor. A stainless steel screw is usually supplied which helps to ensure a good electrical connection. It should be noted that while the anodized surface insulation on PV modules makes it hard to get a good equipment grounding connection, the aluminum frame is still exposed metal, and if not grounded, can produce an electric shock when ground faults occur between the current-carrying parts of the module and the frames or when the frames are inadvertently energized by other power sources.

Aluminum PV module frames do not stay well grounded when they are only bolted to the metal mounting stands. If the UL listing allows and the module manufacturer provides special parts and instructions, some PV modules may be grounded through the mounting bolts to the frame. The NEC prohibits

the earth from being used as the sole equipment grounding conductor, so bolting the PV modules to a metal stand that is inserted in the ground does not meet the requirements for a safe installation unless a separate equipment grounding conductor is used from the frame to the main grounding point or electrode.

The NEC requires that all conductors for a given circuit be routed together in the same cable or conduit. An exception is the equipment grounding conductor for DC circuits.

When secondary grounding electrodes are used and they are bonded to the primary grounding electrode (as described below for surge protection) the bonding conductor may become an equipment grounding conductor and should be sized appropriately.

Grounding the Current-Carrying Conductor

The connection between one of the current-carrying conductors and the grounding electrode conductor is made only at one point in the system and is known as the system ground. This single-point connection is usually made in a power center and is shown as the bonding conductor in Figure 1. If this connection is inadvertently made in more than one place (e.g. at the PV modules and in the power center), then unwanted currents will flow in the equipment grounding conductors. These unwanted currents may cause inverters and charge controllers to be unreliable and may interfere with the operation of ground-fault detectors and overcurrent devices.

The use of RV and automotive electrical appliances and audio gear sometimes causes problems as does the use of dc-powered radio and telephone equipment. Much of this equipment operates at 12-volt dc with chassis and antenna ground connections that are common with the negative dc power conductor. It is pretty easy to get the negative dc conductor connected inadvertently to ground in two or more places when using these types of electrical devices. Since the NEC also requires that equipment grounding conductors be used with these appliances to ground the exposed metal surfaces, it becomes problematic on how to do this with a third conductor that does not result in multiple point system grounds. Solutions to minimize the problems include non-metallic enclosures to isolate the grounded chassis and ground-isolated antenna connections.

Listed power centers and disconnect switches usually have a provision for the single-point connection. In some DC power centers, ac load centers, and disconnect switches the connection is automatically made when all equipment grounding conductors, the negative conductors, and the grounding electrode are tied to a single, grounding bus bar. A central location such as the inverter disconnect, battery disconnect or main power center is where the connection to the grounding electrode conductor is made.

When using standard, fused safety switches for disconnects throughout the system (PV subarray, string, array, battery, etc.), an insulated bus bar usually must be added for making the connections for the unswitched, grounded conductor running through the switch enclosure. While there is frequently a bus bar supplied for the unswitched conductor, this bus bar is sometimes grounded to the enclosure presenting the opportunity for an inadvertent second grounding of the conductor that is intentionally grounded elsewhere in the system. Insulated, or ungrounded, bus bars should be used in these devices to prevent that second ground connection.

The Grounding Electrode Conductor

The grounding electrode conductor (a.k.a. the ground wire), is usually a single conductor bare wire (it can also be insulated-color is not specified) connected from a grounding bus bar in a power center or other disconnect to the grounding electrode (a.k.a. the ground rod).

In the 1993 and earlier editions of the NEC, this ground wire had to be the same size as the largest conductor in the DC system. In the 1996 NEC, a number of exceptions, when met, allow smaller conductors to be used. There are jurisdictions throughout the country that are still applying the 1993 and earlier versions of the NEC so some inspectors may require the larger conductors.

If there is only one conductor connected to the grounding electrode, then Section 250-93 of the 1996 NEC allows grounding electrode conductors as small as number 8 AWG copper to be used (see NEC Section 250-93 for the exact requirements). Appropriate mechanical protection is required where this conductor may be subject to physical abuse. However, if multiple conductors are connected to the grounding electrode, then the exceptions do not apply and a grounding electrode conductor as large as the largest conductor in the dc system must be used. Multiple connections to the grounding electrode conductor refer to connections from the power system and do not refer to telephone, TV, cable, or other types of communications grounds. Multiple connections to the grounding electrode occur when several ground rods are bonded together to form a grounding electrode system and when metal water pipes or well casings are bonded to the ground rod. Multiple connections are also common where DC and ac grounding electrode conductors are connected to the same ground rod. Several equipment grounding conductors tied to the ground rod also nullify the exceptions that allow a small grounding electrode conductor.

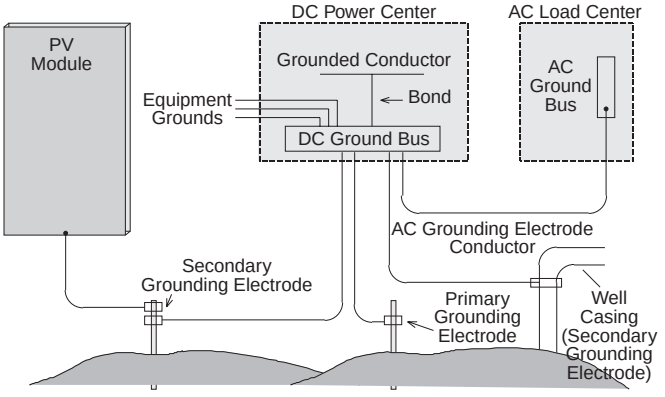
The reasoning behind the exceptions is that if more than one conductor is connected to the ground rod, some of those conductors may be required to carry high fault currents. If only one conductor is connected to the ground rod, then the other properly sized and connected conductors in the system will carry the fault currents, and the Number 8 AWG conductor to the ground rod will only be required to stabilize the system voltage with respect to earth. Only in lightning strikes and inadvertent connections to high-voltages, will the grounding electrode conductor be required to carry high currents.

There are similar requirements and exceptions for the ac grounding electrode conductor.

How then, can the system be connected so that a small equipment grounding conductor be used?

One method is to designate a single grounding bus bar in the system. This bus bar is usually found in listed DC power

centers. All equipment grounding conductors should be connected to this bus bar. If there are multiple grounding electrodes in the system, the secondary electrodes should all be connected to this bus bar to complete the grounding electrode system. If there is a requirement to provide a single-point ground for the ac portions of the system, then the grounding electrode conductor from the ac part of the system should be tied to this bus bar. Finally, the smaller (as allowed by the NEC) grounding electrode conductor can be connected from the grounding bus bar to the primary grounding electrode conductor. Figure 2 demonstrates these connections.



While this method meets the requirements of the NEC it may not provide the best protection against lightning damage. Running all grounding conductors to a common point inside the building may have the potential for increasing damage from nearby lightning strikes. In high lightning areas, it may be preferable to bite the bullet and use the larger grounding electrode conductor from the power center to the ground rod. Then secondary grounding rods and pipes and metal well casings can be connected directly to the primary grounding electrode without coming into the building. Equipment grounding conductors from the PV modules may also be run directly to secondary or primary grounding electrodes providing additional surge protection.

Each of the grounding electrodes described below, where used as a primary electrode, has a different requirement for the size of the grounding electrode conductor. See NEC Sections 250-93 and 250-94. If the requirements for the ac and DC grounding electrode conductors are different, then the larger of the two should be used for any common conductor.

Grounding Electrodes

The NEC, in Sections 250-81 and 250-83, considers that metal building frames that are in contact with the earth and metal water pipes (also connected to the earth) are the preferred grounding electrodes. Unfortunately, wood frame buildings, plastic pipes, and plastic sleeves on copper pipes make these options frequently unavailable to the renewable energy user. The NEC details the more commonly available grounding electrodes such as “made” electrodes (the common 8-foot ground rod), concrete encased cables or electrodes, and ring electrodes which consist of buried conductors encircling the building. Made grounding electrodes are listed by UL and are bonded (connected) to the grounding electrode conductors with clamps that are listed for this purpose. If the clamps are to be buried, they should be listed and marked for such use.

As a primary grounding electrode, the ground rod must be driven into the earth to a depth of at least 8 feet. Angles of no more than 45° away from the vertical are allowed where the ground is rocky. If these conditions cannot be met, then a second rod (best performance will be achieved if more than six feet away) or one of the other grounding electrodes must be used to supplement the primary electrode.

In some areas of the country where homes are built on concrete slabs, a grounding electrode is buried in the concrete slab and usually works better as a grounding electrode than an eight-foot ground rod.

Summary

System grounding is an important detail of the renewable energy power system. It reduces the potential for electrical shock and allows the system to respond safely to ground faults. The requirements for PV systems are generally the same as the requirements for other electrical power systems that have evolved over the 100-year history of electrical power systems in the United States.

In the next Code Corner, several different types of grounding systems will be shown including examples of PV systems located in power buildings separate from the main house.

Questions or Comments?

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

Access

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IAEI Soares Book on Grounding, International Association of Electrical Inspectors, 901 Waterfall Way, Suite 602, Richardson, TX 75080-7702 • 800-786-4234.

Mother Nature Says Hello!

Don Loweburg

Winter storms have been ravaging California and the northeast. The states' infrastructures have been slammed. Power outages up and down both coasts coupled with flooding and road closures keep people home. Many work places and schools are closed.

Here at Offline it's business as usual. In fact, we've never had a power outage during our 15 years in business here. No kidding! My intention is not to grandstand anyone's misfortune, but rather to simply and clearly assert that a renewable based, distributed energy system with local storage is far more reliable than the centralized carbon based system in place today. We, like many *Home Power* readers, are living the future and I want to get the word out. Also, I want to acknowledge the tens of thousands of heros working around the clock on both coasts who restore lost power. Hats off to the extraordinary job being done by utility workers!

Net Metering—Snags and Restructuring

Among the issues discussed last issue was a challenge to Maine's net metering law posed by state restructuring legislation. Though not resolved, the situation there seems headed in the right direction. A very similar challenge came up in Iowa several months ago. As in Maine, the process now seems headed in the right direction. At the heart of both challenges is a serious misunderstanding of net metering by the respective public utilities commissions (PUCs). In Maine and Iowa their PUCs adopted rule changes eliminating net metering based on the fact that utilities were no longer required to purchase power from independent producers. Customers that engage in net metering are not independent energy producers. There is no intention of selling power to produce income. Net metering customers generally produce only a fraction of their total energy requirements. The purpose of net metering is to reduce the cost of small systems by eliminating batteries and to reduce interconnection cost and complexity by using a single meter rather than the dual meter system used in commercial installations such as cogeneration facilities. The renewables community must make this distinction very clear. We must not make reference to "selling back" excess power to the utility. This phrase unfortunately appears in the advertising of several manufacturers and muddies the waters. Net metering customers are not selling power. We should make every effort to clarify our thinking and speaking. Using terms like net metering, grid interactive, and grid connected rather than utility "sell back" is accurate and does not fuel the misconception that utilities and PUCs seem all too eager to adopt. I should add here that in both states the large IOU's were arguing in favor of the rule changes that would have eliminated net metering.

Being Organized is Crucial

There is another valuable lesson here. Organized group response is very effective. A well organized effort worked in Maine to get the message out. That kind of effort was also mobilized in Iowa. The Iowa Renewable Energy Association (IRENEW) issued an action alert back in December that appeared in the Sustainable Energy Coalition Update. In a short period of time a number of groups were mobilized. They included IRENEW, Iowa SEED (Sustainable Energy for Economic Development), the National Wind Coordinating Committee, Solar Energy Industries Association, American Wind Energy Association, and a number of wind turbine owners and citizens who were willing to testify at the hearing. Testimony against the rule change (that is, for net metering) was very effective.

Citizen Action

Reader James Mell, a renewable energy worker and activist from Massachusetts, contributed some news quotes that appeared last issue blasting that State's restructuring law. As follow up for this issue of *Home Power* he sent a news clipping that suggests a possible course of action that could correct the inequity. The

January article authored by Michael McAuliffe titled "Electric rate protesters make Internet history" states, "An organization seeking repeal of the new law deregulating the electric industry in the state say they are doing something unique in this country—using the Internet in a petition drive to contest the law on the fall 1998 ballot. The Cambridge based Campaign for Fair Electric Rates went online yesterday at 11 a.m. with a Web site that includes information on deregulation and instructions on how voters can get involved in challenging the new law." Organizer Shawn Murphy said, "It gives us another way to reach people and to get our message out." That message is that the new law, signed by Gov. Cellucci on Nov. 25, will not lower consumers' electric bills long term and will, in fact, result in a bailout of about $12 billion to utilities for their bad investments. That's like Ford collecting a surcharge from anyone who buys a new car, regardless of the make, to recoup losses on the Edsel." (See Access.)

And on the West Coast

Dan Berman, co author of *Who Owns the Sun* is Chair of a group in Davis, California called the Coalition for Local Power. The Coalition is developing a "Community Choice" approach to the issues of electricity restructuring and solar energy. Community Choice would aggregate willing customers into a power purchase co-op that could shop for the best energy package. Hopefully that package would include renewable energy. Another activity could be co-op purchase of roof top PV systems for members to install.

Fine Tuning Net Metering

In order to address issues brought about by restructuring, some changes in California's net metering law have been proposed. New legislation, supported by CALSEIA amending California's existing net metering law, will hopefully serve as a model for other states as well as for any upcoming national net metering law. These are its main points (See Access for an updated version of the law).

1 Requires all Energy Service Providers (ESPs) to offer net metering for PV customer-generators under 10 kW. The old language addressed utilities only.

2 All customer generators under 10 kW are eligible. The original law did not include businesses.

3 If an ESP requires an additional meter, the cost will be at the ESP's expense and the meter is used only for informational purposes.

4 All energy charges and other retail rate components shall be "netted out," meaning that all other consumption-based "bundled costs," such as taxes, CTC, etc. shall be based only on the net consumption.

5 Changes the period for "netting" from monthly to annually.

6 Gives any energy generated by an eligible customer-generator beyond the amount consumed over an annual period to the customer-generator's ESP free of cost. The thinking here is to put to rest any notion that the net metered customer-generator is selling power to the ESP. Remember that if the customer were to be paid for any net excess, it would be at avoided cost, way less than it is worth. The fact is that most net metered systems produce a fraction of total load so there would not be a net excess.

7 Establishes that several national safety and performance codes and ratings shall be the standards to which systems are held.

8 Provides property tax exemptions for solar systems.

National Standards

John Stevens of Sandia Labs chairs an IEEE work group developing "Recommended Practice for Utility Interface of Photovoltaic (PV) Systems." A project document (P929) is in it's fourth draft and may be nearing completion. The work consists of a number of recommendations regarding the safe interconnection of small inverters to the utility grid. One of the big items covered is islanding, a condition in which a grid outage has occurred and the grid interactive inverter continues to produce power and injects it onto the grid, contrary to the design intentions of the manufacturer. This is a safety issue that is important to everyone. One recommendation will be a test procedure administered by UL as part of the inverter standard UL1741. The designation "non islanding" inverter would give assurance to utility protection engineers that a system that bore this designation, and was installed according to the other recommended practices in P929, is safe.

The specific UL1741 inverter test details are being worked out by work group members. Once the test is adopted as part of UL1741, inspectors, electricians, and utility personnel will have a reference based on industry consensus as expressed in IEEE P929 and NEC 690. A nationally recognized reference for the correct and safe installation of PV systems to grid connected households will be welcome by all.

Numbers, Numbers, Numbers

Last issue I asserted that utilities were competitors, not customers, of the renewable energy industry. I picked up some industry statistics at the last PV Alliance meeting that support this conclusion. The numbers were compiled by the Energy Information Administration as Form EIA-63B, "Annual Photovoltaic Module/Cell Survey" dated 1996, and appear in Table L, "Modules and Cells by Market Sector, End Use, and Type."

Under Cell Type are; Crystalline, Thin Film, and Concentrator. I'm sure it's no surprise to installers and others in the PV business that crystalline (includes mono and poly) account for 96% of the total. Thin film is about 4%, while concentrator is less than 1%. My only comment is, where is that inexpensive thin film material that manufacturers have been promising for over 15 years? The categories Market Sector and End Use both split the same PV pie in different ways. Under Market Sector we find subcategories like; Industrial, Residential, Utility, etc. Under End Use, subcategories include Remote, Communication, Transportation, Grid Interactive, etc.

I choose to deal with the information in a simpler way. From my perspective, there are two markets, Utility and End User. The data as presented supports this. Under Market Sector the Utility category is 13% of total sales. Under End Use, the Grid Interactive category is 14%. I feel confident to equate Utility and Grid Interactive since each amounts to nearly the same percentage, about 14% of the total. The other category of End User accounts for 86% of total PV sales. End User includes industrial, residential, communication, and remote end users; everything except utility. So if utilities only purchase 14% of the total, why does the utility market command such attention when it is proven to be a minority player? My guesses include imbedded, rote thought processes (i.e. utilities are assumed to be the "natural" provider of electric service) that persist in spite of clear contradictory evidence. Another possibility is wishful thinking on the part of module manufacturers. Filling multi-megawatt orders for utilities must seem more attractive than multi-kilowatt orders for distributors. And then there is the issue of corporate culture. Most module manufacturers are affiliates of large energy corporations and I'm sure they share affinities with large IOUs.

