Smart choice for power

What's the Plus?

The new Xantrex SW Plus Inverter/Charger improves upon the classic SW Series that has been the industry standard for 10 years.

+ Superior Efficiency - The SW Plus maximizes your PV investment by providing superior efficiency at the load levels typically found in an off-grid home.

+ Higher Surge Power - The SW Plus Inverter/Charger can start even tougher loads than the original SW. Unlike competing products, it maintains voltage regulation so loads like computers continue to run, even while the Plus surges to start heavy loads like well pumps.

+ Lower Price - The Xantrex-SW Plus raises the bar on performance, yet costs up to 20% less than the original.
  - SW Plus 2500 - $2300 MSRP
  - SW Plus 4000 - $2800 MSRP (a $700 saving)
  - SW Plus 5500 - $3500 MSRP (a $500 saving)

+ Reduced radio & TV Interference - Unlike competing products, our SW Plus meets FCC Part B regulations. These regulations are intended to ensure that radios, TVs, and telecommunication equipment do not suffer from interference.

+ Extended Battery Life - We've added a Silent Standby Mode which turns the SW Plus' power circuit off after your batteries are fully charged. This extends battery life and maximizes your PV investment.

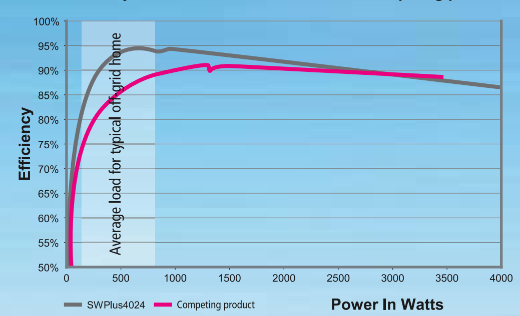
+ It Never Forgets! - The new SW Plus has non-volatile memory so customized settings will never have to be reprogrammed.

+ Proven Technology - The SW Plus is built on a trusted platform that is installed in more than 20,000 homes and businesses. It has been meeting user and installer needs for 10 years. The SW Plus output waveform meets all ANSI, IEEE and Canadian standards for utility power quality.

Legendary reliability and improved performance combined with a lower price… now that's a Plus!

For more detailed information on the advantages of the Xantrex SW Plus, please visit: www.xantrex.com/swplus.

Efficiency curves - SW Plus 4024 vs. 3.5 kW competing product



Contact a Xantrex Certified Dealer for more information. You'll find a complete list at **www.xantrexredealer.com**

www.xantrex.com

BP Solar–setting the standard for quality and performance.

the natural source for electricity.®

bp solar

Recognized as an industry leader for over 30 years, BP Solar produces premium panels guaranteed to provide years of superior performance. But a system is only as good as the dealer who installs it. BP Solar's precision engineering, record field reliability and expansive product line is complemented by the best distribution network in the business.

To start building a brighter tomorrow today, contact the BP Solar dealer nearest you.

For more information, visit our website:

www.bpsolar.com/homesolutions

To learn more about our dealer programs
visit **www.bpsolar.com/joinus**

HP101 contents

The Bottom Line

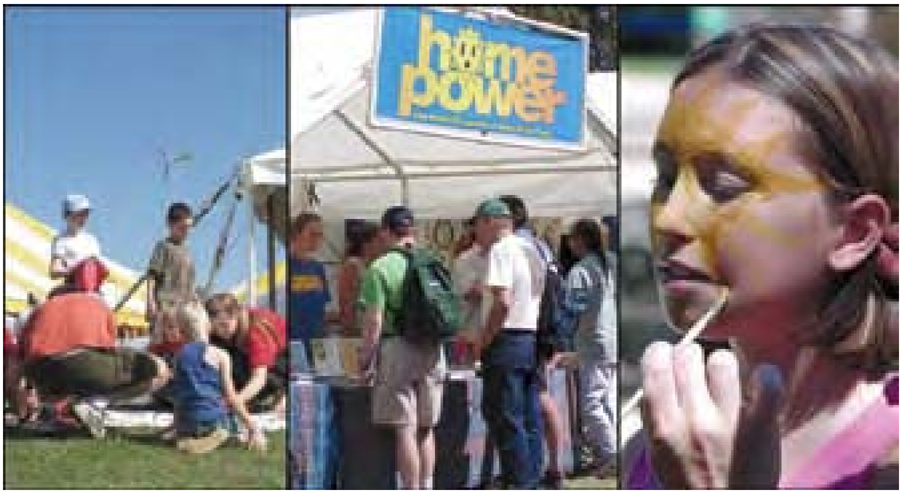
Internal rate of return	13.3%
Green bragging rights	Priceless

On the Cover

Author Chris Magwood (see page 14) was one of the builders of this three-story straw bale, post and beam home in Ontario, Canada.

Photo by Catherine Wanek.

Regulars



Everybody Loves a Fair

Spring marks the beginning of this year's energy fair season. Each year, energy fairs introduce renewable energy (RE) to tens of thousands of people in the U.S. and around the world, and provide further education to attendees already up on home-scale RE. They are big fun too.

Nearly every RE festival has workshops, demonstrations, vendor exhibits, and family activities covering a wide range of subjects. Topics include solar electricity and hot water, microhydro and wind power, alternative vehicles and fuels, green building, and a whole lot more.

The *Home Power* crew always looks forward to the energy fair season. It's a chance for us to hit the road and catch up with our readers, authors, and friends in the industry. We'll be attending many of the energy fairs this season, and encourage you to attend your local fairs, and to support the hard-working groups and volunteers that organize them.

For all the details of this year's energy fairs, check out the events section at www.homepower.com, and the Happenings section and energy fair ads in this (see pages 101–105) and upcoming issues of *Home Power*.

See you at the fair!

–The *HP* crew

Think About It

People who say it cannot be done should not interrupt those who are doing it.

–George Bernard Shaw, (1856-1950) Irish playright
and winner of the Nobel Prize for Literature 1925

Legal: Home Power (ISSN 1050-2416) is published bi-monthly for $22.50 per year at PO Box 520, Ashland, OR 97520. International surface subscription for US$30. Periodicals postage paid at Ashland, OR, and at additional mailing offices. POSTMASTER send address corrections to Home Power, PO Box 520, Ashland, OR 97520.

Paper and Ink Data: Cover paper is Aero Gloss, a 100#, 10% recycled (postconsumer-waste), elemental chlorine-free paper, manufactured by Sappi Fine Paper. Interior paper is Connection Gloss, a 50#, 80% postconsumer-waste, elemental chlorine-free paper, manufactured by Madison International, an environmentally responsible mill based in Alsip, IL. Printed using low VOC vegetable-based inks. Printed by St. Croix Press, Inc., New Richmond, WI.

HP staff

HP access

Home Power, Inc.
PO Box 520, Ashland, OR 97520 USA
Phone: 800-707-6585 or 541-512-0201
Fax: 541-512-0343
hp@homepower.com
letters@homepower.com

Subscriptions, Back Issues, & Other Products: Shannon and Nat
subscription@homepower.com

Advertising: Connie Said
advertising@homepower.com

Marketing & Resale: Scott Russell
marketing@homepower.com

Editorial Submissions: Eric Grisen
submissions@homepower.com

www.homepower.com

Straw Bale Building

On the Cusp of the Mainstream

This two-family straw bale home in southern Oregon incorporates many other energy saving technologies, such as solar hot water, rainwater collection, and photovoltaic panels.

The use of straw bales as a building material is reaching a very interesting juncture, one that has many similarities to renewable energy systems. Both straw bale building and renewable energy hold tremendous promise—significantly lowering our impact on the planet, without sacrificing most of the comforts we've become accustomed to having. Both have been driven largely by passionate people willing to do it themselves for practical and altruistic reasons. But the use of renewables is ahead of the use of bales on the curve of public acceptance, and bale builders can learn a lot from the development of the renewable energy field.

In load-bearing construction, a rigid "top plate" or "bond beam" is placed atop the straw bale walls, joined at the corners and secured to the foundation. This beam allows the weight of the roof to bear equally on all four structural bale walls.

Only twenty years ago, straw bale building was virtually unheard of. Although many of the successful pioneer homes that were built with bales 100 years ago in the Sand Hills region of Nebraska are still occupied, interest in the idea of creating new buildings with bales only reemerged in the 1980s. People looking to build affordable, comfortable homes with minimal impact on the environment "rediscovered" this century-old idea and began to reapply it in a modern context.

Then, in 1994, a book by Steen, Steen, and Bainbridge called *The Straw Bale House* quietly began to introduce the concept and more important, the beauty of straw bale walls. The book sparked a small revolution, and in a decade, bale building went from being a "fringe" concept to courting mainstream acceptance. There are now provisions for straw bale construction in the building codes of several states, most notably in California, where a well-funded testing program is helping to write a new, state-of-the-art building code.

Colored clay plaster with decorative bas relief adorns the walls of this California home.

As with renewable energy, straw bale building enthusiasts can list all kinds of great reasons for adopting the technology. Compared to standard wood framed walls, bale walls offer much greater insulation value (figures vary from R-37 to R-51) with a much lower environmental impact. Enough straw is already produced in North America to completely replace wood framing, saving millions of trees by using an agricultural by-product that is harvested annually.

The building system can be very simple: the bales are stacked like large bricks and capped with a wide wooden beam. The bale walls are then plastered on the interior and exterior, creating a wall system that is strong, resilient, and very attractive.

The Good, the Bad, & Public Opinion

There are now thousands of examples of straw bale houses in North America and around the world. Bale buildings exist equally well in the harsh northern climate of Alaska and the desert climate of Arizona, and in all points between. In fact, there are bale buildings on every continent, and in almost every country. Most of these homes, cottages, and commercial buildings live up to the promise offered by bale building.

But supporters of renewable energy know all too well the pitfalls that can come with more widespread use of a new technology; the variety of results and public perceptions is very mixed. In the same way that a single, crumpled wind generator tower can sully the reputation of hundreds of functional installations, problems with a few bale homes can dangerously color the perception of bale building by contractors, code officials, and the general public. What

A straw bale wall has ideal qualities for passive solar design. The bales provide insulation for the thermal mass of the interior plaster, which captures the warmth of the winter sun through south-facing windows.

follows is an attempt to realistically address a number of the questions that exist about straw bale building, and to debunk some of the negative and positive myths that exist regarding this building material.

Fire

Many straw bale skeptics are concerned about the vulnerability of straw to fire. Straw bale supporters tend to throw reports of the near fireproof nature of bale walls back in response. The truth is, both sides have a point. Numerous fire tests have been performed on plastered straw bale walls, and all reports have shown outstanding results that far exceed all residential code requirements.

Plastered bale walls can easily withstand a two-hour fire test, outperforming almost all other wall systems. However, loose and unplastered straw is very susceptible to fire, and some bale buildings have burned down in the time between stacking the bales and plastering them. So plastered bale walls are indeed as resistant to fire as supporters claim, but great caution must be taken during construction to avoid the kind of inferno that doubters predict. This means cleaning up loose straw around the building site and avoiding smoking, welding, and other spark producing activities near exposed straw.

Thermal Performance

Supporters of bale building often attribute a near mythic insulating quality to straw bales. The fact is, straw is only a moderately good insulator. However, it happens to come in bundles that are big and thick, so there is lots of straw to do the insulating. Those big, thick bundles also cost a lot less (in dollars and environmental impact) than the equivalent amount of any other insulation. Because they can play a structural role as well as an insulating one, bales are an attractive and effective insulation.

This excellent, affordable thermal performance attracts many people to bale building. Several studies in the U.S. and Canada have shown that bale walls can help reduce heating and cooling energy consumption by 25 to 60 percent. In a world where we struggle to make very small dents in our consumption, these figures are inspiring.

But it is certainly possible to make a bale home that is every bit the energy hog as its neighbors. The use of straw alone does not make an energy efficient house. Quality windows and doors, proper insulation and construction details at the top and bottom of the wall, and a good plastering job are all necessary to make the walls work effectively.

Attention must also be paid to properly insulating foundations and roofs, since the best walls in the world can't contain heat that is escaping elsewhere in the building envelope. Ignore some or all of these concerns, and those big, thick bale walls won't save you or the planet as much energy.

Environmental Impact

The construction world is currently being rocked to its foundations by a new way of looking at the environmental impact of building materials—embodied energy.

Straw bale pioneers Judy Knox and Matts Myhrman wrapped their concrete block home with straw bales to increase its insulation against Tucson's intense summer heat.

Simply put, we are finally starting to consider the cost of a material to the planet, in addition to its dollar cost and its performance. Embodied energy encompasses all of the processes associated with producing a material, such as the energy required in mining, transport, manufacturing, administration, use, and disposal. Seen in this light, straw bales are an extremely attractive option.

This Taos, New Mexico, home has monitoring probes in the walls of the bathroom to keep track of humidity levels in the straw.

Since grain crops are already being planted and harvested, using the by-product of this agricultural activity means that straw bales are made with only minor additional inputs of energy for manufacture (baling). The embodied energy of straw bales has been shown to be 0.24 MJ/kg. MJ/kg is a measure of energy use (megajoules) per kilogram (2.2 pounds) of material. So for every kilogram of straw bale, 0.24 megajoules of energy was expended to create it. Compared to 30.3 MJ/kg for fiberglass or 117 MJ/kg for expanded polystyrene, it is obvious that remarkable gains can be made in the reduction of energy use by redirecting this material for construction use.

Even with these figures, it is possible to build a straw bale house with an overall embodied energy that is just as shockingly high as anything from conventional construction. Often, bale homes are mistakenly built using concrete foundations that are the width of the bale; all this extra concrete (which has a very high embodied energy) can negate any positive impact on the environment.

For a bale home to make good on its promise to help the environment, the design of the home must minimize embodied energy in all phases of construction. Earthen plasters, rubble trench foundations, and other strategies greatly multiply the environmental gains. Built thoughtfully, bale walls can make a big difference in environmental impact. But slapped into a building envelope that otherwise doesn't care about the planet, bales won't save the planet.

Reliability

I always find it funny when a building inspector tells me that he doesn't trust these "experimental" building styles. Straw bale building predates modern frame construction, with the earliest examples dating from the turn of the last century. While wooden framed homes share an equally long and proven history, the modern frame home with its chipboard exterior cladding, fiberglass insulation, plastic vapor barriers, and drywall, has a much shorter history. In fact, we really don't know the life expectancy of a modern home. We do know that simply built bale homes can last at least a hundred years!

That said, it must be remembered that a poorly built bale home will fall to pieces just as quickly as a poorly built conventional home. In particular, skeptics will point to the vulnerability of bale walls to moisture induced rotting. They forget that straw and wood are very similar materials, and that either material must be protected from moisture penetration.

Moisture comes at our walls from all directions, and for all of these, well proven measures can easily be taken. While these moisture-proofing details can be different for bale walls, most are adaptations of the lessons learned from mainstream construction, and have been used to keep bale walls high and dry for the life of the building.

The soft edges of straw bale walls help make this bedroom cozy and romantic.

Cost

Early proponents of bale building extolled the low cost of the system, perhaps overstating the case. Building is never "cheap." I tell potential clients that buildings are expensive or slightly less expensive, but never cheap. While using straw bales and plaster as a wall system can cost less, the wall component of a building is usually only 10 to 20 percent of the overall cost. So at best, the bale walls can reduce your overall budget by 5 to

10 percent. Less expensive components and labor strategies must be sought at all phases of the project to make a real difference in price.

Many modern bale homes do not rely on the simple load-bearing straw walls of the pioneer examples. Instead, they use some form of structural framework in which the bales act only as insulation. Depending on the style and complexity of the frame system, this kind of building can easily be more expensive than its conventionally framed equivalent. And even when using a load-bearing bale wall, the unique labor and material requirements of this wall system can raise the costs to the point where the savings can be lower than originally anticipated.

Bales and plaster are fairly low cost items. But bale raising and plastering involves plenty of labor, and it's labor that doesn't come from a deep, knowledgeable, and competitive pool, as is the case with framing. In fact, in my own practice, we have found that the labor cost of professionally raising bale walls is more or less on par with the labor cost of framing. Owner/builders of bale homes can certainly save money using their own labor, but so can owner/builders of any style of housing.

I don't see this as a negative thing: a bale home (R-37 to R-51) raised for the same cost as a conventional home (R-12 to R-20) offers its owner a significant reduction in ongoing energy costs at a lower cost to the planet. Most "green" products cost more than the conventional products they replace. Bale building right now costs the same, and the price will only go down as the labor pool and techniques develop, while lumber prices are only going to get higher.

Learning & Growing Together

As with renewable energy systems, sweeping, generalized statements about straw bale building cannot be made. Yes, it is possible to benefit from a whole range of potential plusses, but it is equally possible to overspend on a finished product that does not perform to the level that is desired. Creating a cost-effective, long lasting, and beautiful bale home requires the same kind of study, thoughtfulness, and skill as creating a good renewable energy system.

Bale homebuilders benefit greatly from the lessons learned by people in the renewables business. We realize that sharing information and being open and honest about our successes and failures is fundamentally important. Strong grassroots support systems, the creation and circulation of valuable books and periodicals, and the dedication of professionals who see their work as a passion as well as a business—these are things that bale building has borrowed from the renewable energy field.

The passion for a greener future is common to bale builders and users of renewable energy. In fact, a high percentage of bale homes incorporate renewables. The desire to create a more sustainable way of life is a strong one, and people who share that desire tend to work together to see it happen. Sure, there are differences of opinion, but the direction is the same and the spirit of goodwill is abundant and infectious!

Will everybody switch over to renewable energy and straw bale building tomorrow? No—there's a long way to go before we'll see that happen. The technologies need to improve and be streamlined, capacities need to be grown, and public relations must develop to create a wider demand. But should everybody start moving toward building with sustainable materials and using renewable sources of energy? The answer is unequivocally, "Yes!"

The rocks at the bottom exterior of this Colorado home are a decorative way to protect the earth-plastered straw bale walls from rain spash.

Access

Chris Magwood, Camel's Back Straw Bale Construction, RR#3, Madoc, Ontario, Canada K0K 2K0 • cmagwood@kos.net • www.strawhomes.ca

Article photos by Catherine Wanek from the book, *The New Strawbale Home,* Catherine Wanek, 2003, Hardback, 188 pages, ISBN: 1-58685-203-5, US$39.95, Gibbs Smith, Publisher, Black Range Films & Natural Building Resources, 119 Main St., Kingston, NM 88042 • 505-895-3389 • Fax: 505-895-3326 • blackrange@zianet.com • www.strawbalecentral.com • Books & videos about natural building

Straw Bale Details: A Manual for Designers and Builders, Chris Magwood, with Chris Walker (Illustrator), 2003, Paperback, 68 pages, ISBN: 0865714762, US$32.95 from New Society Publishers, PO Box 189, Gabriola Island, BC, Canada, VOR1X0 • 250-247-9737 • Fax: 250-247-7471 • info@newsociety.com • www.newsociety.com

Straw Bale Building, Chris Magwood & Peter Mack, 2000, Paperback, 235 pages, ISBN: 0865714037, US$24.95 from New Society Publishers (see above)

The Last Straw Journal: The International Journal of Straw Bale and Natural Building, Chris Magwood, editor, published by The Green Prairie Foundation for Sustainability (GPFS). PO Box 22706, Lincoln, NB 68542 • 402-483-5135 • Fax: 402-483-5161 • thelaststraw@thelaststraw.org • www.thelaststraw.org

Serious Straw Bale: A Home Construction Guide for All Climates, Paul Lacinski & Michel Bergeron, Paperback, 371 pages, ISBN: 1-890132-64-0 US$30 from Chelsea Green Publishing Company, PO Box 428, White River Junction, VT 05001 • 800-639-4099 or 802-295-6300 • Fax: 802-295-6444 • hanrahan@chelseagreen.com • www.chelseagreen.com

The Straw Bale House, Athena Swentzell Steen, Bill Steen, & David Bainbridge, Paperback, 336 pages, ISBN: 0-930031-71-7, US$30 from Chelsea Green Publishing Co., see above for access

Building Official's Guide to Straw Bale Construction, edited by Kelly Lerner and Pamela Wadsworth Goode, (out of print but under revision) California Straw Building Association (CASBA), PO Box 1293, Angels Camp, CA 95222 • 209-785-7077 • casba@strawbuilding.org • www.strawbuilding.org

The Natural Plaster Book: Earth, Lime and Gypsum Plasters for Natural Homes, by Cedar Rose Guelberth & Dan Chiras, Paperback, 304 pages, 2003, ISBN: 0865714495, US$29.95 from New Society Publishers (see above)

virtually silent

NREL's Wind Turbine Generator System Acoustic Noise Test Report for the Whisper H40 Wind Turbine indicated the difference between the turbine and background noise was between 3 and 7 dBA, a difference imperceptible to the human ear.

WHISPER H40

MADE IN USA
up to 900 watts for only $1595 msrp

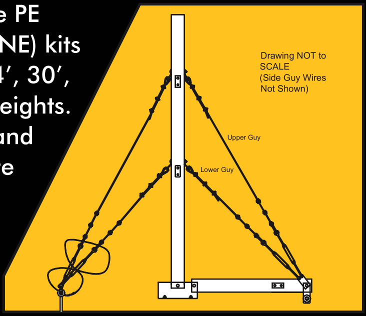
quiet easy

Certified Whisper Quiet

"The quietest turbine ever tested here" reports the NREL (National Renewable Energy Laboratory). Their acoustic test reports the sound of the Whisper H40 never exceeds background noise by 7 dBA making the H40 virtually silent. To see for yourself, download the full report at windenergy.com/SUPPORT/downloads.html

Easy to install...

...and now we have made it even easier with the revolutionary Whisper Tower Kits. Complete installation is possible in just a few hours. Kits include all hardware and easy to follow instructions. These PE Certified (in CA & NE) kits are available in 24′, 30′, 50′, 65′ and 80′ heights. Visit our web site and download complete manuals at windenergy.com



Southwest Windpower
Renewable Energy Made Simple

2131 N. First Street • Flagstaff, Arizona 86004 USA
Tel 928-779-9463 • Fax 928-779-1485
www.windenergy.com • E-mail info@windenergy.com

AIR X
400 watt rating
Newest version of our best selling turbine

Whisper Nautica
Marine Grade for coastal sites

Whisper H80
Perfect for low wind areas

Whisper H80 WP
Low cost 3-phase AC water pumper uses conventional pump technology

Whisper 175
Over 3000 watts of power

Grid-Tied Solar In Small Town, USA

Andy Kerr

Small town paradise, and carbon neutral too, thanks to conservation, solar thermal, photovoltaics, and more.

Veteran installing dealer Bob-O Schultze of Electron Connection arrived to discuss my long-fantasized solar-electric system. While I speak pidgin electricity and can usually pound a nail straight, I knew that I didn't have the skills, tools, or time to do this job myself. Since it was the winter solstice, high noon, and uncharacteristically sunny, the maximum shading at my site could be observed on the landscape. Bob-O, who has lost count of the systems he has installed, would help me achieve my goal.

The goal of my family and business is to be "carbon neutral" so our activities do not contribute to global warming. This is done by conservation through using less fossil fuel, switching to carbon-neutral fuels, and mitigating carbon emissions that we cannot presently avoid by paying others to conserve, switch fuels, or sequester carbon in vegetation. (See the green tags sidebar.)

Of course, conservation and efficiency were our first strategies. Since moving into our Ashland, Oregon, house in 1999, we have installed a solar hot water system, compact fluorescent bulbs, a Sun Frost refrigerator, three Sun Pipes for natural lighting, a Tamarack whole-house fan, and three Natural Light solar powered attic fans for cooling. All are quite cost effective (see my article in *HP86*). While we aggressively conserve electricity, we suffer no hardship.

Thirty-two Siemens SR100 photovoltaic panels generate about 85 percent of the Kerr family's electricity.

Assessing Our Demand

After completing most of those conservation measures, a review of twelve months of utility bills determined our annual load to be 6,011 KWH. Concurrent with the PV system installation, I installed an electronic timer to switch the electric water heater off when it was unneeded, so household demand is now somewhat lower. Heating water at 3 AM makes as much sense as leaving the car idling because you need it in the morning.

Many modern appliances are not off when they say they are off. Phantom loads are devices with a remote control, a clock, or a wall cube (AC to DC power converter) that uses some energy even when the appliance is turned off. I have at least 34 phantom and always-on devices that draw a combined minimum of 100 watts 24/7. It works out to be 876 KWH per year, or 15 percent of my annual load.

The devices include several Limelites, energy efficient night lights (0.3 watts; 0.2628 KWH per year) that I don't unplug every morning, televisions, clocks, telephones, fax machine, stereos, smoke detectors, and other devices that either must be on to work or that need to be reprogrammed after power outages. I have no guilt about these modern conveniences since our household (which also includes my business) uses 57 percent of the national average for residences, and the majority of that is generated from sunshine.

Sun Pipes transmit sunlight directly into the house, offsetting daytime lighting loads.

System Sizing

The sizing of my system was not based on demand, but rather was a function of how many PV panels would fit on the roof of the new detached garage. Anticipating this PV project, I'd specified an extra underground conduit between the garage and house during garage construction.

As Bob-O and I stood on the garage roof in late 2000, we could see our shadows being cast to the north across the alley and onto the neighbor's fence. The City of Ashland's solar access ordinance precludes structures that cast more than a 6 foot (1.8 m) high shadow on an imaginary fence along the south property line of your neighbor.

Bob-O brought his Solar Pathfinder to produce a chart that depicted vegetation and structures that would stand between the PV panels and the sun. I would need this chart later to document my tax credits, other incentives, and for specific additional protections for solar facilities under Ashland's solar ordinance.

GREEN TAGS

"Green tags are the environmental attributes of a renewable energy system, including the ability to offset greenhouse gas production," according to Cascade Solar. "Green tags are now a separately marketable commodity and can be sold by owners of renewable energy systems, including photovoltaics and wind."

Through the Northwest Solar Cooperative (administered by Cascade Solar), the Bonneville Environmental Foundation (BEF) pays the Larch Company US$0.10 for each solar kilowatt-hour produced. As a result, the Larch Company can make no claim that it is "green," "climate neutral," or the like, because we've sold all environmental attributes of our PV system to BEF.

We do make those claims, but only because the Larch Company buys green tags from BEF, based on the amount of electricity, "natural" (methane) gas, gasoline, and jet fuel my family and business use. Each year at tax time, I use BEF's online calculator to determine our own private carbon tax. I pay the equivalent of about US$0.02 per KWH for green tags that allow me to proclaim my carbon neutrality.

Many entities are selling green tags. I chose the BEF because they are based in my ecopolitical region, they cooperate with my utility in marketing green tags, and I know the founder. Even though wind-powered green tags are far cheaper for them to acquire, BEF is very committed to solar electricity.

The rack manufacturer engineered the panel arrays and their precise locations on the garage roof. Not wanting, or being allowed, to covet our neighbor's sunshine, we were limited as to how high the upper arrays could be. There wasn't enough room on the roof for the lower arrays to be in their winter position without casting a shadow on the upper arrays. So the lower panels stay in their equinox position from fall through spring.

A Very Cooperative City & Utility

Unfazed by PV systems, the Ashland Building Department issued the building and electrical permits in one day. Ashland's Electric and Telecommunications Department was even more cooperative. Dick Wanderscheid heads the municipal utility, and had already fathered grid-tied PV demonstration projects at Southern Oregon University, the Oregon Shakespeare Festival, and on City of Ashland buildings.

The KWH meter, installed by the city, totals incoming and outgoing electricity independently.

Not only did Ashland give me cash for installing the PV system, they installed a new bidirectional, digital kilowatt-hour meter at their expense. All staff took constructive interest, to the point of fine-tuning the voltage on their transformer on my street to optimize my sale of excess kilowatt-hours to the grid. The city goes one better than "net-metering" (buying and selling electricity at the same rate) by purchasing my surplus at the highest retail sale rate (US$0.0295 per KWH greater than what I pay for the first 500 KWH each month).

While I was the first residential customer with a grid-tied connection, another Ashlander, Risa Buck, already had a PV powered home, but she chose to forgo the intertie option (See *HP48*). Today, Ashland has seven institutional or residential grid-intertied solar-electric systems.

Production Year 1

After passing inspection, I discovered that the city's new meter was inaccurate, severely exaggerating my sales. The city meter repairer was initially perplexed as to how

A lockable disconnect, accessible to utility line workers, is standard equipment in utility-intertied

he could test a bidirectional meter that not only records purchases from, but sales to, the grid. He solved it by simply plugging the meter in his test unit upside down.

While the system went on line in July 2001, the matter of the misreading meter wasn't resolved until October 10, 2001 with the installation of a new device. Since the new meter started at zero, October 10 is a solar anniversary celebration for me. Every year on that day, I read the meter and note how much I'm ahead or behind at being electrically self-sufficient over the life of the system. For annual calculation purposes, however, I started with the next full utility billing period.

During my first full solar year, I bought 3,563 KWH and sold 3,024 KWH. My self-sufficiency deficit was 539 KWH. I paid the City of Ashland US$155.25 and the city paid me US$198.22, clearing US$44.97 of "profit." This data reflects how much electricity I bought from and sold to the grid, not how much we used. My solar-produced electricity is "consumed" in the following descending priorities:

1. Topping off the battery bank;
2. Servicing household 120 VAC loads;
3. Servicing household 240 VAC loads; and only then,
4. Sale to the grid.

The Bonneville Environmental Foundation (see Green Tags sidebar) estimated my system's first-year production at 2,816 KWH per year, based on 55 percent system efficiency and sunshine data gathered at the city's PV system a few blocks north. This is quite conservative since I know I sold 3,024 excess KWH to the grid, after meeting my household needs.

Was Year 1 an "average" year for production and consumption? No year is ever average. I witnessed a 40 to 50 percent reduction of panel output during several weeks of summer 2002, due to severe forest fire smoke. I guesstimate that I might well have been electrically self-sufficient that year had it not been for a chronically red sun.

Each Xantrex TCB-10 PV combiner box fuses four strings of four photovoltaic panels.