But the numbers speak for themselves. The remote (offgrid) power market alone accounted for about 31% of PV sales. In my experience these systems are in the .5 to 2 kW range. Most of this product moves through the distributor-installer channel. With the experience gained in the offgrid market over the last 20 years, the distributor-installer channel is poised to handle the expanding grid connected market. We have the expertise. Customers, too long squeezed, abused, insulted, and enraged by iniquitous utility restructuring, will choose independent power.

Washington State Net Metering

Last issue we outlined some interconnection difficulties in Washington. The specific issue is not resolved yet, but some shift in the right direction is taking place. The requirement for a massive system isolation and transfer switch may be dropped. Probably of greater interest is the fact that a net metering bill has been introduced in the state legislature. I have not seen the bill but assume it includes a majority of the features present in the new California net metering law. Our work in the trenches proceeds one state and one system at a time.

Net Metering in Oregon

A bill will soon be introduced in the Oregon legislature mandating net metering. Thanks to all who are making this happen. The bill is sponsored by Oregon Solar Energy Industries Association (OSEIA) and a broad spectrum of business and environmental groups. IPP will periodically update readers as these bills move along.

Correction

The web address for the California Energy Commission rebate program in last issue should have been www.energy.ca.gov/energy/renewables. The area of interest is designated "Emerging Renewables" and includes customer sited PV and wind systems under 10 kW. Also included as "Emerging" are fuel cell (but must be fueled by a renewable source) and dish Sterling.

Access

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California's new net metering bill (Assembly Bill 1755) updates • Web: www.leginfo.ca.gov/bilinfo.html

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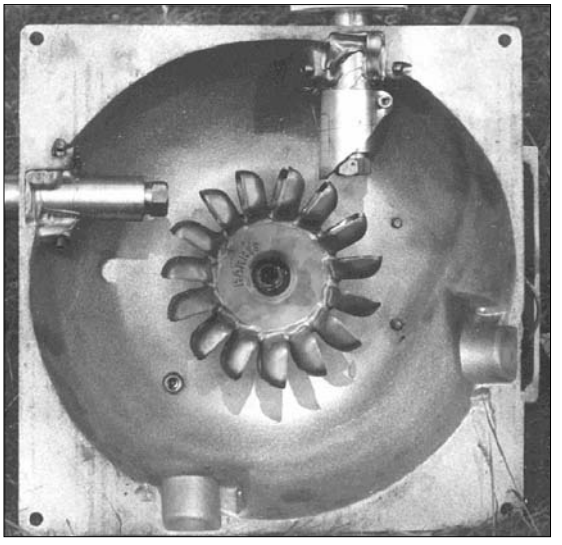

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Drake Chamberlin and Bob-O Schultze

Solar electric systems and the National Electrical Code® are interfacing at an ever increasing level. Several years ago, inspectors showed little interest in these systems. As photovoltaic technology has evolved, efforts have been made to better define the Code as it applies to solar and other renewable energy installations. Unfortunately, the failure by the Code forming committee to include the PV Wrenches' experience and perspective will cause some parts of the new 1999 NEC to contain unrealistic and unworkable provisions on day one of publication.

Safety

Basic safety devices quickly became mandated for off grid systems. All wires coming from a battery bank were required to have over current protection. Fuses and breakers needed to have DC ratings.

As the solar code continues to evolve, more detailed questions are being asked. New requirements have been implemented, and more are being proposed.

The Issue

Unfortunately, certain requirements increase the cost of solar electric systems and/or decrease efficiency. Many are questioning the necessity of some of these provisions.

It is the intent here to examine these requirements, to see what is necessary and what is not. Code language is often difficult to understand and is open to interpretations. I will attempt to clarify some of these code interpretations from a Wrench point of view.

Liquidtight Flexible Conduits

One possible requirement that has been discussed lately concerns the use of liquidtight flexible conduits. Mr John Wiles, in Code Corner, is concerned that the 60°C wet rating of liquidtight flexible nonmetallic conduit might not be adequate for modules. Although it is a favorite wiring method of many installers, John recommended that it not be used.

The wet rating of both metal and nonmetallic liquidtight flexible conduit is the same, 60°C. It is readily observable that liquidtight flexible metal conduit is often used for the connection of commercial compressors, which are often located in direct sun. If these conduits are forbidden on the basis of temperature, the standards for low voltage solar electric systems would become more stringent than those required for ac wiring of up to 600 volts.

The Wire to Use

Another question regards the temperature rating of the wiring used in module junction boxes. Mr Wiles writes that a 90°C wiring requirement may soon be extended to all listed modules.

In Code Corner of HP issue #62, he wrote that I [Drake] "thought there wasn't much reason to use 90°C conductors on PV modules."

But my view is that the 90°C, dual rated wire, THHN - THWN-2, is the best choice for solar module connections.

Although all the data is not in, it seems possible,at least in some locations, that wiring could get hot enough to need 90°C insulation. This wire is the most accessible conduit wire on the market, at least in this area. It is easy to install, inexpensive, and happily, rated at 90°C. It covers all the bases; equipment compatibility, code compliance and economic viability. It is unquestionably adequate for safety.

Temperature Rating of Wire and Breakers

A related issue raised concerns the compatibility of circuit breakers and wiring of different temperature ratings. To clarify the issue, it is standard procedure to connect a wire rated at 90°C centigrade to a 75°C

breaker. The actual operating temperature of the wire is the issue.

For example, THHN wire is rated at 90°C. However, wire sizes AWG #14, #12 and #10 (the most popular wire sizes used for PV module connections) are only allowed to be operated at 15, 20, and 30 amps respectively. (A note at the bottom of Table 310-16 requires these limits).

Many popular circuit breakers are rated at 75°C. (John had sent me an e-mail, correcting my mistake, when I wrote that Square D breakers had a higher rating). Common GE, ITE and Square D breakers are rated at 75°C. Whenever a number 14, 12 or 10 THHN wire is connected to one of these breakers, it is a connection between a 90°C rated wire and a 75°C rated breaker. As THHN is widely used, this is a very common wiring situation.

It is permissible to run larger wires, operated at 75°C, to 75°C breakers, but one would want to have a specific reason for doing so. In any system, If the run is long, the voltage drop would be too great. For wires bigger than # 10, it is still safest to size wiring for the 60°C rating corresponding to Table 310-16.

Shaping the Evolving Technology

PV is an evolving technology. Field data needs to be evaluated to demonstrate what is needed and what is not. I would like to hear from anyone who has seen safety problems with solar electric systems. Have battery cables failed? Have inverters gone out of control and had to be shut down from the DC side? Have modules been destroyed by ground faults or reverse polarity hookups to batteries? Has anyone been shocked or injured by a low voltage solar array? Are flexible conduits disintegrating in the sun?

There are many issues that need to be addressed. The tendency has been to make complex, a type of system that can be installed very simply. Solar installers are happy to do what ever is necessary to make their installations safe. The question is, “are all these complexities really necessary, or do some represent arbitrary rules?”

To produce efficient and cost effective systems, it is important to avoid becoming encumbered by needless institutional barriers. We want to be certain that money spent makes for better systems.

Batteries and Battery Cables

I get more mail about using non-UL listed battery cables than about any other issue. It is Mr Wiles’ belief and expressed opinion that using ANY unlisted wire in a PV battery system is “unacceptable”. Pretty strong language. Let’s take a look at the realities.

For starters, batteries, the heart of all off-grid PV systems, are not UL listed. There is no requirement in the Code for listing, labeling or identifying batteries. Nothing is said in NEC 480 (Storage Batteries) about listing for either the batteries themselves OR about battery interconnection. Section 690-74 for PV systems, on the other hand, says that flexible battery cables “shall be listed for hard service use and identified as acid and moisture resistant.” Neither section speaks to solid, bus bar type of interconnection. Mandating listed flexible cables alone seems pretty random and arbitrary to me.

The reality is that there are untold MILLIONS of flexible battery cables in use every day in cars and trucks. These cables are subjected to all manner of vibration, flexing, high heat, freezing cold, water, mud, etc. Welding cables are designed to spend their whole working life carrying huge current loads at similar DC voltages AND survive being dragged across the floor time after time AND withstand incredible heat from sparks and hot slag every day. Most are rated by the manufacturers to 105°C, but not listed. Battery cables in most PV systems are subjected to NONE of these things. Is this a real problem?

True, there are big variations in the quality of battery cables designed for automotive use. I’ve seen some of such poor quality that I wouldn’t use them for any purpose. At the same time, I’ve seen some imported UL listed 120 vac receptacles that I wouldn’t use in a doghouse. Assuming the use of a good quality cable of the proper AWG size, the question is one of cost rather than safety. Listed flexible cable in sizes 2/0 and larger is THREE TIMES the cost of an equivalent battery or welding cable. They are not readily stocked by battery shops. While most RE installers and suppliers will do a good job making up custom cables from listed wire if requested, the probability of a poorer terminal connection is much higher than from a national cable manufacturer, where powerful hydraulic crimping equipment is employed.

The big problem, as I see it, is the Code’s failure to recognize that the vast majority of PV systems operate at less than 50 VDC and to develop a lesser standard for these systems. Let’s face it, safety issues caused by voltage leaking through wire insulation in a 24 VDC system is just not the problem it is at 240 vac or higher. There seems to be no safety vs cost benefit to hold low voltage systems to the 600 V wire standard. One of the main reasons the NFPA tries hard to involve manufacturers in the Code forming process is to get a good feel for this cost vs safety issue.

Unfortunately, our industry is still so small that we tend to fall through the cracks and get saddled with

unnecessary—and expensive—regulations. The academics, quasi-governmental laboratories, and the standard electrical associations just can't have the perspective or experience we Wrenches do. Mr Wiles and Company's failure to tap our knowledge in their efforts to update the Code was, and is, a huge and unsupportable mistake.

The real danger lies in the reality that some people will distrust or reject the whole Code because of a very few obviously flawed, ill-conceived, and onerous sections. Many systems are never inspected at all. Even in those that are, the inspector can't be expected to catch every violation. Safety is the issue. If the Code requires unnecessary or unreasonable expenses due to the inexperience or conflicting agenda of the section forming committee, installers will not follow it and THAT will cause hazards to exist.

Calling All Wrenches

A "Wrench" is someone that is actually involved in the installation of RE systems. In other words, them what's doin' as opposed to them what's talkin'. IPP members, folks that have installed their own systems to Code, and many others are mostly Wrenches. If the shoe fits... tell us about it!

Access

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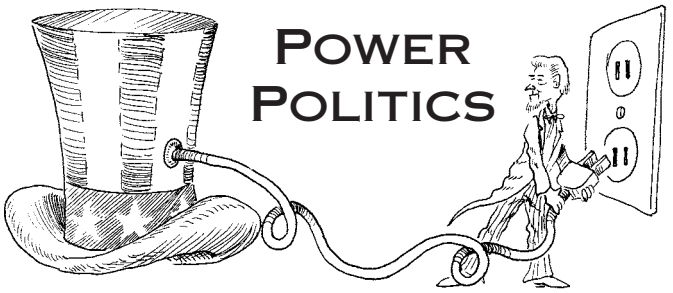
Technical review of Mr Chamberlin's writing by: John Lotus, Lotus Electric, 1132 Northridge, Columbus, Ohio 43224 • 614-447-9000



Green Power

Michael Welch

I know I promised you an article on customer choice for renewable energy providers. But just after my last column got locked into place for HP#63, the California Public Utilities Commission (CPUC) announced that it would postpone the startup of customer choice in California until at least March 31, 1998.

That was a disappointing move for those of us that were looking forward to customer choice as a way to "just say no" to the dirty utilities. Ostensibly, the reason for the delay was that the computer software necessary to change customers from the utilities to the long list of new providers was not in working order. Phone calls to the CPUC yielded no further info. Is it just me, or does anyone else out there suspect something fishy here? The investor owned utilities (IOUs) stand to lose millions of dollars every day, depending on how many of their customers switch over to non-utility electric service providers. I'd like to give the CPUC a break here, but it is difficult when a similar program already exists to switch natural gas customers in California over to non-utility providers. Why won't it work for electricity?

At any rate, the one thing I was looking forward to was practical experience before making recommendations to those Californians interested in switching. This information is also applicable to non-Californians. The providers available to the Golden State are likely to be the very same ones available in other states as each visits their own form of deregulation. Becoming a provider in California is no simple matter, I can't imagine other states' requirements becoming more rigid. There are qualifications that each must meet, and the California Attorney General's office is keeping right on top of electricity providers. Already, one potential provider has been axed because of alleged involvement with a pyramid scheme and misleading customers.

So far there are about 260 electricity providers signed up in the state. Presumably, a California customer could sign up with most any of them, but many may choose to operate on the wholesale level or in niche markets, like the one which is specifically set up to sell to San Francisco area city governments.

Unfortunately there is no good way to know which of the providers are going to be marketing "green" energy. The California Energy Commission has a green marketing registration set up, but that is specifically for providers that can meet the stringent qualifications for receiving state grant money. At this time, only one company, Clean'n Green, is registered with the CEC as a green energy marketer. Many green providers will not qualify as they won't be purchasing the required amount of power within California, they buy and/or generate elsewhere and sell it to Californians.

There is a non-profit registration organization called the Green-e Renewable Electricity Branding Program. But, it has big problems. The one that gets my craw is that in order to qualify to be able to use the Green-e logo and name in advertising, an electricity reselling company can get by with providing a mere 50% of its electricity in the form of renewables! It reminds me of the famous oil company that wanted to let people know that they were environmentally concerned so they kicked off a huge advertising campaign to point out the handful of environmental projects they had helped with while totally ignoring the rampant destruction of the environment that they were otherwise famous for.

I can't help but think that there are some shady back room negotiations that took place in determining the RE threshold level for the Green-e program. No long-term energy activists worth their salt would go for such a lopsided deal. If the point is to promote renewables, why give coal, nuclear, and large scale hydro 50% of the renewables pie? It turns out that the Green-e designation is sponsored by The Energy Foundation and the huge non-profits that get most of that foundation's grants. This is the same group of folks that sold California ratepayers out by supporting the nuclear utilities plan to collect billions of dollars under deregulation for their uneconomic power plants. It is also the same granting foundation whose roots are in the oil industry.

We also have to remember that every green energy company we look at is going to have some warts. In the

case of Green Mountain Energy Resources (the company that Redwood Alliance will be testing soon), we have been hearing some complaints already. The main one comes from energy activists in New England who are concerned that GMER's parent company is one of Vermont's IOUs. It purchases much of its power from Hydro Quebec, which has long been decried for flooding native lands to make cheap hydro power for the U.S. Green Mountain Power started GMER and sold 2/3 of its interest to a family in Texas in exchange for $30 million in investment capital. Though there are definitely connections between the parent and the sibling, GMER claims it will not be purchasing Hydro Quebec power, but the hydro power it does use will come from small and large scale systems through Pacific Power. The only two other companies actively marketing green electricity in California are Enron and Edison Source (a division of the huge nuclear IOU Edison, formerly Southern California Edison). There is one other promising looking company on the horizon, Clean'n Green, mentioned briefly above. They look good, but haven't started marketing or finalized their mix as of this writing.

Right now, the largest controversy among energy and environmental activists centers on the use of hydro power as part of a renewables mix. An organization I deeply respect is Friends of the River, and they have been urging caution. They suggest we ask any green provider we consider the following additional questions: what percentage of power comes from hydropower, what hydropower project(s) in particular is the energy coming from, and do you have an alternative energy (the river folks have not yet gotten the difference between "alternative" and "renewable") program that excludes hydropower? While not having as much environmental impact as using nuclear or coal, hydro projects can be devastating. A quick case in point; damming the Columbia River has ruined the salmon runs of much of the Pacific Northwest. By asking these three questions of your potential providers, you can make sure you are having as small an impact as possible with your energy choice and, maybe more importantly, you will be letting your provider know that you don't want your RE dollars to kill rivers.

I hope you don't mind me teasing you with these electricity provider tidbits. Once again, Redwood Alliance doesn't feel like it can make any specific recommendations until we've had more practical experience under our belts and until we've had more of a chance to put the green providers on the hot seat for awhile. Certainly, it does not look like we are going to find the "ultimate" green energy provider among those we've heard of, but with any luck the final choice will become clear.

Net Metering a Bust

I think we can finally say it, California's net metering law has proven to be a bust. What it all comes down to is that any state's net metering must provide more incentive than a "to parity" program can offer. A whole bushel of I-told-you-so's are sent to the California Solar Energy Industries Association for blowing it on that one. As you may recall, CalSEIA took the lead in negotiating a final bill in the California legislature. But those folks didn't do it right and actually promoted a bill that was a compromise before it even got started, saddling the state with a net metering law that did not have enough teeth to encourage a single new on-the-grid system. When activists like myself tried to get involved we were shut out of the process. CalSEIA complained to me that I was getting in the way of their "progress," and the legislative aids for the lawmakers interested in carrying the bill wouldn't take any input unless it came officially from CalSEIA.

The fix was definitely in. I never was able to figure out if the point of the fix was a law that intentionally wouldn't work or if it was just blind faith on the part of the promoters that something is better than nothing (no good if that "something" doesn't work). Either way, failure is failure.

Now, California's Net Metering II is moving forward. While it makes up somewhat for a few of the problems in Net Metering I, it demonstrates a disturbing trend in the direction that other net metering proposals in the West are taking. Namely, it provides that any power beyond net parity that is produced in a grid tied system will be donated to the utility or power provider.

That's right, if you want to have a net metering system under the newly proposed laws, you will give away the excess energy you produce. Net Metering I was bad enough because it only provided "avoided cost" for any thing above net parity. To be more effective, the original bill should have paid at one to one and a half times what the customer pays the utility or provider for power instead of the paltry $0.018 plus or minus per kWh that avoided cost gives the producer.

The new laws should be pushing for a real payback. Instead, true to form, CalSEIA and other state SEIAs are foisting bills upon their respective states that give us literally nothing! There justification is that the focus of net metering laws should be to reduce system cost by getting rid of the batteries, an extra meter, and expensive disconnect gear, and that this focus is being harmed by expecting a financial return. They say that profiting on a home system puts net metering systems in the same category as many other small power producers like cogeneration and thereby helps unify utility effort against rooftop grid-tied systems.

I say baloney. The only way to make Net Billing effective is to let the system owner profit on the installation. We need real incentives for installing these systems. See the IPP column in this issue for an opposing viewpoint and a listing of some of the positive points of Net Billing II.

Direct Action at Ward Valley

As I write this, hundreds of people are occupying Ward Valley, California at the site of a proposed nuclear waste dump. The only recourse left when our government and corporations refuse to listen to the people and the environment is direct action, which in this case takes the form of non-violent civil disobedience.

The campers are there in support of the Colorado River Native Nations Alliance and local communities that have been fighting the nuke dump tooth and nail for about ten years. Their reasons for fighting are well founded. The site is host to the endangered Desert Tortoise; the land is held sacred by local native tribes because of its proximity to Spirit Mountain, the birthplace of their ancestors; the chosen contractor has a history of environmental abuse; and the site has been characterized by the nuke industry as being built for local medical and research wastes, but the reality is that nuclear power plants will be the major dumpers.

The native tribes occupying Ward Valley include the Chemehuevi, Fort Mojave, Cocopah, and Colorado River Indian Tribes. They set up encampment last year when the federal government decided it wanted to do test drilling on the sacred lands. Now they are occupying the land in defiance of a federal and state eviction notice aimed at clearing the site to allow test drilling. Until recently, it is the feds that have been holding up the dump's construction. The nuclear industry and California Governor Wilson have been pushing to have it built, but that cannot happen until the federal Bureau of Land Management transfers ownership of the land to the state. If and when that happens, then the dump is cleared to move forward quickly. The Clinton Administration, so far, has been adamant that the land not be transferred, but the feds' move toward approving drilling to test for the possible migration of radioactive tritium is viewed as a softening of that position.

The tribes and community members fear that the BLM, under intense pressure from the nuclear industry and Wilson, will be rigging the test study to support the dump proposal. There is a feeling that the feds and the state have no credibility and the tests will not be performed honestly.

If you are interested in helping stop the Ward Valley Nuclear Waste Dump, send money, send moral support, and take part in their direct action. Call them to see how you can help.

Access

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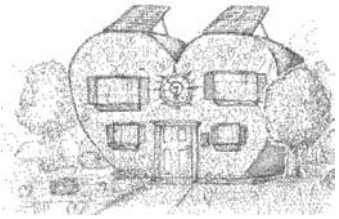
E-Mail: michael.welch@homepower.org
Web: www.igc.org/redwood

Info on Ward Valley: Save Ward Valley, 107 F St., Needles, CA 92363 • 760-326-6267
Fax: 760-326-6268
Ward Valley Web Sites:
www.shundahai.org/SWVAction.html •
earthrunner.com/savewardvalley •
www.ctaz.com/~swv1 • banwaste.envirolink.org •
www.alphacdc.com/IEN/wardvly4.html

Friends of the River, 128 J Street 2nd Floor, Sacramento, CA 95814 • 916-442-3155
Fax: 916-442-3396 • Web: www.FriendsOfTheRiver.org

Home & Heart



Kathleen Jarschke-Schultze

Our house is actually an old cattle round-up cabin. Down at the lower end of the property is a corral and cattle chute. Just in front of that was a very large open sided hay barn. A year or so after we moved here we noticed it was leaning a bit towards the creek.

Barn, er, Brainstorming

The side supports are large poles set atop a long flat topped log on either of the long sides. The problem was that the base logs on the sides were rotting away. We moved our travel trailer out of the barn. We propped poles on the leaning side to support it. The problem of rebuilding the base supports while the barn was still standing was discussed with everyone we could think of. While not impossible it would be costly and dangerous.

We decided we would drop the barn and salvage the roof tin. There was a lot of tin and it was in excellent shape. If we could save the tin we could use it to cover the walls of a smaller shop built in the same place. So we discussed how to bring down the barn without damaging the tin roof. By this time it was too scary to even consider sending anyone onto the barn to remove the tin.

Several people had ideas about how we could drop the barn. The thing was we didn't want anyone to get hurt and it was such a large barn. I vetoed most of the ideas because I am just plain chicken.

The barn continued to lean more and more. The diagonal supports were twisted from their posts by the tension and dropped to the ground. We had quit storing anything of value in there. Every time it snowed I expected the barn to give way and collapse.

Auntie Em, Auntie Em

One morning Bob-O and I woke up to the sound of the wind whistling around the house. We could feel the gusts hitting the north side and shaking the walls. "Maybe we don't have a barn anymore" I said. Bob-O got up to start the coffee and let the dog in. "Hey!" he says, "we don't have a barn anymore." I jumped up and sure enough the barn had fallen. We both felt relief at this as now it was done for better or worse and no one had been at risk.

The really great thing turned out to be that we couldn't have planned it better ourselves. The barn fell away from the road and toward the creek so our lower road isn't blocked. It seemed to have fallen rather slowly as only two pieces of the roof tin got bent. There were a couple of piles of scrap lumber I had always meant to move on the road side of the barn. When the weather was warm there was the possibility of rattlesnakes and then the short days of winter so the lumber was still there. Well, the way the barn fell left the lumber piles untouched except for the side support poles which didn't hurt anything.

I had six bales of hay in the barn to shred for garden mulch. The barn roof fell to the far side of them so they are totally accessible. There was an old gas range in there that took a direct hit though. I found an oven door handle popped off and flung thirty feet from the barn.

Recycling

Allen came over and removed the tin from the roof with a little help from Bob-O. The purlins (2"x4"s) that run parallel to the ridge line are all salvageable. they will be used with the roof tin for the sides of the new shop. We will be getting new tin for the shop roof. Any wood that can be used for firewood or kindling will be utilized. I am keeping an eye out for any 'distressed' wood that is usable for bird houses and feeders. All the rotted wood will be burned and the whole area gone over with a large magnet to pick up any nails. We should be able to recycle about 60% of the old barn.

We are looking forward to having a shop with walls and a cement floor. This will make automotive repair and maintenance so much easier for Bob-O. Of course the shop will be smaller than the barn was. We just don't need all that space. I guess sometimes procrastination can turn out alright.

Sun Frost by the Numbers

A large part of living with renewables is being efficient in your use of power. This includes using appliances that are super efficient. If you can heighten that appliance's efficiency, all the better. Our 24 VDC Sun Frost F-10 freezer (10 cubic feet) is down in our basement which stays about 52°F during the winter. In the summer the basement warms up a little so I will have to get more data then.

The official specifications say that the F-10 should use 690 watt-hours per day at 70°F. At the start of our test

the freezer temperature was at 0.2°F. Throughout the test the temperature ranged from -1.4°F to 0.4°F. The humidity was at 48%. The average amps were 0.7 and the max amps were 4.84. The final result was the F-10 used only 437 watt-hours per day.

Wasabi Sought
Watching the Winter Olympics from Japan I had an opportunity to see the green Japanese horseradish, Wasabi, in its natural form. Karen, Myna and I all want to grow some. If anyone knows where we can find growing stock in the U.S. please tell me, I am keen to get some.

Access
Kathleen Jarschke-Schultze is busy pruning trees, grapes, and roses and planning her spring garden at her home in northernmost California, c/o Home Power, PO Box 520, Ashland, OR 97520 • 916-475-0830
E-Mail: kathleen.jarschke-schultze@homepower.org
kjs@snowcrest.net

Sun Frost, PO Box 1101, Arcata, CA 95518-1101
Voice 707-822-9095 • FAX 707-822-6213
www.sunfrost.com

HAPPENINGS

ARGENTINA
XII World Hydrogen Energy Conference, June 21-26, 1998, Buenos Aires, Argentina. For more information contact: Secretaria General: Congresos Internacionales S.A., Moreno 584-Piso 9-(1091) Buenos Aires, Argentina; Tel: 54-1-342-3216/3283/3408 • Fax 54-1-331-0223/334-3811 • e-mail: congine@mbox.servicenet.com.ar

AUSTRALIA
The World Solar Challenge is now a biennial event and will run October 18–27, 1998. It is the premier solar car race in the world and contributes vital research and development towards the quest for sustainable future transportation. New: Entry Competition open to school and tertiary entrants. Free entry to the first school and tertiary teams to register. Contact: Ray Wieland, Event Manager, level 7 178 N Terrace, Adelaide 5000, South Australia • +61 8 8303 2021 • E-mail: wsc@saugov.sa.gov.au • Web: www.wsc.org.au

CHINA
International Conference & Exhibition on Energy & Energy Conservation, Oct. 20-22, 1998, Shanghai Mart, Shanghai. Contact: ICEEEC, Rm 1322 Bldg. 3, 1486 Nanjing Rd. (W), Shanghai 200040, P.R. China • Fax: 86-21-62049481 • E-Mail: wjyao@online.sh.cn.

Renewable Energy & Energy Efficiency Asia-Pacific '98 (REAP'98) Conference and Exhibition, Shanghai, China, October 14–16, 1998. Contact: Alternative Development Asia Limited, 1406 Leader Commercial Building, 54-56 Hillwood Road, TST, Kowloon, Hong Kong • +852-2574-9133 • Fax: +852-2574-1997 • E-Mail: office@adal.com • Web: www.adal.com

CANADA
The "Alberta Sustainable House" is open for public viewing the 3rd & 4th Saturday of every month (except holiday weekends) 1:00-4:00 PM free of charge. The project emphasizes cold-climate features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Already in place: R17 windows, multi-purpose masonry heater, solar hot water, grey water heat exchangers, LED and electro-luminescent lighting, solar cookers, and others. Under development: hydrogen fuel cells, Stirling co-generator, Tesla bladeless steam turbine, and others. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc/Alternative & Conservation Energies Inc, 9211 Scurfield Dr NW, Calgary, Alberta T3L 1V9, Canada • 403-239-1882 • Fax: 403-547-2671 • http://www.ucalgary.ca/~jdo/ecotecture.htm e-mail: <jdo@acs.ucalgary.ca>

The Institute for Bioregional Studies was founded to demonstrate and teach recent ecologically-oriented, scientific, social and technological achievements that move us toward ecological, healthy, interdependent and self-reliant communities. For info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada • 902-892-9578.

Electric Vehicle Society of Canada, Toronto Chapter—whose purpose is to promote EVs in order to reduce the terrible environmental impacts of conventional automobiles (and have some fun at the same time!) are a group of enthusiasts, inventors, Sunday mechanics and environmentalists from every walk of life who share the belief that EVs are a viable alternative. Meetings on the 3rd Thursday of each month, September through June. New Members welcome! Contact: Howard Hutt, 21 Barritt Rd, Scarborough, Ontario, M1R 3S5 Canada • Phone/Fax: 416-755-4324

Renewable Energy Technologies in Cold Climates '98, May 4-6, incorporating the 24th Annual Conference of the Solar Energy Society of Canada Inc. A forum for the exchange of information, research and development for renewable energies in areas with cold or extreme climates. For more information contact: RETCCC'98, c/o Solar Energy Society of Canada Inc., 116 Lisgar St Ste 702, Ottawa, Ontario, Canada K2P 0C2 • 613-234-7004 • Fax: 613-234-2988 • E-Mail: RETCCC.98@sympatico.ca

THE NETHERLANDS
Sustain '99, The World Sustainable Energy Trade Fair, May 25-27, 1999, Amsterdam, incorporating RE, waste to energy, and sustainable transport. Contact: European Meda Marketing, PO Box 259, Bromley, BR1 1ZR, UK • +44-181-289-8989 • Fax: +44-181-289-8484 • E-Mail: sustain@emml.co.uk • Web: www.emml.com

TURKEY
International Istanbul Energy Technology Exhibition, Oct. 22-25, 1998, CNR World Trade Center-Istanbul. Trade show, professional contacts, and technical meetings toward informing industrial and government offices about new energy technologies. Contact: Center for New Relations, World Trade Center, Atatürk Havalimani Darsisi, Yesilkoy 34830 Istanbul • 90-212-663-08-81 • Fax: 90-212-663-09-73-75 • E-Mail: ifnrg@ibm.net

NATIONAL
The PRSEA Chapter of ASES is sponsoring the 4th annual National contest for high school students. To enter, students design a photovoltaic powered device. Entries are judged by originality, presentation, and understanding. First prize is $500 with additional prizes for other winners and teachers and schools that sponsor entries. More information is available at solstice.crest.org/renewables/prsea/.

National Summary Reports on State Financial and Regulatory Incentives for Renewable Energy. These two reports provide the most current info on state and federal tax, grant and loan programs that target renewable energy. Also, check out the online Database of State Incentives for Renewable Energy at their web site. To order reports: North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 • Fax: 919-515-5778 • Web: www.ncsc.ncsu.edu/dsire.htm

Sandia's new WWW address is www.sandia.gov/pv and they have added new material and organized it to make material easier to find. It includes "Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices," "Working Safely with PV," and balance-of-system technical briefs which provide information about battery and inverter testing.

Solar Energy & Systems, a college credit course by Mojave Community College. Covers fundamentals of RE for the home owner or small village. Taught on the Internet using the latest technology. Weekly assignments for students to review various text books, videos, WWW pages, a weekly chat room, and email questions and answers from students. Tuition $100 plus $10 registration. Contact Don Timpson • 800-678-3992

DOE Online Energy Info Resources—Information on energy efficiency or renewable energy technologies. The Energy Efficiency and Renewable Energy Clearinghouse (EREC) BBS Online Service offers users free access to text files, share and freeware programs and utilities, and a free publication ordering system. Accessible via the Web: erecbbs.nciinc.com • Modem: 800-273-2955. The Energy Efficiency and Renewable Energy Network (EREN) is accessible on the Web at www.eren.doe.gov and provides links to hundreds of government and private internet sites. EREN also offers an "Ask an Energy Expert" online form that allows users to E-mail their questions directly to specialists at EREC. For more information • 800-363-3732.

American Hydrogen Association, national headquarters, 216 South Clark Dr. #103, Tempe, AZ 85281 • 602-921-0433 • Fax: 602-967-6601 • E-Mail: aha@getnet.com • "Prosperity Without Pollution" Web: www.getnet.com/charity/aha

Energy Efficiency and Renewable Energy Clearinghouse (EREC) offers free info: 1998 Fuel Economy Guide (SD404), Insulation Basics (FS142), Small Wind Energy Systems for the Homeowner (FS135) Reviews system requirements, site determination, and costs of residential wind turbines. Also; The New Earth-Sheltered Houses (FS120), Photovoltaics: Basic Design Principles and Components (FS231), Cooling Your Home Naturally (FS186), Automatic and Programmable Thermostats (FS215). Contact EREC: PO Box 3048, Merrifield, VA 22116 • 800-363-3732 • E-Mail: energyinfo@delphi.com • TDD: 800-273-2957 • Modem: 800-273-2955 • Web: www.eren.doe.gov

American Wind Energy Association World Wide Web: www.igc.apc.org/awea. Obtain information about the US wind energy industry, AWEA membership, small turbine use, and much more.

The Federal Trade Commission is offering free pamphlets on: Buying An Energy-Smart Appliance, the EnergyGuide to Major Home Appliances, and the EnergyGuide to Home Heating and Cooling. Write to: EnergyGuide, The Federal Trade Commission, Room 130, 6th St and Pennsylvania Ave NW, Washington, DC 20580 • 202-326-2222 • TTY: 202-9326-2502. The full text of these and more than 160 other consumer and business publication are available • Web: www.ftc.gov

The Surface Solar Energy data set, derived from satellite observations and produced by the Atmospheric Sciences Division of NASA Langley Research Center is now available. The data set contains site specific insolation values with monthly fluctuations, three hourly cloud fraction, and additional useful data. Text files, color plots and contour plots on a global scale are also available. Web: eosweb.larc.nasa.gov/DATDOCS/Surface_Solar_Energy.html

The Interstate Renewable Energy Council (IREC), in cooperation with the SEIA and Sandia National Lab has a handbook to guide state and local government procurement officials and other users in the specification and purchase of renewable energy technologies. Information on biomass, photovoltaics, solar domestic water and pool heating, and small wind systems. Technology specs

about equipment, photographs and vendor contact info. Contains information on simple methods for estimating the pollution benefits of RE systems. Send $15 ppd USA to Interstate Renewable Energy Council Distribution Center, c/o ASES, 2400 Central Ave Ste G-1, Boulder, CO 80301 (make checks to ASES).