Tech Specs

System Overview

System type: Battery-based, grid-intertied PV system

System location: Ashland, Oregon

Solar resource: 4.5 average daily peak sun hours

Production: 285 AC KWH per month average, estimated

Percentage KWH offset by PV system: 85 percent

Percent utility bill offset by PV system: exceeding 100 percent

Photovoltaics

Modules: Thirty-two Siemens SR100, 100 W STC, 12 VDC nominal

Array: Eight, four-module series strings, 3,200 W STC total, 48 VDC nominal

Array combiner box: Two Xantrex TCB-10 combiner boxes with 10 A fuses

Array disconnect: Xantrex DC175 enclosure with two, 40 A breakers and one, 100 A breaker

Array installation: Direct Power racks on south-facing roof, adjustable tilt angle

Balance of System

Charge controller: Two RV Power Products (now Blue Sky Energy) Solar Boost 3048, MPPT, PWM

Inverter: Two Xantrex SW4048, 48 VDC nominal input, 120/240 VAC nominal output

System performance metering: E-Meter AH meter measures inverter DC input, two Brand AC WH meters measure each of two, 120 VAC circuits, ABB bidirectional digital KWH utility meter

Energy Storage

Batteries: Sixteen Dyno L-16WP, flooded lead-acid, 6 VDC nominal, 350 AH at the 20 hour rate

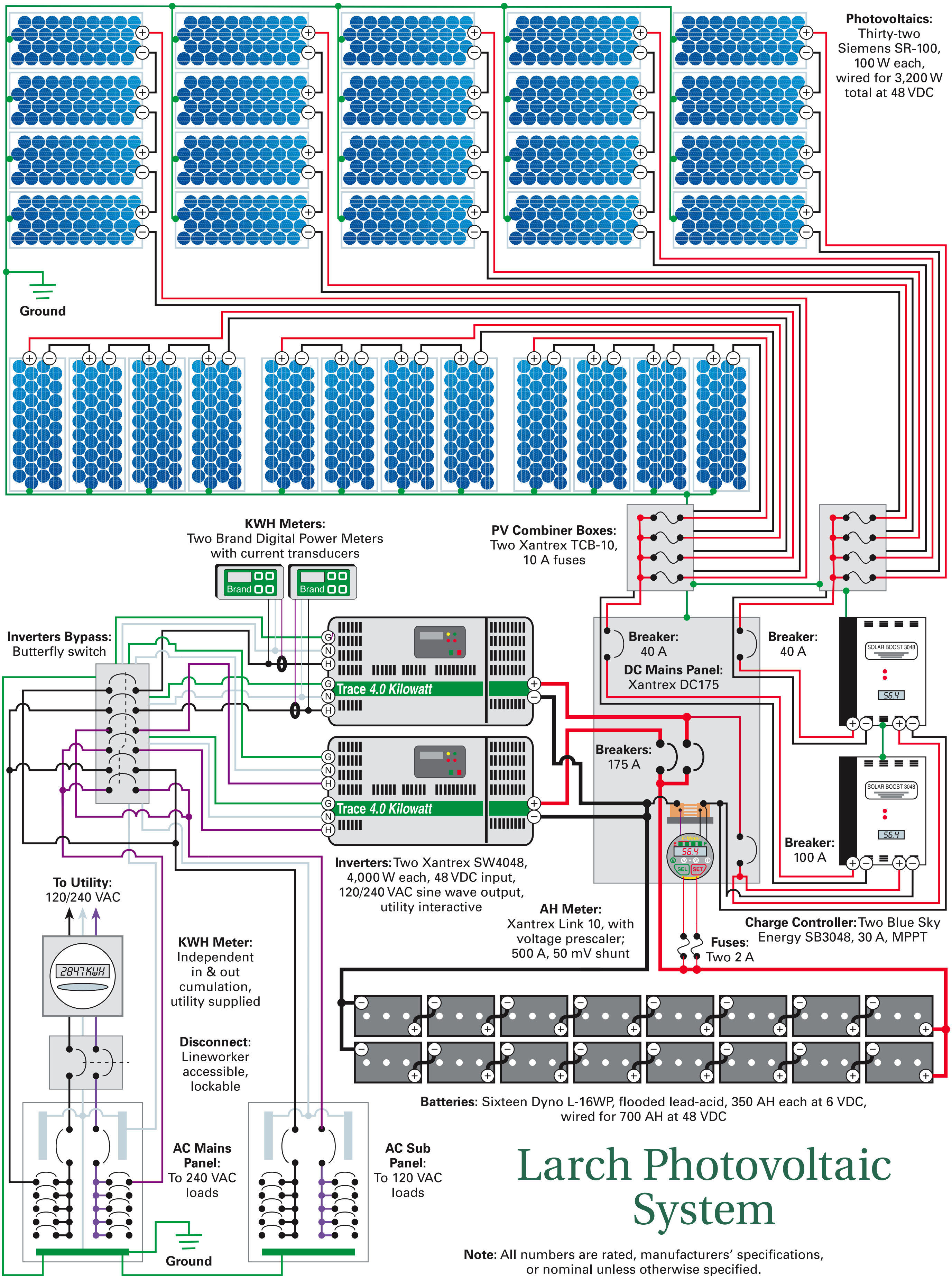
Battery pack: 48 VDC nominal, 700 AH total

Battery/inverter disconnect: Xantrex DC175 enclosure with two 175 A breakers

Production Year 2

What a difference a year can make! During my second full solar year, I bought 4,139 KWH and sold 2,847 KWH. My self-sufficiency deficit was 1,292 KWH. I paid the City of Ashland US$201.76 and the city paid me US$207.68, clearing US$5.92 of "profit."

One year does not an average make. What caused the dramatic difference? It wasn't as smoky for as long, so performance should have improved. Perhaps we were not gone as much, there were more cloudy days, it was a colder winter or hotter summer, or we had more guests than the year



Larch Photovoltaic System

Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

before. Perhaps it was all those loads of laundry done by a friend. Adding a room to the house increased the gas furnace load so that it needed more electricity for the blower. Perhaps we left the lights on more, if only because we felt subconsciously less guilty.

Ongoing Maintenance

The panels are vertically repositioned four times per year to maximize energy capture. Since the panel mounts were designed to be perpendicular to the sun's rays during the solstices and equinoxes, the panel adjustments occur on the fifth days of February, May, August, and November (San Marino Independence Day, Cinco de Mayo, Hiroshima Day, and Guy Fawkes Day), which are midway between these solar events. It takes 30 minutes with a $^{9}/_{16}$ inch socket and combination wrench to make the adjustments. I do it at first light before the panels and black roof become too hot to handle.

When I notice dirt build-up due to a lack of rain, I hose off the panels. Meter readings indicate that a quick rinse can increase production by 2 to 3 percent. Out-of-pocket maintenance expenses have been limited to US$5 for a battery post cleaning tool.

No spaghetti here—the power wall installation is clean and professional.

Sixteen Dyno L-16WP batteries provide 700 AH at 48 VDC.

In Perfect Hindsight

Like a computer, as soon as you buy a photovoltaic system, inevitably the price goes down and the capabilities go up. Knowing what I know now, I would make several changes.

Forgo battery backup. Before moving to Ashland, we had lived in Joseph, Oregon, where the utility grid often went out. Since living here, the electrical grid has been out a few times, totaling perhaps a day. Providing backup for these few times doesn't seem worth the expense, replacement cost, and lower overall efficiency of a battery-based, grid-tie system. Of course, my mind may change after the first extended outage when I can share either hot tea or cold beer with my neighbors. With battery backup during a winter outage, the gas heat would still work.

Including installation, cabling, and materials for the battery containment, the battery bank cost about US$4,500. This includes all the equipment I *wouldn't* need with a batteryless system, including two 30 A, 48 V MPPT charge controllers, two combiner boxes, and several disconnects. Without batteries, I could have gone with one of the batteryless grid-tie inverters, which are more efficient, and also have built-in maximum power point tracking.

A manual transfer switch is a smart addition to battery-based inverter systems. It allows grid or generator power to be fed directly to the household loads in the event of an inverter failure.

Meter Medley

How much electricity did I actually produce in my first solar year? I really cannot tell you. My inverters cannot record accumulated kilowatt-hours produced. I can only tell you how much I bought from and sold to the city. When my 120 VAC loads were light, the sun was shining, and I was drying clothes, my solar production helped meet the dryer load. However, it was supported by grid electricity; by how much, I don't have a clue.

I later installed a Xantrex Link 10 meter between the arrays and the inverter to measure DC production in amp-hours, and I installed Brand KWH meters to record 120 VAC household demand. Initially, I didn't record the readings, but now do so religiously every Sunday.

More recently, Bob-O helped me rectify the problem by installing a two-register, digital AC meter. Now I can see what we are consuming in the house from the grid and through the inverters, *and* what the inverters are selling to both the house 240 V loads and the grid. With the setup I had before, we could never figure out what the house 240 V loads—which are on the grid, not the inverter outputs—were consuming. Now we can also get a handle on the inverter efficiency alone since we can measure DC in from the PVs and AC out to the house and grid.

Two Brand meters measure AC watt-hours from the PVs.

Author Andy Kerr soaks up sun.

Rewire away the Edison circuits. Two inverters were necessary because our vintage 1944 house was originally wired with "Edison" or multiwire branch circuits. One inverter would only feed half of the house. To save copper, such circuits have four conductors that run from the main panel to junction boxes in the attic (if you have both black and red wires in your mains box, you may have Edison circuits). At the junction box, the two positive 120 volt legs (red and black wires) are coupled with the neutral leg (white wire) to create two, 120 volt circuits. The neutral and the ground (green wire) between the junction box and the main panel are shared, saving some wire. For more details about dealing with multiwire branch circuits, see *Code Corner* columns in *HP54* and *HP59*.

Just before construction began on the PV system, a neutral connection opened in an Edison junction box. The result is that the two, 120 volt positive legs, in combination with the ground, were now one, 240 volt circuit. The damage to electrical devices was considerable. How an Edison circuit can be code—where a fault doubles, rather than zeros, the voltage—is beyond me. Not only would I feel safer not having them, it would have meant only one inverter (saving around US$3,500).

Fixed mount panels. Every time I climb onto the roof to adjust the panels, it is a little less fun. The production increase is not worth my time, even at the rate of unskilled labor. Since very little production occurs in the rainy, short-daylight days of winter, I would choose a fixed panel angle optimized for probable sunny days.

In spite of changes I might make "next time," I am quite pleased with our solar-electric system and our conservation measures. I am very happy with how effectively we offset our impact on the planet. But what about the economics of it all? Well, that's the surprising part that pleases me almost as much as doing good for the planet. In the companion article in this issue, I show you that not only are my actions ecologically beneficial, they're also good for my pocketbook.

Access

Andy Kerr, Czar, The Larch Company, 1213 Iowa St., Ashland, OR 97520 • 541-201-0053 • Fax: 541-201-0065 • andykerr@andykerr.net • www.andykerr.net/Energy/EnergyPT.htm

Bob-O Schultze, Electron Connection, PO Box 203, Hornbrook, CA 96044 • 800-945-7587 • Fax: 530-475-3401 • bob-o@electronconnection.com • www.electronconnection.com • System design & installation

Pat Nye, Sales Manager, Bonneville Environmental Foundation, 133 SW 2nd Ave. Ste. 410, Portland, OR 97204 • 866-233-8247 or 503-248-1905 • Fax: 503-248-1908 • info@b-e-f.org • www.GreenTagsUSA.org • Green tags

Doug Boleyn, P.E., President, Cascade Solar Consulting, 17610 Springhill Place, Gladstone, OR 97027 • Phone/Fax: 503-655-1617 • doug@cascadesolar.com • www.cascadesolar.com • Northwest Solar Cooperative

Solar Pathfinder, R 1, Box 260-1, Linden, TN 37096 • 317-501-2529 • Fax: 931-589-5400 • info@solarpathfinder.com • www.solarpathfinder.com

Tamarack Fans, PO Box 490, West Wareham, MA 02576 • 800-222-5932 or 503-295-8103 • Fax: 503-295-8105 • sales@tamtech.com • www.tamtech.com

Sun Pipe Co., PO Box 5760, Elgin, IL 60121 • 800-844-4786 or 847-888-9222 • Fax: 847-888-9444 • support@sunpipe.com • www.sunpipe.com

Natural Light Solar Attic Fans, 2640 E. Rose Garden Ln., Phoenix, AZ 85050 • 800-363-9865 or 602-485-5984 • Fax: 602-485-4895 • elio@nltubular.com • www.solaratticfan.com

Haven't Gone OutBack yet?

Here's what some of our customers have to say!

- "Many thanks and, again congratulations to your team for what appears to be an excellent product. As a production manager for Hewlett Packard, I can tell how proud it makes me to see a fine product like yours manufactured state-side!" *Owen Youngblood*

- "I have enjoyed doing business with you and am pleased that you took time to answer my emails. Everyone here is amazed at the amount of time and effort you have expended for me. It's things like this that America is known for. It is unfortunate that it is now rare indeed. Keep up the good work." *Alvin McDonald*

- "I just think it is cool to find a company where the people are obviously passionate about their work and also seem to be having a great time with it. (e.g. the bad boyz ads and your promo CD - what fun). So refreshing! I practice law (formerly with the "big guys" in Milwaukee, before heading to the hills) and rarely see companies with such spirit. Just thought you'd like to know someone noticed! Actually I am not just basing my praise on the equipments looks, but also on our installer's positive comments. In fact he has been using Brand X for years and had decided to go with OutBack in the future (knows your history, had lots of nice stuff to say about you guys - so people do know there are brains behind it all). So we are his first OutBack installation and he was very impressed when he came to put in the equipment. Had lots of nice things to say that are too technical for me to recall and repeat. And when the toggle switch on our 250 amp main DC came broken off in the box (oh well, no one's perfect) and we had a new one on the way from OutBack the very same day, well that was just icing on the cake. He said not everyone in the industry is so responsive! Thanks for the wonderful equipment and service." *Julianne Barker*

- "Hello to all, and thanks for the help. When I asked this back in September, I had a 2 stacked SW5548 inverter system that would not reliably start a large pump (kicked out on overload). The background load was from 2 to 25 amps. When the pump started the surge was 130 amps on grid, and 30 amps running (240VAC). Installed an OutBack Quad Stack of VFX3648's - Success! The installation looks good and functions perfectly. I started the pump from several conditions, never failed once. The amazing thing to me is to see the system with one inverter running, the 7 HP pump start and the system immediately has all four inverters running." *Darryl Thayer - Innovative Power Systems, Inc.*

- "I must say your PS2 system is great. We installed the unit with very little issues. The unit is easy to install, well balanced, and looks incredible. It is very quiet also. Two thumbs up from SC Solar." *Dan Whigham*

- "Hello OutBack, First let me say I enjoyed your presentation at Energy Outfitters in Grants Pass last weekend. I bought a MX60 charge controller while there and installed it on my home system replacing an RV Solar Boost 50 that I will use at another site. I noticed from the start that MPPT on MX60 was operating more effectively at lower input amps than the Solar Boost . For example, at this time with overcast skies I am boosting 22% from 1.8 to 2.2 amps (30 volts in and 24.7 volt battery). On the Solar Boost, I would have the opposite condition actually losing more power in MPPT mode at this amp input level. This may not add up to much accumulative power lost or gained, but it is sure satisfying to see boosting across the input spectrum. Also I am very impressed with all the functionality of the MX60 especially the logging capabilities. Although most of the tweaking capabilities will be lost on many customers, the display information and logging info will be a selling point." *John Wiley - Norhtwest Solar Electric*

- "Thanks again for your help, interest and support. Most of all anyone who's as interested in improving their product and seeing how it works in real world conditions as you guys are - can't help but have happy customers." *Andy Keith, Hawaii*

- "Thanks again for last Saturday. Being at the phone to provide technical assistance saved me numerous hours of trouble shooting." *Todd - Common Energy LLC*

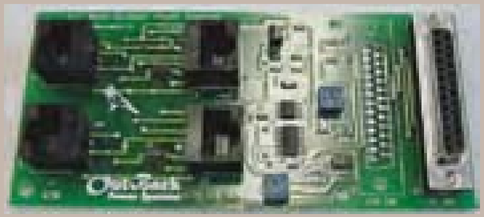
- "I do not have the e-mail address for John Rodgers (Dooba), he was very helpful to us. I spoke to him about a system that would not have survived if it had not been the sealed FX's. 3000 liters of water fell on the system and it all works still." *Abhay - Ultratec, Unganda Africa*

- "I replaced a C40 with a MX60 for a friend, Bill on 1/1/04. I'm 5 years removed from working at a high-end AV shop for 6 years. I unboxed many very expensive pieces of gear - some packed nicely, some not so nicely. The MX60 was packed very well. While taking it out of the box, I felt I was holding something of quality., the weight, the metal case work (rivals American audio companies Krell and Theta) and the fit and finish. The MX60 oozed with quality - especially comparing it to the C40. Hooking it up was a snap. The well thought out knockouts lined up perfectly to drop into the DC-250 where the C40 was previously. Set-up was a no brainer, easy to follow manual. Bill is very happy with his upgrade - less generator time is a wonderful thing." *Kevin*

The OutBack MIG2 Unveiled

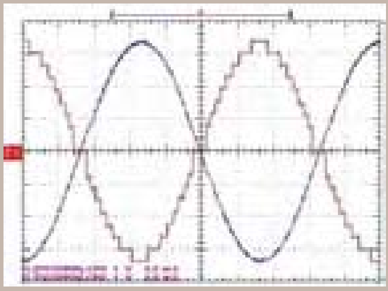
Two FX's & One SW

Guess who's the Master?



FX & SW AC Output Waveforms

Stacked for 120/240VAC



The FX is the pretty waveform

- "For the last two months I have been testing a new migration board (MIG2) from the good folks at OutBack. It allows me to series stack the OutBack inverters with Brand X inverter. It works like a champ. I was able to replace one dead SW4024 of a pair, with two FX2024's. The two FX's are parallelled together, and then they are stacked with the remaining SW. This will allow me to cut-over to the OutBacks as the SW's fail, while maintaining the clients' investment in the SW's til their demise. " *John McNicholas - Key Power Services, Inc.*

(John's write up was unsolicited and unexpected. Frankly, we had almost forgotten about the MIG2 project. Not anymore!)

Meet Ed Wold

Ed enters the orders, gets them ready and then ships them.

In a hurry? Call Ed - He makes it happen!

Meet Denise Campbell

Denise builds all the integration products - PS2, PSPV, PSDC etc.

Denise take great pride in making your OutBack experience successful!

Mixing Business & Pleasure

Andy Kerr

The Larch electrical generating station (see companion article in this issue) definitely satisfied my environmental goals. But what about the economics of it all? Oregon only allows a US$1,500 income tax credit toward the purchase of 500 watts (US$3 per watt) of photovoltaic panels for residential PV systems. But the state allows a tax credit for up to 35 percent of the cost of a PV system for a business. This made it easy to decide that the Larch Company was going into the solar-electric generating business.

The Larch Company is my consulting firm, through which I offer advice and services to environmental conservation organizations. This article examines the economics of the Larch generating station, from both business and personal economic perspectives. The numbers make one point crystal clear: if at all possible, you should merge your solar electricity production business into part of an already profitable business.

The tax breaks (credits and deductions) available to businesses are currently critical to any potential profitability of a solar-electric generating station. Actual revenues from generating electricity are far less than the expenses. So this PV system works economically only because it has related taxable business income against which to receive credits and take deductions.

Initial Cost & Benefits

	Cost (US$)	Salvage Factor	Salvage Value (US$)
32 PV panels	$16,320	50%	$8,160
2 Inverters	6,291	20%	1,258
16 Batteries	2,880	30%	864
PV mounts	2,830	20%	566
Labor	2,720	0%	0
Cable, hardware, etc.	2,557	5%	128
2 Charge controllers	952	20%	190
Meters	763	20%	153
Breakers, disconnects, etc.	734	20%	147
Permits, misc. costs	200	0%	0
Initial Cost & Salvage Value Totals	$36,247		$11,466

Business Economics

By law, managers of publicly traded corporations must seek to maximize profit every reporting quarter, lest they violate their fiduciary responsibility to shareholders. This deeply held, and even more deeply flawed, principle of business management does not allow a profit-maximizing concern to be overly worried about anything that may have societal value, but no corporate profit.

Fortunately, the Larch Company is not publicly traded, but rather wholly owned by me. I am the sole principal (my title is "Czar"). Organized as a limited liability company (LLC) under Oregon law, I have the liability shield of a corporation, without having to hold annual meetings. I also don't file separate personal and business tax returns, but must include some additional forms on our personal return.

How does the Larch generating station pencil out? While my personal economics and philosophy have convinced me of the necessity of renewable and sustainable energy, solar-electric power will only become mainstream when it is "profitable" in a traditional business sense.

Revenues & Expenses

	2001	2002	2003	2004	2005	2006
Gross system cost	-$36,247	$0	$0	$0	$0	$11,466
City of Ashland cash incentive	4,800	0	0	0	0	0
Federal income tax credit, 10%	3,625	0	0	0	0	0
Oregon income tax credit, 35%	3,625	3,625	1,812	1,812	1,812	0
Tax savings (depreciation)	2,273	3,636	2,182	1,309	1,309	655
Green tags	0	282	302	302	302	302
Forgone electricity purchases	166	175	184	193	203	213
Net Annual Income	$14,488	$7,718	$4,480	$3,616	$3,626	$1,169
Maintenance	$0	$0	-$5	$0	$0	$0
Net Annual Costs	0	0	-5	0	0	0
Net Cash Flow	-$21,759	$7,718	$4,475	$3,616	$3,626	$12,635

Since my business is environmental protection, a solar-electric facility was a very legitimate business purpose and therefore deductible. The Larch Company now has two profit centers—the electrical power division and the political power division.

Alternative Investment: 5 Year Treasuries

Treasury Bond	2001	2002	2003	2004	2005	2006
Initial investment	-$36,247					$36,247
Interest income	997	997	997	997	997	997
Net Cash Flow	-$35,250	$997	$997	$997	$997	$37,244

Interest Earned	$5,981
Internal Rate of Return	3.4%

	Solar	Treasury Bonds
Value at End of Six Years	$46,558	$42,228

Analyzing Dollars & Sense

My project spreadsheet considers initial outlay, annual revenues and costs, and the bottom lines. (The original Excel spreadsheet can be obtained from the Promised Files section of the Downloads area at www.homepower.com.) The total initial cost was substantially offset by state and federal tax credits and deductions, and also a cash payment from my municipal utility. In this case, annual "income" can either be money received or money not spent. Money I don't have to spend is money I don't have to earn and pay taxes on.

I also considered an alternative investment option for comparison. In this case, I chose a conservative five-year U.S. treasury bond (extrapolated to six years to ease comparison). In our capitalist system, money makes money. What, if instead of installing a PV system, I had put the US$36,247 initial cost elsewhere? If in a passbook savings account, I might only get 0.5 percent, but the principal is very secure and fully liquid. Federal treasury bond principal is just as safe, but generally tied up, so I might make 3 percent. I might lose my principal in the stock market, but the long-term rate of return has been 10 percent for large firms. (Of course, past performance is no indicator of future returns.)

My amortization (payback) period is six years, based on standard depreciation at that time. The internal rate of return (IRR) on the Larch generating station is projected to be 13.3 percent. Internal rate of return is the amount of money made for an investment considering cash flows over time. This analysis has two very major assumptions:

- The electronics (inverters, charge controllers, etc.) won't fail in six years.
- The estimated salvage value is accurate.

The former is a reasonable hope and the latter is an informed guess. If a transformation in PV module technology takes hold, then the panels will be worth very little. If not, since they have another 19 years under warranty, they might be worth more than 50 percent of cost. Even if the PV panels are worth only 20 percent of the original value at the end of six years, I will end up with the same amount of money as having invested in a five-year bond.

Simple payback, while not as financially accurate or elegant, is another way to consider an investment: how many years of income does it take to pay back the original investment? In this case, just over eight years.

I also assumed another six years of operation after the amortization. Assuming the salvage value is correct (and the electronics don't fail), along with the other assumptions on costs and income, the return on investment (R.O.I.) on the system salvage value continues in excess of 4.6 percent for as long as the system lasts.

Since I installed my system in 2001, federal tax law now (set to expire after 2005) allows for far more generous and rapid depreciation of equipment. It is now possible to write off the entire system cost in one year. Incentives have also improved. The City of Ashland now offers US$3.50 per watt installed, increased from US$1.75 per watt, to a maximum of US$10,250 per household.

If my utility raises the price of electricity, I'll make more selling excess electricity, and I'll save more by having avoided purchasing so much grid electricity. Perhaps the market price for green tags will go up as well.

A 13.3 percent internal rate of return looks very good to me, especially compared to 3.4 percent IRR for a treasury bond. However, the former entails much more financial risk than the latter. I could sell a five-year treasury bond before it's due, although with some penalty.

Large businesses have an internal "hurdle" rate, which any new undertaking must exceed. The Larch Company hurdle rate of return is less that 13.3 percent, but such is not the case for most large corporations. "Normal" business profit expectations often approach 20 percent. Therefore, a

Post Amortization Period Economics

	2007	2008	2009	2010	2011	2012
Bonneville Environmental Foundation green tags	$302	$302	$302	$302	$302	$302
Forgone electricity purchases (tax-free)	223	235	246	259	271	285
Total Annual Income	$525	$537	$548	$561	$573	$587
Annual R.O.I. (Salvage Value)	4.6%	4.7%	4.8%	4.9%	5.0%	5.1%

Salvage Value (After Six Years) of Functioning Solar Power	$11,466

pure bottom-line analysis suggests that this solar-electric generating system is a poor investment (only 13 percent versus 20 percent doing something else). However, standard business practices acknowledge other values.

Hedge against higher utility electricity rates. Most analysts project electricity rates in my region to rise faster than projected inflation. I am now in a position where I want rates to rise so I can make more money.

Hedge against lost productivity. When I don't have electricity, I cannot work.

Goodwill. The reputation of a professional conservationist is enhanced by walking the talk. Having a company and home that runs primarily on sustainable electricity distinguishes me from my competitors. From a purely business standpoint, I can rationalize the Larch Company's electrical power division as making a marginal profit, because it enhances these other business values.

Personal Economics

Since I don't have to answer to a board of directors whose sole interest is profit maximization every quarter, the Larch Company can have other objectives besides profit, such as sustainability, justice, and other comparable values.

From a personal standpoint, the money I spent on the Larch generating station has given me some of the best returns I have ever received. Humans do not live on money alone. Every time I gaze out my office window and see the photovoltaic panels or glance at the production numbers as I walk by the inverters, I feel slightly better than I did—knowing that my electrical consumption is not contributing to melting the glaciers in Glacier National Park or the polar ice caps right out from underneath the polar bears and penguins.

If I were installing a similar system today, the initial costs would be significantly lower and incentives significantly higher, making the economics more attractive—approaching the realm of "normal" profit.

Should you install your own photovoltaic system as a financial investment? If you can include it as part of a business, you should certainly run some numbers. If you can't do it as a business venture, then consider it as a hobby. You could easily spend comparable amounts on a boat, camera gear, a home entertainment center, or other toys and joys. For me, the "utility" (the economist's word for "pleasure") of the expenditure is comparable. The bottom-line financial analysis is but one factor to consider. Money is not the measure of all things.

Simple Payback

	Net Income	Net Payback
Year 1	$14,488	$14,488
Year 2	7,718	22,206
Year 3	4,480	26,686
Year 4	3,616	30,302
Year 5	3,626	33,928
Year 6	1,169	35,098
Year 7	525	35,623
Year 8	537	36,160

The Bottom Lines

Internal rate of return	13.3%
Green bragging rights	Priceless

Access

Andy Kerr, Czar, The Larch Company, 1213 Iowa St., Ashland, OR 97520 • 541-201-0053 • Fax: 541-201-0065 • andykerr@andykerr.net • www.andykerr.net/Energy/EnergyPT.htm

This article would not have been possible without the services of my friend, accountant, and financial advisor Linda S. Craig, CPA, CFP.

Experience Hands-On Training From World-Class Instructors At

SOLAR ENERGY INTERNATIONAL

Upcoming Workshops:

Wind Power

Natural Home Building

Renewable Fuels

Women's PV

In Colorado

PV Design & Installation	May 3–14
Successful Solar Business	May 15–16
Advanced Photovoltaics	May 17–21
Renewable Fuels	May 24–28
Solar Hot Water	Jun 1–4
Solar Home & Natural House Building	Jun 7–18
Advanced Straw Bale	Jun 19–20
Advanced Natural Building	Jun 21–25
RE for the Developing World	Jun 21–25
RE for the Developing World hands-on	Jun 28–Jul 1
PV Design & Installation	Jul 5–16
Successful Solar Business	Jul 17–18
Advanced Photovoltaics	Jul 19–23
Biodiesel	Jul 19–23
Wind Power	Jul 26–Aug 6
Micro-Hydro Power	Aug 9–13
Solar Water Power	Aug 14–15
PV Design & Installation	Aug 16–27

PV Design & Installation, Outside CO

Salt Lake City, Utah	Apr 12–17
Woodstock, NY	Apr 12–17
Guemes Island, WA	Oct 25–30

Other Workshops, Outside CO

Utility-Interactive PV, Guemes Is., WA	Apr 8–10
Homebuilt Wind Gen., Guemes Is., WA	Apr 12–17
Utility-Interactive PV, San Diego, CA	Apr 16–17
Utility-Interactive PV, Lincroft, NJ	Apr 17-18
Intro to RE, Guemes Is., WA	Apr 18
Understanding PV, The Farm, TN (Contact # 931-964-4474)	Apr 21-24
Natural House Bldg, Kingston, NM	May 3–7
Intro to RE, Guemes Is., WA	Oct 16
Wind Power, Guemes Is., WA	Oct 18-23

Women's Workshops

Carpentry Skills for Women, CO	Apr 26–30
PV Design & Installation, Paonia, CO	May 3–14

Distance Courses on the Internet

PV Design	Aug 30–Oct 8 Nov 1–Dec 10
Solar Home Design	Oct 11- Nov 19

Call or Write for the FREE 2004 Workshop Catalog.

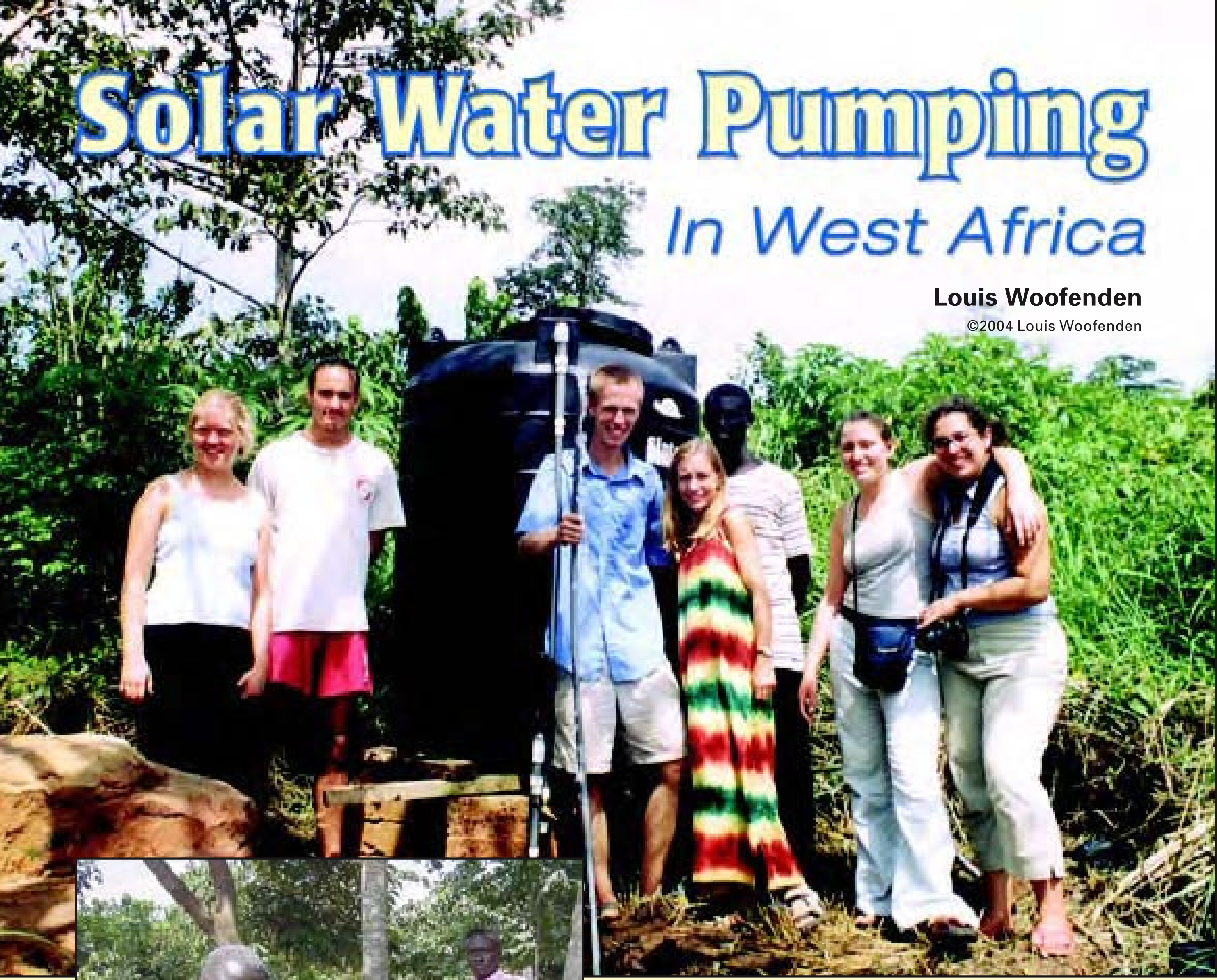
SEI

Hands-On Education for a Sustainable Future

voice: 970.963.8855 • fax: 970.963.8866
www.solarenergy.org • e-mail: sei@solarenergy.org
P.O. Box 715, Carbondale, CO, USA 81623

Solar Water Pumping
In West Africa

Louis Woofenden



The Ghanaian schoolchildren gathered excitedly around as Reverend Gyamfi got ready to open the water spigot. It was only minutes since the water had started to flow from the holding tank into the pipes, so I wasn't sure if it would be at the spigot yet. But I had nothing to worry about. The water flowed out in a satisfying stream.

Above (L to R): Laura Gladish, Brian Smith, Louis Woofenden, Kelly Waddell, Kwame Adu, Rachel Gardam, and Sarah Walker were the main installation crew of a PV-powered water pumping system for the school in Asakraka, Ghana.

Left: Reverend Gyamfi uses the first water from the spigot to the delight of the schoolchildren.

I was so relieved—all the planning, preparation, and work had successfully come to completion. The staff and children at the school wouldn't need to walk down the hill to the well or return up the hill, trudging under the weight of full buckets. The New Church Preparatory School in Asakraka, Ghana, now had running water.

Students learn the fundamentals of solar electricity—the pump stops when a kid shades the PV panels.

Planning

The process had started months ago. Six Bryn Athyn College students (including me) had been planning a service internship since the fall of 2001. We'd be spending ten weeks in Ghana, West Africa, as interns in conjunction with our church's outreach office and the college we all attended. I'd heard from my older sister (who did a similar internship, and had also led a trip to Ghana over the summer of 2001) that the rural Asakraka school would love to have running water.

The school has three buildings, all with electricity, but the electrical supply was not entirely reliable, and expansion of their electrical system was not likely. All the water used for cooking, washing hands, and other tasks had to be hand-carried anywhere from 100 to 300 feet (30–90 m) up a steep hill. I started some research on what it would take to put together a solar-electric water pumping system to fill the school's needs.

With last-minute funding acquired from New Uses, a nonprofit church foundation, I spent much of my last two weeks before leaving for Ghana gathering the components for the system. Bob Maynard of Energy Outfitters, Inc. helped enormously. He made it possible to get everything together in time by quickly shipping two Sharp, 80 watt, solar-electric panels; a rack for the panels; and a Shurflo pump across the country. He also provided valuable advice about system components and other technical issues.

Kudos also to Direct Power and Water Corporation, whose staff took time out from other projects to build the rack for the panels. Thanks to this and other help, everything was ready and packed the day before we were scheduled to leave the U.S. When it came time to fly, Swiss Air was gentle with the panels and other equipment, and everything made it safely to Ghana.

African Arrival

Once we arrived in Ghana, my fellow interns and I worked at teaching, doing other projects, and simply acclimating to a new and wonderful culture. A few weeks later, we made a day trip up to Asakraka, a rural village near Volta Lake, the biggest man-made lake in the world. The trip was four slightly bumpy hours from the coastal city we were staying in through lush and beautiful jungle. During this short visit, I was able to take specific measurements and figure out how much pipe, wire, and other supplies we'd need for the water pumping system.

Over the next few weeks, I was able to buy wire and other electrical supplies in the electrical market in Ghana's capitol, Accra. I later went with Reverend Gyamfi (the minister and principal of the Asakraka church and school) to a commercial section of Accra where plumbing supplies are sold, and bought a polyurethane tank for water storage, some flexible tubing, and a few other needed supplies. Rev. Gyamfi had all the equipment trucked to Asakraka, where it awaited our arrival.

Arrival & Teaching in Asakraka

A week later, we arrived in Asakraka, and began work on the solar pumping system. We would have only eight days in Asakraka. In addition to the solar project, our group would be building a jungle gym for the schoolkids and organizing a library. We would all have to work hard to get everything done. Because of the time crunch, I'd need to cut back on teaching about solar electricity to the people there. Instead, I'd have to concentrate on simply getting the system up and running.

I did, however, have a chance to teach three different school "stages" (grades) about solar electricity. Using the two panels, I set the pump up as a small fountain in a bucket. The teachers were great—they took my simple explanations of how the panels and pump worked, and translated them into Twi, the local language.

The kids were very excited about the whole thing, and gathered around the bucket, pushing each other and jostling for position. We had to set up a perimeter of pieces of wood, just to protect the pump and panels. One of the most fascinating moments for the kids was when they shaded the panels and saw how the flow from the pump diminished. For a grand finale, I used the pump as a mister, and sprayed the kids all around. They had a blast. In fact, it soon turned into pandemonium, at which point we turned off the pump and went on to other parts of the project.

Locals and visitors work together to hoist and install the PV panels.

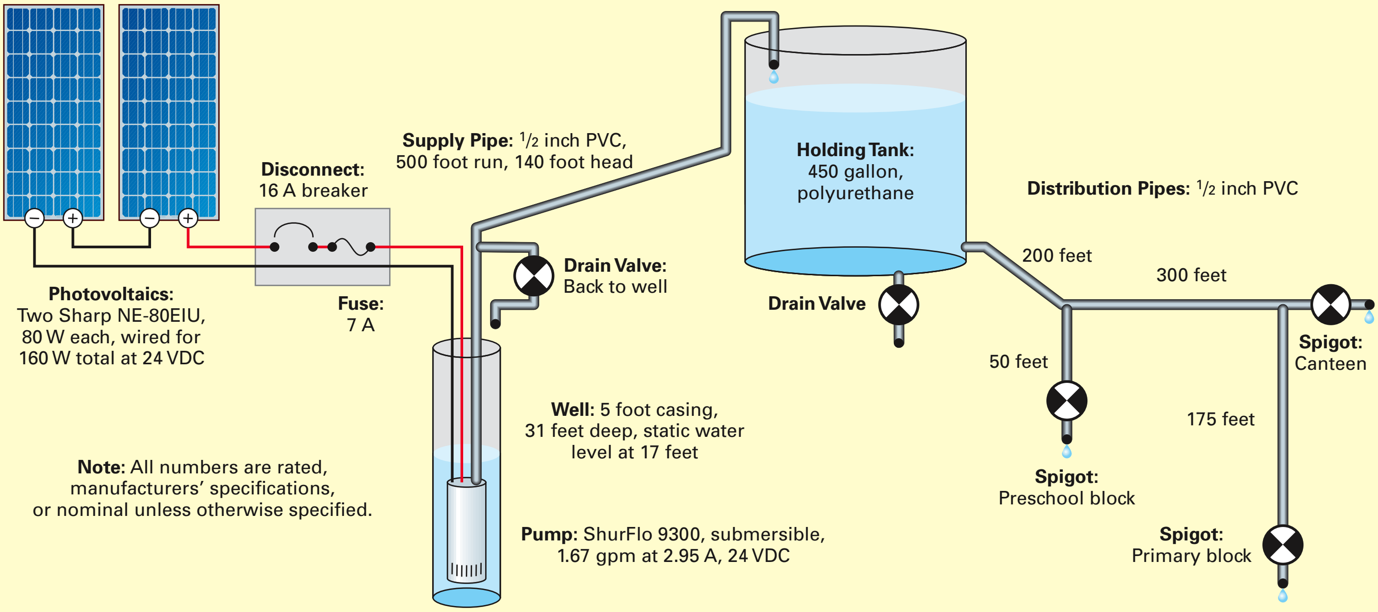
Mounting the panels on the DP&W rack—a 17 foot tall, 2 inch diameter steel pole supports the whole assembly.

Getting the Basics Done

The first order of business on the project was to look over everything. I then started working with Kwame, an active and enthusiastic church member and my main helper, to install the 185 foot (56 m) wire run. It would go from the top of one of the school buildings, where the panels would be mounted, to the wellhead, where the pump would be installed. Kwame, my five American companions, and I finished digging a 140 foot (46 m) long ditch.

The next couple of days were spent on the mostly mundane. We set the bottom of a 17 foot (5 m) tall, 2 inch diameter steel pole in concrete, and secured the pole to the school building's rafters. The rack for the panels would rest on the top of the pole. Kwame and I started running the wires through the conduit from the well to the panels.

I tried to glue all the pieces of conduit together first, and then run the wire through. This didn't work, because the conduit was undersized (by U.S. standards) for the job. In Ghana, they feed wire through each piece of conduit, and then glue them. So we broke the conduit run into a few sections and ran the wire. Kwame had fabricated new joints in the PVC, using a pointed tool and some hot coals. Then we glued it all back together. Ghanaian ingenuity triumphs—the Ghanaians can fix or do almost anything with very simple tools.



This completed the wire run from the pump site. We also made connections in an intermediary junction box. Kwame built a wooden box to hold a disconnect and fusing. It would be near the base of the pole that the panels would sit on.

By this time, I was a little worried. Although I would be able to get everything up and working, I thought I wouldn't have enough time to do the thorough education needed for Kwame and others to be able to maintain and troubleshoot the system. But there wasn't much I could do about it but keep on going. In fact, I was able to do a lot of teaching—mostly the hands-on type. I tried to get Kwame and other Ghanaians to do as much of the work as possible.

Whenever I or anyone else had spare time, there was always ditching to do! There was about 1,300 feet (396 m) of ditching, not even counting the ditch for the electrical conduit. The ditching included 500 feet (152 m) for the 1/2 inch water pipe that would run up to the water storage tank. From there, about 800 feet (244 m) of pipe would run to three different places where water was needed in the school—the school canteen (kitchen), the primary block, and the preschool block.

Concrete & Plumbing

By Friday night, halfway through our time in Asakraka, the project was in good shape. We'd been able to get a tremendous amount done in a single day, thanks to four Ghanaian workmen, as well as my fellow interns, particularly Sarah and Brian. Kwame and Omani (another Ghanaian carpenter) had previously built a form for a small structure on top of the wellhead. It had a bar to hang the submersible pump from. It would also protect the plumbing and electrical connections for the pump. On Friday, we poured the concrete into the form, so the pump house would be ready after the weekend.

Kwame practices testing the panels and fuses in case there is a problem with the system in the future.

Technical Specifications

System Overview

System type: Off-grid, PV-direct water pumping

Location: Asakraka, Ghana

Solar resource: 4 Average daily peak sun hours

Well depth: 31 Feet

Static water level: 17 Feet

Photovoltaics

Modules: Two Sharp NE-80E1U, 80 W STC, 24 VDC nominal

Array: 160 W STC, 24 VDC nominal

Array disconnect/overcurrent protection: 16 A breaker for disconnect with additional 7 amp automotive fast-blow fuse in-line with pump

Array installation: DP&W pole-mount, 15 degree tilt angle

Pump Details

Pump: Shurflo 9300 submersible

Pump design: Positive displacement 3-chamber diaphragm pump

Typical applications: Potable water well pump

Materials: High strength engineered plastics, stainless steel fasteners

Motor: Permanent magnet, PIN 11 126-10 (thermally protected)

Nominal voltage: 24 VDC

Maximum current: 4.0 A

Maximum lift: 230 Feet

Maximum submersion: 230 Feet

Outlet port: 1/2 Inch (12.7 mm) barbed fitting for 1/2 inch I.D. tubing

Inlet: 50 Mesh stainless steel screen

Weight: 6 Pounds (2.7 kg)

By mid-afternoon, the ditching was all finished. So we started on the next part of the project, gluing the PVC water pipe. This was a fun time, because in addition to all the rest of the workers, the Ghanaian children jumped in to help. They'd already been helping with the ditches at times, but now they were really in the middle of things. They were good at it too.

Either they had done this before, or they were very smart, or both! We were all glad that even the children had an interest in the system. After all, it would benefit them in many ways. At day's end, the pipe was all glued, the ditches were backfilled, and the three spigots were all set up, just waiting for the water to flow…

The completed "pump house." The electrical connections are on the left, the plumbing is on the right, and the pump is hanging from the bar in the middle.

Installing the Panels

After a weekend of other projects and responsibilities, we went to work Monday morning. A hired crew of masons stripped the forms from the concrete at the pump house down at the wellhead. Next on the agenda was putting up the panels—a moment that we'd all been waiting for. Kwame, Omani, another Ghanaian, and I worked on the roof. Brian and Sarah helped to hand the two panels and tools up to us. Kelly and Rachel took pictures, while everyone else helped in whatever way was needed, and watched.

The crew on the roof first put the rack together. The Direct Power rack was simple and sturdy, and we had no problems assembling it. I tried to take a backseat in the process as much as possible, letting the Ghanaians put it together. They were so good at doing everything that all I needed to do was provide some general direction, and they were off and running.

We set the tilt angle on the rack to 15 degrees to maximize output in winter, and rotated the rack to face a few degrees to the west of due south. This would provide the most output in Ghana's rainy season, when it's often raining in the morning, but usually clear in the afternoon.

After the rack was set up, Brian and Sarah handed up the first panel, which we bolted on with no trouble. The second panel followed soon after. When both panels where secured on the rack, we connected the 12 VDC nominal panels in series, so they could power the 24 volt Shurflo pump. This was an easy process, since the Sharp panels have MC connectors. All you have to do is push the connectors firmly together and the connection is made. To make the connection more secure, we also taped around each connector. After connecting the ground wire to the panels, we used zip ties to attach the wires to the rack and pole, and headed down the ladder to the disconnect box.

Successful Testing

When we measured the output from the panels, all was well. They were producing approximately what I'd expected, given the high temperature that day. Kwame and I worked for some time making the connections in the disconnect box. Because of the extra complication and expense of a float switch, the system was designed for manual control. When the water storage tank fills, the Ghanaians can flip a switch to turn off the pump. When they need more water, they can turn the pump back on.

Because of the simple design, there wasn't that much to show Kwame—just a locally obtained breaker for a disconnect, and a fuse to protect the pump in case it failed. We wired the positive leg from the panels to the wire running to the pump, after first running through the fuse and disconnect. The negative from the panels was wired directly to the negative terminal on the pump.

It was late afternoon by this time. But before the sun went down, I was able to make measurements down at the wellhead. Yes, the connections were all correct. Now that the solar-electric panels and wiring to the pump were done, there was only one more major part of the project to finish—installing the pump. There was only one hitch—we'd have just one day to do it!

Preparing the Pump

Tuesday morning, I worked with Kwame and another local man to disassemble and reassemble the pump, so they would know how to maintain the pump, and repair it in case of any malfunctions. The Shurflo pump can be easily rebuilt, and I'd brought along various extra parts kits, so that they would have all that they needed to fix the pump. I'd also brought a multimeter and a few other specialized tools that would be hard to obtain in Ghana. Kwame was trained as a carpenter, not an electrician, and this made the process of working on the pump slightly unfamiliar, but he caught on quickly. By the time the pump was successfully reassembled, he had a good grasp of how it all worked.

The kids at the school help glue PVC pipe. After just a few minutes of instruction, they were gluing like pros!

PV Pumping System Costs

Item	Cost (US$)
2 Sharp NE-80E1U PV modules	$568.00
Shurflo 9300 submersible pump	484.00
Shurflo spare parts	309.00
Shipping & transportation	267.69
PVC pipe & misc. plumbing	195.37
Cable, conduit, J-boxes, disconnects, fuses	181.97
Tools, misc. electrical, & other supplies	114.52
Polyurethane water tank, 450 gal.	103.70
Direct Power & Water top-of-pole mount	80.50
Total	$2,304.75

When we were done, Kwame had some other duties to attend to. Laura, Kelly, and I worked to connect the submersible cable, outlet hose, and safety rope to the pump. We then secured these three together with wire ties, while the Ghanaian teachers and children watched, asking us what we were doing. We cut the outlet hose and cable to approximately the correct length, and headed down to the wellhead to install the pump.

There was quite a crowd at the well. Rev. Gyamfi, Kwame, and the other workmen were there, as well as my five fellow interns, and teachers and students from the school. After getting the wires to the pump stripped and ready to go, I carefully lowered the pump into the well. I hung the safety rope on the bar that had been built for the purpose. It took a few minutes to get the electrical connections made. I was working with four fairly large wires in a small box, which can be a slightly frustrating experience. But soon, the connections were made and sealed with silicone, and the box was securely closed.

The System Today

When Reverend Gyamfi recently visited the U.S., I was able to hear a full report on the solar water pumping system. It's been running well, with absolutely no problems. They have always had enough water, even during cloudy periods. In fact, Gyamfi said that they have to turn the pump off frequently. A 12 foot (3.6 m) stand has been built for the tank, to provide better water pressure. All in all, Reverend Gyamfi and the Asakraka New Church School seem very pleased with the system.

Acknowledgements

This project could never have happened without the support of many wonderful people and organizations. I'd like to thank Dr. Bill Radcliffe and the New Uses Foundation for their solid support, and Reverend Martin Gyamfi and Kwame for their help getting materials, installing the system, and doing whatever else needed to be done.

I'd also like to recognize the church's outreach office and the college for sponsoring the internship. And last, but certainly not least, I'd like to thank my five fellow interns, Rachel Gardam, Laura Gladish, Brian Smith, Kelly Waddell, and Sarah Walker. I couldn't have done it without you. And to all the Ghanaians who helped, encouraged, and aided the whole process, thanks—you made the whole experience worthwhile.

Water at the Wellhead

I made the last connection, and the pump started up! The water poured out, and there were smiles all around, with excited children forming a ring around the well. Reverend Gyamfi got into the action too, posing with the water and beaming from ear to ear.

The pump was working, but the pipe still needed to be tested. We stopped the pump, and connected the outlet hose to the pipe running to the tank. Then we had to wait for the water to travel from the well to the tank, a height of about 140 feet (43 m), and a distance of about 500 feet (152 m). We did get some water up to the tank site, but we ran out of sun for the day before we could get it all set up and tested.

I knew that I would have limited time to test the system the next morning before we had to leave Asakraka. Before we went home for the evening, I spent a little time with Kwame and Omani, showing them some more possible problems that could occur with the panels, adjusting the rack to its final position, and explaining to Kwame how he could adjust the rack if the output was unsatisfactory. As I walked home in the dusk, I wracked my brain, making sure that I wasn't forgetting to do something important.

The Morning Brings Success

The morning was a blur. As soon as I got to school, I turned on the pump. While waiting for the water to reach the top, I worked with Kwame at the disconnect box, showing him how to troubleshoot various problems. Soon the water was flowing at the tank! Just then, Reverend Nicolas Anochi, a Ghanaian pastor who would be our ride back from Asakraka, arrived. He came and joined Kwame, my five fellow interns, and me, as we watched the water pour out in a steady stream. I was so relieved that it was all working as planned. We attached a short hose to the outlet pipe, and started to fill the tank.

Down at one of the spigots, Reverend Gyamfi turned on the water. It was running! The kids gathered round in excitement, posing for the photos that we were taking. At the same time, Reverend Anochi told us it was time to leave, and headed towards the pickup truck. We all shook hands with Reverend Gyamfi, bid farewell to teachers, and hugged kids as we walked to the truck.

The kids ran after us as we drove down the school driveway. We waved goodbye until the school was out of sight. As we neared the end of the church driveway, I caught a last glimpse of the Asakraka church and school, with the beautiful landscape in the background. Turning the corner, I thought I saw the sun glint off two panels nestled just above the African jungle.

Access

Louis Woofenden, 3314 E. Flower St. Unit F, Tucson, AZ 85716 • lwoofen@newchurch.edu

Rev. Martin Gyamfi, The New Church, PO Box 10, Asakraka-Kwahu, E/R, Ghana, West Africa

William B. Radcliffe, M.D., New Uses, Inc., 11604 Chantilly Ln., Mitchellville, MD 20721 • 301-464-1587 • wbraddoc@msn.com • Project Sponsor

Dr. Sonia Werner, Director of Internships, Bryn Athyn College of the New Church, Box 717, Bryn Athyn, PA 19009 • 215-938-2502 • sswerner@newchurch.edu • www.newchurch.edu • Internship

General Church Office of Evangelization, Box 743, Bryn Athyn, PA 19009 • 877-411-HOPE or 215-914-4911 • ncquest@aol.com • www.newchurch.org • Internship

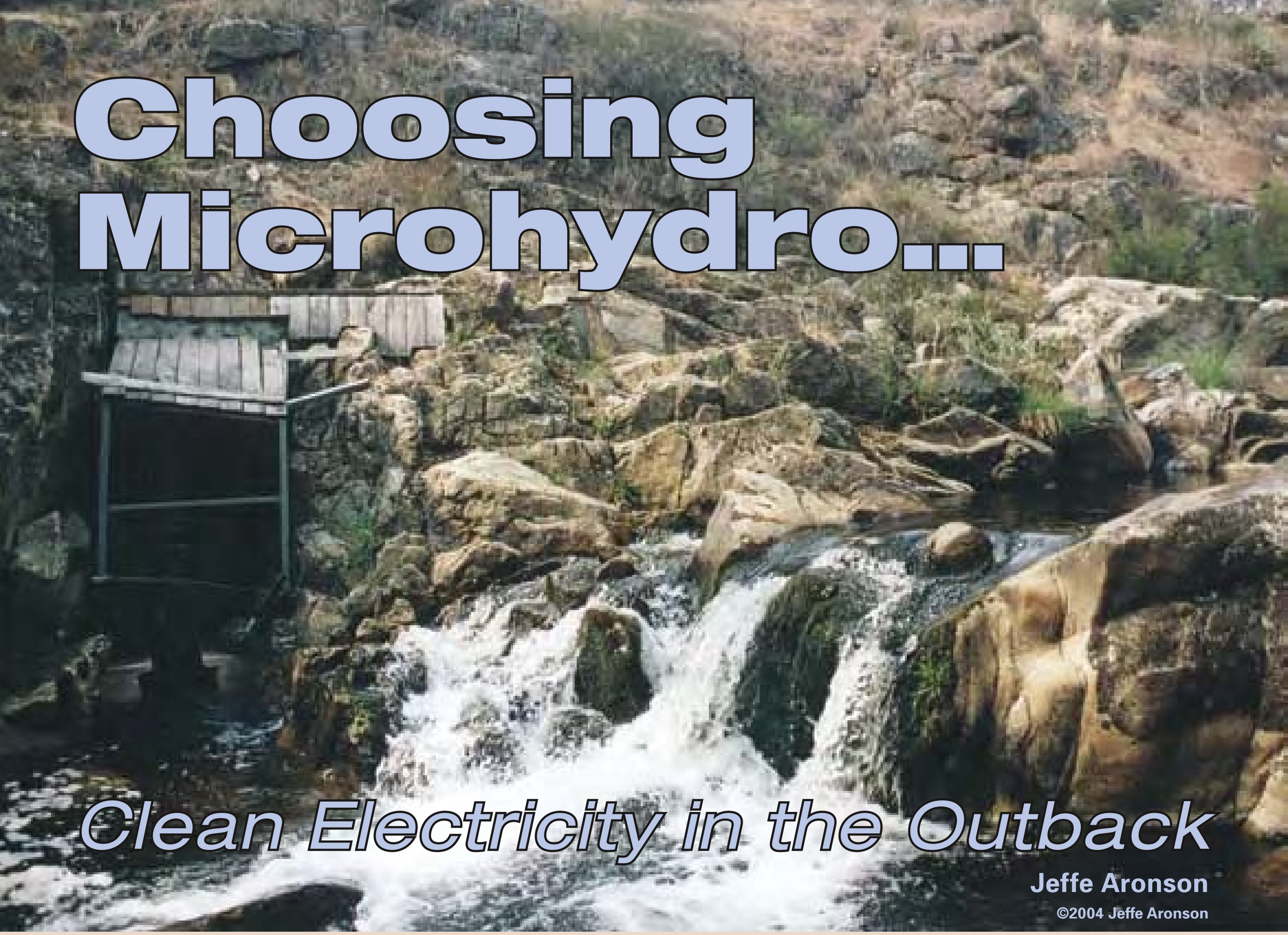
Bob Maynard, Energy Outfitters Ltd., 543 NE "E" St., Grants Pass, OR 97526 • 800-Go-Solar or 541-476-4200 • Fax: 888-597-5357 or 541-476-7480 • bob@energyoutfitters.com • www.energyoutfitters.com • System components

Direct Power & Water Corporation, 4000 B Vassar Dr. NE, Albuquerque, NM 87107 • 800-260-3792 or 505-889-3585 • Fax: 505-889-3548 • dirpowdd@directpower.com • www.directpower.com • PV rack

Choosing Microhydro...

Clean Electricity in the Outback

Jeffe Aronson



From penstock to tailrace, Jeffe Aronson designed his hydro system to have minimal impact on the ecosystem and the aesthetics of the river.

It was a dream of mine since my teens—building my own microhydro-powered homestead in the mountains, on my "own" river. And finally, here it was. We had the money, we found the right property, and all was "go." When you've spent close to AU$25,000 to power your home, you learn some lessons. Here's some perspective for the next dreamers, to prepare for the good, the bad, and the ugly.

In spite of our problems, we have what we consider to be the cleanest, most cost efficient, best source of electricity in our remote mountain setting. Being on the grid was impossible, since we are over 10 kilometers (6 miles) from the end of the line, with only a couple of dozen inhabitants in the vicinity. So the choices were solar-electric panels, hydro, diesel or petrol engine generator, wind turbine, or no electricity at all.

Water Is the Answer

We wanted the modern conveniences we were used to, but couldn't see the point in living next to a beautiful river constantly murmuring in the background, but drowned out by the sound of an engine generator. The environmental consequences didn't appeal either, and I figured I had better things to do with my time than constantly working on a greasy, oily, cantankerous engine.

When we found our valley, we visited some soon-to-be neighbors who had a combination solar/hydro system, and who recommended their installer to us. They had a hundred-year-old water diversion, and used that water for their high-head hydro. They had enough electricity for basic living, but didn't seem to have much left over for laundry, power tools, TV, etc. We contacted the installer, since he'd put together four local hydro systems, and everybody knew him and was happy with his work.

Our first real lesson in hydro, though I'd read quite a bit about it in alternative living books, was the difference between high head and low head systems. "Head" is the height of fall of the water. To run a hydro system and calculate the potential output, you have to know the head and the flow, including the lowest and highest flows expected during the year. You can get sufficient power from a combination of high head and low flow—say, 10 to 20 liters (3–5 gal.) per second dropping from a spring 20 meters (65 ft.) or more above your hydro unit. Or you can get similar output from a low head, high flow

Calculating Hydropower

Have a potential hydro site and want to estimate the power available? If you know your head and flow, you can do a very simple calculation for a rough estimate of the continuous output in watts.

Just multiply the net head in feet by the flow in gallons per minute, and divide by an adjustment factor. Use a factor of 9 for an overall efficiency of 59 percent, typical in AC systems. Use a factor of 10 to 13 for an overall efficiency of 53 to 41 percent, typical in DC systems. If you don't know your net head (which includes friction losses in the pipe), use the total head, and then take 10 to 20 percent off the total.

Examples:

7 feet of head x 6,000 gpm ÷ 9 = 4,667 W

70 feet of head x 600 gpm ÷ 9 = 4,667 W

700 feet of head x 60 gpm ÷ 9 = 4,667 W

5 feet of head x 1,000 gpm ÷ 10 = 500 W

50 feet of head x 100 gpm ÷ 10 = 500 W

500 feet of head x 10 gpm ÷ 10 = 500 W

2 feet of head x 700 gpm ÷ 13 = 108 W

20 feet of head x 70 gpm ÷ 13 = 108 W

200 feet of head x 7 gpm ÷ 13 = 108 W

Remember that all the energy you get from a batteryless AC hydro system has to be used at the same time it is produced. In battery systems, you can store unused energy for use later when you actually need it.

Load Analysis

For those first contemplating homemade electricity, there are some things to know. To figure how much energy you'll need in your household, you have to put together a chart of all the appliances you want to use, their rate of energy consumption, and how long you'll use them each day. Like a budget, you should be pessimistic and overestimate how long and how often you'll use things, just in case.

Using these calculations, you can then figure out how much energy your household will need on an average day and on a high-use day. All households are different, and if you're moving from being on the grid to homemade electricity for the first time, you'll find the learning curve steep in the beginning. Over time, you'll see your roles as "power plant managers" evolve—your family will have to be involved as well! Things get easier and more like habits later, but at first you might be a tad overwhelmed.

Whatever system you use, from solar-electric to gas generator to hydro, they all take time, thought, and effort. For some, a very simple system will do, since the requirements will be small. We wanted a washing machine, stereo, reasonably sized TV, computer, microwave, water jug, toaster, fridge and freezer, vacuum, and to use power tools, all without the hassle and noise of a generator. So we needed lots of electricity, which translates into lots of money and sweat! Having done our load chart, we saw that a 400 watt output, or more than 9 kilowatt-hours a day, was perfect. Remember, hydro is 24 hours a day, as opposed to PVs, which obviously only produce when the sun is shining. We were ready to get started.

Permits

Before we could start on the actual work, we had to deal with the permits, and also the need to alter our beautiful little river. In terms of permits, "everybody" suggested we just do it and let the bureaucrats find it if they could. Despite my natural tendency to hate the bastards, just like

One of the most difficult elements of the system to install was the intake (seen from above).

system like ours—a constant supply of between 125 and 190 liters (30–50 gal.) per second dropping only 2 meters (6.5 ft.).

Our installer came out to check our little waterfalls out, and pronounced the site doable. He'd been in the area before, and had two other units in the valley (high head ones). He'd never before seen a site he'd guarantee in the main river, since the danger of floods ripping out the turbine was too high. Our site, however, had rocky banks and eddies that seemed as if they'd protect the works from major floods. He confidently told us to expect "at least" a 400 watt output.

Aronson Loads

Item	Watts	Hours / Avg. Day	WH / Avg. Day
Assorted always-on & phantom loads, including computer, answering machine, stereo, TV, composting toilet fan, & clocks	57.6	24.00	1,382.40
Ceiling fan (summer)	360.0	3.00	1,080.00
Larger power tools	720.0	1.00	720.00
Washing machine	192.0	1.10	211.20
Microwave oven	960.0	0.20	192.00
Freezer	288.0	0.66	190.08
Small power tools	180.0	1.00	180.00
Satellite TV & VCR	50.4	3.00	151.20
Radio, stereo, CD player	24.0	6.00	144.00
Refrigerator	144.0	1.00	144.00
Kitchen lights, fluorescent	21.6	4.00	86.40
Hot tea water jug	576.0	0.15	86.40
Living room lights, fluorescent	7.2	4.00	28.80
Mixer, juicer, blender, etc.	168.0	0.16	26.88
Blow dryer	792.0	0.03	23.76
Toaster	600.0	0.03	18.00
Bedroom lights	7.2	2.00	14.40
Outdoor lights	84.0	0.16	13.44
Bathroom lights	7.2	1.00	7.20
Vent fan	2.4	2.00	4.80
Computer printer	4.8	0.08	0.38
Total WH on Avg. Day			4,705.34

everyone else, I had worked for years with politicians and bureaucrats, and knew two things about them (besides what we all experience and know, of course…).

First, if you work with them and don't show anger or frustration at some of their quirks, establish a good working relationship, show them respect (whether you really think they deserve it or not), "butter them up," so to speak, you just might get what you want out of them, sooner or later. Second, and perhaps more important, since they do have the law on their side, if they catch you in a lie or doing something against the rules or trying to pull the wool over their eyes, you are screwed. Royally.

I didn't want to deal with that weight on my shoulders, ruining my feelings about my home, so we decided to go through the permit process. Indeed, after a little while and a modicum of paperwork and approvals by all sorts of agencies from environmental to Aboriginal groups to parks and onwards, our hydro system was approved.