SOLAR 98: Renewable Energy for the Americas, June 13-18, 1998, Albuquerque, New Mexico. The conference includes all renewable energy technologies and professions. For more information contact: American Solar Energy Society, 2400 Central Ave. G-1, Boulder, CO 80301: phone • 303-443-3130, Fax • 303-443-3212 • e-mail: ases@ases.org; web-site: http://www/ases.org/solar

NORTHEAST US
Tour de Sol, the US electric vehicle championship, May 7-15, 1998, NY, NJ, DE, MD, and DC. Hybrid Electric Vehicle Conference, May 7-10 in NY City. Contact: Northeast Sustainable Energy Association, 50 Miles St. Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053 • Web: www.nesea.org

ALABAMA
The Self-reliance Institute of Northeast Alabama is seeking others in the southeast interested in alternative energy, earth sheltered construction, and other self-reliant topics. Contact SINA, Route 2 Box 185A1, Centre, AL 35960 • E-Mail: cevans@peop.tdsnet.com.

ARIZONA
Tucson Solar Potluck and Exhibition, 16th Annual, May 9 at Catalina State Park. Join 1,000 people for a day in the sun with lots of solar cooked food. See exhibits of PV, cool towers, water pumping, electric cars, and more. Free fair, but the park has a $4 per car fee. Camping available. Info: Toby Schneider, 520-292-9020 • Citizens for Solar, PO Box 36744, Tucson, AZ 85740

A workshop featuring Tesla technology will be held in Phoenix, Arizona on April 25-26. You can get more information by calling 719-475-0918.

The State of Arizona is offering a tax credit for installation of all types of solar energy systems. A solar technician certified by the AZ Department of Commerce must be on each job site. For info contact ARI SEIA • 602-258-3422.

The Southwest Energy Fair, September 19-20, 1998, Flagstaff Arizona will offer technical, general public, and children's workshops as well as project, debate, and essay contests for students. An electric car race and EPCOT center solar exhibit. Commercial booths will be available and we are looking for individuals and companies to give demonstrations, hold workshops, or have ideas to contribute. On-site camping will be available as well as numerous free recreational opportunities for vendors. For more information call the Greater Flagstaff Economic Council at 1-800-595-7698 • e-mail: gfec@primnet.com

ARKANSAS
Cob Building Workshops "98 Workshop, prices are sliding fee depending on what you can afford. Cob Bread Oven Workshop, May 8-9 and one day natural plasters workshop, May 28, Contact Path Walker, 440 S Willow, Fayetteville, AR 72701 • 501-443-9564. One Week Cob Arkansas Intensive, May 15–21. Contact: River Spirit Retreat, HCR 72 Box 85, Parthenon, AR 72666 • 870-446-5642

CALIFORNIA
Campus Center for Appropriate Technology, Humboldt State University, Arcata, CA has ongoing workshops and presentations on a variety of alternative, renewable, and sustainable living subjects. Contact: CCAT, HSU, Arcata, CA 95521 • 707-826-3551 • E-Mail: ccat@axe.humboldt.edu • Web: www.humboldt.edu/~ccat

1998 US National Electrathon Championship, April 17-19, Encino Velodrome, LA, CA. Contact: Gary Ramond, PO Box 1722 Thousand Oaks, CA 91358

1998 EV World Expo, May 16-17, 1998, Los Angeles Petersen Automotive Museum. Education and awareness about the advantages of EVs. Contact: 1254 14th St. #B, Santa Monica, CA 90404 • 310-393-6141 • Fax: 310-458-7537 • E-Mail: emlupe@aol.com

Tehachapi Wind Fair, A celebration of renewable energy choices, is scheduled for July 18th & 19th, 1998 in the Tehachapi City Park. For additional information or questions you can call the Kern Wind Energy Association at 805-822-7956.

Home = Education Conference, HomeSchool Assoc. of CA conference, Aug. 21-23, 1998, Radison Hotel in Sacramento, CA. Contact: PO Box 2442, Atascadero, CA 93423 • 888-HSC-4440 • E-Mail: conference@hsc.org • Web: www.HSC.org

Windpower '98, April 27 to May 1, 1998, Bakersfield, CA. Contact: AWEA, 122 C St. NW, 4th Floor, Washington, DC 20001 • 202-383-2500 • Web: www.igc.apc.org/awea

Siemens Solar Industries offers two levels of PV training: Basic PV Technology Self-Study Course (continuously available), and the Comprehensive Photovoltaic System Design Seminar (call for seminar dates). Instructor Mark Mrohs, Manager of Training for Siemens Solar. The Self Study program includes our 500-page Training Manual and 9 hours of video lessons and applications, with exercises and examples throughout. The System Design Seminar is a 5-day intensive mixture of lecture, hands-on assembly, labs, and team system design problem solving. Completion of the Self Study program ($500 plus shipping and tax) is a prerequisite for the System Design Seminar ($1000). Contact: Siemens Solar Training Department, 805-388-6568 • Fax: 805-388-6395 • E-Mail: cvernon@solarpv.com • Web: www.solarpv.com

Rising Sun Energy Center presents ongoing Solar Energy Classes including electricity, water heating, cooking, and a kids' day. Contact for schedule and info: PO Box 2874, Santa Cruz, CA 95063 • 408-423-8749 • E-Mail: sunrise@cruzio.com • Web: www.cruzio.com/~solar

The National Marketplace for the Environment Conference and Trade Shop, A project of Eco Expo and the Environmental Education Foundation, May 6–8, 1998, Los Angeles Convention Center. For more information call • 800-334-3976

COLORADO
Solar Energy International (SEI) offers hands-on workshops on the practical use of solar, wind, and water power. The Renewable Energy Education Program features one and two week sessions, PV Design & Installation, Advanced PV, Wind Power, Micro-hydro, Solar Cooking, Solar Home Design, Cob and Natural Building, and Straw Bale Construction. Experienced instructors and industry representatives. For owner-builders, industry technicians, business owners, career seekers, and international development workers. The workshops may be taken individually or as a comprehensive program. $500 per week. SEI is a non-profit organization dedicated to the practical use of RE. SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 • E-Mail: sei@solarenergy.org • Web: www.solarenergy.org

National Wind Technology Center operated by the NREL, just outside of Golden, CO. The facilities assist wind turbine designers and manufacturers with development and fine-tuning and include computer modeling and test pads. Call in advance 303-384-6900 • Fax: 303-384-6901.

FLORIDA
Environmental Essentials conference, April 8, 1998, Radisson Mart Plaza Hotel, Miami, FL. Topics for helping your business survive. Contact: Dept. of Environmental Resources Management, 305-372-6784 • Fax: 305-372-6760.

SOLTECH, IREC, AND UPVG annual meeting, April 25-30, 1998, Coronado Springs Hotel, Orlando FL. Contact: Sharon Wilson, SEIA • 202-383-2620.

IOWA
Iowa Renewable Energy Association board meetings are held the second Saturday of every month at 9:00 am, at Cooper's Mill Restaurant (Village Inn Motel) in Cedar Rapids. Everyone is welcome. Time and place of meeting may change so call I-Renew for updated information. Contact: I-Renew, PO Box 2132, Iowa City, IA 52244 • 319-338-3200 • Fax: 319-351-2338 • E-Mail: irenew@igc.apc.org

The Iowa Renewable Energy Association is sponsoring the second annual Iowa Electrathon on May 16th, 1998, at Hawkeye Downs race track in Cedar Rapids, Iowa. The number of cars and schools has more than doubled in one year. The purse is bigger. For more info contact IRENEW at PO Box 2132, Iowa City, IA 52244 • irenew@igc.apc.org or Tom Deves at deves@mwci.net.

The Iowa Renewable Energy Association is sponsoring workshops this spring on Strawbale houses, Domestic Hot water installations, and DC Photovoltaic systems at Prairiewoods Nature Center near Cedar Rapids, Iowa starting in June. For more info contact IRENEW or Tom Snyder, 611 Second St. SE, Dyersville, IA, 52040, tsnyder@mwci.net or Prairiewoods, 120 E. Boyson Road, Hiawatha, IA 52233 • 319-395-6700.

KENTUCKY
Appalachia - Science in the Public Interest has ongoing projects and demonstrations in gardening, solar, sustainable forestry, and others. Contact: ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • E-Mail: aspi@kih.net • Web: www.kih.net/aspi

MAINE
American Solar Energy Society annual conference, Solar 1999, June 12-17, Portland, ME. Contact: NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053

MASSACHUSETTS
The Northeast Sustainable Energy Association (NESEA) and the Timber Framers Guild of North America are presenting the 14th Annual Quality Building Conference, the 14th Annual Timber Framers Guild of North America's Eastern Conference, RENEW '98 and a week-end Solar-Powered Music & Educational Festival at Westfield State College in Westfield, MA, July 23–26, 1998. For further information please contact NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 • fax 413-774-6053 • e-mail: nesea@nesea.org • web site: www.nesea.org

Greenfield Energy Park needs your help building its efforts preserving Greenfield's historic past, using today's energy and ideas, and creating a healthy sustainable future. Contact: Greenfield Energy Park, NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053

MICHIGAN
EnV'98, Environmental Vehicles and alternative fuels conference and exposition, June 15-17, 1998 Ypsilanti, MI. Contact: 29355 Northwestern Hwy #200, Southfield, MI 48034 • Web: www.esd.org

Tillers International lists classes in draft animal power, small scale farming, blacksmithing and woodworking. For a class catalog contact: Tillers International, 5239 S. 24th St., Kalamazoo, MI 49002 • 616-344-3233 • Fax: 616-344-3238 • E-Mail: TillersInt@aol.com • Web: www.wmich.edu/tillers

Cob Workshop Intensive as part of the Michigan Women's Festival, August 11–16. Contact: PO Box 22 Walhalla, MI 49458 • 616-757-4766

MINNESOTA
The Minnesota Renewable Energy Society will host the seventh Solar Regatta (See Running the Solar Boat Regatta in Home Power #59) on Saturday May 30. At least 15 student-built, solar-powered boats will be on display and competing on Island Lake, at the intersection of I-694 and Victoria Street, in Shoreview, Minnesota. The event is free, open to the public, and a guaranteed good time. May 31 is the rain date. Contact Tom Roark at 612-721-2103 • roark@fishnet.com, for more information.

MONTANA
Sage Mountain Center offers its Lifeskills Workshops for 1998. One day, comprehensive classes include: inexpensive earth-friendly home building, strawbale construction, making log furniture, cordwood construction, natural and nontoxic interiors, and more. $45 includes lunch and literature. Also, a free tour of SMC is set for April 25 in commemoration of Earth Day. For details call or write: SMC, 79 Sage Mountain Trail, Whitehall, MT • 406-494-9875

NEW MEXICO
Solar 98: Renewable Energy for the Americas, June 13-18, 1998, Albuquerque, NM. Featuring the ASES, ASME, and AIA conferences for RE. Contact: ASES, 2400 Central Ave., #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 • E-Mail: ases@ases.org • Web: www.ases.org/solar

NEW YORK
Hybrid Electric Vehicle Conference, May 7-10 in NY City. Contact: Northeast Sustainable Energy Association, 50 Miles St. Greenfield, MA 01301 • 413-774-6051 • Fax: 413-774-6053 • Web: www.nesea.org

OREGON
APROVECHO RESEARCH CENTER is a non-profit educational institute on forty acres nestled in the forest of Oregon. Internship programs March 1, June 1, and September 1. Also, a six week winter internship in Baja, Mexico which focuses on studying and researching appropriate technology applications, learning Spanish, teaching in a grade school, and working in fruit orchards and gardens. Contact: Internship Coordinator, Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198.

1998 H.O.P.E.S. Eco Design Arts Conference, April 17–19. Urban Farm Sustainable Structures, bamboo Building Techniques, Natural Dyes are among the workshops offered. For more information: University of Oregon, School of Architecture and Allied Arts, H.O.P.E.S., 5249 University of Oregon. Eugene, OR 97403-5249 • 541-346-0719 • fax 541-346-3626 • e-mail: hopes@laz.uoregon.edu • www: http://gladstone.uoregon.edu/~hopes/

TEXAS
SEASUN, El Paso Solar Energy Association • Web: www.epsea.org

VERMONT
Free PV Workshops for beginners and experienced off-gridders. 9 am to 3 pm the first Saturday of most months. Participant interest determines the topics: site selection, PV modules, batteries, charge controllers, inverters, lighting (ac & DC), balance of system components, system monitoring and maintenance, water topics, snow topics, ponds, living in cold climates, living with our woods, heating with wood, and root cellars. Visit a beautiful part of Vermont and meet other people living with renewable power or considering it. This is a freebie so bring your own lunch and coffee. Contact: David Palumbo, Independent Power and Light, RR1 Box 3054, Hyde Park, VT 05655 • Voice/Fax: 802-888-7194 • E-Mail: indeppower@aol.com

WASHINGTON
GreenFire Institute is offering workshops and information on straw bale construction. Contact: GreenFire, 1509 Queen Anne Ave #606, Seattle, WA 98109 • 206-284-7470 • Fax: 206-284-2816 • Web: www.balewolf.com • E-Mail: wilbur@balewolf.com

WE-Design presents its 1998 series of sustainable living workshops in Seattle, WA. Ecological Design Workshop, April 4-5 in Seattle, a two day hands-on workshop, instructors Ted Butchart and Michael Lockman, $125. Sustainable Living Apprenticeship, July 13 - Aug. 9 in Orcas Island, $1500. Permaculture and Natural Building Design Course, Dates TBA in Oakville, $550. Contact: WE-Design, PO Box 45472, Seattle, WA 98145 • 206-323-6567

Women's Natural Building Symposium, June 15-22, Open Symposium, July 1-7. Near Seattle. Contact: Groundworks, PO Box 381, Murphy, OR 97533 • 541-471-3470 • www.cpros.com/~sequoia

The First Open Natural Buildings Symposium, July 1–7, 1998 near Seattle, WA. Come Co-create magical natural buildings out of earth, straw, wood, and stone with homemade plasters, paints and floors. For more information contact: Groundworks, PO Box 381, Murphy, OR 97533 • 541-471-3470 • www.cpros.com/~sequoia

The River Farm Community Land Trust in NW Washington is hosting its second annual Renewable Energy Fair and Solstice Celebration, June 20th & 21st. This year features a "coopetition", with prizes in various categories of appropriate technology and environmentally friendly energy systems. The mission of the Fair is to display, promote and foster learning of alternative methods of generating power and doing work, in an atmosphere of playful celebration. This Fair will also feature a multitude of regional musicians on a solar-powered stage,a kid's carnival, and organic food. For more information on presenting and attending, contact the River Farm Renewable Energy Fair, 3231 Hillside RD, Deming, WA 98244. (306) 592-2716 ext. 4

WASHINGTON, DC
Excellence in Building Conference and Expo, Oct. 28-31, 1998, Sheraton Washington Hotel. Building science, construction practices, marketing, utility, and gov't. programs. Contact: EEBA, 2950 Metro Dr. #108, Minneapolis, MN 55425 • 612-851-9940 • Fax: 612-851-9507 • Web: www.eeba.org

Utility PV Experience, Conference and Exhibition will share experience of energy service providers engaged in introducing solar electricity to customers. Contact: Erin O'Donnell, Utility Photovoltaic Group, 1800 M Street, NW, Suite 300, Washington, DC 20036 • 202-857-0898 • Fax: 202-223-5537 • E-Mail: eodonnell@ttcorp.com

WISCONSIN
Midwest Renewable Energy Association Workshops. Call MREA for cost, locations, instructors and further workshop descriptions. See our ad in this issue. Membership and participation in the MREA are open and welcome to all. Significant others may attend for 1/2 price. Contact: MREA, PO Box 249, Amherst, WI 54406 • 715-824-5166 • Fax: 715-824-5399

Bioenergy '98, 8th Biennial Conference, Oct. 4-8, 1998, Madison. Contact: Great Lakes REgional Biomass Energy Program, 35 East Wacker Dr. #1850, Chicago, IL 60601 • 312-407-0177 • Fax: 312-407-0038 • Web: www.cglg.org/bioenergy98

The Affordable Comfort Conference, Madison, May 3-8, 1998. RE systems are expensive but can become more viable when installed on efficient buildings. Addresses concerns from how to evaluate the energy efficiency to the most cost effective way to improve its efficiency. Sessions on sustainable housing and communities, health and safety, multifamily buildings, utility involvement, marketing, and more. Workshops include classroom presentations and practical, hands-on sessions in the field. Contact: Affordable Comfort, Inc., 894 Beaver Grade Rd., Coraopolis, PA 15108 • 412-299-1136 • E-Mail: JudeRut@aol.com

the Wizard speaks...