This was fortunate, since only a couple of years later a visiting fisherman, who had fished this section of river for decades and considered it his own, came upon our works, was outraged, and rather than discuss it with us, sent in a complaint to the water catchment authority. They sent the representative with whom we'd dealt originally. He thankfully found that we'd done what we'd said we'd do, and even felt the works to be "very discreet." He was visibly shocked to learn that we planned to cover what we could with wood to make it fit in even better (since done). We now have a letter of approval to this effect, just in case…

Loving & Using the River

As for the river alterations, this actually caused us the most anguish. I've been a river guide all over the world for nearly 30 years. I love rivers. They've nourished me and healed me, not to mention providing my living and years of fun and excitement, my whole adult life. Contemplating moving things around, and then pouring concrete was agonizing. Twice we begged the installer to consider doing the project with pipes rather than the water channel. He refused.

We considered nixing the whole project, but when we compared it with the environmental damage and visual and noise pollution of a generator, we balked. When we considered the cost, even after rebate, of enough solar-electric panels for our lifestyle, it was prohibitive—much more than the AU$15,000 to AU$18,000 estimate for our hydro.

We ended up justifying things to ourselves by committing to making the least possible change to the river's edge, not affecting the course of the river in any way, and making sure that it remained fishable and kayakable (even though it is only high enough to kayak for maybe 3 to 7 days a year, at best). We also planned to make the works as inconspicuous as possible, to the extent our ingenuity and pocketbook allowed.

Utility electricity, which we'd been on all our lives, results in air pollution, hundreds of miles of rivers drowned under huge reservoirs, hundreds of square miles of open coal pits and mines, and more. Our commitment to minimal impact seemed like a better bet to us. We've since had a few neighbors, as well as some river running colleagues, admonish us for what we did. Expect this, especially if you're building a hydro in a formerly "pristine" area. But those who have had the courage to discuss our options with us agreed in the end that, considering all the alternatives, we were choosing the lowest-impact option. These on-grid folks had to admit that we had affected the environment far, far less than they do just by having a hot cup of tea or a cold beer.

Custom-Built Turbine & Civil Works

Our low-head hydro unit was going to be built specifically for our site by Peter Barrett's Platypus Power in Bright, Victoria, Australia. Our first challenge was to create a water channel for the intake of water into the turbine. High head units only require an intake screen and a pipe—pretty simple.

However, our installer wouldn't guarantee our hydro with a piped inlet, since he'd seen this river in flood, and was afraid the pipe would get ripped away downstream, tearing out other bits along with it. He insisted on a water channel intake from one pool in the middle of our little waterfall to the pool below the last drop—a total fall, or head, of just under 2 meters (6.5 ft.).

This required a great deal of moving of rocks along a 15 meter (50 ft.) section of riverbank—by hand. It was probably over 5 tons, by my back's estimate. After this work, we had to pour a concrete retaining wall or weir, where the water would pool at the end of the new concrete channel, or "water race." It would then drop into the turbine through the intake pipe built into the bottom of the weir.

The turbine is over 6 feet tall and 10 inches in diameter. A shaft connects the alternator on top to the runner below. Below it is a Glockmann water-powered pump.

Technical Specifications

System Overview

System type: Off-grid microhydro
Location: Victoria, Australia
Hydro resource: 6.5 Feet (2 m) head, 30–50 gallons/second (125–190 liters/second) flow
Production: 180 AC KWH per month average

Hydro Equipment

Turbine: Custom
Runner: Custom by Platypus Power, 150 mm (6 in.) hub with ten, 50 mm (2 in.) aluminum blades
Alternator: Fisher & Paykel Smart Drive, 24 VAC nominal, 750 W max
Measured performance: 13.5 A max at 500 rpm, 130 liters per second
Hydro overcurrent protection: 30 A breaker

Balance of System

Charge control and dump load: AERL Maximizer
Inverter: Solar Energy Australia 2500, 24 VDC nominal input, 220 VAC, 50 Hz sine wave output
System performance metering: Plasmatronics PL- 20

Engine Generator

Make/model: Honda 6X200, 6.5 hp

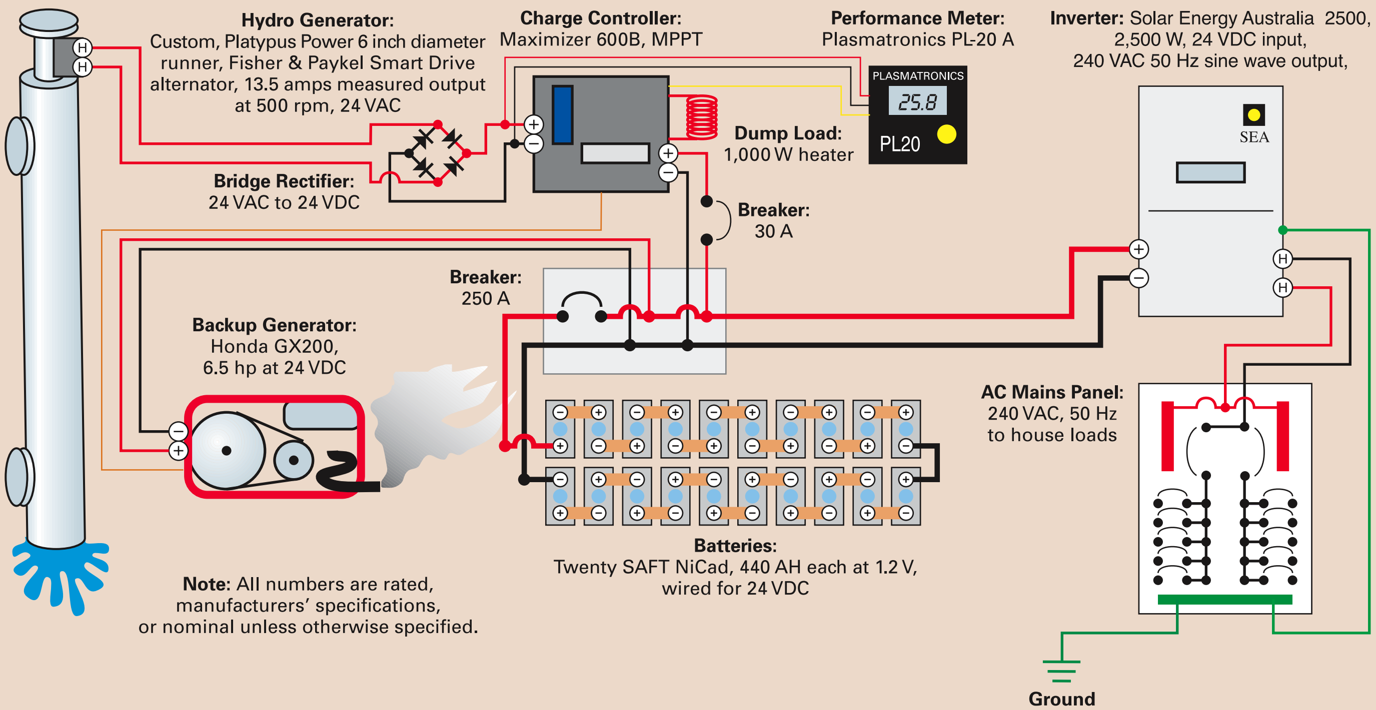
Energy Storage

Batteries: 20 SAFT, NiCad, 440 AH, 1.2 volt cells
Battery pack: 24 VDC nominal, 440 AH total
Battery/inverter disconnect: 250 A

This concrete weir is about 1.5 meters per side (24 sq. ft.), and poured to fit snugly in the natural gully between two very large protective rocks. The concrete "water race" is a 15 meter (49 ft.) long diversion, built into the rocks along the bank, about 1/2 meter (1.6 ft.) deep and 200 mm (8 in.) wide, channeling water along one bank of the river to the weir. The space between the water race wall and the bank averages about 1/2 meter. The water then pools behind the weir. The 250 mm (10 in.) intake pipe in the bottom of this weir takes the water into the turbine itself.

All of this was done on some rather uneven and rocky terrain, at the bottom of a very steep and rocky 8 meter (26 ft.) bank, accessible only as far as its top by four-wheel drive. Needless to say, we had our work cut out for us. In fact, I soon learned to describe this project as the hardest job I'd ever done.

Aronson Hydro System



Pouring Concrete

After digging the channel in the bank, we hired a contractor to build the forms for pouring the concrete. I'd worked with concrete before, but forming over very rocky and uneven terrain, in a very remote spot, where it needed to withstand tons of water flooding over a waterfall for several weeks a year, convinced me to seek someone with real experience. Our installer made it clear that he wasn't a concrete man, and wasn't really interested in doing the civil works, preferring the electrical end of things for his stimulation. He told us how long, how wide, how high, and how level he wanted the channel, and left us to our devices. "Let me know when you're ready for the hydro."

Thankfully, our neighbors and the son and daughter of the local concrete contractor helped us with the pour. It involved tons of sand and gravel, bags of cement, a petrol-driven motorized concrete mixer, a fire pump with intake hose in the river for water, a corrugated iron chute, shovels, and buckets. It was a lot of sweat for a half day, after getting the equipment to the end of that very steep four-wheel-drive track.

Turbine Installation

After our preparation was done, the turbine was delivered, and two neighbors and I dragged it down the hill and put it into place. Basically, it's a 2 meter (6.5 ft.) long by 250 mm (10 in.) steel pipe. The top end is capped except for a hole drilled for the shaft and shaft housing. A 19 mm (3/4 in.) stainless steel shaft goes through the pipe attached to a housing for the generator at the top. Near the bottom, the shaft goes through a fitting that the vanes and propeller blades (made from air fan hubs and blades) are attached to.

The vanes aim the water onto the angled propeller blades, which turn the shaft. A small, capped flange for blade access is on one side of the pipe near the blades at the bottom, with another flange to attach the intake pipe to near the top. A butterfly valve between the intake pipe and turbine allows us to turn the water, and thus the power, on and off. An air bleed valve was attached to the top cap.

Fortunately, everything fit perfectly with the intake pipe, which was already cemented in place in the weir. Now it was the installer's turn, while I continued building our house, complete with water tank and plumbing, woodstove, access roads, etc.

The installer came out and installed the inverter and controller, and hooked up the battery backup system. He then installed the generator (a rewired Fisher & Paykel washing machine motor) on top of the turbine, and we fired the thing up for the first time. After all that work, fear, and agony, we were so happy to turn on our first light. It worked!

Problems

As it turned out, the highest output the installer could coax out of the turbine was about 324 watts, or not quite 8 kilowatt-hours a day. We tweaked it for months, but that was it. Mostly, it averaged between 250 and 290 watts, but since we had electricity (and we didn't have much choice anyway), we took a wait-and-see attitude.

We had a number of other problems. Leaf litter and stick debris constantly clogged the blades. To avoid an expensive, time-consuming, and visually destructive retrofit, we installed three separate stainless screens, with 12 mm holes, along the water race. We now take a daily walk down to the river to clear them of debris, but it eliminates the need to freeze or nearly drown while clearing the blades.

We also changed the blade angle to allow more debris to pass through. The blade access hole was built too small for me to fit into, but my wife Carrie was worrid about more retrofits, and agreed to do the blade cleaning. The water flow through the turbine was very turbulent due to the lack of a cone above the vanes to smooth and direct the flow, and another below the blades to reduce cavitation, as well as the lack of a vacuum outlet. Fixing this will require a major rebuild. Air pockets at the top of the turbine were fixed with an air bleed valve.

Our controller didn't give us some information regarding amp-hours and daily histories, which we wanted for system evaluation. We got a new one installed. The steel intake pipe and turbine are rusting faster than we'd like, and weren't coated with epoxy. On our next rebuild, we'll coat it for longevity. A backup engine generator wasn't installed, so when we had floods or did maintenance, we had no reserve past the minimal battery bank. We've since installed a backup generator to top up the batteries when the turbine is off-line.

The author doing nonscientific analysis of head and flow on the river that provides his electricity.

Advice Column

Virtually all types of hydro-electric systems have one major problem in common—debris. You should definitely predesign an efficient and perhaps automatic debris deflector/eliminator. Do not be talked out of this under any circumstances. Some very ingenious ways—some expensive, some cheap as dirt—have been developed over the years to do this job. But once you've built the inlet pipes or canal, it may very well be too late.

You have two choices: Get a firm prediction of the expected output in writing, or expect less than predicted. Be very suspicious of potential installers unwilling to back up their estimate by writing it down. And when you get an estimate in price from an installer, add at least one-third to the price to make it more realistic.

Expect to spend more time and energy than you would on a solar-electric installation that has no moving parts and less of Mother Nature to deal with. Our hydro system has been about the same amount of work over time as a generator, though less greasy, dirty, and noisy.

Plan for the worst-case scenarios. In terms of energy needs, get the next bigger size inverter to the minimum you need. Otherwise, if you're having a party, or guests, or a big project, your inverter may kick out or even fry, and leave you back in the stone age for a time.

Steel rusts when in constant contact with water. Unfortunately, stainless steel is expensive and can be brittle. Numerous coatings are available for the innards of your turbine and intake. Coat your exposed steel before you install or expect to have to replace it sooner rather than later.

If the thought of being without electricity for a day or even a week scares you, include a backup generator to charge your batteries right from the start. This eliminates the need to endanger your life to fix a problem or clear out debris during a flood or electrical storm. Just fire up the generator and wait it out. It also is a stress reducer during maintenance.

Check out www.microhydropower.net, a Web site for microhydro folks from all over the world. Join the discussion forum. They accept requests for information, guide you to professional Web sites, offer advice, and have a great archive with drawings and photos of things like debris-free intake systems and installations. These folks pored over my photos and descriptions, asked questions, and helped me to not only understand my system but to figure out how to improve it when I'm ready. They are people who have built numerous systems in the U.S., India, Europe, and elsewhere. Their help was invaluable.

Mixed Success

After three years experience, and much studying and discussing with experts, we've had a little better than mixed success with our power plant. It does indeed "work," but after much analysis by several microhydro experts, it should be producing two to three times as much power with the head and flow we have. It should also be far easier to maintain. We've even asked our installer to fix the bugs in it, offering to pay for the labor and material, but he's simply not interested. Living in Australia, there isn't much opportunity to find others to help us. After three years of research, phone calls, mailed videotapes, e-mail, and photographs, we find that the few individuals or companies that work with hydros either don't do low-head systems or live too far away.

We're glad we've gone hydro for many reasons. If and when we gather the money and fortitude, and find someone to assist us, we believe we could improve our system to provide more output, even during floods, and eliminate most of the daily maintenance hassles as well. In the meantime, we love our home and the silent, clean, near-constant, smooth electricity our system gives us.

We love saving literally thousands a year on ever more expensive gas (propane in the States) by having an electric freezer and fridge. We love simply turning on the circular saw or hair dryer or toaster without hearing the generator out back. It does require a quick glance at the battery status and power generation. Several of these items require more than we can produce at once, necessitating the use of stored energy from the battery bank, after which the hydro replaces it over a short period of time.

Listen to the River

Realizing your dreams sometimes takes you down paths you didn't expect, and often requires a lot more work than you'd planned. We've made some mistakes along the way, some of which are fixable, some not. But we're proud and thrilled that we've persevered and overcome. In the end, we have come darn close to achieving our goal of environmentally friendly, efficient, reliable homegrown electricity.

If you're on the same path we are on, consider how much money you have to spend, how many appliances you feel you "must have," how much time and energy and strength you want to put into energy management, and take it from there. Whatever your choices, make sure you take time out to listen to the river.

Access

Jeffe Aronson, RMB 2143, Anglers Rest, Victoria 3898, Australia • 03-5159-7252 • jeffe@tpg.com.au • U.S.: c/o Echo River Trips, 6529 Telegraph Ave., Oakland, CA 94609 • 800-652-3246 or 510-652-1600 • Fax: 510-652-3987 • www.echotrips.com

Solar Australia, Melbourne, Unit 1, 15 Nicole Close, Bayswater North VIC 3153 • 03-9761-5877 • Fax: 03-9761-7789 • sales@solaraustralia.com.au • www.solaraustralia.com.au • Inverter

Australian Energy Research Laboratories P/L (AERL), Stuart Watkinson, 2 Roslyn Ct., North Tamborine 4272, Queensland, Australia • 07-5545-0177 • Fax: 07-5545-0866 • aerl@hotkey.net.au • www.windsun.com/ChargeControls/maximize.htm • Original charge controller and dump load

Plasmatronics, 14 Gipps Street, Collingwood, Victoria, Australia, 3066 • 03-9486-9902 • Fax: 03-9486-9903 • admin@plasmatronics.com.au • www.plasmatronics.com.au • PL-20 charge controller and metering

Saft Nife Power Systems Australia P/L, Gary Piper, 18 May Road, Lalor, Victoria, Australia 3075 • 03-9465-5734 • Fax: 03-9465-6213 • gary.piper@saft.alcatel.com.au • www.saftbatteries.com • Batteries

A 1,360 watt PV array on a Wattsun dual-axis tracker follows the sun all day, like a big silicon flower, maximizing solar output.

Trackers are PV mounting racks that follow the sun. PVs generate more electricity when they are directly facing the sun, but the sun is constantly moving across our sky. In the morning, it's low on the eastern horizon, and at sunset, it's low on the western horizon. At noon, the sun stands high in the sky. This apparent solar motion is due to the earth's rotation. Trackers maximize energy production by keeping the PV modules perpendicular to the incoming sunlight. How much more energy do you get? Well, this depends on the site and the type of tracker—from 25 to 40 percent more energy annually over a static mounted array.

Location, Location, Location...

For a tracker to be effective, it must be placed in a suitable location. A good tracker site is one that receives dawn-to-dusk sun—seeing the sun very early in the morning and receiving sunlight until sunset. There is no point in buying a tracker if your site doesn't begin receiving sunlight until 10 in the morning, or if it loses sunlight at 2 in the afternoon.

A good tracker site is free of solar obstructions, such as trees and buildings. A good tracker site needs access to sunlight all during the day, during all seasons. It's always best to evaluate the solar site with a device such as the Solar Pathfinder before even considering a tracker.

Trackers are usually ground-mounted, using a heavy steel pole sunk into a concrete foundation. While I've known of a few that were mounted on roofs, this is not recommended—it creates structural problems on the roof and tends to be noisy during windy weather. When siting your array, keep in mind that pole mounts might be considered unaesthetic by your neighbors, and they take up physical and visual space in your yard.

Trackers come in two basic types—electrically operated and thermally operated (sometimes called "active" and "passive"). Each type has its advantages and disadvantages. Each has sites to which it is more suitable. And each is different in cost, effectiveness, and reliability.

Thermally Operated Trackers

Thermally operated trackers use the transfer of mass (weight) from one side of the tracker to the other to track the sun. This mass transfer causes the tracker to pivot from east to west to follow the sun. These units are basically "balancing acts." Two tubes with strategically placed shading are mounted on the east and west sides of the tracker. These tubes are filled with a material—usually Freon—that vaporizes (becomes a gas) at relatively low temperatures. As the sun warms up the Freon on one side of the tracker, the

Freon vaporizes. This vapor takes up more space than the liquid Freon, pushing some of the liquid Freon to the other side, where it stays in the heavier, liquid form on the cooler, shaded side of the tracker.

This process transfers weight from the one side of the tracker to the other side. This weight transfer causes the balance of the tracker to change, and it rotates to the west. Since the vaporization of the Freon is caused by solar heat, the tracker follows the sun's motion across the sky. The most common thermally operated tracker is made by Zomeworks. UniRac also manufactures a small passive tracker that accommodates up to two, 120 watt modules.

The big advantage of the thermal tracker is simplicity and thereby reliability. There are no electrical parts to fail. The Freon is inside a sealed system, requiring no maintenance or energy to operate other than solar heat. A second advantage of thermal trackers is cost—they are generally less expensive than electrically operated trackers.

Thermal trackers have several disadvantages. First is that, being powered by solar heat, they are slow to react to solar motion. At night, they remain facing west and rely on early morning sunlight to return to the east—this process may take an hour or more depending on ambient temperature and wind. In winter weather, thermal trackers are somewhat sluggish and imprecise in performance because they are dependent on building up enough heat to vaporize the Freon.

A second disadvantage is that thermal trackers only track the daily east-west motion of the sun; they do not track the daily and seasonal north-south motion of the sun. Thermal trackers need to be manually adjusted about four times per year to compensate for the sun's seasonal north-south motion. I figure I increase annual output by 4 to 7 percent by doing this.

The third potential disadvantage of thermal trackers is that some models are shipped completely assembled. This makes shipping and installing the tracker more difficult and expensive, because of its size and weight. Zomeworks currently manufactures a line of thermal trackers (F-Series Track Rack) that come partially assembled, and easily fit in the bed of a pickup truck. Some smaller passive trackers can be shipped UPS.

Electrically Operated Trackers

Electrically operated trackers use photoelectric sensors to determine the location of the sun. The sensors and an electronic control box activate electric motors to position the tracker so that the PV array is perpendicular to the sun. The most common electrically operated tracker is made by Array Technologies under the brand name Wattsun. SolarTrax and Small Power Systems also manufacture active trackers in various sizes.

The big advantage of electrical trackers is that they are super precise. The PV array mounted on them is always perpendicular to the sun (assuming that the weather is clear and not cloudy). Most of these trackers can be purchased with a dual-axis option so they track not only the east-west motion of the sun, but also the daily and seasonal north-south motion. In addition, electrically operated trackers can be wired to return to the east at sunset so that the array will already be facing the sun at daybreak.

A second advantage of electrically operated trackers is that they ignore temperature, since they are powered by electricity, not the sun's heat. This makes this type of tracker more accurate in climates with cold winters.

Freon in the two side tubes allows this Zomeworks thermal tracker to follow the sun. The braced pole supports were custom-made to aid installation in rocky ground.

Precision—this large Wattsun tracker moves east to west with a top-of-pole gear; north-south adjustment is powered by a screw-drive actuator arm.

A third potential advantage of this type of tracker is shipping and installation. Since the tracker doesn't have to be assembled at the factory, it can be shipped in a number of boxes, reducing shipping expense and handling difficulties. The tracker can be assembled piece by piece on its mount; this is far easier than trying to hoist a heavy preassembled tracker onto its mounting pole.

It might at first glance seem that electrically operated trackers are the only way to go. But unfortunately, these trackers are not without their weak points. Their main problem is reliability. Electrically operated trackers are complicated and employ electronics and electric motors. Their reliability is much lower than thermally operated trackers. Being electrically operated devices, these trackers are sensitive to damage from lightning. The manufacturers of these trackers have made great strides in making their products resistant to lightning damage, but in the event of a close or direct strike, damage still may occur.

A second disadvantage of electrically operated trackers is expense. The initial cost is somewhat higher than thermally operated trackers, and since reliability is lower, there will likely be maintenance costs over the years.

Another minor disadvantage is that these trackers use some electricity to operate. The whole idea of tracking is to maximize energy production, and using electricity to accomplish this reduces maximization. How much? Well, actually, not very much at all. Wattsun trackers consume an average of 5 watt-hours per day. This energy use is insignificant in terms of total array production.

Tracker Economics

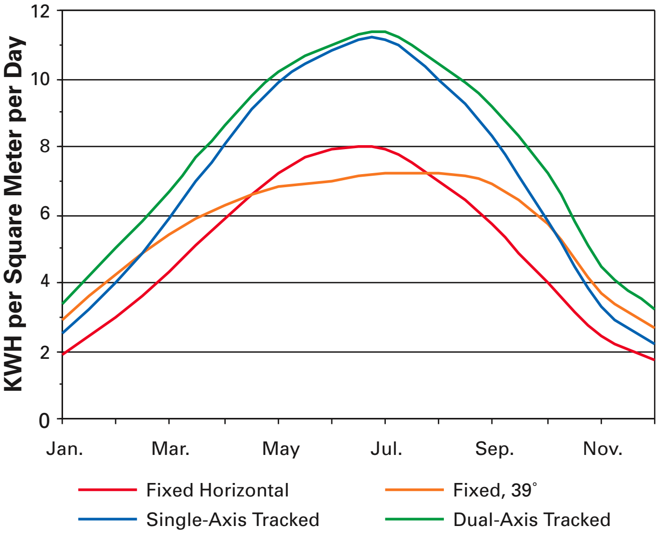
PV modules cost money, as do trackers. Where is the break-even point? At what point does the tracker become more cost effective than simply buying more PV modules and using a fixed mount? Currently, this break-even point is at about 500 to 600 watts, depending on location (solar window) and type of tracker.

If you are installing an array with six to eight, 75 watt, PV modules and you have a dawn-to-dusk sunlight tracker site, it may be cost effective to place them on a tracker rather than buying more PVs. Cost effectiveness will also depend on when you need more electricity. Obviously, trackers give you more gain in the summer when the days are longer, and less in the winter. For grid-tied systems with annual net metering, this can be a bonus because the tracker's excess summer production will help offset your winter utility bill. Trackers with as few as two PV modules can be cost effective in PV direct (batteryless) water pumping systems. See http://rredc.nrel.gov/solar/calculators/PVWATTS to compare the difference between fixed mount and single-axis or dual-axis tracking for your own site.

Tracker Tips

Plan on spending some bucks on the tracker's foundation—this is not the place to save money. A tracker, regardless of type, is a huge wind sail, and you don't want it blown over in high winds. The mounting pole for a home-sized array will be a 6 to 8 inch (15–20 cm) diameter steel pipe (or larger, depending on tracker size). This pipe needs to be secured into the ground with a substantial

Fixed & Tracked Arrays in Sacramento, California



Graph and data courtesy of NREL and Array Technologies

No motors or sensitive electronics on the back of the Zomeworks trackers—simplicity is reliability.

concrete base—don't skimp on the concrete! Follow the manufacturer's recommendations for mounting, and then add a bit more concrete to make sure that your tracker stays in the ground.

If you are installing a large, preassembled tracker, get some help. Assuming that your tracker holds eight or more modules, it may not fit into the back of most pickup trucks if it comes assembled. Have at least four friends (or a crane) assist you in placing the tracker on top of its mounting pole—this beast is heavy. It's also best not to mount the modules on the tracker until it is resting atop its pole.

Electrically operated trackers can be configured to run either directly off of the PV array, or from the system's main battery. In my experience, the model powered by the system's battery is far more reliable and precise in its tracking because it has a steady, 24/7 power source. For grid-tied applications, the Wattsun tracker can be run from an AC circuit instead of a battery. It uses a converter to provide 24 VDC.

These trackers are available with an external, manual switch kit (an additional cost option) that allows you to manually position the tracker. Buy this manual control! It allows you to manually position the tracker for easy snow removal during the winter, and for installation and maintenance. It also allows you to face the tracker south in the event of failure in the tracker's control electronics.

Tracker Experiences

I operate both thermally and electrically operated trackers here at our off-grid site in southwestern Oregon. I have found our thermally operated Zomeworks tracker to be supremely reliable, although somewhat imprecise at following the sun, especially during our cold and windy winters. Our electrically operated Wattsun trackers are super precise, but have not been without their failures during the thirteen years we've used them—twice from lightning, and six times from just plain old electronics failures. Since we have a dawn-to-dusk-sun tracker site and use lots of energy in the summer, using trackers here is a real energy booster for us.

Access

Richard Perez, *Home Power*, PO Box 520, Ashland, OR 97520 • 541-941-9716 • richard.perez@homepower.com • www.homepower.com

Tracker economics and comparisons • www.wattsun.com/faq/cost_comparison.html • http://rredc.nrel.gov/solar/calculators/PVWATTS

Zomeworks Corporation, 1011A Sawmill Rd., Albuquerque, NM 87125 • 800-279-6342 or 505-242-5354 • Fax: 505-243-5187 • zomework@zomeworks.com • www.zomeworks.com • Thermally operated trackers

UniRac, Inc., 3201 University Blvd. SE, Suite 110, Albuquerque, NM 87106 • 505-242-6411 • 505-242-6412 • info@unirac.com • www.unirac.com • Small thermally operated trackers

Array Technologies, Inc, 3312 Stanford NE, Albuquerque, NM 87107 • 505-881-7567 • Fax: 505-881-7572 • sales@wattsun.com • www.wattsun.com • Wattsun electrically operated trackers

SolarTrax Power Stations, 619 Commercial Ave., Covina, CA 91723 • 626-331-9570 • Fax: 626-331-8584 • info@solartrax.com • www.solartrax.com • 1.4 KW to 5.1 KW electrically operated trackers

Small Power Systems, 74550 Dobie Ln., Covelo, CA 95428 • 707-983-8498 • Fax: 707-983-6525 • george@smallpowersystems.com • www.smallpowersystems.com • Electrically operated trackers

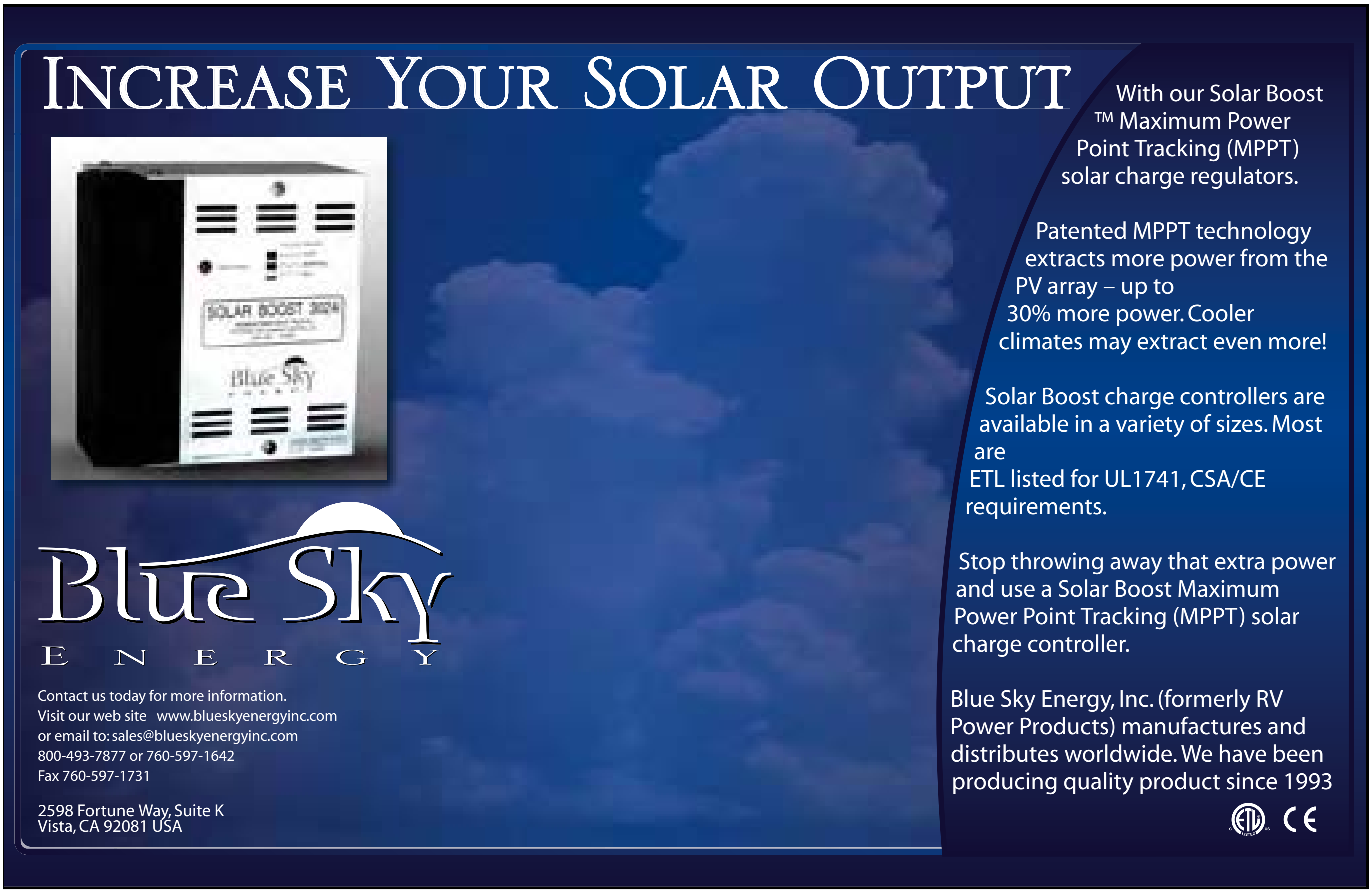

WATTSUN™
SOLAR TRACKERS
A diverse line of quality trackers for: Grid-Intertie, Commercial Applications, Remote Homes and Water Pumping.
Trackers from 150 W to 15 kW.
Complete pre-engineered TracKits™ available.
Patented technology.
15 years of solar tracking experience.
Array Technologies, Inc
505-881-7567
www.wattsun.com


What's Your Time Worth?
Are you a Dealer or Installer?
Hutton Solar understands your time is valuable. That's why we have established a national dealer/installer referral network to connect you to those in need of your products and services. Members of this coast-to-coast referral program save time by allowing us to identify opportunities for them. Our network is growing and we want you to be a part. There's no risk, only the opportunity to expand your business potential. Call 877-648-8866 to join! At Hutton Solar, our results are electrifying!
Looking for a Dealer/Installer in your area?
One of the most frustrating and time-consuming aspects of any project can be finding the right resources. With Hutton Solar's expansive dealer/installer network, we can connect you with the qualified experts who will get the job done right, coast-to-coast. Log on to Huttonsolar.com and use the find a dealer/installer feature on the home page. Let Hutton Solar work for you.
huttonsolar.com
The true leader in solar products distribution


Working For Your Environment.
DEKA SOLAR
RENEWABLE ENERGY GEL BATTERIES
TECHNOLOGICALLY-ADVANCED AND ENVIRONMENTALLY-CONSCIOUS.
East Penn recycles 100% of scrap lead-acid batteries at our state-of-the-art, E.P.A. permitted recycling facility. In fact, we safely recycle 20,000 batteries a day on site.
We are the world's largest and most modern single-site battery manufacturer offering premium quality valve regulated lead acid batteries in both Gel and AGM types to exceed the solar industry's high standards.
PROVEN PRODUCT IN DEMANDING PHOTOVOLTAIC APPLICATIONS • LESS THAN 2% PER MONTH STAND LOSS MEANS LITTLE DETERIORATION DURING TRANSPORT AND STORAGE
U.L. RECOGNIZED COMPONENT • MINIMUM MAINTENANCE • COMPETITIVE WARRANTY • MADE IN THE U.S.A.
DOMESTIC INQUIRIES:
800-372-9253 • www.mkbattery.com
EAST PENN manufacturing co., inc.
INTERNATIONAL INQUIRIES:
610-682-3263 • www.dekabatteries.com


Ontario Solar and Wind
Alternative Energy Products
We are a Xantrex Certified Dealer. We specialize in system trouble shooting and education. We are an Onan dealer and repair facility, servicing all types of generators—big and small. We sell Solar i.e.; Sharp, Uni-Solar, Kyocera, BP, Shell, Wind: Southwest Wind, Surrette Batteries, Interstate Batteries, Morningstar Controllers and many more... Please visit our Web site or call for details.
ARISE
Design, Sales, Installations
We service Ontario, Canada.
Ontario Solar and Wind Inc.
Freelton, Ontario Canada • 905-546-6224 • 888-703-8391
www.ontariosolarandwind.com


Sun Frost
Energy Efficient
Refrigerators & Freezers
Customized To Fit Your Needs
Available in DC or AC
Select From Over 10 Models
Choose from 1000's of Colors, Finishes & Woods
Providing an Effective Alternative for Energy Conscious Consumers.
Now Making Stylish Home Composting Systems Too!
Please Contact Us For More Info
P.O. Box 1101, Arcata, CA 95518
tel: (707)822-9095 ▪ fax: (707)822-6213
info@sunfrost.com ▪ www.sunfost.com


INCREASE YOUR SOLAR OUTPUT
SOLAR BOOST 3024
Blue Sky
With our Solar Boost ™ Maximum Power Point Tracking (MPPT) solar charge regulators.
Patented MPPT technology extracts more power from the PV array – up to 30% more power. Cooler climates may extract even more!
Solar Boost charge controllers are available in a variety of sizes. Most are ETL listed for UL1741, CSA/CE requirements.
Stop throwing away that extra power and use a Solar Boost Maximum Power Point Tracking (MPPT) solar charge controller.
Blue Sky Energy, Inc. (formerly RV Power Products) manufactures and distributes worldwide. We have been producing quality product since 1993
Blue Sky
E N E R G Y
Contact us today for more information.
Visit our web site www.blueskyenergyinc.com
or email to: sales@blueskyenergyinc.com
800-493-7877 or 760-597-1642
Fax 760-597-1731
2598 Fortune Way, Suite K
Vista, CA 92081 USA

Solar Energy

Southern Style

Joshua Tickell

The Magee family's lakefront getaway cabin near Bogalusa, Louisana, has all the comforts of home and is powered by the sun. So far, the sapling doesn't shade the array.

Crawfish boils emit a pungent aroma that triggers your sweat glands before you've pinched your first spicy tail or sucked your first head. The smell hit me full force as I opened the car door. The fragrance was wafting from the "camp"—an elegant blue cabin perched on the side of a big pond. Aside from its octagonal shape, rich wood interior, and expansive deck, only one thing is out of the ordinary about this little getaway—the twelve solar-electric panels that bask in the sun on its south-facing roof.

As seen from the cupola, the small but modern kitchen uses solar electricity and a propane range to feed a family of six between vacation adventures.

This solar powered oasis is the brainchild of attorney Bill Magee, age 49, born and raised in the tiny town of Bogalusa, Louisiana. After we chowed down on steaming crawfish, corn, potatoes, and enough boiled garlic to keep the mosquitoes away indefinitely, Bill and I sat down to talk turkey.

"I was an environmentalist in college," says Magee. "I was anti-nuke and pro-clean. I went to law school at LSU [Louisiana State University] and founded the first environmental law society there. I thought solar energy was the biggest no-brainer ever. But I also knew that since the big multibillion dollar corporations have their investments in fossil fuel and nuclear, [solar] wasn't going to happen anytime soon. After all, how are they going to make money if they can't send you a monthly bill?"

The open floor plan makes the small cabin feel cozy and spacious at the same time.

Magee didn't give up his dream of solar energy, though. According to him, it was just a matter of time. "I put it on the back burner for 24 years," says Magee. "I've reached the point in my career where I can do solar. It was going to cost $4,000 to run [grid] power to the camp." Additional expenses would have pushed the total bill for running grid electricity to the camp to more than US$6,000.

Faced with this high expense, Magee decided, "I'll use that money to offset the cost of the solar-electric system and let the sun provide the electricity for the camp." He hired Louis Martin, a local contractor who specializes in solar installations.

Critical Loads

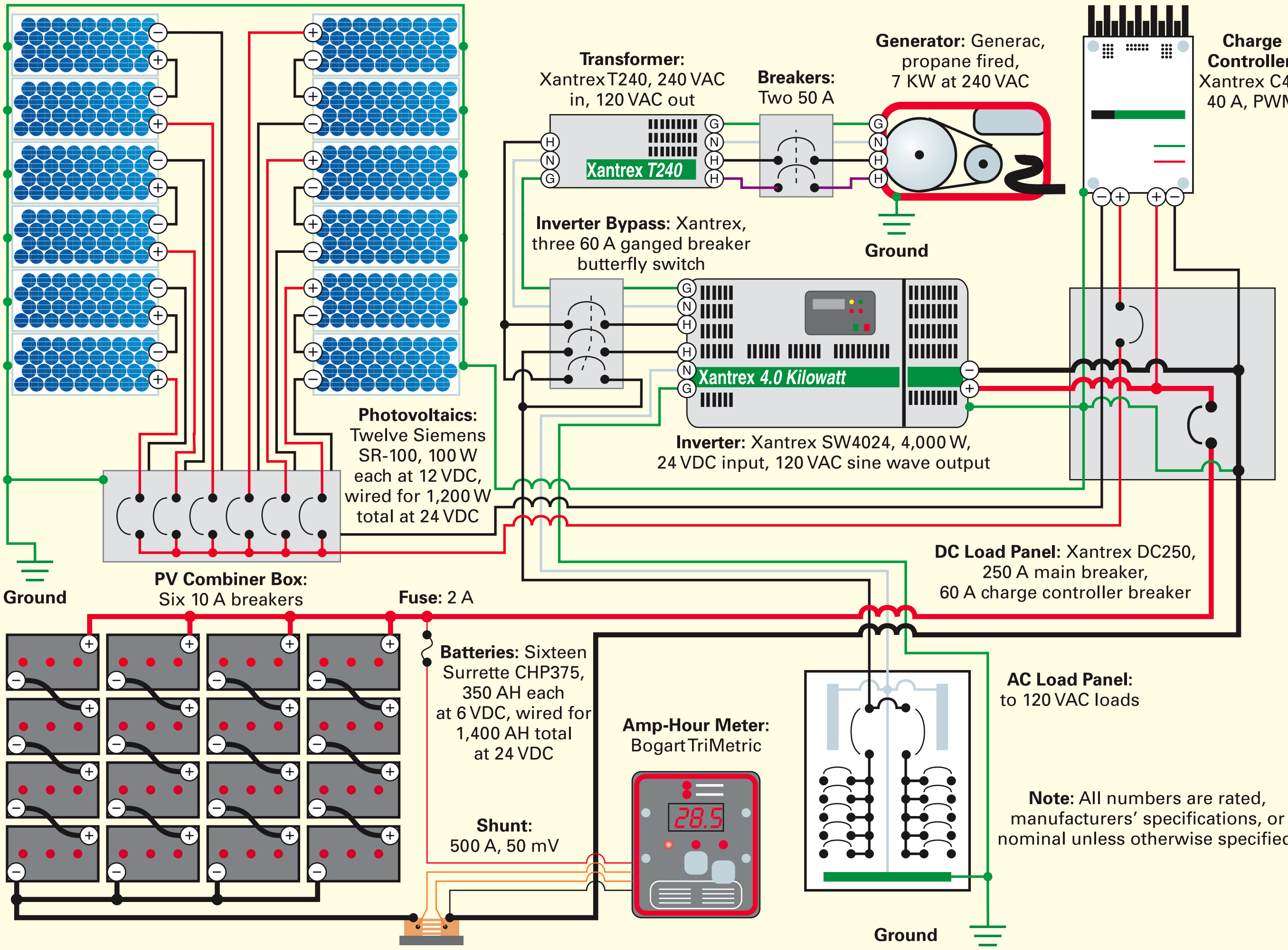
Item	Watts	Avg. Hrs. / Day	Avg. KWH / Day
GE refrigerator	120	10.00	1.20
TV	150	5.00	0.75
Surround amp	60	5.00	0.30
DVD	25	0.50	0.01
VHS	40	0.50	0.02
Laptop computer	50	10.00	0.50
Printer/fax machine	10	10.00	0.10
Microwave	1,200	0.10	0.12
Toaster	1,000	0.10	0.10
Fluorescent lights	30	6.00	0.18
Incandescent lights	60	3.00	0.18
		Total	3.46
		Total Weekly	24.24

Take a Load Off

Together, Bill and Louis made a list of the loads in the house. Loads are all of the electrical appliances, such as the refrigerator, the fans, and the air conditioner. They also listed how many hours per day each appliance would be used. Once the list was complete, they added it all up to see how much total electricity per day the house would use, and how much the solar-electric system would have to produce.

Bill faxed his load list as well as a diagram of his available roof space to renewable energy equipment suppliers around the country. He chose Sierra Solar in Grass Valley, California, because of their helpful phone support and competitive pricing. They planned a package consisting of twelve Siemens, 100 watt, photovoltaic (PV) panels; sixteen Surrette, deep-cycle batteries; and a Xantrex power panel. The power panel combines the major system components into one unit, and with the TriMetric meter shows how much energy is being used by the household, how much is being generated by the solar-electric array, and how much is stored in the batteries.

Even though the camp is a getaway for Bill, his wife Karen, and their four children, Bill still wanted it to have all of the conveniences of a normal home. Bill researched energy efficient appliances and found that by installing items like the AquaStar on-demand water heater and a propane stove and heater, the house's electrical energy consumption would be greatly reduced. Bill and Louis figured that the peak electrical load of the house would be around 800 watts without the air conditioner. With the air conditioner, the peak load jumped to 2,000 watts (2 KW). For times when the air conditioner is in use, they decided on a propane-fired, 7 KW Generac brand generator.



Bill Magee shows off the Xantrex power panel.

The Way Everyone Should Live

Bill says that, overall, the response to his solar-electric house from friends and colleagues has been very positive. But not everybody has been supportive of Magee's desire to be off-grid. "You know what?" he asks, "They don't give you any tax credit for using solar. And there's no benefit in Louisiana for selling electricity back to the grid. They want you to pay a monthly minimum amount whether you use their electricity or not."

Cost Estimate

Item	Cost (US$)
12 Siemens 100 W modules	$6,000
Xantrex Power Panel	4,000
16 Surrette CHP375 batteries	3,200
Additional wiring & hardware	1,000
PV mount	600
Battery box	500
TriMetric meter	235
Total	$15,535

Magee sees his solar-electric house as a solution to the energy problems of society. "When you live in a solar house," explains Magee, "you're aware of how much energy you're using and you pace yourself. That teaches you efficiency. But the energy policy of this country does not encourage efficiency—it encourages waste. You're not paying for the actual cost of energy, so you don't care how much you use."

Magee says his children now understand how the PV panels work, and they are able to gauge how much energy is produced and how much they consume in a day. "For my kids," he says, "it's a great behavior modification system. You leave the lights on and go play, and you run out of energy and that's it—there is no more."

And for the adults? Bill's wife Karen has no complaints about their solar abode. "I don't really have to think about it. The kitchen, the lights—everything functions just like a normal home."

The Magee clan loves to escape to their lakeside retreat, especially with the independence and comfort provided by solar power.

Tech Specs

System Overview

System type: Off-grid PV
Location: Talasheek, Louisiana
Solar resource: 3 average daily peak sun hours
Production: 75 AC KWH average per month

Photovoltaics

Modules: 12 Siemens, SR100, 100 W STC, 12 VDC
Array: 1,200 W STC, 24 VDC
Array combiner box: Six-circuit load center with 10 A, DC-rated breakers
Array disconnect: 60 A breakers mounted in a Xantrex DC250 enclosure.
Array installation: Custom aluminum frame, SSW orientation, about 35 degrees tilt

Balance of System

Inverter: Xantrex SW4024, 24 VDC input, 120 VAC output, 4,000 W
Charge controller: Xantrex C40, PWM
System performance metering: Bogart Engineering TriMetric AH meter
Engine Generator: Generac 7 KW, 240 VAC, with balancing transformer for 120 VAC output; average annual run time approximately 150–200 hours

Energy Storage

Batteries: Sixteen Surrette CHP375 flooded lead-acid, 6 VDC, 350 AH at C20
Battery pack: 24 VDC, 1,400 AH total
Battery/inverter disconnect: Xantrex DC250, 250 A breaker

Standing on his deck looking out over the calm lake and the setting sun, Bill mused, "This is the way it should be. This is the way everybody should live."

Access

Joshua Tickell, The Veggie Van Organization, 8033 Sunset Blvd. #154, Hollywood, CA 90046 • tickell@veggievan.org • www.veggievan.org

Bill and Karen Magee • 985-809-8082 • wmagee@mageeanddevereux.com

Louis Martin, 427 W. 25th Ave., Covington, LA 70433 • 985-893-5886 • louieandamye@charter.net • System installer & licensed electrician

Sierra Solar Systems, 563 C Idaho Maryland Rd., Grass Valley, CA 95945 • 888-ON-SOLAR or 530-273-6754 • Fax: 530-273-1760 • solarjon@sierrasolar.com • www.sierrasolar.com • System equipment

Solar Heating

Three in One

David Sweetman

The Sweetmans' six, original, 4 by 8 ft., American Solar King collectors. An electrically operated awning is used to cover three of the panels to limit hot water production in the summer.

I am now retired, living in remote Nevada. The location is perfect for the use of renewable energy systems—plenty of land, clean air, sunshine, and wind. I described our renewable energy electrical system in *HP86*. I also wanted to use solar heating, not only for hot water, but also for spa heating and backup space heating.

We had heard varied reports on the workability of solar heating. But we were determined to try, since solar heating is clearly one of the most cost-effective applications of renewable energy to implement.

Three Applications

Prior to retiring and moving, we had to make some improvements on our home-to-be. One immediate improvement was to install a new roof, so the time seemed appropriate to install a solar heating system.

We live in the high desert, at about 38 degrees north latitude. We have plenty of sunshine. The high desert gets cold—it can reach -15°F (-26°C) at night in the winter—and heat is an important commodity. Our house had an existing electric forced-air furnace, which was subsequently replaced with a geothermal heat pump. Additionally, a therapy pool has been installed. So there are three uses for solar heat: first to heat domestic water, second to heat the pool, and third to heat the house. The concept was to use one system to accomplish all three purposes.

The Sweetmans' newer 4 by 10 ft. SunEarth collectors.

Our three new sources of heat are solar hot water panels, a geothermal heat pump, and a wood-burning furnace. The therapy pool is only heated by solar panels. Domestic hot water is normally heated by solar panels, but can use either the wood-burning furnace or electricity as backup. Space heating is normally done with the heat pump, but can use solar hot water (if available) or the wood-burning furnace as a backup. All electrical equipment, with the exception of the geothermal compressor, is on the renewable energy electrical system. So even if the grid goes down, wind, sun, or batteries will power the applicable pumps and fans.

Evolution

The system was originally designed to provide normal usage of hot water, about 40 gallons (150 l) per day for two adults, at about 120°F (49°C). There was also capacity to heat a spa of about 500 gallons (1,900 l) and to provide some backup space heating for the house. The backup space heating used a liquid-to-air heat exchanger in the forced-air ducting. Additionally, the system interfaces with a wood-burning furnace to provide another backup source of heat, for those days when there is inadequate sunshine.

The system underwent quite an evolution over the last seven years. The primary change was to increase the system size to account for the use of a 3,800 gallon (14,000 l) therapy pool instead of the 500 gallon (1,900 l) spa. When the original electric furnace failed and was replaced with a geothermal heat pump, the system interface (using the same heat exchanger) to the forced-air ducting had to be modified.

We have buried 3,000 feet (914 m) of coiled hose, 10 feet (3 m) underground to circulate the heat pump transfer fluid. A trench 3 by 100 by 10 feet (0.9 x 30 x 3 m) was dug and filled. The system needs a 50 to 55°F (10–13°C) inlet temperature, which for us in the dead of winter occurs at about 9 to 10 feet (2.7–3 m) underground.

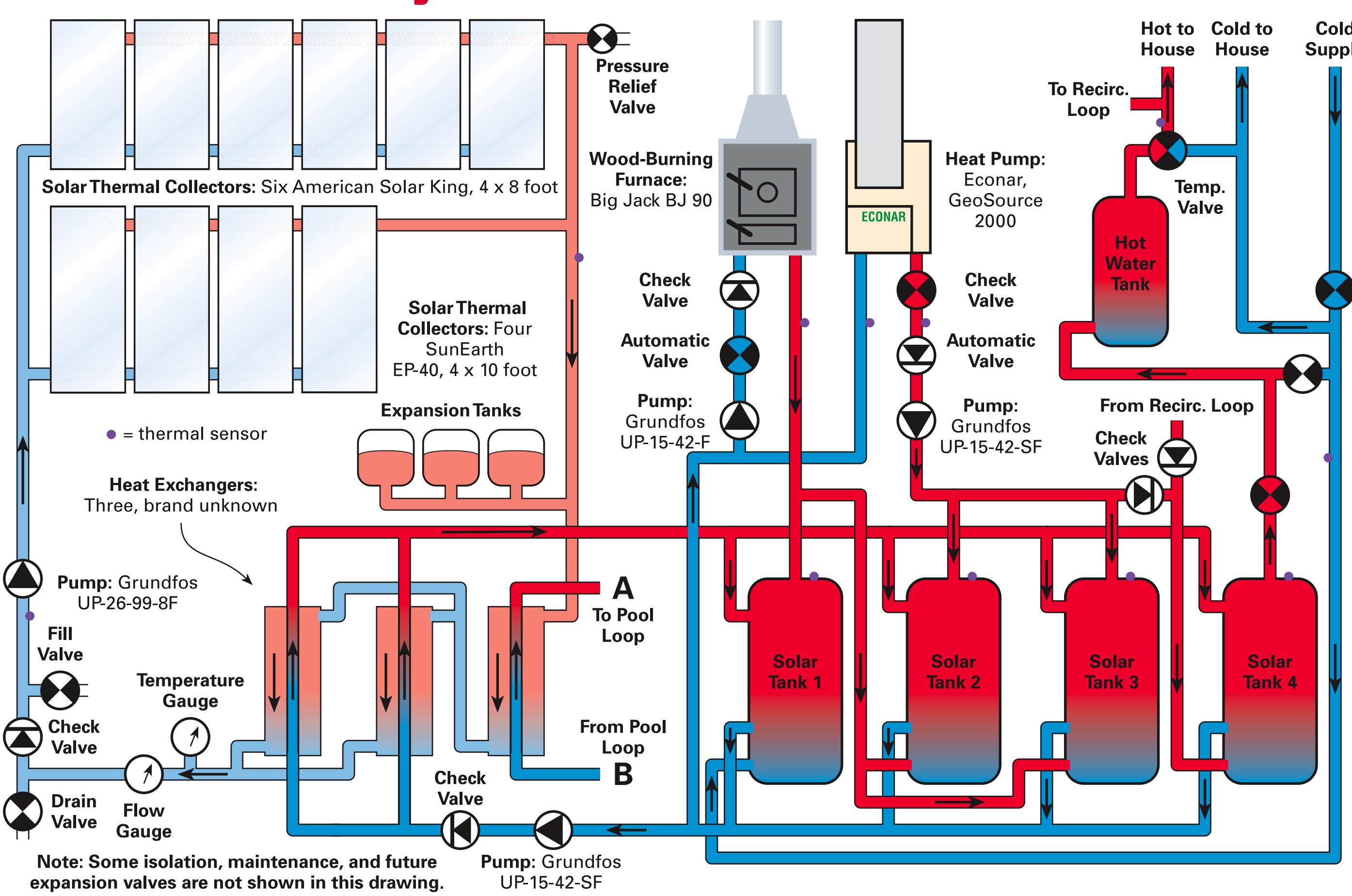
Ingenious Awning

The system was designed for winter loads, so excess heat is often produced during the summer. Climbing on the roof to cover the collectors is impractical for me, and the system did not incorporate a summer heat dissipation coil. Another plan was required. We have an electrically operated awning on our motorhome, and I thought the same principle could be used.

I had an awning made to cover three of the six 4 by 8 foot (1.2 x 2.4 m) panels. The awning is normally used as a window shade for a house or a patio cover, with a manually operated switch to open and close it, and an anemometer to automatically close it during high winds.

A dedicated GL-30 is used to automatically extend the awning whenever the temperature of the heat transfer fluid exceeds 180°F (82°C). This uses the NO (normally open) contacts in the GL-30. I could wire the NC (normally closed) contacts to automatically retract the awning when the temperature drops, but have chosen not to. We get enough wind that the anemometer control normally closes the awning during the night.

Solar Thermal System



The 3,800 gallon therapy pool is heated with solar energy.

Multiple Loops

This is a multi-loop system, with the primary loop circulating a heat transfer fluid (antifreeze) through the solar panels and liquid-to-liquid heat exchangers. Secondary loops circulate water through the heat exchangers to and from the storage tanks or pool. Additional loops and pumps circulate hot water through the heat pump heat exchanger and the wood-burning furnace heat exchanger.

The primary loop is filled with an antifreeze solution. We originally used standard RV propylene glycol solution (nontoxic), but the fluid appears to degrade after a few months of summer use. We changed to DowFrost HD, as recommended by SunEarth, the solar panel manufacturer.

The system was originally constructed with 3/4 inch copper pipe, although the fittings for the original six, 4 by 8 foot (1.2 x 2.4 m) solar collectors were 1 inch. The idea was to save money on piping, yet this can create problems with system expansion. In addition, a slightly larger pump may be needed to overcome the friction loss (head loss) associated with smaller diameter pipe. If large diameter pipe is used initially, it will be easier to expand later by replacing the pump with a larger one. When we added four SunEarth EP-40 (4 x 10) panels to the system, as much of the 3/4 inch piping as possible was replaced with 1 inch.

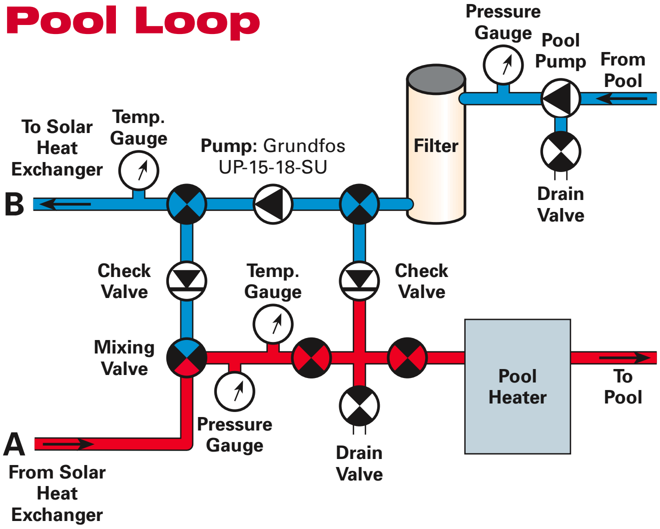
All primary loop piping has special high temperature insulation called Rubatex. Regular insulation used for domestic hot water lines will melt when exposed to the high temperatures that can occur in a solar heating system. I used the same insulation on the hot water lines in the storage tank system for the same reason.

There are two major secondary loops. The first heat exchanger heats the therapy pool, and the second parallel pair of heat exchangers heats the storage tanks used for hot water and space heating.

The heating of the storage tanks was straightforward. Essentially, the major job was with the plumbing—installation of pipes, valves, gauges, pumps, fittings, and insulation. The only major changes from the original design were to add an additional storage tank, install a tempering valve (the water gets really hot, and you do not want to get scalded when turning on the hot water), install a recirculation pump for the hot water (the upstairs shower is quite a distance from the hot water tank and water in the desert is more precious than heat), and install solenoid isolation valves in various loops (to prevent thermosyphoning).

The therapy pool heating system had to be designed from scratch, since the pool manufacturer was only familiar with electric or gas heating. Since the filter pump would not necessarily run at the correct hours, duration, or correct flow rate, an additional solar heating pump and Goldline

Pool Loop



Detail of the pool loop.

The water heater and four solar storage tanks.

pool temperature controller were added. Since the water can get hotter than the plastic piping rating (standard for the pool), a tempering valve was added so that the pipe temperature limit (140°F; 60°C) would not be exceeded. This system works extremely well, keeping the therapy pool at a constant 98°F (37°C), which also helps heat the house during the winter.

Controls

Since the solar heat storage tank room can get quite warm during the summer, a fan was installed to vent air from the basement room. The fan is controlled by another GL-30. (These differential temperature controllers are very useful for a wide variety of tasks, not just turning solar pumps on and off.) A field adjustable dial in the control allows you to adjust the fan turn-on temperature. The other input is connected to a thermistor (10 K-ohm sensor) that measures ambient room temperature.

The storage tanks are specifically designed for use with a solar heating system. The normal cold-water inlet is at the bottom of the tank and the hot-water outlet is at the top of the tank. One third up from the bottom is the heat exchanger inlet, and two thirds up from the bottom is the exchanger return. The tank has the option of electrically heating the water, which I have not connected. A 10 Kohm sensor that can be used for either controlling or monitoring temperature is also installed.

The original system used a GL C-100 differential temperature controller (no longer manufactured). This controller has the advantage of being able to display up to six different temperature locations. Although this controller's pump-switching function was replaced with the GL-30, I still use the monitoring capability (five of the six inputs still work). Goldline also now makes a separate unit to display up to six locations. The GL-30 has the option of including a digital display, which can be valuable.

Monitoring temperatures at various locations in the system is vital if you want to optimize performance. I made a simple temperature probe with a standard 10 K-ohm sensor attached to some alligator clips to clip on an input to the GL C-100. This allows me to check various points in the system.

The central mounting board for various GL-30s and the old GL-100 used for monitoring, along with a box containing relays for geothermal control.

Sizing & Design Considerations

Sizing and design is relatively easy for small solar thermal systems, but larger complex systems are difficult to engineer with precision. Energy from sun, earth, and wood all contribute in varying degrees depending on the season, time of day, living patterns, and end-use efficiencies. This system evolved over a period of time and has integrated multiple energy uses and multiple energy sources. The system is in the process of being upgraded again to correct some known and suspected inefficiencies that are probable causes of the lower than expected system output.

An armchair estimate of the system design would attribute one or two, 4 by 8 foot (1.2 x 2.4 m) collectors to domestic hot water (for an energy conservative two-person household in Nevada). Collector area for the pool is generally about about half to three-quarters of the pool surface depending on the pool temperature and whether the pool cover is used when not in use. The rest of the system contributes to home heating.

Ken Olson—Solar On-Line (SōL)

The Econar GeoSouce heat pump adds to the system with heat from 3,000 feet of buried tubing.

Although the physical interface of the hot water heat exchanger in the forced-air ducting was just a matter of some sheet metal fabrication work with appropriate plumbing, the control system was not so simple. As with a normal heat pump, the geothermal heat pump turns on when the thermostat calls for heat. The heat pump extracts heat from a fluid circulated underground. Since the underground temperature is much higher and more stable than the outdoor air temperature, much less energy is required to extract the same amount of heat compared to using an air source heat pump.

In this case, I wanted the fan to turn on (forced air), but the heat pump to stay off when hot water circulates in the ducting heat exchanger. With help from Econar (the geothermal heat pump manufacturer), control circuitry was designed and built to operate only the solar heating side when the solar heat storage tank temperature is above 135°F (57°C), and turn on the heat pump when the solar heat storage tank temperature is below 135°F.

Wood Furnace

Originally we had a wood-burning stove with a simple, copper tube heat exchanger on top. Not only were the stove and heat exchanger not very efficient, the stove drew combustion air from the house, which is even worse. The stove was replaced with a wood-burning, forced-air furnace that is also plumbed for a heat exchanger to heat the water in the storage tanks.

A separate area in the basement was walled off for this unit, with direct ducting to the outside for combustion air. When the furnace is operating, a GL-30 will turn on a pump to circulate storage tank water through the heat exchanger. An external manifold on the furnace is directly ducted into the forced-air system (supply and return), with an associated fan to circulate hot air (with no combustion byproducts) in the forced-air ducting.

The fan is controlled using a standard fan temperature controller. A separate fan and controller vents the room air to a cooler part of the house, in case the temperature in the room exceeds a preset value.

Financial Analysis

The cost of all the components and installation in the various systems is probably in excess of US$40,000. The cost of the wood-burning furnace was about US$2,500 (including special tools to install the water heating exchanger), plus installation. The cost of the geothermal furnace was about US$9,000, plus installation.

The wood-burning furnace with fan controls and ducting.