Dimension

We usually consider the space-time continuum to have three spacial dimensions. It is possible, however, that the spacial aspect of the continuum has more than just the three known spacial dimensions. Many modern theories of physics incorporate the concept of more than three dimensions of space. In most of these theories, however, these extra dimensions are somewhat inaccessible. They are often considered either empty, or rolled up into a very small space beyond the limits of perception. Sometimes, they are just abstract mathematical entities having no real existence.

There is another way to look at the possibility of more than three spacial dimensions. We may consider our three-dimensional space to be embedded in a higher space of n dimensions, where n is greater than three. From this viewpoint we can consider the possibility of a myriad of different three-dimensional universes, each with their own associated temporal components. There could be an infinite number of these universes, each occupying an infinite three-dimensional volume. This super universe is often referred to as the multiverse or the metaverse.

To travel in this metaverse, one would need to be able to move orthogonally through the dimensions. This means moving perpendicular to the three-dimensional space that you start from. To navigate, you would have to choose the correct orthogonal direction out of many. There would be many directions for super spaces of five or more dimensions, but only two for a super space of four dimensions. This might be possible using gravitational and electro-magnetic fields with the proper dynamic topology. It is theorized that such topologies could exist in nature in the form of certain rotating black holes or in the form of wormholes in space.

Power is Power

Hello Home Power. First I want you to know that I think your magazine is wonderful and that I truly admire you and Karen, et al., for what you are striving for and for your remarkable accomplishments to date.

I just read "No More Mr. Nice Guy" on page 106 of HP #63 I went back and read the articles you referred to. Richard, it's about time you got pissed off and put it in writing. I have worked in hydro for 20 years now. I've dealt with utilities and government agencies directly, and indirectly through experiences of friends and associates.

Grid interconnection to sell power has been one expensive nightmare and heartbreak from word one. The utilities hold all the cards and for some reason they are scared to death of independents producing power. The only reasonable cooperation I've ever seen was for good PR. I can list one nightmare after another.

You're not paranoid and neither am I, the powers that be are the ones that are paranoid and they hear us tapping at the door. Believe me, the people fighting for PV and wind have got it made. Hydro people don't only have the utilities to deal with, we've got the federal government to contend with.

All, and I mean technically all, no matter how small, hydro sites require a federal license. This includes even a tiny Pelton wheel. The Federal Energy Regulatory Commission (FERC) has jurisdiction and requires federal licensing on all projects built after 1934. Even on sites built earlier, they claim jurisdiction if the site hasn't been in continuous operation since before that date. Any hydro site interconnected with the grid requires a license because it affects interstate commerce when some of those electrons sneak across a state line or, worse yet, displaces one or two that would have come across. Why doesn't this apply to PV and wind? Watch out, it could someday.

Any site which is on a "navigable waterway" needs a license. Understand, the federal government has worked it out in court so that every stream, no matter how small, is deemed navigable by their definition. In 1979, I received a standing ovation at a Hydro Conference in Albany,New York when I took on the Chief Counsel for FERC on this very subject. He turned out to be a nice guy and we discussed this later in private. They have their definition of navigable nailed down in court to the point where if three people stand on a hill and pee it's navigable if it runs into a tiny stream that runs into another stream and finally into the sea. If that waterway is navigable at any single spot between their kidneys and the sea the whole waterway and all it's tributaries are considered to be navigable. If it can be proved that anyone, and I mean over all time in history, has ever floated or dragged a boat or raft on any portion of that waterway then it is considered navigable. The example the FERC used for me was shingle rafts dragged by mules.

"Oh, well," you say. Do these rules have any teeth? That's being fought in court right now. FERC has a staff of over 200 lawyers on the taxpayer payroll, but up until it was challenged a couple of years ago, and probably soon again, they levied fines of $10,000 a day. This is from the personal experience of my best friend. Imagine the whole weight of the federal government leaning on you and your beliefs, for years, with the threat of millions of dollars worth of fines against your property and beliefs. Once you have a license you're really on their list and the arbitrary bullshit studies, etc. they can force you to do can cost thousands. Hey, the feds say you have to comply. His story is amazing. For example, he just got a five page letter asking him for his address (good old FERC) that was followed up with a seven page letter asking him for his fax number… ain't bureaucracy wonderful?

For years I've tried to reason out why the federal government and the utilities are so afraid of these tiny projects. The only reasonable conclusion I have goes back to the broader meaning of the word power. Power is power; political, economic, psychological, or military, and they want to control it and us. This isn't some wacko conspiracy this is a well thought out power issue. It even has to do with national security. What branch of the federal government was first given jurisdiction over water power in the last century? Aha, the Department of the Army, via the Army Corps of Engineers. For further insight visualize the broader meaning of the word "powerless" and recognize that with the exception of yourself and some of your readers, the average American would be really powerless without electricity from the grid. They have most of us by the short hairs; no water= no food preservation, no heat, no communications. Hey, are these utilities powerful; do they have power over the average citizen?

In this technical age most of us can't maintain our lifestyle or maybe even stay fed and alive without electricity. This isn't the ravings of a madman. I don't expect them to shut us off, but it does seem they are fighting awfully hard to maintain control of this power.

Home Power has to watch out for the ivory tower effect. To achieve your goals with the magazine and promote this terrific philosophy of earth awareness and self reliance combined with energy independence, you are creating a new reality for your readers. This is good, it encourages folks and moves things toward actualization. Your attention to hands on details helps make it physically possible.

My guess is that when you started this magazine you aimed it at stand-alone power users like yourselves and, as I recall, you gave the magazine away. I doubt very much if there was any talk of interconnection. As your magazine improved and the market expanded with glossy cover, etc., your readership probably expanded into the armchair market and finally the wealthy retired and younger upwardly mobile sets.

As a result, now we hear talk of interconnection and financial justification. These folks don't live in the woods anymore and although they like to think and say, "I built my site," the truth is they didn't — they just paid for it. The best of them did it for philosophical reasons because, like you and me, they took control of their lives and needs and do their tiny part. Hooray! Most of them will never get that investment back, they'll never come close. Often as not, though, interconnection is just a wasteful justification for an investment in a system that is too small to provide for bloated needs. It obviates the realities of our world situation and justifies halfway measures.

I recognize that the long term goal and justification is that as millions of homes hook into the grid and provide tiny amounts of power, in a better world this makes a big difference and we use less fossil fuels and nuclear. With PV and wind (there aren't enough hydro sites, either) this will not happen until each of these houses is a net energy producer and WE LEARN TO CONSERVE POWER IN EACH INDIVIDUAL HOUSEHOLD. At this time grid interconnection is just a wasteful excuse. People need to realize that they'll never learn to live on the power they produce and that they'll never conserve until they stop using the grid as a giant battery.

The hard reality is that utility-provided power is dirt cheap. It's an unbelievable bargain and all of us on the grid are just as hooked and dependent as the common heroin addict. To face this reality and make a real difference one has to to make one's own power and live within the restraints involved by conservation. People need to be told

this is extremely tough to do. People who have done it already know it, but the armchair crowd and those folks smart enough or wealthy enough to pay someone else to do it should be told. The effort is either very very expensive, time intensive, or both. I really believe that grid intertie is a cop-out and a great way for equipment dealers to help justify an investment (cashectomy).

The price of power is a political number and as long as we continue to pull those resources out of the ground with no acknowledgement of replacement and environmental costs, it will stay that way. The powers that be will always be happy to give it away by raping the earth and make millions in the process.The result is that most Americans don't even think about conservation (they would be stupid to at these prices). As long as they can drive their cars to work, buy frozen food, stay warm and comfy, and sleep in front of the TV with a beer in their hand every night, things are not going to change much. Don't forget they are bringing up future generations to do the same thing. Ron Macleod • E-Mail: microhydro@dplus.net

Hello, Ron. If we don't watch out we will be renting sunshine from fat-cat power companies. You're right, we started HP for the off-the-grid set. They were the only one's doing small scale RE in those days. Things have changed now. Check out the dynamite article about grid-connected PV in this issue. It addresses the whole bogus concept of payback.

Every home could reduce its energy consumption. This is the first step to going RE and maybe the most important. On the other hand, if every home came with a 10 kW PV array, then what are we conserving? I am long past caring why folks use RE. It's enough for me that they do.

Every PV module that sees sunshine, every wind genny that flies, and every microhydro which sips and returns water to a mountain stream is a victory. It is a victory for personal freedom and for our environment. Don't ask the "powers that be" to approve or make it easy for us. They have different motives—control and profit. If we want this freedom, then we have to do it for ourselves and for our planet. So, what else is new? Richard Perez

Wind Tower Free to Good Home

I have a 50 foot, 3 legged, free-standing, wind tower. I would like to donate it to any nonprofit organization who can come to the Ozarks and take it away. Chip Brewer • brewerchip@townsqr.com

Bathhouse Letter/Response

From my point of view, your bathhouse has a design defect. You assert the six-inch layer of stones and sand provides a thermal mass. The thermal mass you have is also called the earth. The gravel and stone is no different than having used bare dirt, except it's far cleaner.

A sub-floor thermal mass is only useful if you prevent the heat you store in it from going into the earth. This requires insulation since, as you state in the sidebar, its only purpose is to prevent heat from escaping.

Where I live, a 4 x 8 foot panel of 2-inch thick TUFF-R costs about $21. Your 12 x 24 foot building would require nine of these panels for less than $200. It has an R-value of 14.4 and will not degrade from being buried, although a vapor barrier around it is not a bad idea.

A quick-and-dirty calculation shows the benefit of the insulation: The specific heat of your sand and stone mix is about 0.2 BTU/lb./Degree F and it weighs about 150 lb/cu ft if the sand isn't wet. Your thermal mass measures 12 x 24 x 0.5 feet or 144 cubic feet, and weighs about 21,000 pounds. (The person who shoveled it knows better!) Therefore, its thermal capacity is 0.2 x 21,600 = 4320 BTU/Degree F.

I don't know the specifics of your glazing or inside temperatures, but let's assume your earth temperature is 56 Deg F and you can warm your thermal mass up to 66 Deg F over the course of the day. This means you will have stored 43,200 BTU of heat and the insulation will keep most of it in there. In fact, you'll only be losing 200 BTU/Hour to the earth. (288 x 10 x 1/14.4)

Until your internal air temperature drops below 66 Deg F, the thermal mass won't give you back any heat, but it won't pull heat out of your air as fast as the earth at 56 Deg F.

It would require a much more lengthy analysis to compute the payback from the insulation, but it is there. I understand your aversion to using factory-made materials, but you did it in the roof for precisely the same reasons. Love your magazine. Keep the faith. Regards, Ivan Riley

Right on, Ivan! We missed the sub-floor insulation in the first bathhouse article. Your numbers are great and illustrate the importance of insulation with regards to effective thermal mass. Our 2 inch sub-floor insulation rode up to Agate Flat in the Ryder truck in the fall of 1996 and should be laid out in the next few weeks. Dave gets the credit for moving most of the sand and at the time of writing, the stone hasn't been collected. Hey Dave! Just kidding... Joe Schwartz

Caveat Emptor—Washers

In issue #62, R.C. Morris, Jr. gave a generous endorsement of the Maytag Neptune laundry pair. Your editorial staff placed the heading "Super-Efficient Washer" above this letter, as if to say that the Neptune is superlative in terms of its efficiency. I believe this is misleading to your readership.

The letter reports that the Neptune consumes 0.8 kWh (800 watt hours) average per load. Compare this to the Staber machine, which needs about 165 watt-hours. The Neptune uses over four times more electricity than the Staber, but it will not hold four times as much laundry.

Consumers should ask about operating the Neptune on inverter power. One Maytag representative stated that the machine's warranty would be voided if operated on "non-standard power." As reported in the HP47 Things that Work!, the Staber machine is inverter friendly.

Here's another question about the Neptune that should be asked: How much water pressure is needed for correct operation? One source told me that a minimum of 30 psi is required, and this could pose a problem for those who are on a private well water system.

Water consumption for the Neptune is difficult to pin down. The advertising says "40% less water than average washers," but a consumer cannot easily determine how much water the Neptune requires. In order to reduce excessive sudsing, I believe the Neptune pumps sudsy water to the drain, replacing it from the supply lines in order to dilute the detergent mixture in the machine. Perhaps this explains why water usage figures are so elusive in the Neptune—the consumption depends on what the suds reduction system is doing.

According to Staber their machine uses 21 gallons per normal cycle if the water level is set to the high setting. A typical agitator machine uses 35 to 50 gallons.

One other important efficiency factor is that of water extraction from the clothes during the spin cycle. As the letter from Mr. Morris states, "they (Maytag) claim…greater water extraction during spin which reduces drying requirements." I do not minimize the importance of greater water extraction, but I believe we need more than just claims of relative superiority.

A typical agitator washer spins at about 550 rpm, and the Staber spins at about 700 rpm. Those of us who have switched to a Staber can attest to the fact that more water is removed, but this is difficult to quantify. Staber says that their machine applies an extraction force of 150 Gs for about five minutes per normal cycle. If we could find out the extraction force in Gs and spin duration for the Neptune, we might make a useful comparison.

The letter from Mr. Morris contains an apparent misprint: "…the gas dryer averages 15 kWh plus 0.11 therms per load." I don't know about the therms, but I would imagine the electrical rating should be 1.5 kWh instead of 15. Could 1.5 kWh be right? If so, that's 1,500 watts running for one hour, which is higher than we might expect for

a gas dryer using a motor of about 1/3 horsepower. By the way, Jim Staber tells me that clothes dryer design does not afford as many areas of improvement as clothes washer design did. That's why they don't build a dryer. They think consumers are better off using the clothes dryer they already own, since a dryer is also one of the most long-lived household appliances.

If we listen only to advertisements, it sometimes seems like every appliance qualifies as "super-efficient." It is sometimes difficult to cut through the sales hype and get down to the facts which will enable consumers to make a well-informed choice. Mick Abraham, Abraham Solar, Pagosa Springs, Colorado

Well, Mick, I must say we like our Staber System 2000 washer here. We are running it on 8 psi of water pressure. While I haven't sicced the computerized analog to digital instrumentation on it, a rough measurement from our system instrumentation indicates it does indeed consume less than 200 Watt-hours of electricity per load of wash. Richard Perez

More Washer Stuff

The Neptune washer from Maytag works great on solar electricity. We have only 500 Watts of PV, 900 Ah of battery, a Trace SW2512 inverter, and 13 PSI gravity fed water supply. The Neptune uses little more than 100 watts. Maytag says it needs 30 PSI water supply but it works for us on 13 PSI except if we put in too much laundry. The machine measures the load and decides how much water it wants. It shuts itself off if it can't get enough water in the time allotted. On 13 PSI our Neptune will do what we considered a full load in an American washer. We chose Neptune over the similar horizontal shaft washers because it is bigger, cheaper, and its maker has an unmatched reputation. Joel Gaalswijk, Spring Green, Wisconsin

Solar2 CD-ROM

Dear Richard: What a treat to get and launch the new Solar2 CD ROM! It's stunning and contains much more than I hoped for, especially after the well intentioned but primitive Solar1 (which I purchased and consider to be a "good faith donation" to the cause of bringing out Solar2). Your use of the Adobe Acrobat Reader to display and index the text and issues brings the issues alive. I was especially amused to see the original art work for the cover of Home Power #1!

As a relatively new subscriber (and after a short lapse now a re-subscriber), it was a pleasure to "make new friends" with the first 42 issues! I've already found the answers to several of my long term nagging solar questions.

Okay, I realize you and the gang have spent a tremendous amount of time on Solar2, but its fine result begs two questions. First, when may we expect a Solar3? Second, are you considering a 50%-50% library donation program similar to the one in place for subscriptions? If yes, I'd like (hope) to be the first library benefactor for a Solar 2 CD. Best regard, Jonathan L. Kramer, Encino, CA • E-Mail: Kramer@CableTV.com

Hello Jonathan. I'm glad you are finding Solar2 useful. Most of the time spent on Solar2 was remedial. First we had to learn to distill Acrobat PDF files. Then we had to resurrect ancient electronic page layouts made with a program which barely speaks PostScript. After we got all of this together we were faced with distilling seven years of our work. It took awhile, and thanks for appreciating our efforts.

I have always dreamed that Home Power would be a cumulative knowledge base. Well, after ten years and with many issues out of print, this was impossible. With the advent of many back issues on a CD-ROM and with a working electronic index, my dream is coming true.

Solar3 is going to be faster and easier for us to produce. We are using Quark Xpress now (and have been since HP#35). Version 3 of Acrobat Distiller is faster. I got a new faster computer (distills at about ten times the speed of the old). I am distilling back issues more quickly, and am now caught up to the present issue.

We plan to debut Solar3 at this year's Midwest Renewable Energy Fair on 19-21 June. It will be for sale via mail and the web once we return from this fair. Solar3 will contain HP43 thru possibly HP59 or maybe even HP60. Depends on files and index sizes. We are planning on putting some executable code on Solar3. Little ditties we use all the time like a PV system design template in Excel and wire sizing program also in Excel. If there is room we would like to include a short video-audio (Quicktime) visit to Funky Mountain Institute. Do you have anything (other than the issues) that you would like to see on Solar3?