Thermal System Costs

Item	Cost (US$)
4 Mor-Flo/American solar tanks, 120 gal.	$3,928
4 SunEarth EP-40 4 x 10 ft. collectors	3,652
5 Goldline GL-30 controllers with displays	1,600
6 American Solar King 4 x 8 foot collectors	1,500
6 Grundfos pumps, various sizes	900
5 Heat exchangers	625
3 Solenoid valves	525
Misc. electrical, insulation, & ducting	500
GE hot water tank, 50 gal. electric	400
Goldline GL-235 pool temp. controller	400
2 Ranco fan electronic temp. controllers	400
Misc. pipe, valves, & fittings	300
2 Flow gauges	200
4 Temperature gauges	80
Intermatic timer	75
2 Tempering valves	58
2 Duct fans, 120 VAC	50
Total	$15,393

Will the system have a reasonable payback? At the current cost of electricity, the entire system is marginal. Obviously, this is a much more complicated system than is needed to just heat water, but I still think the effort was worthwhile.

The systems to heat water for home use and the therapy pool are definitely cost effective. The space heating system is probably marginal, especially since the therapy pool adds significant heat to the house during the winter.

The geothermal heat pump is much more efficient than other forms of nonrenewable energy heating. The geothermal system uses a standard forced-air circulation system to heat the house. Since the geothermal heat pump gets most of its heat (or cooling) from the relatively constant earth temperature, as opposed to the ambient air temperature, much less heat (cooling) is required from conventional energy sources, such as fossil fuels, wood, etc. Since the heat pump is installed indoors, not only does the system last longer, but it is also not exposed to the temperature (and humidity) variations that make it work harder.

We use about 40 gallons (150 l) of hot water per day, which would take about 9 KWH per day to heat electrically. The therapy pool would take about 21 KWH per day. At US$0.08 per KWH, that is a savings of about US$876 per year. That is a long payback, except that the cost includes the geothermal and wood-burning backup systems, and the savings do not incorporate the home heating savings (which are very difficult to estimate). There is no question that just the water heating (both home and pool) is cost effective. The rest of the items are useful, but will not fully pay for themselves until the cost of nonrenewable energy becomes higher—which will happen!

Practical Solutions

The average homeowner does not want to be concerned with design, component selection, or installation, and wants minimal operation and maintenance requirements. Manufacturers should put together standard systems, with good written documentation that people can buy off-the-shelf and install using standard plumbers and electricians, or by themselves.

Tech Specs

System Overview

System type: Two-loop heat exchanger, antifreeze, direct pump

Location: Dyer, Nevada

Climate: Moderate to harsh, with hard freezes throughout the winter

Solar resource (annual average): 6 peak sun hours per day

Production: 3,125,000 BTUs per month average, (panel capacity ~ 50,000 BTU/day)

Number of people in household: 2

Percentage of hot water produced annually: 95

Equipment

Collectors: Four SunEarth Empire series, 4 x 10 foot; six, 4 x 8 foot from American Solar King

Collector installation: Roof mount, 210 degrees aligned with roof (corrected for magnetic declination) tilt at 50 degrees from horizontal (raised from roof)

Circulation pump: Grundfos UP-26-99-BF for primary loop of DowFrost, Grundfos UP-15-42-SF for secondary loop of water, Grundfos UP-15-42 (SU, SF, F) for other

Pump controller: Goldline GL-30

Heat transfer fluid: DowFrost HD from Dow Chemical

Storage

Tanks: Four Mor-Flo/American solar tanks, 120 gallons, plus GE 40 gallon electric water heater

Heat exchanger: Three, unknown capacity and manufacturer

System Performance Metering

Temperature: Three Letro SL2D (50-220F) plus 10 K-ohm thermistors to GL-30s and C-100

Pressure: Three Ashcroft, oil-filled, 0–100 psi

Flow: Two Letro LDF357B, 1–10 gpm in primary loop in series with parallel water storage heat exchangers; one Letro LDF359T in secondary loop

I have wondered for a long time why more people do not use solar heating. At first, I thought the reasons were economic, but especially for domestic water heating, there is every economic reason to use a system. I personally believe that virtually everyone should be using solar collectors to preheat domestic hot water.

So economics is not the major reason, especially with all the excess wealth in the country today—just look at what is spent on entertainment. Perhaps there is just a lack of consumer knowledge, which calls for more understandable and standardized system documentation. Documentation for design, installation, operation, and maintenance varies from mediocre to poor. Standardization of documentation and equipment would reduce costs and accelerate usage.

This article summarizes some of the issues in designing, installing, operating, and maintaining a complicated solar heating system. The hardware available is excellent, so that once the components are assembled, the system works well within expected performance parameters. Solar heating of hot water, either for domestic use or pools, is a practical solution to save money and energy.

Access

David Sweetman, PO Box 189, Dyer, NV 89010 • d-dsweetman@att.net

Ken Olson, SoL Energy, PO Box 217, Carbondale, CO 81623 • Phone/Fax: 720-489-3798 • sol@solenergy.org • www.solenergy.org

GFC Sales, Gary Fedor, HC 72, Box 03515, Dyer, NV 89010 • 775-572-3231 • Fax: 775-572-3343 • g.fedor@att.net • Solar thermal system installer

SunEarth, Inc., Rick Reed, 4315 Santa Ana St., Ontario, CA 91761 • 909-605-5610 • Fax: 909-605-5613 • rreed@sunearthinc.com • www.sunearthinc.com • Solar hot water panels

Econar Energy Systems Corp., Larry Wurtak, 19230 Evans St., Elk River, MN 55330 • 800-4ECONAR or 612-241-3110 • Fax: 763-441-0909 • lwurtak@econar.com • www.econar.com • Geothermal heat pump

The Dow Chemical Company • 800-447-4369 • Fax: 989-832-1465 • www.dow.com/heattrans/index.htm • DowFrost heat transfer fluid

CI Solar Supplies Co., John Clothier, PO Box 2805, Chino, CA 91710 • 909-628-6440 • Fax: 909-628-6440 • jclothi@attglobal.net • www.cisolar.com • Solar thermal components distributor

Alpha American Co., PO Box 20, Palisade, MN 56469 • 800-358-0060 • Fax: 800-440-1994 • sales@yukon-eagle.com • www.yukon-eagle.com • Wood furnace

UpLand Technologies

Energy Viewer

AJ Rossman

Application: UpLand Technologies' Energy Viewer is an electrical power and energy monitoring package that displays the AC electrical consumption of an entire house or building. My wife and I used the Energy Viewer to monitor the energy usage in our home.

System: An Ideal Model 61-805 power quality analyzer and digital utility KWH meter (ABB Type A1TL+) were used to assess the accuracy of Energy Viewer's instantaneous power and energy measurements.

The Energy Viewer kit includes software on CD-ROM, remote display, computer interface cable, two current transducers, datalogger, and power supply.

Knowing your whole-house electrical energy use is helpful for becoming energy efficient and for renewable energy system design. If you get your electricity from the grid, your utility measures your monthly energy usage—and then presents you with a bill.

Unfortunately, the energy total in the bill does not show you instantaneous power measurements and short-term energy use trends. Both are useful for hunting down inefficient appliances and providing information that will enable you to modify and reduce your energy use. Energy Viewer has a wall-mounted display that shows a snapshot view of whole-house apparent power. A software package is also available that shows volt-amp trends by the minute, day, and 30 day period.

The Energy Viewer monitoring system will track the electrical energy use in any building where the maximum current draw does not exceed 200 amps (rms). The common service panel rating in most residences is 100 to 200 amps. This makes the Energy Viewer useful for some small commercial spaces and all but the most energy-consuming homes.

Energy Viewer vs. Other Meters

Home Power has reviewed several portable kilowatt-hour (KWH) meters in the past. What are the differences between Energy Viewer and the KWH meters profiled in *HP67, HP90,* and *HP95*?

The major function of portable KWH meters is to measure the energy use and electrical characteristics (volts, amps, watts) of individual, 120 V, single-phase appliances that can be plugged into an outlet or a plug strip. The Energy Viewer is a permanently installed metering system that provides whole-house power and energy monitoring.

Why is this useful? Most people are simply unaware of their energy use, until it comes time to pay the monthly utility bill. The exception is off-grid system owners, who are undoubtedly some of the most savvy energy users out there. Off-grid homeowners are used to watching both energy production and usage displayed by their system's amp-hour meter, which lets them continually track the energy that their appliances are using.

Energy Viewer allows this same kind of energy tracking on the AC side of the system. Real-time use and cost information is available at any time, and in an easy-to-understand format. This promotes conservation (turning appliances off when they're not in use), and educates users about their daily energy use patterns.

Utility KWH meters, and portable KWH meters measure power in watts (true power.) Some portable KWH meters also display volt-amps (apparent power). The Energy Viewer package only measures volt-amps. This measurement discrepancy is not a big deal for most on-grid homes where large resistive loads like electric ranges and water heaters typically account for the majority of the home's energy use. The Energy Viewer is able to closely track the energy usage in these applications.

Energy Viewer Setup

The Energy Viewer package includes a small datalogger for mounting to the side of the home's main distribution panel, two solid-core current transducers (CTs) to be installed on the service mains coming from the utility KWH meter, a digital display to show instantaneous power and cumulative energy measurements, a cable to connect the datalogger to a computer, and software to show historical trends.

The LOG-100 datalogger comes with a standard, 4 inch (10 cm) electrical junction box for easy installation. Two CTs are mounted on the service entrance cable before your main panel breaker. The terminations of the CT wires plug into the circuit board of the datalogger.

The included communication wires and 9 volt wall cube are connected to the front panel of the datalogger. The datalogger integrates the CT output every 7.5 seconds to measure the average current. It then calculates and stores an average energy measurement in nonvolatile flash memory, and sends out a communications signal with the compressed data.

The data goes to the EV-100 digital display and computer COM port for the Soft-100 program using the RS232 data communication standard. Ethernet, telephone, or thermostat wire can be used to connect the datalogger to the digital display and computer COM port. According to the manufacturer, up to two digital displays and three computers can be connected to a single datalogger.

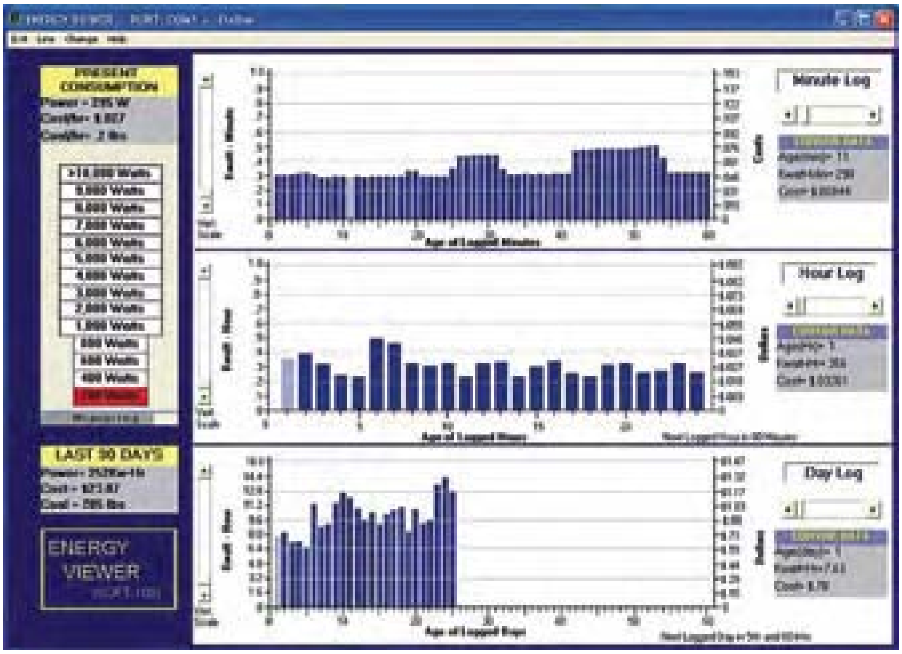
The EV-100 digital display has an attractive faceplate that can mount inside a standard 2 inch (5 cm) electrical switch box. The display is easy to read, not cluttered, and is available in either white or almond. The faceplate has three buttons: Select, an "up" arrow, and a "down" arrow. The Select button is used to switch between five different display modes: Power, Daily Rate, Last 24 hours, Last 30 days, and KWH Cost. The up and down arrow buttons are used to set the utility rate.

Energy Viewer Display

Mode	Explanation
Power (Watts)	Measured power,* updated every 7.5 seconds
Daily Rate ($)	Projection of 24 hour energy cost, using current consumption rate
Last 24 hrs ($)	Energy cost for last 24 hours, using measured power*
Last 30 days ($)	Energy cost for last 30 days, using measured power*
Kwatt-hour Cost	Input for utility's per-KWH price

* Actually volt-amps—measured current times assumed 117 volts

The Energy Viewer Soft-100 software window.



What Is Power Factor?

Ian Woofenden

In alternating current (AC) electricity, two things alternate. Both voltage (electrical pressure) and amperage (electron flow rate) peak, go to zero, peak in the other direction, and go back to zero many times per second.

In many electrical circuits, the voltage and amperage peak and go to zero at the same time. But some electrical devices cause these two characteristics in AC to be out of synch—"out of phase." The voltage can peak and zero before the amperage, or vice versa.

In DC and resistive AC circuits, where voltage and amperage are in phase with each other, volts times amps equals watts (power). Things get more complicated in circuits that have not only resistance, but also "reactance," the characteristics mentioned above that push voltage and amperage out of synch with each other. In these circuits, multiplying volts times amps gives you "volt-amps," (apparent power), but does not give you watts (true power).

The ratio between volt-amps and watts is called "power factor." In purely resistive circuits, when voltage and amperage are exactly in phase, power factor is 1, or "unity." In this case, volt-amps and watts are exactly the same.

In reactive circuits, the voltage and amperage are not always working together, so there are electrons moving against the electrical pressure at times, making energy transfer less effective. The extra electrons are bouncing back toward the source, so the energy they carry is not wasted, but you need more generating capacity to do the same work. If the circuit voltage is 100, and the amperage is 50, volt-amps will be 500. But if voltage and amperage are out of synch so that power factor is 0.5, actual wattage delivered and used will be only 250 watts.

Meters that don't account for power factor may not give a completely accurate picture of energy usage. Because the extra energy in reactive circuits is returned to the source, measuring volt-amps will give you higher numbers than measuring watts.

The buttons have a nice feel, and the unit appears relatively well built, with the exception of a slight misalignment of a couple of the LED display mode indicators in the unit we tested. The table shows the different display modes.

Power is displayed in watts, but this is a bit misleading because it was calculated by multiplying the measured current by an assumed 117 VAC. That is volt-amps, which will equal watts only when the household power factor is at unity (1.0), and utility voltage is in spec. This makes the Energy Viewer's readings err on the conservative side by the amount of power factor, which varies based on your specific electrical loads.

The Last 24 Hours and Last 30 Days display modes were useful in understanding our electrical use patterns. The KWH Cost display mode is used to set your utility's cost per KWH into the unit, but does not allow for time-of-use or tiered billing systems. If you are not billed for your electricity (off-grid), you can enter a value of $0.9999, and this field will essentially show you the number of KWHs you have consumed.

The software, SOFT-100, is a really nice part of the system. The display is neat and clean. A stacked bar graph shows your present consumption in terms of watts and in pounds of coal per hour (if your utility is using coal to generate electricity). The display summarizes energy use for the last 30 days in both KWHs and in pounds of coal.

Three different graphs show use trends: for each minute of the last 2 hours (KVA-minute), for each hour of the last 48 hours (KVAH), and for each day of the last 120 days (KVAH). A really nice feature is that the computer does not have to be left on to capture these trends! The trends are automatically updated each time you turn on your computer and start the SOFT-100 program.

Installation

Portable KWH meters, while somewhat limited, are extremely easy to install. Simply plug the appliance into the meter and the meter into a wall outlet. The Energy Viewer kit was a bit more complex to install because it requires an electrician to install the current transducers (CTs) on the main lines. An electrical permit was needed because the utility meter must be temporarily removed in the process.

It took my electrician, Don Schroeder, about an hour to install the CTs, mount the LOG-100 datalogger enclosure, and power the LOG-100. He should be commended because he did the outdoor work in -10°F (-23°C) conditions. It took about an hour to run telephone cable and install the EV-100 digital display in our office, and to wire the computer interface. The software installation was very straightforward and worked without a hitch. The instruction manual was helpful, if sometimes a bit grammatically awkward.

Programming

Programming was simple—just enter the utility cost per KWH. Pressing the select button on the faceplate four times brings you to the KWH Cost mode. Then you select your billing rate by using the up and down arrows.

There are also a couple of options in the software configuration. A pull-down menu allows you to change the communications port and toggle between a small and large display. We have our computer monitor set to a high resolution, so this allowed us to set it so we could read the screen easily.

Test Results

The Energy Viewer was tested for accuracy by comparing measurements to an Ideal Model 61-805 power quality analyzer for ten different load scenarios with varying power factors, as shown in the table. The Energy Viewer was accurate for all loads with a close-to-unity power factor (1.0). When the power factor dropped, the unit was not as accurate, but in all cases was within the published specifications of +/- 5 percent when the measurement was compensated for power factor. The power factor was measured independently using the Ideal power quality analyzer.

Thanks to the Energy Services division of the Burlington Electric Department of Burlington, Vermont, for graciously supplying the power analyzer meter and initial training. They were particularly interested because they have been involved in energy efficiency activities for more than ten years and like to see this type of product come to market. Thanks also to my assistant Logan Brown for help with switching loads and recording data.

Comparing energy measurements was a bit challenging because the results are heavily dependent on the building's power factor. Almost every building has its own load profile with regard to power factor. This power factor profile will depend on the types of appliances used and the lifestyles of those in that building.

Our home was not the ideal test site for this energy monitoring system. The power factor profile for our energy efficient house will challenge any meter that uses apparent power to measure energy. Our electrical load has a low

Features

High Points:

- Attractive EV-100 digital display faceplate
- EV-100 faceplate is laid out well with nice feel to buttons
- No need for a dedicated computer to get continuous trends
- Software option very informative
- Low cost AC monitoring
- Accurate energy use metering for average homes with household loads having close to a 1.0 power factor

Low Points:

- Inaccurate for metering with household loads that have a power factor other than 1.0
- Slow sampling rate (7.5 seconds)
- Does not compute true power or power factor
- No option for split-core transducers, so it requires an electrician and permit to install
- No support for Mac computers
- Relative, not absolute time

List Price:

Three kits are available and all components can be purchased individually:

- Kit 1: US$290 for datalogger, power supply, digital display, software, and communications cable
- Kit 2: US$235 for datalogger, power supply, and digital display
- Kit 3: US$225 for datalogger, power supply, software, and communications cable

Warranty:

- Hardware: 1 year
- Software: 90 days

Energy Viewer Test Readings

Test Load	Ideal Reading (W)	Energy Viewer Reading (VA)	Difference	Ideal PF Reading	Energy Viewer (W, PF-Corrected)	% Difference (After PF Correction)
Dehumidifier	779.0	847.5	68.5	.91	771.2	-1.0%
CF lights & iron	2,120.0	2,166.3	46.3	.98	2,122.9	0.1%
Vacuum	2,022.0	2,060.0	38.0	.97	1,998.2	-1.2%
Dishwasher start	1,725.0	1,787.5	62.5	.94	1,680.3	-2.6%
Dishwasher cycle 2	2,989.0	3,008.8	19.8	.97	2,918.5	-2.4%
Grinder	1,878.0	2,253.3	375.3	.86	1,937.9	3.2%
Heat gun	2,989.0	3,003.8	14.8	.98	2,943.7	-1.5%
Fridge	1,684.0	1,722.5	38.5	.94	1,619.2	-3.9%
Heater	3,271.0	3,318.8	47.8	.98	3,252.4	-0.6%
Circular saw & heater	4,064.0	4,081.3	17.3	.98	3,999.6	-1.6%

power factor because we use compact fluorescents for most lighting (0.6), and our primary loads all include motors. A quick survey of a handful of residences revealed an average household power factor of 0.95. The Energy Viewer will accurately track energy usage in these applications.

Periods of low energy use may not be measured accurately due to the 100 amp range of the CTs. This is common with many power meters that are designed to measure a wide range of power levels. For comparison, our energy use was often too small to register on the much more expensive Ideal power quality analyzer as well.

The utility digital KWH meter was used to compare accuracy in the cumulative energy measurements. We tested for four-day and thirty-day periods and found that the Energy Viewer overestimated whole-house usage by 29 percent (38.7 KVAH vs. 30.0 KWH) and 45 percent (266 KVAH vs. 184 KWH) respectively. This is expected for our house when logging apparent power instead of real power, because we have periods of low electrical draw and a low power factor from the refrigerator, washing machine, and compact fluorescent lighting.

The accuracy of the energy measurement is dependant on the power measurement, so I would expect the energy measurement to be much more accurate in buildings with lots of resistive loads. Data supplied by the manufacturer for a load profile with a high power factor and higher consumption supports this assertion.

In our situation, this makes the Energy Viewer most useful for looking at our energy usage trends. I use the unit on a regular basis in our home to see what I have left on in the house before I go out. With practice, you will be able to recognize the characteristics of your appliances too.

Overall, the Energy Viewer is a very useful tool—especially when you consider its price and functionality. The Ideal meter retails for more than ten times the cost of the Energy Viewer, and there is no way my wife would allow me to install the super-techie Ideal meter in our kitchen!

Conclusions

I really like the Energy Viewer monitoring package. The unit allows homeowners to see trends in energy usage and modify their behavior accordingly. Homeowners, building owners, families, and people at educational facilities can instantly see the impact of turning off lights or other appliances when they are not in use. (The Energy Viewer measures AC only, so it will not measure total usage for off-grid systems using some DC, and it will not measure usage before the inverter.)

The installation was clean, the digital and software displays were easy to read and program, and the information presented is very useful. The system does not require a dedicated computer, and the digital display can be integrated into most home decors. The accuracy was a bit off, depending on power factor, but for the price, the information gained is very useful for relative monitoring, and can help you better understand your electrical usage.

The Energy Viewer is an awareness tool. It makes a great educational tool. It would be a good first step for people who want to eventually switch to renewable energy (RE), but need to change their energy use patterns before making RE equipment purchases. Best of all, it gives you instant gratification for doing the right thing when you shut an unneeded appliance off.

Tech Specs

Measures:

- Instantaneous volt-amps
- Kilovolt-amp-minutes and kilovolt-amp-hours used
- Cumulative cost

Sampling Rate: Current measurements are integrated every 7.5 seconds

Accuracy: +/- 5 percent

Physical Characteristics:

- LOG-100: 4 by 4 by 2 3/8 inches (10 x 10 x 6 cm) enclosed in standard 4 inch electrical junction box, supplied by manufacturer
- EV-100: 2 3/4 by 4 1/2 by 2 inches (7 x 11.4 x 5 cm); fits nicely in standard 2 inch electrical switch box, user-supplied
- Recommended operating temperature: 50–90°F (10–32°C) for all components

Computer Requirements for SOFT-100 Software:

- Windows 95, 98, or XP
- Minimum 8 MB RAM
- Minimum 10 MB free hard drive space
- Minimum 800 x 600 display
- Available COM port
- CD-ROM drive

Access

AJ Rossman, Draker Solar Design, PO Box 8346, Burlington, VT 05402 • aj@drakersolar.com

UpLand Technologies, 502 Prairie Hills Dr., Dodgeville, WI 53533 • Phone/Fax: 608-930-3384 • info@uplandtechnologies.com • www.uplandtechnologies.com • Energy Viewer kits

Hydrogen: Solution or Distraction?

A Debate on the "Hydrogen Economy"

For years, talk of the coming hydrogen economy has excited some in the renewable energy movement and irritated others. Will hydrogen be the solution to our energy woes? Or is it a distraction that siphons dollars and attention away from more practical solutions?

Home Power asked Richard Engel, hydrogen promoter, and Dominic Crea, hydrogen critic, to air their views. Each submitted a 1,000 word statement independently, and then had a chance to rebut the other's statement briefly. We hope you enjoy the discussion.

A Renewable Energy Future Needs Hydrogen

Richard Engel

As fossil fuels become scarce, renewable energy is poised to emerge as the best alternative for our future global energy economy. Given the intermittent nature of renewable energy resources, however, some form of energy storage will be a critical element of this new renewables-based economy. Hydrogen is the best all-around energy storage technology identified to date.

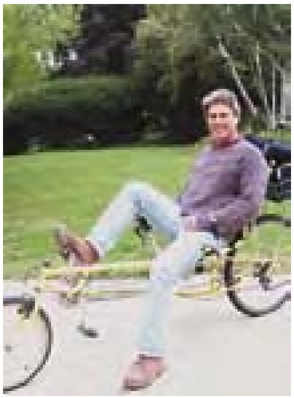
Today's household-scale users of renewable energy already know that energy storage—whether it's a bank of batteries or the grid—is essential for any practical system. There are a number of technologies for storing electrical energy, including batteries, superconducting magnets, ultracapacitors, pumped hydroelectric storage, compressed air, thermal storage, and flywheels. Hydrogen beats these other methods in balanced overall analyses considering technical feasibility, cost, wire-to-wire efficiency, lifespan, weight, and volume. Author A. Ter-Gazarian, in the book *Energy Storage for Power Systems*, agrees: "There are major technical problems to be solved in

Drunk on Hydrogen—Some Sobering Facts

Dominic Crea

As a physics teacher, I often study and lecture on renewable energy, and occasionally my calculations uncover some disturbing contradictions. The "hydrogen economy" is just such a case, and I think it's time to point out some reasons why we should be careful about pinning all of our hopes on this technology.

Let's start with the generation of hydrogen. Of the various ways it can be produced, two techniques are being considered—steam reforming of coal and natural gas, and electrolysis of water via renewable energy sources. The reforming process, while technically feasible, leaves much to be desired from an environmental and sustainability perspective. Hydrogen generated in this manner still produces the same, if not more, CO_2 (various proposals for sequestering the CO_2 are speculative). And in the case of natural gas (coal has its own, unique issues), merely shifts our dependency to a commodity whose future supply is in serious question. A fossil-fueled hydrogen economy is a gamble at best and a nightmare at worst.



Richard Engel, continued

the production, utilization, and storage of hydrogen, but, nevertheless, it is the most promising concept for future environmentally benign energy systems."

Batteries are today's most widely used form of energy storage. Off-grid solar electricity users are already aware of batteries' drawbacks. They know that batteries are the weak link in stand-alone renewable energy systems. They incorporate large amounts of hazardous materials, are too heavy and bulky for many portable and transportation applications, and have a relatively high self-discharge rate, making them unsuitable for longer-term seasonal energy storage. Batteries are inappropriate for energy storage on a national or global level. The other storage technologies listed above are limited by high cost or by narrow applicability.

Misdirected Funds

In spite of hydrogen's promise, many environmentalists and advocates of renewable energy are understandably suspicious of all the recent hydrogen happy talk from the White House and Wall Street. Hydrogen can be reformed chemically from any hydrocarbon fuel or split from water using electricity from any source. The nuclear and coal industries are thus latching onto hydrogen as a means to assure their continued dominance of energy markets.

In the public sector, the U.S. federal government has greenwashed itself by increasing spending on hydrogen energy research and development. At the same time, it is shelving policies such as improved auto mileage, building efficiency standards, and deployment of cost-effective renewable energy technologies that could offer greater benefit sooner, and at lower cost.

Hydrogen research and development (R&D) is a great use of tax dollars, but much of the recent federal spending increase is directed at nonrenewable hydrogen technologies. President Bush's fiscal year 2004 budget

The Schatz Solar Hydrogen Project in Trinidad, California, has been generating and using solar hydrogen to help power a marine research laboratory since 1991.

Dominic Crea, continued

Renewable Hydrogen?

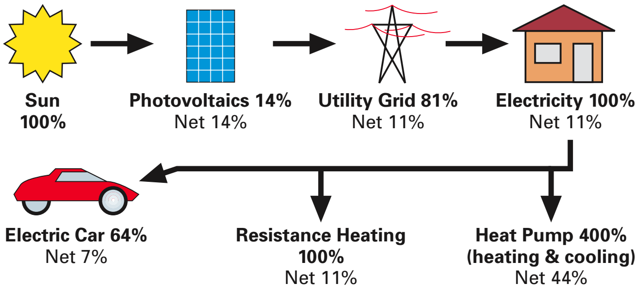
What about a renewably based hydrogen economy? In this scenario, vast arrays of photovoltaic modules and large wind farms will, through electrolysis, split water into hydrogen and oxygen. The hydrogen will be pumped down a pipeline and delivered to homes and industries, where the gas can be used in several ways:

- Direct burning, as in a furnace, to provide for heat, hot water, and cooking
- In a fuel cell, to generate electricity for residential and industrial use
- In fuel cell powered cars, boats, or lawnmowers

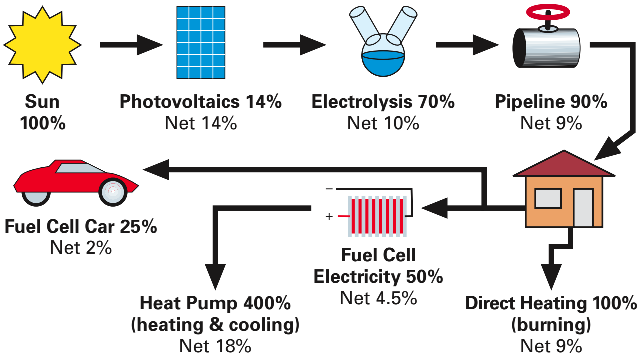
Superficially, these ideas seem palatable, and could in theory reduce or even eliminate our dependency on fossil fuels. But let's examine these claims in greater detail, starting with the pipeline. It doesn't exist. Nor, for that matter, does the rest of the hydrogen infrastructure, the total cost of which is open to debate. Moreover, we already have a proven system that can, and does, deliver energy to us with great efficiency—the utility grid.

The diagram below illustrates the two pathways—the hydrogen pipeline vs. the electricity grid—and displays how much of the original energy is left (net energy) after it is converted (net energy x conversion efficiency). Both systems assume the use of photovoltaic electricity. Remarkably, the hydrogen route wastes twice as much energy as the utility grid pathway!

Distributed Electricity Efficiencies



Distributed Hydrogen Efficiencies



Richard Engel, continued

proposal to Congress earmarked US$22 million for research related to generating hydrogen from coal, natural gas, and nuclear power, with just US$17 million for renewable hydrogen R&D. Both of these figures are dwarfed by the US$62 million Bush earmarked for research on carbon sequestration, without which coal-to-hydrogen is a worthless concept. The same budget reduced overall funding for renewables and energy efficiency by US$86 million.

Spending decisions like these may help to explain why some renewable energy advocates are looking askance at hydrogen. But we need to remember that hydrogen and renewables are natural allies. Let's not be lured into fighting each other over scraps while the oil, coal, and nukes gang stays firmly in control of our energy policy.

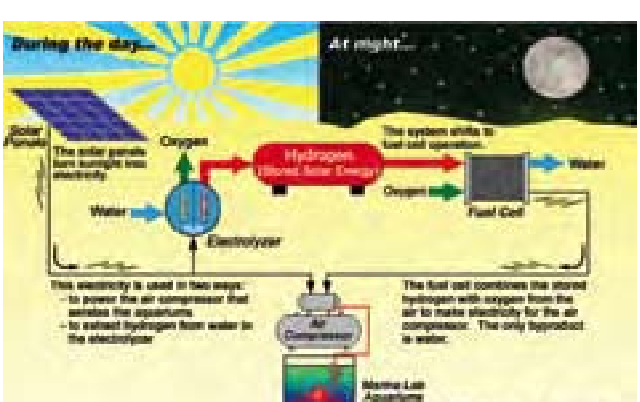
Fuel Cells Work

As manufacturers repeatedly push back release dates for their products, people are starting to ask whether fuel cells really work. At the Schatz Energy Research Center, we know that they do. Like many renewable energy technologies a few decades ago, fuel cells today are still in their infancy. But hundreds of real-life installations worldwide are proving that this clean, quiet, and efficient technology is ready to play an important role. Our work at the Schatz lab continues to improve the reliability, longevity, and cost of fuel cells to make them more acceptable to consumers.

Perhaps an excess of hype has made us all a bit impatient. Bragi Arnason, one of the creators of Iceland's national plan to switch to hydrogen power, notes, "If you look back in history, it has usually taken half a century to change from one type of energy to another—from wood to coal to oil. My generation will see the first steps."

Even more urgent than the need for technological advances, however, is the need to educate the public about hydrogen and fuel cells. Providing this understanding is another role that our research center plays every day.

This diagram is posted at the Schatz Solar Hydrogen Project to help visitors understand how a renewable hydrogen cycle works.

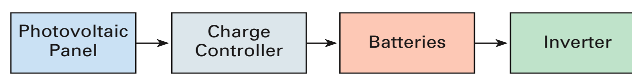


Dominic Crea, continued

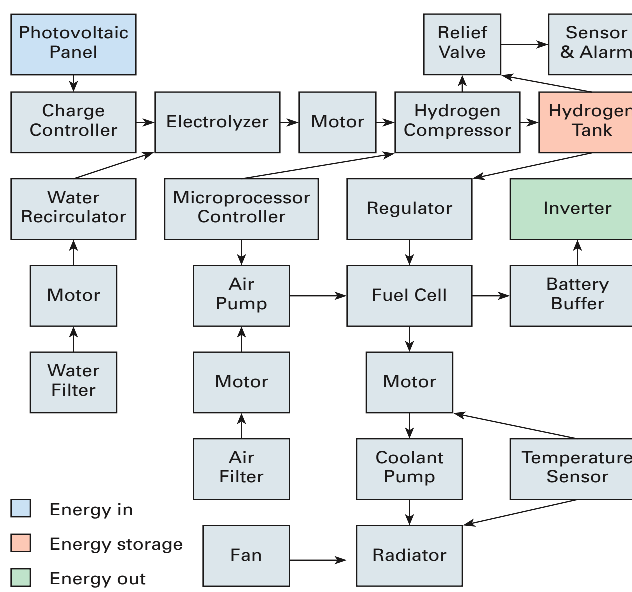
Direct heating with electric or hydrogen combustion at 10 percent net efficiency is dubious too. Even a simple rooftop solar heater (50 percent overall conversion efficiency) can outperform this by many times, and at a fraction of the cost. A case can be made for direct electric heat pumps providing both heating and cooling, but even here, the hydrogen system is still less than half as efficient as the grid system.

Okay, let's say we skip the hydrogen pipeline entirely and consider the most idyllic setting, a totally off-grid home. True, we can generate electricity for our homes and fuel our cars with hydrogen, but we must remember that our photovoltaics ultimately provide the electricity—hydrogen acts simply as a storage medium for that energy. A battery will do the same. Consider the complexity of the hydrogen fuel cell system below, and compare it to the battery storage system. Simplicity speaks volumes.

Battery System Complexity



Fuel Cell System Complexity



Questionable Efficiency

Now, let's examine the fuel cell powered car in greater detail. We'll start with the assumption that the electricity is coming out of a wall socket, and measure efficiencies from that point onward. (The case of pipeline transmission is even worse.)

A fuel cell has an electric conversion efficiency of around 50 percent. The real-world efficiency of PEM fuel cells is different from the theoretical maximum (83 percent). Calculation depends on the terminal voltage of each cell divided by the theoretical separation voltage of

Richard Engel, continued

In our educational outreach, we constantly reinforce the link between hydrogen and renewable energy. We also work to clear up misconceptions, such as the belief that hydrogen is a particularly dangerous fuel, or that hydrogen is a primary energy source we can exploit like oil or sunshine.

We live in a special time of cheap and abundant energy. Despite their potential to pollute air, water, and soil, fossil fuels provide us with cheap, portable, high-density stored energy the likes of which we may never see again. We should use them wisely.

Our Choice

The coming hydrogen energy economy will be what we choose to make it. At its worst, hydrogen could be a launching pad for the return of nuclear power and expanded use of coal, as world oil and natural gas supplies dwindle in coming years. An energy economy built on hydrogen derived from these nonrenewable sources would allow us to carry on with business as usual for a few more decades as our environment continues to deteriorate.

A much better, and I believe realistic, outcome is to build an economy based on renewable electric and thermal energy, incorporating hydrogen where needed to store and transport this energy, and for use as a transportation fuel.

However, there's a big "if" hanging over all our discussions of renewable energy, hydrogen, and sustainability. In the wealthier countries, we cannot keep increasing our energy use, or even maintain our energy use at current levels, under a renewable hydrogen economy. Renewable hydrogen will only prove viable if we greatly improve energy efficiency and, far more important, realign our behavior and expectations with regard to energy. In a steady-state renewable hydrogen economy, we will have to consume less than we do today.

This is not doom and gloom, but rather a necessary coming to terms with planetary resource limits. A renewable energy future will be healthier and more secure than the world we live in today. The path to such a sustainable outcome begins with all of us lobbying political and industry leaders with our votes, our voices, and our consumer dollars to develop clean and renewable energy technologies.

Response from Dominic Crea

I would like to start off by saying that I agree with many of the fine points Richard Engel has raised over such issues as conservation, concern over misuse of research funds, and

Dominic Crea, continued

water (1.23 volts). Typical values for 50 percent loaded cells hover around 0.55 to 0.8 volts.

To that 50 percent number, we must add the inefficiencies of additional components—the inverter at 90 percent, drive motor at 90 percent, electrolyzer at 70 percent, hydrogen storage at 80 percent, O_2 (air compressor) at 80 percent, and finally, the heat management systems at 98 percent. The total efficiency is about 18 percent! A battery electric car has an overall efficiency of about 65 percent—over three times the efficiency of the fuel cell powered car!

These points, and numerous others, are cause for a serious reassessment of the hydrogen economy. At the very least, a renewably based hydrogen economy will require the installation of US$40 trillion worth of photovoltaic panels, of which US$20 trillion is wasted in overcoming the inefficiency of the system—minimum!

In simple terms, the decision to go with a renewably fueled utility grid system, as opposed to the hydrogen system, would save enough money in photovoltaic panels alone to provide every American family with an electric car and the photovoltaic panels to run it. Furthermore, enough would be left over to handle all of the electricity, heating, and cooling needs for the entire house—for free!

Solutions that Deliver

Hydrogen may hold a place in our energy future, but we must remain mindful of its limitations as well as its potential. A headlong rush to develop a hydrogen economy might well distract us from other solutions whose practicality is not in question—conservation, carpooling, public transportation, electric and alcohol fueled cars, biking, walking, telecommuting, online education and shopping, rooftop solar heating and electricity, three and four day optional work weeks, etc. These ideas and many more have proven themselves. Time is running out. Let's make sure that we follow a course that makes sense and does more than promise—let it deliver!

Response from Richard Engel

I agree with Dominic that renewable energy has to be the foundation of our energy future. Our difference of opinion is on how best to store renewable energy to make it portable and to match loads over time.

Wherever possible, renewable energy needs to be used directly at the time and place of generation. This avoids the complexity and inefficiency found in any storage scheme.

Crea Response, cont.

the potential of hydrogen to "greenwash" the American public. Richard and I both feel very strongly that an energy policy based on the use of nonrenewable feed stocks, such as coal and natural gas, has the wrong focus.

That being said, I must point out that we differ in our perception of the likelihood of hydrogen becoming a viable fuel in the near future. While hydrogen arguably has the potential for significant energy storage, it is by no means the only—or even the most desirable—method by which to accomplish this task. At 300 BTUs per cubic foot, hydrogen, even at 400 atmospheres pressure, contains only about one-quarter of the thermal energy of ethanol on a volume basis.

In terms of domestic electricity, it must be remembered that the transmission of hydrogen entails many loss mechanisms, amounting to fully half or more of the original energy contained in the gas. On the other hand, a national grid-intertie system that allows homeowners to dump excess PV electricity back into the grid during daytime hours (when demand is highest) is a proven technology. Likewise, the storage of heat and cold can be accomplished with exceedingly simple, reliable, and above all else, safe heat of fusion chemical systems.

Hydrogen has potential—perhaps in aviation, nautical, and rail vehicles in the form of liquefied gas where destinations and schedules are well known. But it also has some very significant limitations, and we should be mindful of this fact. Hydrogen is being promoted as a panacea for all our energy woes, but we must examine the quantitative realities, not the qualitative promises offered by hydrogen advocates.

It is my belief that we can ill afford to place such emphasis on hydrogen. To do so will divert attention from technologies that are better suited to a national energy policy. As a start, why not use our tax dollars to supply homes with net metered PVs before spending it on hydrogen demonstration filling stations?

Certainly, if hydrogen technologies mature, they will need a renewably based energy source. Let's make sure we put the horse in front of, rather than behind, the cart.

Engel Response, cont.

But where storage or portability is necessary, hydrogen is the best choice. Do we want to keep relying on batteries for all of our energy storage needs?

Like Dominic, I'm a fan of simplicity. But complexity in power and transportation technologies can and does work for us every day. The renewable hydrogen systems we design, build, and operate at Schatz don't even approach the complex synthesis of computer and mechanical technologies under the hood of any new car. For that matter, how simple are the computers on which Dominic and I are composing our debate?

Regarding Dominic's schematic comparison of hydrogen and battery systems, it's unfair to ignore the complexity, cost, and environmental impacts inherent in safely disposing of and replacing batteries every few years.

As for the electrical efficiency of fuel cells, most of their losses, particularly in larger stationary applications, can be recaptured as useful heat energy. Such co-generating fuel cell systems can compete with batteries on overall efficiency. Here are just a few examples of applications where hydrogen energy already makes sense:

Transportation fuel. Battery powered cars will never go far enough or charge fast enough to approach the performance we take for granted today. A gasoline or hydrogen pump transfers energy to a car at a rate of about 10 MW. Battery cars can't come close to matching this.

Seasonal energy storage. Batteries' high self-discharge rates make storing summer solar energy for winter use infeasible. We regularly store hydrogen at pressures of thousands of psi with no measurable loss over months.

Portable energy. On a weight basis, a regenerative fuel cell system (fuel cell, electrolyzer, and storage) offers two to five times the energy storage of the best available batteries.

Direct use of renewable energy is beyond a doubt our best option for the future. Where storage or portability is necessary, hydrogen's abundance, cleanliness, and efficiency make it renewable energy's greatest ally. Combined with efficient and conservative use of energy, renewables and hydrogen can lead us to a healthier and more secure future.

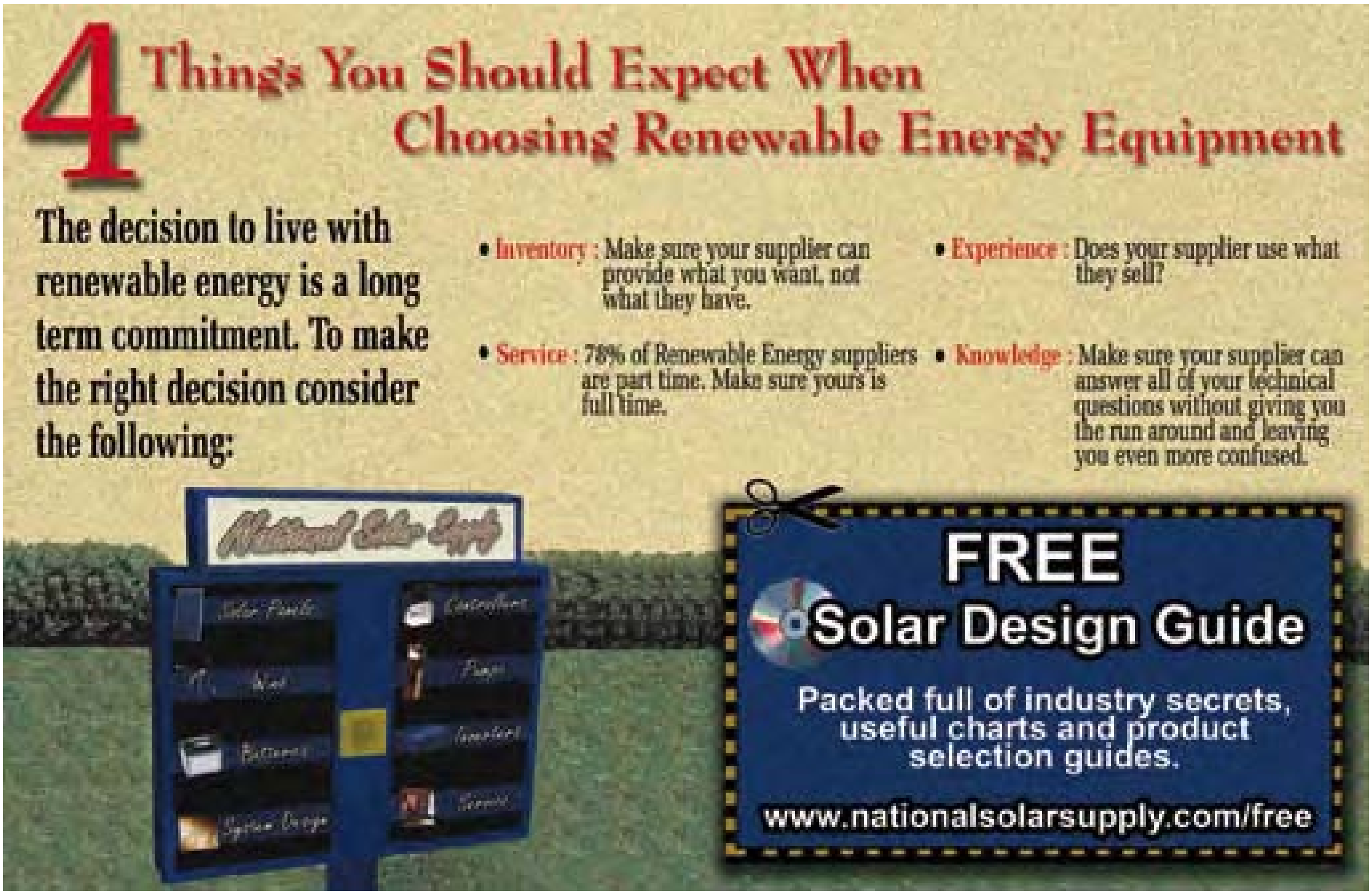
Access

Richard Engel is a research engineer at Schatz Energy Research Center, Humboldt State University, Arcata, CA 95521 • 707-828-4345 • Fax: 707-826-4347 • rae7001@humboldt.edu • www.humboldt.edu/~serc

Dominic Crea is a science instructor and runs his own business, Science Wonders, 37880 Moravian, Clinton Township, MI 48036 • dom120@ juno.com

Ian Woofenden, debate moderator/editor, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com


Summer is here... temperatures are RISING...
TRISTAR™
THREE-FUNCTION SOLAR CONTROLLER
45A and 60A at 12-48vdc
UL LISTED
• our 60 amp version operates at 48V
• ours includes an RS-232 comm port
• ours accepts larger cable with more bending room
• our meter has much more information including graphics
• ours has a 5 year warranty
• ours fits on power panel
• ours is competitively priced!
yet the TRISTAR is still COOL!
...Much larger heat sink and proprietary thermal design keeps the TriStar operating at lower temperatures, increasing reliability and product life. Ratings are actual to 45°C (113°F). No need to derate.
MORNINGSTAR corporation
Phone: +1-215-321-4457
Fax: +1-215-321-4458
info@morningstarcorp.com
www.morningstarcorp.com


4 Things You Should Expect When Choosing Renewable Energy Equipment
The decision to live with renewable energy is a long term commitment. To make the right decision consider the following:
• Inventory : Make sure your supplier can provide what you want, not what they have.
• Experience : Does your supplier use what they sell?
• Service : 78% of Renewable Energy suppliers are part time. Make sure yours is full time.
• Knowledge : Make sure your supplier can answer all of your technical questions without giving you the run around and leaving you even more confused.
National Solar Supply
FREE
Solar Design Guide
Packed full of industry secrets, useful charts and product selection guides.
www.nationalsolarsupply.com/free

Alternatives That Don't Cost an Arm and a Leg

Zeke Yewdall

You want to do your part to help the environment. PV sounds great, but realistically, it is beyond the financial reach of many of us. Sure you can argue that the real cost of other energy sources isn't accounted for, but does that convince your bank account that your check for the PV system won't bounce?

There are a lot of other ways you can walk your talk that are more achievable for the average person, and can actually have just as great an impact on cleaning up the environment. Let's explore some of the options in the realms of electricity and transportation.

Efficiency

Conserving energy is almost always the most cost effective thing you can do. A home energy audit will find many ways, but there are a few things that most homes need.

Buy a new refrigerator. Many mainstream refrigerator manufacturers offer efficient, low-end models that are not costly, but perform extremely well compared to refrigerators made a few years ago. If you replace a 10-year-old fridge, you could save up to 1,000 KWH per year. See *HP84* for a review of one Maytag. The American Council for an Energy Efficient Economy (ACEEE) can tell you which appliances are the most efficient.

Put in compact fluorescent lights in the most used fixtures in your house. These have progressed immensely in the last few years. I can now go into most home centers and hardware stores and buy a three-pack of 60 watt equivalent compact fluorescent lightbulbs for less than US$9. These are now small enough to fit almost anywhere an incandescent does, and the problems of cold weather starting and flicker have largely been solved.

Eliminate phantom loads. Your computer system should be on a power strip or switched outlet, which you can turn off when not in use. Newer electronics with switching power supplies are getting better. For example, DVD players usually have a phantom load under 1 watt, instead of the 5 to 15 watt phantom load for older VCRs. Especially beware of wall-warts (those wall-cube power supplies)—they usually consume about 50 percent of their rating while not powering anything. Unplug them when they're not in use, or put them on switched outlets or plug strips.

The U.S. DOE's Consumer Energy Information Web site at www.eere.energy.gov/consumerinfo is a good place to start for more info on efficiency.

Buy Green Power

In many states, you can choose to buy green power from your utility. In states that have opened electricity generation to competition, this may mean switching utility companies. In others, it may just mean signing up for a premium product from your utility. Some states require utilities to offer a green power product. You can find a list of utilities offering green power at www.dsireusa.org and by searching the Web for green pricing programs.

What does signing up for this actually mean? You don't get a wind turbine at your house. The utility company commits to purchasing a certain percentage of its electricity from these sources. The small premium you pay (usually around 2.5 cents per KWH) covers the extra cost of those wind turbines, compared to the base power mix.

In some states, the extra cost may actually be less than this because it is exempt from fuel charges normally tacked onto your bill. Usually people buying 100 percent wind power are exempt from these fuel charges from natural gas price escalations (which last year spiked to ten times the long term average). Even if wind power costs a little more on average, the reduction in price volatility can convince some people or businesses to consider it.

Why am I talking only about wind? Because the overwhelming majority of true green power programs are based on utility-scale wind farms. This is only slightly more expensive than natural-gas-fired generation, and is almost an order of magnitude cheaper than solar electricity.

How do you know the electricity you are buying is really green? Sometimes it is hard to tell. Some companies are selling "green" power that not everyone might call green, such as large hydroelectric generation, or even natural-gas-fired generation! Some may charge a premium for electricity from RE facilities that have been around for years and are already paid off.

The good green products put the money towards new facilities in wind, PV, or low impact hydro (certified by the Low Impact HydroPower Institute). Some companies are selling hydropower from existing plants for a 2.5 cent per KWH premium. Having lived in the Northwest, where residential rates can be as low as 4 cents per KWH precisely because existing hydro is so cheap, I find this sort of ironic. It's good marketing, I guess.

Disclosure. When you sign up for any program, request a disclosure sheet about where the "green" power comes from. If they can't or won't tell you, consider a different option, such as buying RECs (see below).

Buy Renewable Energy Credits

What if your utility does not offer green power, or you can't get a competitive product in a restructured state, or they are just greenwashing, *or* if you just don't like them? You can buy RECs—renewable energy credits (also called tradable renewable credits—TRCs, or green tags). RECs are a similar idea to the wind green-pricing programs, but the wind farm may be far away.

You still buy your electricity from the local utility, but you also buy green attributes for that many KWH from a REC retailer. They use this money (usually 2 to 2.5 cents per KWH) to support the construction of new wind farms, and sometimes new PV. They may also include low impact hydropower or biomass (including landfill methane). Retailers are required to tell you what the energy mix is. Green-e (a division of the Center for Resource Solutions) independently certifies that the kilowatt-hours of RECs you purchase were actually generated.

You can also buy RECs to offset the carbon emissions of your car or your propane use, and retailers can tell you how many pounds of carbon emissions were avoided for each KWH you buy. Major companies are Bonneville Environmental Foundation (the purchase is tax deductible) and Renewable Choice. Green-e has a list of all certified retailers. Purchase varies from a one-time purchase to monthly payments more like a traditional utility bill.

RECs have the advantage over green power programs that you can buy them anywhere, for whatever purpose you want. Some environmental groups buy many more of them than they need, just to retire them. Effectively, what they are doing is putting money towards development of new wind farms. Disadvantages are that you are not isolated from fuel price volatility, and because the wind farm may be half a continent away, your local airshed does not receive the emissions reductions from SO_X or NO_X. Carbon dioxide is a worldwide problem, so reducing emissions anywhere benefits everyone equally.

Transportation

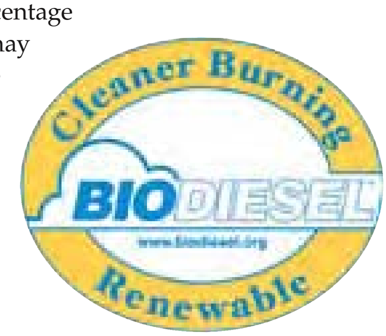
Transportation is another major energy use of the average American. Electricity and transportation are both largely fossil-fuel-fired, but at least electricity comes mostly from domestic fuel sources, whereas 60 percent of our oil (mostly going to transportation, see "In the Belly of the Beast," Randy Udall, *HP87*) is now imported—and about 20 percent comes from the Middle East.

Reduce consumption. First, try to reduce gasoline consumption as much as possible. Combine trips, carpool, and drive the more efficient vehicle most of the time if you have two. Take the bus, walk, or bike if possible.

I heard of someone in Norway who skied an hour to work each day, and remember thinking he was insane. But isn't it funny that in America we accept an hour's drive to work as normal? The skiing Norwegian is getting exercise and a relaxing time outdoors every day, while we have to pay for our recreation, and do it on the weekends, if we even have time. I'm not sure who is really crazy.

Buy domestic fuel. You can buy gas from companies that do not import from the Middle East or support drilling in the Arctic. BP/Phillips, Citgo, Conoco, Sinclair, Sunoco, and Hess do not import oil from the Middle East, while Shell, Chevron, Texaco, Exxon/Mobil, Marathon/Speedway, and Amoco do. Shell and Amoco (now combined with BP) do generally have a better record on environmental issues. Exxon/Mobil has particularly reprehensible policies regarding climate change, the Middle East, and the environmental impact of petroleum use and extraction.

Use biodiesel. You could buy a diesel car and use biodiesel to fuel it. In addition to supporting American farmers instead of foreign oil interests, biodiesel reduces SO_X, CO, HC, and particulate pollution over petroleum-based diesel, even in small percentage blends. However, NO_X may increase slightly. Massive purchases of biodiesel, such as Minnesota's requirement that all diesel sold be 2 percent biodiesel, are because it is an alternative lubricant to sulfur in the fuel.



Comparing Strategies to Save Energy & the Environment

Scenario	Conventional Energy Savings / Year (KWH or Gal.)	CO_2 Intensity of Conventional Fuel (Lbs. / KWH or Gal.)	Up Front Cost (US$)	Loan Time (Yrs.)	Loan %	Additional Payment / Month	Benefit / Month	Net Monthly Cost
New fridge (vs. 10-year-old fridge)	730.00	1.40	$800.00	NA	NA	$0.00	$5.17	-$5.17
Compact fluorescents in 10 most used lights	492.75	1.40	$25.00	NA	NA	$0.00	$3.49	-$3.49
Buying 100% wind power, Colorado	10,800.00	1.96	NA	NA	NA	$22.50	$0.00	$22.50
Buying 100% wind power, New York	10,800.00	0.88	NA	NA	NA	$22.50	$0.00	$22.50
Buying green tags	10,800.00	1.40	NA	NA	NA	$18.00	$0.00	$18.00
PV system, 2.8 KWp, in Los Angeles, with rebate	4,743.20	0.55	$2,940.00	20	6%	$20.22	$114.63	-$94.40
PV system, 2.8 KWp, in Georgia	4,323.20	1.39	$18,200.00	20	6%	$125.20	$25.22	$99.98
Bergey XLS wind turbine, in 12 mph avg. wind speed, in Colorado	10,800.00	1.96	$35,000.00	20	6%	$240.76	$58.50	$182.26
Biodiesel pickup, 27 mpg average	400.00	19.50	$1,200.00	3	8%	$42.60	$43.67	-$1.06
Electric car conversion & green tags	400.00	19.50	$8,000.00	3	2%	$234.14	$58.33	$175.81
New hybrid Civic vs. normal Civic (12 K miles / year)	96.04	19.50	$3,000.00	3	2%	$85.93	$14.01	$71.92
Trade in old 15 mpg SUV for new 40 mpg car (12 K miles / year)	406.53	19.50	$10,000.00	3	2%	$286.43	$59.29	$227.14
Electric car & PV carport (2 KW), 10 K miles / year	400.00	19.50	$21,000.00	20	6%	$144.46	$58.33	$86.12

Assumptions:
RE systems are paid for by home equity loan, 20 year, 5.5%. New cars are bought on 2% financing, 36 month. Other loans are 3 year, 8% loans. Biodiesel cost is $0.54 per gal (homemade from waste oil, and assuming no net carbon emissions. If purchased, biodiesel will be around $2.80/gallon, with about 5lbs/gallon net CO_2 emissions). Gas cost is $1.85 gal. Carbon reductions per $ spent are for initial price, and carbon reduction over lifetime. EV or biodiesel truck replaces 25 mpg vehicle.

Homebrew biodiesel (see *HP93*) can be made from used restaurant oil. The National Biodiesel Board's Web site—www.biodiesel.org—has lots more information on biodiesel and where you can buy it. Biodiesel is only cheaper than regular diesel if you get free vegetable oil and make it yourself. Commercially sold biodiesel runs about US$2.80 per gallon.

Drive a hybrid. If you are planning to buy a new car, consider buying a hybrid. You can now choose between the Civic, Insight, and Prius, with more in the works. Hybrids qualify for around a US$2,000 tax credit, about half the cost of the premium over the nonhybrid equivalent car.

Need an SUV? If you drive an SUV, consider how much you actually need it. On an icy or snow-packed road, a Civic will handle better than most SUVs anyway, and all-wheel-drive cars are better than SUVs until the snow gets deep.

For households that own two or more SUVs, keep one and trade in the other for a hybrid for the majority of trips. Even many nonhybrid compact cars get near 40 mpg. For ratings of all of the new cars, see www.greenercars.com. For info on tax credits, see www.cleancarcampaign.org. *EV World's* AFVmarket.com Web site also has information on where to buy used or recently off-lease EVs and hybrids.

Years Simple Payback	Simple Rate of Return	Carbon Reduction Lbs. / Year	Project Lifetime (Yrs.)	Carbon Emissions Reductions (Lbs. / $ Spent)
12.89	0.08	1,022.00	10	12.78
0.60	1.68	689.85	5	137.97
NA	NA	21,170.16	NA	78.41
NA	NA	9,456.48	NA	35.02
NA	NA	15,120.00	NA	70.00
NA	0.47	2,598.32	30	26.51
NA	0.02	6,009.25	30	9.91
NA	0.02	21,168.00	25	15.12
NA	0.44	7,800.00	10	65.00
NA	0.09	7,800.00	10	9.75
NA	0.06	1,872.80	15	9.36
NA	0.07	7,927.26	10	7.93
NA	0.03	7,800.00	25	9.29

Buy an electric car. Admittedly this is getting hard. Major manufacturers have discontinued selling or leasing new electric cars in the United States. Home conversions or buying a used electric car are one of the few options now. And in states with really dirty coal power plants, this may not be much better than a good hybrid car, but will eliminate dependence on foreign oil. If you have a green power program or buy RECs, you can eliminate emissions for your electric car. And you could always put PV on the carport.

Install Your Own RE System

And last, you can install your own RE system. This can be much more rewarding than merely buying renewable energy credits, but can also be expensive. Prices to offset all electricity used by the average conserving house range from US$10,000 to $30,000 for a PV array or small wind system.

In some lucky areas such as California, Oregon, Illinois, and several northeastern states, generous financial rebates are available, up to 80 percent of the cost of the system, and more commonly about half the cost. Rebates can make these systems a little more accessible (check out the *HP* Web site for a list of these rebates). Also, PV is very easy to start with a small system and expand as expenses allow.

You Can Do It

You can do many things to reduce the environmental impact of your energy use. They range from the simple and cheap methods of replacing incandescent lightbulbs or checking off a green-power box on your utility bill, to making different decisions when you buy your next car, to installing your own renewable energy system. All of these have different costs, pollution reductions, and payback times. They are also all different in how they can fit in with your particular lifestyle. It's up to you to make the informed decision about what is best for you.

Access

Zeke Yewdall recently graduated from the University of Colorado, Boulder, and works at the Wind Technology Center of the National Renewable Energy Lab, 2937 Broadway St. Apt. A, Boulder, CO 80304 • 720-352-2508 • zyewdall@yahoo.com

See "Doing Well While Doing Good," *HP86*, where Andy Kerr analyzes the payback on compact fluorescents, solar water heating, a hybrid car, LED lighting, and a PV system. These different options are analyzed in several ways—first cost (or monthly cost, for loans), cost/benefit ratio, total carbon emissions avoided, and carbon emissions avoided per dollar invested.

See also:
HP71, page 84 • Energy savings made easy
HP94, page 92 • Alternative vehicle choices
HP93, page 32 • Homebrew biodiesel
HP91, page 90 • Is an EV for you?
HP85 , page 62 • Toyota Prius inside and out
HP83, and *HP82* • Hybrid electric vehicles
HP93, page 86 • Renter's small PV system

American Council for and Energy Efficient Economy (ACEEE), ACEEE Publications, 1001 Connecticut Ave. NW Suite 801, Washington DC 20036 • 202-429-0063 • Fax: 202-429-0193 • aceee_publications@aceee.org • www.aceee.org • www.greenercars.com • Energy efficiency ratings of appliances and cars

Database of State Incentives for Renewable Energy USA is an excellent Web site with summaries of all of the tax rebate programs, net metering laws, rebate programs, etc. • www.dsireusa.org

Green-e Renewable Energy Certification Program, PO Box 29512, San Francisco, CA 94129 • 888-63-GREEN • Fax: 415-561-2105 • webmaster@green-e.org • www.green-e.org

Low Impact Hydropower Institute, 319 SW Washington St. Suite 706, Portland, OR 97204 • 503-227-1763 • Fax: 503-223-8544 • info@lowimpacthydro.org • www.lowimpacthydro.org

Bonneville Environmental Foundation, 133 SW 2nd Ave. Suite 410, Portland, OR 97204 • 866-233-8247 or 503-248-1905 • Fax: 503-248-1908 • info@B-E-F.org • www.GreenTagsUSA.org • Green tags—RECs

Renewable Choice Energy (American Wind RECs), 6309 Monarch Park Pl. Suite 202, Longmont, CO 80503 • 303-652-0770 • Fax: 253-679-8610 • customerservice@renewablechoice.com • www.renewablechoice.com

Sterling Planet (Green America RECs), 3775 Mansell Rd., Alpharetta, GA 30022 • 800-473-1335 • Fax: 770-594-0815 • comments@SterlingPlanet.com • www.sterlingplanet.com

Sunpower (ReGen RECs) • 800-689-7957 • info@sunpower.org • www.sunpower.org • Note: this is 1 percent solar and 99 percent biomass

Community Energy, Inc. • 150 Strafford Ave. Suite 110, Wayne, PA 19087 • 866-WIND-123 • communityenergy@newwindenergy.com • www.newwindenergy.com • NewWindEnergy RECs

National Biodiesel Board, PO Box 104898, Jefferson City, MO 65110 • 800-841-5849 or 573-635-3893 • Fax: 573-635-7913 • info@biodiesel.org • www.biodiesel.org

Clean Car Campaign, 117 N. Division St., Ann Arbor, MI 48104 • 734-663-2400 • Fax: 734-663-2414 • info@cleancarcampaign.org • www.cleancarcampaign.org

Information on buying used Hybrids and EVs • www.EVworld.com & www.AFVmarket.com

Home energy efficiency information • www.eere.energy.gov/consumerinfo


15th ANNUAL
RENEWABLE ENERGY & SUSTAINABLE LIVING FAIR
June 18-20, 2004
Custer, Wisconsin (7 miles east of Stevens Point)
workshops, exhibits, music, food, and family activities
all powered by the wind & sun!
MIDWEST RENEWABLE ENERGY ASSOCIATION
7558 Deer Road
Custer, WI 54423
info@the-mrea.org
www.the-mrea.org
register online
Featured Speakers
• Amy Goodman, co-host of "Democracy Now!"
• Richard Heinberg, author of "The Party's Over"
• Richard Perez, Publisher of "Home Power" magazine
• John Stauber, Center for Media & Democracy, author of "Mad Cow U.S.A."
Sorry, no dogs at the Fair.
NATURAL HOME
home power
focus on energy
The power is within you.
we energies

For a complete listing
of renewabe energy events,
see the RE Happenings section
starting on page 134

Honda's Hybrid Duo

Shari Prange

The Civic hybrid provides the same five-passenger room as the gas Civic.