We don't presently have an Adopt a Library program for the CD-ROM. We priced it so low (job one is get the info out there) that I don't think we can do the 50/50 deal and not lose money on it. While the ROMs are not very expensive to press, there is a lot of peoples' time in production, sales, and shipping. After talking to the front office, we decided to offer libraries Solar2 at $17.40. Check with the library first before adopting them, then give us a call. Sorry, private or corporate libraries are not eligible for this deal—the library must give free public access. Richard Perez

Prices

I think advertisers should be allowed to print prices if they choose to do so. I'm offended by advertisers who seek to exert such control over your magazine.

Keep up the good work. It might be interesting to see demographic info of subscribers sometime. Things like, "How many people went from on-grid to off-grid this year?" Kevin Corridon, Smiling Kitty Farm, Bayfield, Colorado

Thanks, Kevin. We want our readers to know that we continue to receive comments in favor of allowing prices in ads. Not one of you has said no. Rumor has it that there is a petition going around our advertisers to ask us to stop, but the readers have spoken about this issue and we have put the question to rest. I'll get to work on our readers' demographics and we'll have an article about this soon. Richard Perez for The Crew

An RE dealer responds about prices in ads

Dear Home Power, Although Lake Michigan Wind & Sun, Ltd. believes that there are advantages & disadvantages to printing prices in HP (printing prices actually allows us to "weed" out those folks who think the least expensive means the best value) but we felt compelled to respond to the readers overwhelming support of continued price printing. The R.E. industry is becoming like many other markets where consumers buy based on PRICE instead of VALUE. The newest trend in renewable energy businesses are these outfits with 800 numbers and 24 hour a day order lines from whom components can be bought at a very low price. Free call for the customer, convenient—so far, so good. The problem is very often the person on the phone knows nothing about the equipment they are selling. Consequently when Jane Q. Public has questions about her new gadget and calls the R.E. Warehouse Co. to ask for technical support, she gets the "Huh, Wha?" reaction so eloquently described in the last issue. Then Jane will have the audacity to call her local dealer who may have spent time and therefore money educating her in the first place to ask for free advice about the gadget she bought elsewhere. Since most R.E. dealers know that each faulty system hurts all of us, they help Jane with her problem. This is what separates R.E. and its' dealers from other businesses.

Dealer discounts in renewable energy are fairly low - often 10% – 30% off retail. Some quick math shows that is very little off the list price of a Trace inverter or a PV panel. This discount gets even smaller when you realize that the GOOD dealer has already spent hours educating Jane about R.E. in general, the purpose of each of the individual components, code requirements, system sizing & siting, equipment maintenance or even holding her hand during a zoning permit hearing or helping her fill out the utility interconnect contract. After all that, Jane buys her gadgets from R.E. Warehouse Co. and saves $50 or $100 dollars. This scenario is not farfetched. It

happens to this extreme on a regular basis as do the phone calls for "free" advice on gadgets bought elsewhere. The moral of the story is buy from your local dealer ESPECIALLY if you have been educated by their knowledge & experience. If you plan on shopping based on PRICE instead of VALUE, take the time to educate yourself by reading Home Power or enrolling in workshops. The ultimate goal for most R.E. dealers is to install many safe & successful systems generating clean electrons. We have a right to make a living doing it. Kim Bowker for Lake Michigan Wind & Sun, Ltd.

Hey, Kim, I couldn't have said it better. Price is not all. The real decision about prices in advertising lies with you folks who sell and service RE equipment daily. This is your decision, not Home Power's. Richard Perez

Wind Book

A couple of points to cover. First, great magazine. This is the first issue (HP#60) I've seen. I borrowed it from an acquaintance and read it from cover to cover. I am sending my subscription with this letter.

Second, the letter from Carl Martin, Arivaca, AZ. I'm not familiar with that model of wind generator, but I have a book that is well illustrated and may be helpful, "The Penryn Windmill Book". The address where I ordered it is: Penryn Farm, PO Box 1677, Petersborough, Ontario, Canada K9J 7S4. The $34.95 price included shipping and handling. There are illustrations concerning various folding tails. I hope this may help him and others. Joel F. Gorby, Manchester, Kentucky

Solar Water Pumping, Re: HP61

I see a few possible NFPA 70 NEC 1996 violations with the ac to DC pump conversion (HP#61, page 28). Article 310-4 only allows conductors 1/0 and larger to be run in parallel. I don't see any exceptions that would apply to this. If direct-buried UF cable with a bare (uninsulated) grounding conductor was used it would not meet 310-2 if the bare wire was used as an ungrounded conductor: "all conductors shall be insulated, except where specifically permitted elsewhere in the Code."

I assume since it was not stated otherwise, that copper conductors were used. Chapter 3 of the State of New Mexico Electric Code limits the use of aluminum or copper-clad aluminum conductors to #2 or larger where covered in NEC Articles 310, 333, 334, 337, 338, 339, and 340.

Please note in Article 90-4, that the Code is also intended for use by insurance inspectors. Most people assume the NEC is for use only by electrical inspectors.

I don't send this with the intent to find fault. I just love a good Code argument. I've worked with and studied the NEC as a M.S.H.A. Qualified Coal Mine Electrician and a New Mexico JE98 Journeyman Electrician. Sincerely, Paul F.Owens-KD5BFW, Aztec, New Mexico

Paul, you are correct. Good eye. 310-4 Exception No.2 provides that "Conductors in sizes smaller than No.1/0 shall be permitted to be run in parallel to supply control power to indicating instruments, contactors, relays, solenoids, and similar control devices provided (a) they are contained within the same raceway or cable; (b) the ampacity of each individual conductor is sufficient to carry the entire load current shared by the parallel conductors; and (c) the overcurrent protection is such that the ampacity of each individual conductor will not be exceeded if one or more of the parallel conductors become inadvertently disconnected."

Assuming that the uninsulated ground wire was not included in the parallel wiring, you MIGHT make a case for the PV to pump controller (it being a "control device") circuit as all three of the conditions were met, but it'd be a weak case at best. Paralleled submersible wires down the well are definitely a no-no by the Code.

The question to my mind is, is this a safety hazard? I think not. The explanation of 310-4 provided by the NEC 1996 Handbook states; "Other than as permitted in Section 250-95 and the exceptions to 310-4, there does not appear to be any practical need to parallel conductors smaller than No.1/0." This indicates to me that the NEC doesn't see any intrinsic safety hazard to paralleling smaller wires, they just haven't seen any need to do it. The flip side of that statement is that someone may have made a compelling case to NFPA IN FAVOR OF paralleling 1/0 wires. As a wild guess, it probably had something to do with upgrading electrical services to many houses or acknowledging the realities of pulling long runs of big wire. It shows me that the NEC can be flexible as long as safely isn't compromised, they just need to see a reason to do so. Bob-O Schultze-KG6MM

Kindred Spirit

I'm very proud of our renewable energy homestead. For over 21 years we have lived off-the-grid in the Missouri Ozarks and are dedicated to our self-sufficient lifestyle.

Only this week, however, I discovered something I hadn't even realized I was missing. I phoned Home Power to renew our subscription and had a wonderful, kindred-spirit conversation with Kathleen. I have lots of supportive friends, but I suddenly understood that they don't really get it about the way we've chosen to lessen our impact on the earth. In conversing with Kathleen (to whom I gushed a bit about turning first to "Home and Heart" when Home Power arrives!) I felt total understanding and harmony. She probably receives a bit of that daily, but it was the first time for me. All this from a subscription renewal! In rapid-fire, long distance fashion, we traded anecdotes and knew each other as common women, living uncommon lives devoted to renewable energy, whether or not we truly understood the batteries, wires, and gauges that make it all work.

My entire adult life has been directly influenced by our energy choices. The freedom of home-produced power led to our decision to home birth and subsequently home school our four children. And now, our growing children are coming full circle and have every intention of building homes incorporating renewables. One of our teenagers wanted "The Straw Bale House" book for her birthday!

So, thank you Kathleen and everyone on the Home Power staff for getting information and heart out there to all of us independent types. We may think we can do it all by ourselves, but now I know that I need an occasional contact with a kindred spirit to make it continue working. Barbara Johnson, Lecoma, Missouri

Hello Barbara. Wow, what a connection. We have realized for a long time that Kathleen is a gem on the phones and a wonderful front line representative of Home Power. Her knowledge and empathy is right on. RE is full of women and men that make the kind of connections you made. That is why we like renewable energy fairs so much. If you can pull yourself away from Missouri for the summer solstice, we'd highly recommend the Midwest Renewable Energy Fair. Watch out, you might be overwhelmed with these kind of connections, and you can meet Kathleen face to face.

Another thought about your wonderful letter: you are a great writer and, as you probably know, Home Power relies on readers to contribute articles. How about an article on what you are doing at your homestead. Richard Perez and Michael Welch speaking for The Crew

Utility Intertie

I need to convince my local utility to allow me to go on line with my photovoltaic system. They are somewhat skeptical about the ability of the Trace inverters to protect their grid. If you can help, please let me know. Winford Nettles, Jacksonville, Florida • E-Mail: scalaremp@juno.com

Hello Winford. The first thing I would do is contact Trace for how to deal with presenting the inverter in the appropriate light. Trace can give you details about which utilities have tested their inverters' ability to make sure they disconnect when they sense the grid going down. I have personal knowledge that Pacific Gas and Electric Co. in California did extensive testing on these units, so there is one resource. Trace should be able to give you their and other utilities'

testing facility contact numbers. In spite of some utilities having already tested these intertie capabilities, yours may want to do testing of their own, which brings me to another point for you to consider. Some utilities will do almost anything to keep their customers from adding an intertie system. Ask yourself, "Is my utility using this unfounded "fear" as a way of keeping me under their thumb?" If so, then you have a bureaucratic problem, not a hardware problem. Michael Welch

Terminology Pet-Peeve

R.W. Long's letter in HP #60 reminds me that there is another glaring inaccuracy in the alternative energy world. Mr. Long's pet peeve was thermosyphon—mine is "modified sine wave" inverters.

Modified sine wave inverters really put out a modified square wave. If you look at the waveform of a modified sine wave inverter it is a pulse waveform designed such that the area under the wave is similar to the area under a sine wave. The problem with calling it a sine wave inverter is that a sine wave is only one frequency, in this case 60 Hz. The pulsed waveform is made up of the fundamental 60 Hz and many odd harmonics, and that's why "Modified Sine Wave" inverters won't run some loads well. Too many harmonics.

Actually the new "True Sine Wave" inverters put out a signal a lot closer to what you might call a modified sine wave. The waveform is made up of many little steps (pulses) that approximate a sine wave.

Maybe some day when technology advances to the point of direct conversion from DC to a single frequency sine wave we will have to invent a new description. How about "Really True Sine Wave?" Ah, advertising! Keep up the good work—I love your publication. Bill Eppick, Port Townsend, Washington

Thanks for the flowers, Bill. We work our butts off and it's wonderful to be appreciated. You are correct about the term "Mod-Sine Wave", it really should be "Mod-Square Wave". This is what happens when the Marketing Department determines the technical terminology. Bottom line on inverter waveform purity is something called Total Harmonic Distortion (THD). THD is measured in percent and the lower this figure the more closely the power waveform replicates the ideal sine wave. THD can actually be measured by hi-tech instruments such as the BMI PowerScope which is an instrument used by utilities to measure the purity of their power. With a price tag of over $50K, I'm not urging folks to go out and buy one, but we were fortunate enough to be able to borrow one from a friend whose company can afford such wonderful instruments (Thanks, George). Here's what we found out. The local utility grid was delivering between 5% and 13 % THD to the wall socket (we let the PowerScope record data for 24 hours). Modern sine wave inverters delivered between 1% and 5% THD. So called modified sine wave inverters delivered between 30% and 50% THD (this depended greatly on the load with resistive loads giving the lower figure and inductive loads such as as motors giving the higher figure). For my money, the sine wave models are the only ones to consider for powering electric motors, electronics, computers, and communications equipment. Richard Perez

Radioactive Frying Pans

I recently picked up a copy of "Home Power" magazine from a book store rack and found it to be a very interesting publication. Interesting enough that a subscription is in order as "Home Power" fills a void in my search for information on the subject.

I have long held the belief that alternative sources of energy derived from wind and solar will take their rightful place in the scheme of things. That is, once the cost of producing energy in this manner becomes reasonably competitive with commercial energy sources using non-renewables. Other factors will obviously enter into the economic equation, such as availability of commercial power, pollution, and public opinion. The time will shortly come when alternative energy sources will play a very important part in the world's energy production alongside other conventional energy sources.

In the December 1997/January 1998 issue of "Home Power," page 88, in "Power Politics," there was a section titled "Radioactive Frying Pans." A reference was made to a press release from some organization called "Nuclear Information Referral Service" (NIRS). I have never heard of this organization and know nothing of NIRS positions on anything related to the nuclear industry.

What I got from reading this press release, was that it appears to be nothing more than a biased statement by a group opposed to anything nuclear. It was the choice and style of the wording that prompted my opinion. First you take a little pinch of truth and then you mix it with a good healthy flavoring of whatever bias you prefer. Then, under a plausible sounding organization name, you then publish this production as a press release purporting to be the profound truth. This process works particularly well with those who have no real reason to know anything at all about the subject.

To the best of my knowledge, it has never been the policy of the Department of Energy (US DOE) to knowingly allow any potentially contaminated surplus material or equipment to be released to the public. The D.O.E. is so paranoid on the subject that even computer video monitors (like TV sets) containing small amounts of very slightly radioactive phosphors behind the glass screen frequently have had problems getting a radiation clearance when being surplused to the public.

The style of writing and the words "converting old radioactive machinery left over from nuclear bomb factories" instantly confirmed to me that this press release probably contained less than the truth, the whole truth, and nothing but the truth. The published fact that author Michael Welch can be contacted c/o Redwood Alliance in Arcata, California tended to reaffirm my opinion. It has been my observation that groups with the word "Alliance" in their name, frequently have tendencies to be strongly anti-nuclear. Maybe not always, but often enough!

The point is, that it is usually a bad plan to attempt to bolster ones particular image by making less than wholly truthful statements about what others supposedly may have said or done. This is about as productive as chopping down the totem pole so one can claim to have raised oneself up from the bottom to the same level as the exalted figure at the top of the totem pole.

Home Power shouldn't have to publish potentially contaminated fallout of a highly debatable and unrelated nature from other group's intent on grinding their own particular axes. The subject matter Home Power addresses is much too exciting to want to risk having it being covered with mud being slung at or by others. Russ Hughes, Richland, Washington

Thanks for your comments, Russ. NIRS and Redwood Alliance are anti-nuclear. The publishers and staff of Home Power are anti-nuclear. It is one of the reasons we push so hard for a renewable energy future. There is no such thing as a safe dose of radiation. If the nuclear utilities and bomb builders can find any way of diluting and releasing into the public their low-level radioactive waste, then they will do so to avoid having to pay for disposal. Also, if they can do anything to make you and the rest of the public think that there is such a thing as a safe level of radiation, then they are one step closer to their goal of foisting more nuclear power plants upon us. The only nuke we need is the one shining in the sky. It's one of the reasons we publish the magazine. Michael Welch

Sharing

Hello to all the wonderful solar power enthusiasts. I had the good fortune of growing up in an alternative area of Tennessee where there are many stand alone PV systems along with other interesting peoples and technologies. However, since we moved to the southern tip of Illinois we have been having a hard time finding people interested in solar, PV, permaculture, and home power. Although we have the joy of having a university town nearby, I am looking for more permanent friends. Anyone can write and we can share information. I am mostly interested in PV but I know about many

other things. Thanks in advance. A. J. Beck, 186 Gates Rd., Pomona, Illinois 62975

System Shortie
I have just purchased a basket case 1980 Ford Courier pick-up with electric conversion. We are just finishing our cabin in Tennessee, built with timber from our land, milled on-site with a band saw mill. We have gravity flow water, eight solar panels (flat plate) for hot water, which we store in a 1000 gallon tank in the insulated greenhouse and pump into the floor of the greenhouse and garage. We have two sets of PV panels for electricity which charge sixteen, 6 V golf cart batteries, and a 4000 watt Trace sine wave inverter. We also have a Delco (homemade) water generator (I need a regulator for it. Can you help?). I also made a composter for toilets and kitchen scraps. We heat mostly with a wood furnace. Bob Berkstresser

Hello Bob. See HP#42, page 28 for a homebrew article on the regulator you need for your Delco alternator. Unfortunately, this regulator is not made commercially so you must make it, or have someone make it. It's not hard, about $50 worth of parts from Radio Shack and a few hours of soldering. How about it RE control makers? We'd love to sell the rights to this control and get it back into production. Richard Perez

Steam
I was delighted to find Skip Goebel's article in HP#62 and I am hoping that it will spark a lot of interest among HP readers.

I understand, as Skip does, that there is a place for small scale steam power as an alternative power source for off-grid residences. But I fear his article may lead some untrained readers to think it's all so simple that they will engage in what can be an extremely dangerous activity.

Steam power may be regarded as one narrow sliver of the subject of thermodynamics. So that you may judge my expertise and the authority of my remarks here, I will give you a bit of my background. I began my education in the Department of Mechanical Engineering at Oregon State in 1941. I received my BS there in 1949 after an interruption by WWII. I subsequently acquired two additional degrees in engineering but they are not germane to the topic of steam. I studied the Mechanical Engineering program option of Power but completed most subjects in the Design option too.

The Power option included thermodynamics as its principle subject. Descending from that covered steam, power plant engineering, internal combustion machines, and laboratory courses in the testing of machines. Reciprocating steam engines were passing from the scene in 1941, even steam locomotives were gone by the early fifties. There has been, to my knowledge, no formal educational attention to them since 1950. My intellectual addiction to steam power and steam engines began at Oregon State. I've not been cured of my addiction to steam engines despite the passage from the scene of all but hobby applications. At Oregon State in the forties, reciprocating steam engines were still a significant part of the equipment employed in engine testing. The engines I tested, if memory serves, were the Corliss, the Ideal, and the Uniflow.

In twenty years of teaching engineering subjects, my favorite has always been thermodynamics. I've relied on the steam engine to illustrate and enlighten the study of steam turbines, air compressors, refrigeration compressors, and the production of cryogenic fluids (liquid oxygen, nitrogen, and hydrogen). All of our understanding of these modern machines can be traced back to development of theory for steam engines by such early pioneers as Newcomen, Watt, Carnot, et. al. Enough of that, I simply want you to know that, at 74, I am one of a vanishing breed of engineers who could design a reciprocating steam engine to meet a given set of specifications. I really can't fault Skip in the comments I make here. No one under the age of 70 can have had much formal exposure to steam engine fundamentals.

Turning now to his article, my first concern is with his discussion on page 50 of evacuating a canning jar by means of a pressure cooker. Without detailed instructions and proper cautions on how this might be done the potential for injury is very great.

On page 51 at the foot of the first column, he confuses watts, a measure of the rate of delivery of energy, with the quantity of energy delivered, watt hours. Watts are like horsepower and watt hours are like foot pounds of BTU. At that point he also suggests that the overall conversion efficiency might be as much as 10%, but my own experience suggests it is unlikely to exceed 5% for reciprocating steam engine plants without resort to such complex refinements as multiple expansion design, condensation of the exhaust vapors, feedwater heating, stack gas economizers, and very careful combustion control at the boiler. Overall conversion efficiency for the best of modern (turbine) steam power plants reaches perhaps 30%.

Skip's comments on horsepower under Engine at the foot of the second column on page 51 are unfounded. One horsepower is one horsepower, whether gas, steam, or electric and I suspect he is confusing engine horsepower and boiler horsepower. One boiler horsepower is commonly held to mean 10 sq. ft. of boiler heating surface. Depending on the quality of boiler design, 10 sq. ft. can assuredly drive an engine of more than one horsepower but a one horsepower steam engine produces one horsepower. It was common practice in the heyday of reciprocating steam engines to rate them at the horsepower where they exhibited maximum efficiency. Stationary diesel engines are rated that way today. Gasoline engines for lawn mowers and automobiles are rated for the very maximum they can deliver. The steam engine, when rated at that power where efficiency is best, can deliver perhaps twice that when pushed to its limit on wide open throttle or driven by higher boiler pressure than rated.

If one carries out his computations at the foot of the first column on page 52, just as listed, and with proper attention to units, the result is 78,500 ft lbs per minute. One must divide by 33,000 ft lbs per minute per horsepower to reach his result of 2.37 hp. HP=PLAN/33,000. That was apparently a typo as he's got it right at the foot of the first column on page 58. His comments regarding torque apply only to stall torque, one of the great pluses of steam engines for automotive use, and do not apply to running torque as given for internal combustion engines in vehicles. The torque at operating speed can be determined from HP=TN/5250 where torque (T) is in foot pounds and N is in rpm. He uses 1000 rpm in this example. That's ok for a small engine but 500 rpm is near the upper limit for engines of the order of ten horsepower or more. For the HP readership I would have used 900 rpm in the example because that's the synchronous speed for a 60 Hertz, eight pole alternator. I agree with Skip's preference for DC however.

At the top of the second column on page 53, he describes latent heat as the heat stored in the water. That is incorrect, latent heat is the heat necessary to change ice at a given temperature to water at the same temperature. Latent heat is the heat necessary to change water at a given temperature (or pressure) to steam at that same temperature (or pressure). Latent heat is the heat that must be added to change the state of a substance (i.e. change from solid to liquid or liquid to vapor) after its temperature has been raised to the point at which the change of state is to occur.

His scheme for determining engine efficiency is only a rude approximation. To do it right, one must determine the quality of the steam entering the engine. That is, how wet is it or how super-heated, pressure and temperature? Knowing these facts, we can determine the enthalpy of the steam (energy content in BTU/lb) entering the engine. We then must determine the enthalpy should be at exhaust pressure (if the engine efficiency were 100%). The Mollier chart is the best tool for this. If we subtract the theoretical enthalpy leaving the engine from the real enthalpy entering the engine and multiply the difference by the lbs/hr of condensate (lbs/per hour of steam passing through) we get a number in BTU/hr. That is the energy made available to the engine.

What the engine does with this available energy determines the

engine efficiency. Suppose that the enthalpy entering was 1200 BTU, the theoretical enthalpy leaving was 980, and the condensate is 40 lbs per hour. Q, the energy supplied to the engine, would thus be (1220-980) x 40 = 12,000 BTU/hr. If the engine were delivering 2 hp during that hour (as measured by a Prony brake), the engine would be delivering the equivalent of 2 x 2545 = 5090 BTU/hr and its engine efficiency would be 5090/12000 = 42.4%.

At this juncture, I am obliged to point out that we are talking about engine efficiency, not system efficiency. It's simply a measure of how well the designer and builder have created the engine. It tells us nothing about how well we've used the energy in the wood we've supplied the boiler. There are myriads of wastes in addition to that wasted by the engine failing to reduce the enthalpy of the passing steam to that theoretical value that would occur at the exhaust if the engine were perfect. To list some of the wastes, let's start with the wood (that 6000 BTU Ozark wood of Skip's isn't at all bad). If this wood is wet, a lot of the wood's own energy will be used to evaporate the water it contains and this energy will go up the stack. If we are forcing air into the furnace, the fan power is a deduct.

Combustion air goes into the furnace, and out the stack goes hot CO_2, N_2, excess air (over the theoretical amount required for combustion) and the water vapor formed by combustion of hydrogen in the wood. These exit gases can carry away as much as 20% of the wood's energy. Heat is bound to radiate from any system element warmer than surroundings, i.e. boiler, piping, engine, etc. There is of course the boiler feed pump which takes quite a lot of energy. When we take all of the wastes or deducts away, all of the good we get is that 2 hp x 2545 and it's no wonder that the overall system efficiency is like 5% for small reciprocating engines. Overall system efficiency is the per centum of the original energy in the wood that we turned into real work. That engine efficiency we calculated above would actually be very good for a small engine.

I heartily agree with Skip's recommendation (see System Cost on page 57) that HP readers should begin their steam education by attendance at steam shows. I am guessing that Skip began his own steam education in just that way, but it is obvious he has gone a long way beyond that. My own experience with steam show exhibitors is that they are long on enthusiasm and pet theories if just a bit short on theoretical truths. One can only be amazed at some of their accomplishments working with nothing but native ingenuity. After being properly exposed at steam shows, I recommend the reading of such works as (a) *Marks Handbook*, (b) *Steam Power Stations* by Gaffert, (especially pages 1 to 30), (c) *Steam Boilers* by Shealy, (d) *Steam Power and Internal Combustion Engines* by Craig and Anderson (pretty good throughout and treats engines and governors pretty well), (e) *Power Plant Testing* by James Moyer, (f) *Steam Engine Principles and Practice* by Terrel Croft (quite surely one of the very best for newcomers to the steam engine fraternity) and finally, by all that's holy, (g) the *Steam Tables*. I have routinely gotten free copies for my students from Combustion Engineering, Inc. This little booklet is reprinted from the ASME STEAM TABLES and comes with a fine Mollier chart that any steam buff should take a vow to learn to read. Reference (f) will help in that difficult task. According to a note inside the cover, copies may be obtained from Marketing Communications, C-E Power Systems, Combustion Engineering Inc., 100 Prospect Hill Road, Windsor, Connecticut 06905

I don't know the cost and believe that I got them free because I was pretty glib tongued.

The books I've listed, other than *Marks Handbook* and the *Steam Tables*, are all old, part of my own library, and may require HP readers to ask their local libraries to get them from rare book dealers and/or out of print sources. It could hardly be otherwise as no one would wish to write a text now for a topic that has gone out of fashion. I've chosen these references because their authors don't seem to find it necessary to show off with high level mathematics. Most can be read without the need to take a course in calculus first.

I would like to fully endorse Skip's remarks regarding safety. I have a design about half done for a neat 3 HP system that I fully intend to complete and build. I'm reluctant to offer it to HP readers for fear of jeopardizing my professional engineering license and my welfare if a reader chose to build it and suffered an accident. The most serious problem, especially with a wood fired system, is the matter of control. Any HP reader worth his salt would use wood in preference of propane. Propane, though very much easier to control, would be very expensive and would seem to me, in view of the overall conversion efficiency, to be a violation of faith.

I intend in my design to steal some control features from the Doble steam car, the finest steam car ever built. Abner Doble, one time professor of thermodynamics at MIT, established and operated the Doble Steam Car Co. in Emoryville, California during the twenties. Some of his cars ran more than 400,000 miles. They burned gasoline and claimed economies of 20 mpg. Sitting cold overnight with the pilot light out, they could be fired up and rolling 60 mph in a matter of two or three minutes. I have some of their sales literature, one piece of which states his warranty "for 100,000 miles for any failure save to expendable items like tires, batteries, lamps, etc. furnished by others." He was, without doubt, the very best of the last great steam engine designers. All of his documents, memorabilia, drawings, etc. are held by the University of California library at Berkeley.

Skip's boiler remarks are right on and the illustrations are great. I very much hope that his article unleashes a flood and that he can forgive me for some of my comments that seem negative. I mean them to be helpful and he had set himself a difficult task. Wayne E. Phillips, Klamath Falls, Oregon

KISS?

Dear Kathleen: I think that you could improve your writing style if you composed more complex sentences. Go through your page 90 and you could replace 'half' of your 'periods' with 'commas'—with an occasional semi-colon. Look them up in a handbook on writing and punctuation use. But then, perhaps you are a child-bride. Write as though you are talking to a person. No name or address on postcard mailed from North Bay, CA

Riposte to the person who sent me this post card. Please read the third and fourth sentences of the paragraph titled 'Article Style and Length' on the Writing for Home Power page. Every one here at Home Power welcomes constructive criticism. However, there is no need to resort to personal insults. If you didn't do so, maybe you could find the courage to sign your name. Kathleen Jarschke-Schultze

Hey, we feel unappreciated! We work overtime at Home Power to keep technical information understandable to all. Part of our effort is simple declarative English. I am the author of two books printed by a large publishing company before we ever started Home Power. They offered me a job as an editor based on my simple and understandable English style. I suggest that your criticism of Kathleen's work is unfounded and downright wrong. Our object is communication. This is best accomplished by simple, direct English. Kathleen would love to have an apology from you, and please, this time sign your name. Richard Perez

A System Update

Keep up the great work you're all doing with Home Power! I've got all the issues, back to #1; all neatly stored in boxes stacked on my shelves. I've been doing my own electricity for over 20 years now! Remember me from HP#11? I just finished re-sanding and painting and taping my own hand carved three blade prop for my Whisper 1000. Never did like the two blade prop it came with. I get the full output (30 amps at 40 volts) with my seven foot diameter triple blade compared to the nine foot diameter two blades it came with!

Bob-O, for what it's worth; my 12 M-65 Arco panels (Siemens, now) are 13 years old and still working fine. I used regular 12/2 indoor Romex stripped down to single wires and connected the panels three

in series with one single #12 wire (I used the white for less heat conduction). I did solder some stranded #12 flexible wire to the solid #12 for the flex loops to the fuse box mounted on the mounting pipe. These wires have been out in the sun and weather for 13 years now in northern New York with No Change! They look and feel like original. I'm sure they'll go another 13 years! Fred Rassman, Belmont, New York

WOW!

I'd just like to thank you for what you do! You've advanced the implementation of PVs, etc. by many years and sent it in a direction which I believe is different and healthier than if you hadn't been there. The only other group that comes to my mind riding/creating a wave like you is the Whole Earth Catalog. You're in good company! Thanks! Randy Sizemore, Cincinnati, Ohio

Aw Shucks, Randy, and all the time I thought we were just coming up with enough electricity to play the Grateful Dead's music on the stereo! Seriously, what began as a small group of off-gridders using RE and sharing our info, has grown into an international movement for using RE both on grid and off. Renewable energy is an idea whose time, and technology, has finally come. We are lucky to be able to help it along. We're going to keep doing it!

Our next challenge is really not technical but political and economic. We have to bring utilities up to speed on energy changes. These folks are still stuck in the "we make it and you have to rent it" mentality. I know everyone has to make a living, but utilities have (or should I say had) a monopoly on power. I could forgive them trying to hang on to this monopoly if it weren't for what they are doing to our environment. If it were just a matter of money, I'd not object to them doing their thing. After all one can always go off-grid and tell them to shove it. But what is really at stake here is not their paychecks, but the future of our planet and our children. This is worth fighting for and you'll find us in the trenches doing exactly that! Richard Perez speaking for The Crew

Offers and Requests for Help

Hi. One thing that seems to be happening lately is that although the market for alternate energy is flourishing, the spirit of the public in general is directing itself away from self sufficiency and towards outside reliance. What a shame to have had it and lost it!

We all see articles about missionary type events going on and how they use alternate energies to enhance their goals. I feel that not only are we only seeing the tip of a iceberg here, but we (the readership of magazines like yours) have a wonderful opportunity to help others and cement our movement.

I suggest that your magazine promote in some serious fashion a "mission" type section to promote such activity and provide a way for readers such as myself to help out or donate resources toward the mission field. By providing a "glue pot" of sorts this way, we can put self sufficiency in a very positive light that will make others want to join our camp.

Most businesses, including my own, look forward to volunteering, helping, assisting, and educating those in the missions field. Obviously, the good p.r. would benefit our business, but more importantly, our consciousness would be elevated knowing that we operate with a positive heart.

Such a goal will be impossible without your major co-operation as you are the means of communication between those that need help and those who can help. I hope that you will seriously consider this. Thanks. Skip Goebel, Branson, MO • E-Mail: 146942@msn.com

Hi Skip. We will publish letters including offers for help as well as requests for same from any bona fide organization whose purpose is to help the cause of renewable energy or improve the plight of people through the use of renewable energy. After discussing your valuable idea amongst ourselves, we decided that we probably couldn't sustain a regular feature column on this subject and will continue to use the Letters section for this purpose. So, if you or your group is doing this type of work in developing nations, let us know. If those of you in these developing nations need help with sustainable energy solutions, please let us know. We'll see that your info gets in print. Michael Welch and Richard Perez for The Crew

Refurbishing Ni-Cds

First, let describe my personal situation for you. I am 75 years old and in less than perfect health. During the past few months I have been delighted to assist some of your readers with questions concerning placement of Solar Arrays, and will continue in that effort.

My reason for writing this letter concerns the possible recovery and utilization of Nickel Cadmium and Nickel Iron Traction Batteries as used in Fork Lift Trucks and the like. There are large numbers of these discarded high capacity batteries sitting around in repair depots at various location in the US. It has been one of my assumptions, based on previous engineering work in the Sintered Plate NiCd Battery Field that there are things that could be done to these extremely durable Pocket Plate Alkaline Cells of large Ampere Hour capacity, that could radically improve their performance to very close to their original condition. Secondly, these cells could be of great interest to the "off line" power users as an economical and long lasting storage device at a personal level.

The major problem has to do with my own physical condition that prevents me from attempting, on a very small scale, to determine whether any of these corrective measures would actually produce the desired results. Therefore, I am looking for a younger "soul-mate" who is already in the battery reclamation business who might be willing to invest an amount of time and practically no money to determine if these pipe dreams of mine might bear fruit.

I don't seek payment, of any kind, for any of the possible results or for any of the information (that if developed would remain propriety to the experimenter), so I think that the price is right.

The reason that I write to you is that your Magazine has such.

• Wide readership among the users as well as the sellers.

• Your personal associates seem to be practical bucket chemists and railroad electricians as well as being very knowledgeable about a wide variety of disciplines.

If you could direct me to an applicable person, who might be willing to enter into a preliminary discussion of the methods and pitfalls involved. William C. Farrell, New Milford, Connecticut • e-mail: u11216@snet.com

Writing for *Home Power Magazine*

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

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

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

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

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

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

Line Art
We can work from your camera-ready art. We can scan your art into our computers.

We can redraw your art in our computer. We usually redraw art from the author's rough sketches. If you wish to submit a computer file of a schematic or other line art, please call or E-Mail us first.

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

You can send your article via modem either to the *Home Power* BBS at 707-822-8640 or via Internet, as an enclosed ASCII TEXT file. On the BBS, address the message with the enclosed file to "Richard Perez". The Internet E-Mail address is: richard.perez@homepower.org. If you are sending graphics, or articles with embedded graphics, then use this special E-Mail address: rap@snowcrest.net

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

Got any questions?
Give us a call and ask. This saves everyone's time.

Access
Richard Perez, c/o *Home Power Magazine*, PO Box 520, Ashland, OR 97520 USA • Voice Telephone: 916-475-3179 (during West Coast USA business hours, otherwise you will get an answering machine)• FAX: 916-475-0836 (24 hours a day)• Internet E-Mail: richard.perez@homepower.org

Ozonal Notes

Richard Perez

Utility Intertie Issues

My "No More Mr. Nice Guy" piece in last issue's Ozonal Notes has generated a great deal of reader response. Check out the cover story and Letters column in this issue. Almost all those who wrote in agreed, "It's time to get tough with utilities regarding interconnection of small scale renewable energy systems."

Here's what we want from a utility when we intertie our renewable energy (RE) sources. We want net metering. We want reasonable, and nationally standardized, technical interconnection requirements. We want an end to megabucks insurance requirements.

Net metering means that the power company pays us the going retail rate for our RE, and we pay the utility the going retail rate for energy we buy from them. This financial decision equally values our RE and the utility's grid power. Personally, I think our electricity is worth much more than the utility's electricity—just look at how the power is made. We use sunshine, blowing wind, and falling water. They use nukes, coal and gas burners, and dam large rivers.

Net metering also has technical ramifications. Net metering eliminates installing a second electrical meter in the system, the necessity of the utility reading the second meter monthly, and all the paperwork and bill processing necessary for the utility to keep track of how much energy you made and where it went. This will reduce both the installation cost of intertie and the ongoing "read and process the second meter" expenses. If you think that is small potatoes, you are wrong. While you can buy a kWh meter in a surplus store for less than fifty bucks, it costs much more when it is installed by the utility. In some cases, the addition of the second meter has cost over a thousand dollars. Many utilities actually charge intertied systems a monthly fee for reading and billing the second meter measuring the RE production.

Net metering laws are active in Arizona, California, Connecticut, Iowa, Indiana, Massachusetts, Maryland, Maine, Minnesota, North Dakota, New Hampshire, Nevada, New York, Oklahoma, Pennsylvania, Rhode Island, Texas, Vermont, and Wisconsin. National net metering laws are in place in Germany, Japan, and Switzerland. Other states and countries are contemplating net metering. Are all these net metering laws the same? No, so check out the local legal scene before making your intertie plans.

We want reasonable and standardized utility interconnection requirements. At this point, some utilities are requiring super-expensive and needless "safety" equipment which can add thousands of dollars to a system's cost. Lockable outside disconnects, additional safety relays, and yearly utility inspection of all this needless equipment increases the system's cost and complexity without providing any real additional safety. We, RE producers, want to have safe systems. After all, they are attached to our homes. What we don't want is bureaucratic BS disguised as mandatory safety requirements. We know road blocks when we see them.

Utilities are requiring insurance packages for RE intertie systems which can run from half a million to over two million dollars. This level of liability insurance is suited for many-million-watt power plants, not our small ten thousand watt or less RE intertie systems. We want reasonable insurance requirements which reflect the much smaller scale of our RE systems.

I've gotten very tired of watching America's utilities put every road block possible in our way. What we are trying to do is share our surplus renewable energy with our neighbors. The utilities view this as a threat to their established power monopoly and profits, and thereby their existence.

Utilities' poor-mouthing falls on deaf ears here. For example, when a local PV system owner approached the power company about utility intertie, the utility trotted out all the standard road blocks—less than one-quarter of retail power price for the solar energy, two kWh meters, an additional monthly fee to read the second meter, and a whopping multi-million dollar insurance policy. Their road block was successful—the owner decided not to share his surplus solar energy with his neighbors. This same energy utility is now bidding 10.7 BILLION dollars to purchase the largest electric utility in England!

While I find the utilities' concern that we small-scale RE types will put them out of business flattering, anyone who can run a calculator can see that this is not true. It would take many millions of these systems to have any significant effect on utility profits. The entire utility industry is on its way to being deregulated anyway, and we RE types are the least of their problems. Utilities have grown fat as they suck up government subsidies, pollute our planet, and pick our pockets. It is a struggle between the way we used to do things versus they way we will do things. At one time electric power was a scarce commodity, generated by acolytes in huge power plants miles away. Now electric power is becoming as simple and democratic as sunshine. It's time for utilities to realize that there has been a fundamental change. While utilities will continue to distribute electricity for awhile, their monopoly on power production is ending. That job has been moved to the big nuke 93 million miles from here and to your roof top.

Advanced Composting Systems Toilet

I want to apologize to the Advanced Composting folks and offer a clarification. Our Bathhouse article in HP#63 reported their toilet was over 13 feet tall, which included our riser and the toilet seat. In another application, the height could be as short as 9 feet. Ours is a jumbo model, good for a dozen people full time. There are smaller models which would suit a smaller homestead. We are very happy with this toilet. No smell, virtually no maintenance, and no problems so far. We can't wait to get our first load of compost.

Clean People and Clothes at Funky Mountain Institute

What can I say about the joy of hot showers and clean clothes? Not much other than we are doing it at home instead

of trucking it to town. This revolution was awhile coming, but it's finally here and we're enjoying it immensely. Sun Frost's "Low Power Shower" is living up to its name. After we adapted it to our low water pressure, it has become the champion of clean. Even before dawn, when the bathhouse is a little chilly (as low as 36°F), the Low Power Shower holds the water's heat in the stall area making for a comfortable shower. The crew here is happy with its large size, high shower head (even six foot, four inch, Michael can get under it without stooping), and effective insulation. Many thanks to Larry Schlussler and the Sun Frost crew. You folks have another great product.

The Staber System 2000 clothes washer is also now operational. We've run a dozen or more loads through it since we reported on it in our last issue. Average electric energy consumption is under 200 watt-hours per load. It doesn't seem to use much water either. Staber says it uses about 21 gallons per load. We are noticing that our clothes are coming out much cleaner than when we hauled them to a laundromat in town. I don't know if it's the washer, our very pure well water, or what, but we're pleased with the results. I figured we'd have to be strategic with our washer use. You know, wash when the sun was shining, the batteries were full, or when we had the back-up genny running. The Staber uses so little energy that we can wash anytime it's convenient without regard to the washer's energy consumption. This washer is a great appliance, both in efficiency and function—we recommend it to you most highly.

Home Power on the Internet
Our web pages have been going crazy. Michael, our web designer, installed a program which records activity. During the months of December and January last, our top page was accessed 31,300 times. These are original hits, not multiple counts for people that start at the top page, go to a secondary page, and then back to the top page.

HP's Electronic Edition, in Adobe Acrobat PDF format, was clicked on 40,700 times. We have no way of knowing whether each click was a successful download or if a particular visitor clicked on a download more than once.

What this means is that *Home Power's* circulation on the internet is now over twice that of our paper edition. Wow! I knew you folks were interested in RE, but I had no idea that there are so many of you. We are deliriously happy to be able to distribute RE information without using up more trees and shipping those dead trees around the world.

The bad news behind *Home Power's* success on the Internet is money. It costs us for every download. Our monthly download fees are now running around $600 to $800. The more you download, the more we pay. We will keep this service operating, but need to figure some way of making it pay for itself. I am writing about this here because *Home Power* is your magazine. It is you, our readers, who really make these decisions, not I. So, we ask you for your input and guidance once again. How do we do this? Here are some ideas we've had.

Establish a *Home Power* Library of RE information on the Internet. This library would contain all of our back issues, a working index, our current issue, a regularly updated international database of RE people and businesses, RE system design computer programs, and other RE related material. We could charge a fee for library access. The question is, how much of a fee and what would this fee buy the library user? Should we offer a one-time fee, of say $100 and allow lifetime access to all files? Should we charge users a yearly or monthly fee, of say $25, for access to the files? Should we sell download access for a single file for a buck or two? Hey, we need your help. We want to make the info flow without making us broke in the process. Until we figure this out, it's business as usual—we're giving it away for free.

You can download the latest *Home Power* by going to www.homepower.com with your favorite web browser. You will need Acrobat Reader, version 3.0 or better. It's available free through a link on our web site. The latest issue of *Home Power* is about 6 MB in PDF. Most folks report download times around one hour.

MREF Hams
We are going to have a dynamite Ham radio station setup at this year's MREF. Any Hams who would like to help out, people the booth, or come and just have fun, please E-Mail me so we can get you into the loop. Here is a list of current Hams involved and their E-Mail addresses:

Bill KA9SWW <dbill@uic.edu>,
Bob-O KG6MM <econnect@snowcrest.net>,
Burch KB9RBN <rkelly@ecec.com>,
Chuck WA7ZZE <penson@sci.mus.mn.us>,
Dan < danl@win.bright.net>,
Don KE6QHP <dkulha@vom.com>,
Doug N7MOK <dougho@niceties.com>,
Fred NK1L <fbeiholz@cris.com>,
Jim WB4SXV <ludwig@yancey.main.nc.us>,
John WD9IUV <sswamer@acs.stritch.edu>,
Kathleen KB6MPI <kjs@snowcrest.net>,
Richard N7BCR <richard.perez@homepower.org>,
Robert AA9JW <rmanak@execpc.com>

It's an El Niño Winter
This has got to be the roughest solar winter on record. Everyone who checks in here is saying that solar insolation has been way down. I estimate that on Agate Flat we have gotten only about 25% of our normal winter sunshine. It has been nothing but cloudy, rainy, and (yes, yes!) windy. Our Whisper wind genny has been a major energy producer this winter. Along with El Niño's wet and clouds, we have been getting regular high winds. We've had about four times our average winter wind power input. In this El Niño winter, the only RE systems not singing the blues are the microhydro maniacs. This is a good lesson in renewable energy's gracious acceptance of Nature's offerings. When it snows corn, make tortillas!

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Hams: we monitor 146.400 MHz FM Simplex

Q&A

Safe levels of hydrogen gas (Q&A, HP#57)
I served for 17 years as an Electrician's Mate on diesel electric submarines. I feel that I can speak with some authority on hydrogen problems in batteries.

The short answer to the question of dangerous hydrogen levels is that any concentration of the gas above 3% of volume is considered to have an explosive potential. To put things in perspective, it's a long way between 252 tons of submarine storage batteries, peaking at 350 Amps with the finishing rate of 2.75% hydrogen showing on the detector, and a 1000 Amp hour battery charging in the basement.

The problem is twofold. Keep the air stirred up with fans and evacuate it to the outside. Hydrogen rises, they used to use it to float air ships. If the air isn't stirred in the battery space the gases can concentrate in pockets in high enough concentration to flash. The second point is force ventilate to the outside to keep the concentrations in the battery space as low as possible.

The gassing takes place mainly on the finishing rate when the voltage goes above the gassing curve. Make sure that your finishing rate is right and that it is not exceeded. Gas generation increases fast when these precautions are not taken. Farnham M. Cornia, Toledo, Washington

Thanks for the info, Farnham. I think most folks are over concerned with hydrogen gas in home power systems. Gassing can be minimized by correctly setting the RE source regulator(s). There are really no rules for exactly where (in Voltage) to set the regulators, only experimentation and experience can tell us the correct settings. The rules for venting battery enclosures are simple, however. Use a sparkless fan to exhaust the containment at its top. Allow air to enter the containment via a vent at the bottom of the containment. Cone Construction (719-530-0718 or E-Mail: coneco@rmii.com) makes a great battery box vent with a damper. The power vent works with either 1.5 or 2.0 inch plastic pipe, is available in either 12 or 24 VDC models, and has an optional voltage sensing switch controller. Prices vary from about $70 to $130 depending on model and controller. Another good way to reduce hydrogen gas in the battery containment is Hydrocaps. These catalytic converters recombine the hydrogen and oxygen gas, produced by the cells, back into pure water. Hydrocaps not only reduce hydrogen, but they also greatly reduce battery watering. See the Hydrocaps display ad in this issue for access.

Fluorescent vs Incandescent
I've been measuring fluorescent and incandescent lights for wattage. It seems all fluorescent lights are pulling more than the advertised wattage while incandescent were almost right on. What gives? Buff Harding Jr., San Francisco, California

Hello Buff. I think you may be getting a measurement inaccuracy. Incandescent lights are resistive loads and even the most inexpensive meter will accurately measure their current consumption. Fluorescents lights are another matter—they are reactive loads. It takes a meter capable of measuring the current consumption of reactive loads to produce an accurate measurement. The power factor of most fluorescents is between 0.5 and 0.8. This means that the current and voltage are out of phase and this confuses most meters. Richard Perez

Lighting Options?
Could you please us. My wife and I are building a 3,000 sq. ft. house in the southern mountains of Colorado. The house will be completely on alternative power since the nearest power pole is none miles away. We currently have a Trace SW4024 inverter, C40 charge controller, 4 BP 275-75 watt panels, 12- 440 watt deep cycle gold cart batteries, a 220 step up transformer and a 4 kW Onan generator. We are planning on expanding the system to 8 panel, a wind genny and 20 batteries over this next year. The power system is set on top of a hill about 400 ft. from the house so we can get the best sun from dawn to dusk. We will run 220 vac from the power shed down the hill to the house so it will be almost like a conventional system when it enters the house.

My question is what are our options for lighting. I know fluorescent lights are good and we will use a few but would like to have some track and recessed lights also. Other than incandescent lights what are our options? I have thought a little about installing a small 12 V system next to the house for a few lights and other low voltage items.

Any help or contact you can give us would be wonderful. By reading Home Power we have learned so much and would not have been able to be doing this project on our own. Thanks again for a great magazine and any help you can give us. Rich and Vonda Mumm, Hartsel, Colorado

Hello Rich and Vonda, and thanks for the flowers. Let's see if we can explore lighting options for your RE system. While I love having a 12 VDC system here, most folks are doing as you are planning and running all the appliances on 117 vac from the inverter. When it comes to lighting, this is by far the best choice.

Without getting into exotic and expensive lighting, you really only have two choices—fluorescent and incandescent. Modern compact fluorescent lights work great—they are color correct, flicker free, fast starting, very energy efficient, and long lived. We use Osram (now owed by Sylvania) compact fluorescents here. Over all our task areas such as desks and kitchen counters, we use Osram EL-15R compact fluorescents with built-in reflectors. These lamps put out about the same amount of light as a 60 watt incandescent bulb, but only consume 15 watts. These compact fluorescents start fast, produce a warm colored light which we find pleasing, and have no unpleasant side-effects (i.e. no radio frequency interference [RFI] or high intensity ac magnetic fields). We have some compact fluorescents here which have been running for over 5,000 hours and still going strong. In general, compact fluorescents have about one-quarter the energy consumption and around ten time the lifetime of regular incandescent bulbs. The brands to look for are Sylvania (Osram) and Philips. These are high quality compact fluorescents with high frequency ballasts (20 kHz or more). Stay away from fluorescents using "magnetic" or "core-capacitor" ballasts—they operate at 60 Hz and flicker both on grid and on an inverter.

While most of our lighting is compact fluorescent here, there are places where an incandescent lamp is better. For example, we use a quartz-halogen incandescent lamp over our cook stove. We tried compact fluorescents there, but they died rapidly due to the high temperatures over the stove top. Another good place for incandescents is any light which is turned on and off regularly, and only used for a few moments. For example, closets, hall ways, and porch lighting. Here we use regular old incandescent bulbs and we're careful not to leave them needlessly lit. When it comes to incandescent lights, use the halogen types wherever you can. They last longer and are more efficient than regular incandescent lamps.

Give careful thought to lamp placement. A desk lamp of 15 watts beats trying to read with a 100 watt lamp mounted on the ceiling. Practice light discipline—the rule here at Funky Mountain Institute is "one person, one lamp." This means that each occupant is entitled to use one light. If someone leaves a room, then they switch that light off and turn one on where they are going.

Paying attention to such lighting details can save hundreds of watt-hours of energy daily. This information can be used either in an RE system or on the grid. Either way you save energy. Richard Perez

Home Power MicroAds

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

Help us prevent fraud! Home Power MicroAds from individuals must supply serial number(s) for equipment being sold. Businesses must supply a published phone number(s) and a physical address. If at all possible, please pay for your ad via personal or business check or credit card.

While Home Power is doing everything we can to prevent fraud, we can assume no responsibility for items being sold.

USED WIND GENERATORS, Towers, Inverters. Many systems in stock, including several 12.5 to 20 KW Jacobs with utility intertie inverters & 100' free standing towers. We repair & make replacement parts & blades for many older wind systems, including pre-REA Jacobs & Winchargers. All rebuilt equipment comes with our one year warranty & technical support. For the do-it-your-selfer we also have "as is" equipment available. Call or write to Lake Michigan Wind & Sun, 1015 County Rd U, Sturgeon Bay, WI 54235, 920-743-0456, (Fax: -0466), LMWANDS@itol.com

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

HYDROELECTRIC SYSTEMS: Pelton and Crossflow designs, either complete turbines or complete systems. Assistance in site evaluation and equipment selection. Sizes from 100 watts to 5 megawatts. Manufacturing home and commercial size turbines since 1976. Send for a free brochure. Canyon Industries Inc., P.O. Box 574 HP, Deming, WA 98244, 360-592-5552.

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