The Honda hybrids—the five-seat Civic and the two-seat Insight—represent a new class of vehicle, the hybrid electric vehicle (HEV). They are the offspring of a marriage between the conventional internal combustion engine (ICE) and the electric motor. Only a tiny handful of HEV models are available to the general public, but more are expected to follow from various manufacturers. Let's take a look at the Honda hybrids to see what HEVs are all about.

What Is a Hybrid?

In nature, a hybrid is the result of crossbreeding two different types of plants or animals, leading to offspring with some characteristics of each parent. In cars, a hybrid is a vehicle that combines two different types of drive technology. There is not one distinct kind of drive system that defines "hybrid." Rather, they can fall anywhere between the two endpoints on a continuum, from pure internal combustion engine vehicles to pure battery electric vehicles (BEVs). In the middle are various degrees of possible hybrid combinations.

For example, in the center of this continuum would be the fifty-fifty hybrid. Both ICE and BEV systems would be equally important. This could take the form of a vehicle with two complete drive systems, and the ability to drive equally well under gasoline or battery power at the flip of a switch.

On this scale, the Honda hybrids fall much closer to the ICE end, probably at about 90 percent ICE and 10 percent battery powered. Most of the car's propulsion comes from the gas engine. For example, at 5,700 rpm, the gas engine on the Civic hybrid is providing 85 hp, and on the Insight is providing 67 hp. Meanwhile, the electric motor adds only 8 hp and 6 hp respectively. At its peak, the electric motor puts out 13 to 14 hp.

The electric system is there to assist the ICE system. It is not powerful enough to drive the car on its own. In fact, the batteries are charged solely by the gas engine (partially indirectly through regenerative braking). It is not possible to plug into an outside charging source, such as the grid or an RE system. In that sense, the car derives *all* of its propulsion from the gasoline engine.

The goal of Honda's design philosophy was to make the ICE system as efficient and clean as possible, without loss of performance. The purpose of the electric system is primarily to provide additional torque at low rpm and boost the performance possible from the gas engine. Honda calls the system Integrated Motor Assist (IMA).

How Does It Work?

The entire hybrid drive system on the Civic fits into the same physical space as the gas engine on a gas Civic. This is because the gas engine portion of the hybrid system is smaller. In a normal gas car, the engine has to be big enough to provide a lot of power at low rpm—when taking off from a standstill and accelerating up to speed.

Once cruising speed is reached, much less power is needed. This makes the standard gas engine bigger than it needs to be, and hence less efficient, for most of the driving cycle. But with an electric motor to add power for takeoff, the

The Insight hybrid is a sporty two-seater.

Since the electric motor is only intended as an assist to the gas engine, it can be very small.

gas engine can be sized more efficiently for cruising speeds. The engine in the hybrid has also been redesigned in several different areas to make it consume less gas, and consume it more completely, creating fewer emissions.

The tiny, permanent magnet, DC electric motor is only 2.6 inches (6.5 cm) wide and sits between the engine and the transmission. The engine shaft is connected to the motor shaft, which is in turn connected to the transmission. So the electric motor is always spinning at the same speed as the engine, whether it is providing power or not.

The power for the electric motor comes from a pack of nickel-metal-hydride (NiMH) batteries in the trunk. Since the batteries only provide an assist, the pack can be very small, only 19.5 by 14.7 by 6.9 inches (49.5 x 37.3 x 17.5 cm) and 63 pounds (28.6 kg). There are 120 "D" cells at 1.2 volts each for a pack of 144 volts at 6 amp-hours in the Civic and 6.5 amp-hours in the Insight. This is only one-tenth the capacity of a pack that would power a pure electric car. The battery pack is warranted for 8 years or 80,000 miles.

The electric drive is kicked into service automatically by the Intelligent Processing Unit (IPU). The IPU determines, according to rpm and torque demands, how much assist is needed from the electric system, if any.

The batteries are charged primarily through regenerative braking. Any time the car is coasting in gear, or braking, the motor becomes a generator. It captures the energy of the car's momentum and turns it back into electricity to charge the batteries, slowing the car down at the same time. If the batteries should become too deeply discharged, the IPU will cause the motor to generate and charge the batteries while being driven by the gas engine. This places some drag on the gas engine, but since the electric system is so small, it is minimal.

The electric motor sits between the gas engine and the transmission.

In addition, the gas engine automatically shuts off when you come to a complete stop under most conditions. It does not "idle" and waste gas or produce emissions at stoplights. When you hit the throttle to go again, the electric motor automatically restarts the gas engine.

Two transmission options are available with the hybrids. One is a standard five-speed manual transmission. The other is a continuously variable transmission, or CVT. The CVT is similar to an automatic, in that it changes "gears" by itself, without any input from the driver. However, an automatic still has several distinct gears, and you can feel when the car shifts from one to another. The CVT uses belts that move gradually back and forth over cone-shaped pulleys to give a smooth continuous gradation between speeds.

How Do They Compare?

The Insight was the first hybrid introduced by Honda. The Civic hybrid uses a second-generation hybrid system that is

A peek under the hood of the Insight hybrid.

a refinement of that in the Insight. To get a feeling for what all this means, let's compare the hybrids to the standard ICE Civics. As mentioned earlier, the gas engine in the hybrids is smaller than the stock Civic engine, both physically and in power output. Both versions of Civic have four cylinders, but the hybrid has only 1,339 cc of displacement compared to 1,668 for the ICE Civic. The Insight's engine is even smaller, at only 995 cc and three cylinders.

This translates to 85 hp for the Civic hybrid's gas engine, 110 hp for the ICE Civic, and 67 hp for the Insight gas engine. When you add the electric motors into the equation, the numbers go up to 93 hp total for the Civic hybrid and 73 hp total for the Insight. So the Civic hybrid has substantially more power than the Insight, but still lags well behind the straight ICE Civic.

In performance, the Civic hybrid and Insight are closely matched, with the power difference erased by the Insight's lighter weight. According to *Consumer Guide* road tests with manual transmission models, 0 to 60 mph (97 kph) times were 11.3 seconds for the Insight, 11.6 seconds for the Civic hybrid, and 9.4 seconds for the gas Civic coupe.

What About Emissions?

Vehicles are categorized by the level of their exhaust emissions. Typical full size cars are rated as LEVs, or low emissions vehicles. Compact and economy cars generally fall into the ULEV category, or ultra low emissions vehicles. ULEV standards are 90 percent tighter than LEV standards. Above that is the SULEV category, for super ultra low emissions vehicles. (Yes, they did start to get a little silly with superlatives here.) SULEV standards are 90 percent tighter than ULEV standards. It is unlikely that a gas vehicle can attain SULEV status without some type of alternative fuel or power being involved.

Above SULEV is a new category called advanced technology partial zero emissions vehicles, or AT-PZEV. "Partial zero" makes even less sense than "super ultra." It's either zero or not zero. But this category was created to give credit to vehicles using some form of alternative technology that exceeds SULEV standards. The highest category is the ZEV, or zero emissions vehicle. The only vehicles to qualify for this category are pure electric vehicles powered by batteries or fuel cells. No full function ZEVs are commercially available in the U.S. at this time.

These classes are based on hydrocarbon (HC) and nitrogen oxide (NO_X) emissions measured at the tailpipe. Emissions from the processes of extracting and refining the gas or other fuels, or of generating electricity for ZEVs, are not included.

On this scale, the Insight, the Civic hybrid, and the gas Civic are all rated as ULEVs in most states. However, in California and a few northeastern states, slightly different versions are sold that meet more stringent standards and are EPA rated as AT-PZEVs.

Efficiency

Where the hybrids really shine is in efficiency, which is measured in gas mileage. Mileage varies a little, depending on which transmission is used. The Insight equipped with the manual transmission gets the best mileage of them all, with 60 mpg for city driving and 66 mpg for highway driving. With the continuously variable transmission (CVT), these numbers drop to 57 and 56. However, the Insight also has a weight advantage, because it is only a two-seater, and weighs in at a flyweight 1,850 pounds (839 kg) with the manual transmission and 1,975 (896 kg) with the CVT.

The five-seat gas Civic, for comparison, weighs between 2,449 and 2,601 pounds (1,111 and 1,180 kg) with the manual transmission, depending on which two-door coupe or four-door sedan model you choose. It is not offered with the CVT. It gets only 32 city miles (7.4 l/100 km) and 37 to 38 highway miles (6.3–6.2 l/100 km) to the gallon, which are still not bad numbers as gas cars go.

The five-seat Civic hybrid outweighs the gas Civic, at 2,732 pounds (1,239 kg) with the manual transmission and 2,661 pounds (1,207 kg) with the CVT. However, even at this heavier weight, it outshines the gas Civic for mileage. The manual version gets 46 city miles (5.1 l/100 km) and 51 highway miles (4.6 l/100 km), and the CVT version gets 48 city miles (4.9 l/100 km) and 47 highway miles (5 l/100 km) per U.S. gallon.

All of the cars have the usual array of comfort and safety features that we would expect in a modern car. The Insight is a two-seater, so this puts it out of the running for a family car.

What is the price tag on better fuel economy? Gas Civics range from US$13,000 to US$18,000 depending on model. The Civic hybrids are US$19,650 with a manual transmission and US$20,650 with the CVT. The Insights are US$19,180 to US$21,380. So the cost is substantially more than the basic gas Civic, but not much more than the high end versions.

The Choice Is Yours

The key issues in choosing a hybrid vehicle over a conventional ICE car are emissions, fuel efficiency, and purchase price. Are hybrids as clean as a pure battery or fuel cell electric vehicle? No. But fuel cell cars are still several years away, and battery cars are only available by conversion. The Honda Civic and Insight are available at dealerships today, and offer fuel economy and emissions that are a step above ordinary gas cars.

Access

Shari Prange, Electro Automotive, PO Box 1113-HP, Felton, CA 95018 • 831-429-1989 • Fax: 831-429-1907 • electro@cruzio.com • www.electroauto.com

American Honda Motor Co. • 800-33-HONDA • www.hondacars.com

PV Basics Affect the Code

John Wiles
Sponsored by the Photovoltaic Systems Assistance Center
Sandia National Laboratories

Photovoltaic modules have some very important characteristics that affect the electrical safety of PV installations. These characteristics drive the installation requirements found in the *National Electrical Code*. Let's review some of these characteristics and see how they should be dealt with.

Sunlight

The intensity of sunlight is called irradiance, and for PV systems, the units are watts per square meter (W/m^2). A square meter is about 11 square feet. A typical, clear sky, solar-noon value of irradiance falling on the surface of the earth at sea level is 1,000 W/m^2. This value of irradiance is one of the standard test conditions (STC) factors used to rate PV module and PV array output.

On clear, cloudless days, irradiance will peak at solar noon. A plot of irradiance vs. time of day is presented in the peak sun hours diagram, and makes an arc-like curve. PV system designers need to know the amount of solar energy available each day (known as irradiation or insolation). Working with irradiance vs. time curves is difficult, since it requires mathematical integration of the data.

To simplify the calculations used in PV system design, tables are available that do the math and present the total available solar energy as the equivalent number of hours of solar irradiance at the 1,000 W/m^2 level. This is seen in the diagram as the rectangular area with the top at 1,000 W/m^2. The rectangle covers the same area as the area under the curve. The width of the rectangle in hours is known as the peak sun hours. These numbers are published by the National Renewable Energy Laboratory (NREL), and can be found on the NREL Web site (see Access) for numerous locations, various array tilts, and for each month of the year. Data is provided for fixed and one and two-axis tracking arrays.

Although PV modules are rated at 1,000 W/m^2, it should be noted, as shown in the diagram, that the irradiance frequently exceeds this value when clouds, dust, or high humidity levels are not present. This peak level of irradiance will vary depending on a number of factors including orientation of the surface, altitude, and the local microclimate. Solar irradiance greater that 1,000 W/m^2 may be expected in many locations where PV systems are installed. At higher elevations, less air is between the surface and the sun (atmospheric density is lower), and the range of irradiance values is higher than at sea level.

In many areas, the time period that the irradiance exceeds 1,000 W/m^2 can be three hours or more. This has an impact on the electrical design of the system and will, as we delve into the code requirements in subsequent columns, drive some PV system design considerations. The peak may be well above 1,000 W/m^2, and values in the range of 1,100 to 1,200 W/m^2 are common. Short-term (10–15 minutes) peaks of more than 1,400 W/m^2 have been measured when cumulus clouds have formed a reflective lens around the sun and concentrated the sunlight on the surface.

Temperature

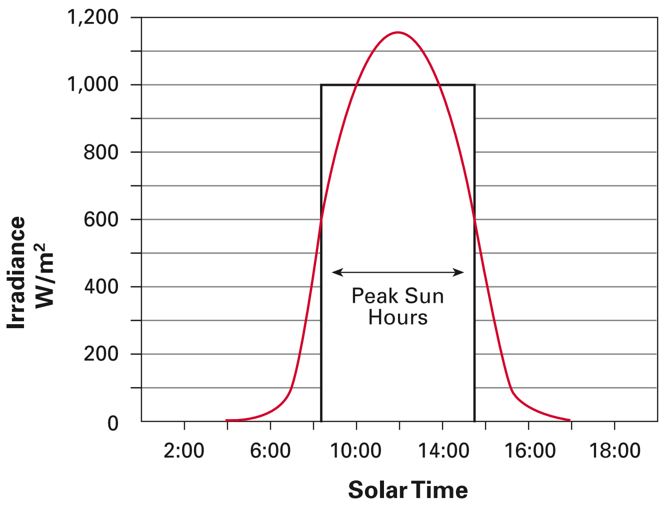
PV modules are rated (power, voltage, current) at a standard test condition (STC) temperature of 25°C (77°F). Surfaces (including PV modules) mounted in exposed outdoor locations are subject to widely varying temperatures that are a result of the ambient temperatures, solar exposure, and cooling by radiation and convection.

A typical PV module mounted outdoors in a well-ventilated area and exposed to 1,000 W/m^2 of solar irradiance with no wind blowing can be expected to operate at 30 to 35°C (54–63°F) above the ambient temperature. If the ambient temperature is 40°C (104°F), the typical PV module will operate in the 70 to 75°C (158–167°F) range on hot sunny days during the solar peak period.

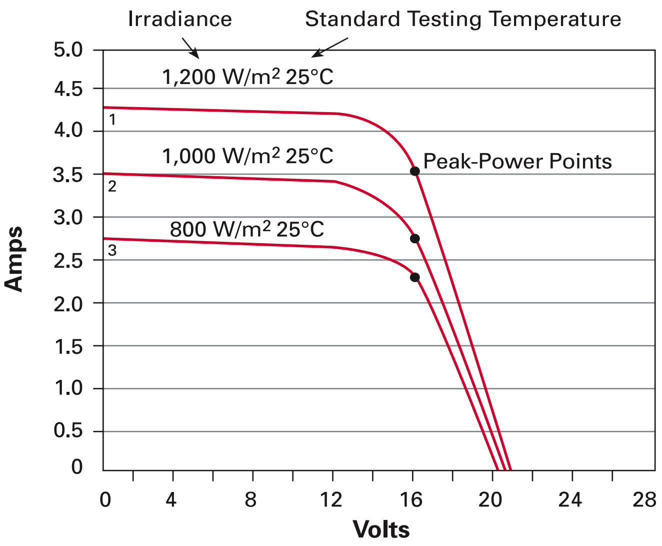
On the other hand, a PV module operating in cold, windy weather may have the heat removed from the module so rapidly that the sun never increases the module temperature by more than a few degrees above ambient temperatures. With winter ambient temperatures in some locations in the U.S. as low as -40°C (-40°F), modules can operate at these temperatures. The NREL Web site also shows the record and average high and low temperatures for hundreds of locations around the U.S. This information is also used in designing a code-compliant, high performance PV system.

Furthermore, surfaces facing the clear, nighttime and early morning sky may be subject to radiation cooling, and the surface may be a few degrees cooler than the ambient

Peak Sun Hours



IV Curve



1. Increased Isc by approximately 20%
2. Rated Isc.
3. Decreased Isc by approximately 20%

temperature. At dawn, when no sun is shining directly on the modules, the available indirect light and the low temperature can create the highest open circuit voltages the system will ever see.

PV Module Characteristics

Crystalline silicon PV modules respond to the widely varying environmental conditions addressed above. From a performance perspective (needed to calculate the output of the PV system), the electrical output is directly proportional to the irradiance and has an inverse relationship with the module operating temperature.

If irradiance increases by 10 percent, the power available from the module will also increase by 10 percent. As the module temperature increases above the 25°C (77°F) level, the module power output will drop about 0.5 percent per degree C increase in temperature. Conversely, if the module temperature decreases, the power output will increase about 0.5 percent per degree C. When a PV module operates at 75°C (167°F; experienced on hot sunny days with no wind), the output may be only 75 percent of the STC rated output, due to the increased operating temperature.

Module power output is the product of the output current and the output voltage. Typically at the peak-power point on the module operating curve (IV curve; see diagram), the peak-power voltage will change about -0.5 percent per degree C, and the module peak-power current will change very little with respect to temperature. Voltage is the primary temperature-dependent factor in the power equation.

For safety purposes and to meet code requirements, we need to determine how the open-circuit voltage and the short-circuit current vary. For silicon PV modules, the open-circuit voltage is an inverse function of temperature. As temperature decreases, open-circuit voltage increases at about 0.38 to 0.4 percent per degree C. At a module operating temperature of -40°C (-40°F), the open-circuit voltage may be 25 percent higher than the STC value.

Open-circuit voltage is only slightly influenced by irradiance. Obviously, in total darkness, the voltage output is zero. However, even in dim light (dusk, dawn, heavy clouds), the open-circuit voltage is very nearly the STC rated value. Direct sunlight does not have to be shining on the module for voltage to be on the output terminals. Current may be extremely low, but nearly full voltage can be expected in dim light. Thin film modules may have different characteristics, and the module manufacturer should be contacted for details.

The short-circuit current is a direct function of irradiance. Increase or decrease the irradiance by 20 percent and the short-circuit current changes by the same percentage and in the same direction. Short-circuit current also increases a slight amount as module temperature increases, but this effect is generally ignored in PV design.

With the irradiance and temperature variations addressed above, PV modules may be expected to have open-circuit voltages from about 15 percent below the STC value in hot, still weather to about 25 percent above the STC value in cold, windy weather. The short-circuit current may be 120 percent or more of the STC value on sunny, hot days, and that output may exist for three hours or more.

Addressing the Problem

Early PV module manufacturers, inverter manufacturers, Underwriters Laboratories (UL), and individuals involved with codes and standards recognized that these variations in temperature and irradiance from standard test conditions affect module output and must be addressed.

Excessive, unexpected voltages can cause arcing in switchgear and overcurrent devices, deterioration and breakdown of the insulation on conductors, and damage to electronic devices such as inverters, charge controllers, and the PV modules themselves. Higher than rated current can cause nuisance tripping of overcurrent devices, overheating of conductors, and the subsequent deterioration of the wiring as well as failed switchgear, electronic devices, and power relay contacts.

AC Is Easy; DC Is Tough

At this point, it should be noted that direct current (DC) is a very different beast than alternating current (AC). Alternating current, as the name implies, alternates its polarity or direction of electron flow 120 times per second in a 60 Hertz electrical system. To alternate the flow, the current becomes zero 120 times a second. When the current is zero, any arcs in switch contacts, circuit breaker contacts, or in melting fuse links are extinguished.

If an arc is visible in an AC circuit, the eye-to-brain filter makes it look continuous. In reality, it is extinguishing itself 120 times per second when the current is zero, and re-igniting 120 times per second as the voltage across the gap increases away from zero. This self-extinguishing feature of the AC arc makes it relatively easy for an AC-rated device to fully extinguish the arc and open the circuit. Typically AC-rated devices are simpler and cheaper than equivalent DC-rated devices.

DC electricity flows only in one direction in the conductor or in the arc that forms when a contact opens or a fuse link melts. The arc has no self-extinguishing capability, and the device must be capable of extinguishing the arc and opening the circuit without help from the arc. This imposes significant design complexities and costs on the DC-rated device. Since opening an AC circuit is easier than opening a DC circuit, many DC-rated devices also have AC ratings, but the opposite is not true.

Unlike AC-rated devices that have a nominal rated voltage, fuses, circuit breakers, and switches that are rated for DC have a voltage rating that is the absolute maximum value that can be applied to the device. Applying DC voltages higher than the rated value may cause the device to fail or to catch fire.

PV Fudge Factors

For the reasons stated above, the early PV pioneers developed mathematical tools to deal with the uncertain nature of the DC voltage and current. The following instructions are found in the documentation supplied with every listed PV module—everyone reads the manuals, don't they?

The rated short-circuit current (at STC, as marked on the back of the module) is to be multiplied by 125 percent to account for those bright, sunny days where the irradiance is above 1,000 W/m^2. This is done before any instructions or requirements in the *NEC* are implemented.

The rated open-circuit voltage (at STC, as marked on the back of the module) is to be multiplied by 125 percent to account for those bright, sunny and cold, windy days. This is also done before any instructions or requirements in the *NEC* are addressed.

Hazards Await the Uninformed

Now let's see what this means in just one aspect of a typical utility-interactive PV system. This example system uses six, 24 volt (nominal) modules connected through a DC disconnect to an 1,800 watt inverter. The peak-power voltage and the open-circuit voltage for each of the six modules at STC are 34 volts and 43 volts respectively. The PV array peak-power voltage is 6 x 34 = 204 volts, and the PV array open-circuit voltage is 6 x 43 = 258 volts.

Can a DC-rated disconnect with a voltage rating of 250 volts be used? The answer is *no* because the STC (25°C; 77°F) open-circuit voltage is 258 volts, and when the temperature drops below this mild value, the voltage will increase as noted above. It is quite possible that depending on the temperature and irradiance, a disconnect rated at 250 volts may be damaged when opened under these conditions. It most certainly would not pass the rigorous (multiple operations) testing required by Underwriters Laboratories at this higher-than-rated voltage, and could pose problems even in a less rigorous PV environment.

In my next column, I'll talk about how the PV industry influenced the *NEC* in a positive manner, and how UL has been lagging behind in modifying the PV module standards that affect what is written in the module instruction manuals.

Access

John C. Wiles, Southwest Technology Development Institute, New Mexico State University, Box 30,001/MSC 3 SOLAR, Las Cruces, NM 88003 • 505-646-6105 • Fax: 505-646-3841 • jwiles@nmsu.edu • www.nmsu.edu/~tdi

Sponsor: Sandia National Laboratories, Ward Bower, Department 6218, MS 0753, Albuquerque, NM 87185 • 505-844-5206 • Fax: 505-844-6541 • wibower@sandia.gov • www.sandia.gov/pv

National Renewable Energy Laboratories (NREL) solar data • http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/sum2/state.html

The 2002 *NEC* and the *NEC Handbook* are available from the National Fire Protection Association (NFPA), 11 Tracy Dr., Avon, MA 02322 • 800-344-3555 or 508-895-8300 • Fax: 800-593-6372 or 508-895-8301 • custserv@nfpa.org • www.nfpa.org

Zero Energy Homes

Don Loweburg

Recently, an acquaintance asked if I had read any of the anti-solar stuff on the Web. "Anti-solar?" I asked. Though aware of considerable online discussion about renewable energy, I was surprised that an anti-solar voice existed. How could anyone be anti-solar?

After some quick Web research, I found that, indeed, there is an anti-solar community out there. Presenting themselves as skeptics, members of this community are intent on debunking the "myth" of solar energy and renewables in general. Interestingly, they also dismiss the idea that conservation and efficiency can have a significant impact on our energy future. They believe that fossil fuels and nuclear energy are essential for our current and future energy usage.

I believe that there is a fundamental flaw in this position. That flaw is simple enough, and is based on the very human tendency to view the future in terms of the past. Our recent past, in terms of energy use, has been one of exponential increase. Thus, when the solar skeptics use numbers to prove that solar energy can't cover our needs, they do so by demonstrating that the low energy density of renewables cannot possibly supply the exponentially increasing energy needs of the future. I would agree, assuming their starting premise. However, the solar skeptics are presuming a "business as usual" approach to the future, and I assert that the future is anything but business as usual.

No Business as Usual

For a "no business as usual" view of the future, read Richard Heinberg's *The Party's Over.* Reviewed in my column in *HP96*, this book presents a profoundly different view of an energy future in which a declining "net energy returned per unit of energy invested" will lead to economic turmoil in all industrialized nations. In Heinberg's future, all sources of energy, renewable or not, will be increasingly expensive. And if industrial economies are significantly disrupted, renewables will have a strong role.

Forgetting for a moment both renewables and Heinberg's economic prediction, is the solar skeptics' implicit conclusion that society can continue to exponentially increase its energy consumption valid? Two serious constraints bear on this scenario.

If the supply of energy is to come from carbon, we must deal with global warming and the "greenhouse" effect. Put in a nutshell, society cannot expect to burn up and dump into the atmosphere carbon reserves sequestered from the environment during the last several hundred million years without significant consequences. Imagine what the climate was like back in the steamy, tropical, Carboniferous Age.

If we envision a future based on nuclear energy, the CO_2 issue is somewhat less important. However, neglecting the questions of nuclear waste, radiation, and containment (none of which are insignificant), there is still a fundamental problem associated with unlimited energy use. Based on physics and thermodynamics, all used energy eventually ends up as waste heat in the environment. This "heat death" postulated by physicists is a direct consequence of the Third Law of Thermodynamics.

Back on Track

I cannot prove what the future will be. However, like the readers of *Home Power*, I am committed to charting possibilities for a renewable energy future. This has taken the form of both intellectual inquiry and pragmatic action in my personal life, including living and operating a business off-grid using renewable energy.

Based on firsthand experience, it is clearly possible to live comfortably and productively while depending on renewable energy. In my home, we do this using about 10 KWH per day instead of the usual 20 to 40 KWH typical for central California. We use less because we need less, having designed and built our home to be very efficient, equipping it with energy efficient appliances.

Zero Energy Homes

Our experience is echoed by thousands of other off-grid residences. It is very clear that the groundbreaking efficiencies enjoyed by many off-gridders could also be realized at grid-connected locations. In support of this possibility, the Department of Energy (DOE) has adopted a program that promotes and demonstrates the synergies of highly efficient structures, efficient appliances, photo-voltaics, and solar thermal technologies applied to grid connected homes. The program is called Zero Energy Homes (ZEH).

ZEH focuses on two tasks. The first is to build, test, and document energy efficient homes that get most of their energy from PV and solar thermal systems. Backup energy is supplied by the local utility through a net metering interconnection. The Florida Solar Energy Center, in conjunction with the DOE, conducted a testing program using two structurally identical houses built in the same neighborhood. One house served as a control and was built and equipped using standard techniques and appliances. The other used the same floor plan, but adopted efficiency measures in the structure, high efficiency appliances, photovoltaics, and solar thermal systems.

The Florida Solar Energy Center (FSEC) set up and conducted the first test in the summer of 1998. The electricity bill for the ZEH that summer (one of the hottest on record in Florida) was just 18 percent of the control house. This dramatic result was achieved by using white reflective roofing that reduced the home's heat load so that the air conditioner could be downsized by 50 percent, eaves that shade the walls, and dual-pane, heat-blocking windows that further reduced the interior heat load. The thermal effectiveness of the concrete block wall construction (common to both homes) was enhanced by an additional R-10 insulation layer applied to the outside of the ZEH.

Inside the ZEH home, compact fluorescent lighting and Energy Star (high efficiency) appliances further reduced energy demand. On the roof, a 2 KW solar water heater and a 4 KW photovoltaic array produced enough energy to further reduce the home's utility electricity needs by a combined total of 82 percent. An overview of the project is available online (see Access). Other test sites have been set up in other climates to expand the understanding of ZEH.

The second objective of ZEH is to make this good data available to home builders and establish "building partners." Four teams have been established in three states—California, Arizona, and Nevada. The goal is to move from single demonstration projects into the new home market and build ZEH tract homes.

Beyond ZEH

The Florida test's zero energy home was intentionally built to be similar to surrounding homes except for the important energy features already mentioned. This makes sense, because the main focus was on comparing energy use and efficiency between the two test sites. But what we really need to do is couple sustainable energy with sustainable building practices and materials.

There have been and will be more great articles in *Home Power* on sustainable building methods and materials, including straw bale and rammed earth. There are also high performance building materials and systems using sustainable and recycled materials that have been developed for the conventional building industry. For example, Agriboard is a building panel made by sandwiching compressed straw between two layers of chipboard. These 8 inch (20 cm) thick panels have high structural value and almost an R-30 insulating value.

Another innovative product is hollow building blocks made of small amounts of cement to bind together recycled Styrofoam pellets. Common trade names are Rastra and Perform Wall. Walls are built using these blocks in the same way standard blocks are used. The blocks made of Styrofoam provide an insulating layer surrounding the concrete core of the wall, giving the kind of superior thermal performance documented in the Florida ZEH. These materials can be used in the commercial construction market to build ZEH homes that appear conventional, but provide high performance while using sustainable building materials.

The Path Ahead

For me it is clear that the present path of exponentially increasing energy use cannot persist. Given this understanding, there is no way the future can be "business as usual."

Those of us excited by the future see many possibilities for innovation in energy use and efficiency, sustainable building methods, renewable energy sources, and new inventions not even presently conceived. Rather than digging in and "proving" that solar doesn't work, I am committed to the possibilities of what does work. The real energy fraud is the implicit assumption that global energy use can continue to increase exponentially without limit!

Access

Don Loweburg, IPP, PO Box 231, North Fork, CA 93643 • 559-877-7080 • i2p@aol.com • www.i2p.org

Summary of the Florida ZEH project • www.eere.energy.gov/buildings/zeroenergy/pdfs/zeb_path_29915.pdf

Basics of ZEH program and list of team partners • www.eere.energy.gov/buildings/zeroenergy

Full Project Report of the Florida ZEH project • www.fsec.ucf.edu/bldg/pubs/cr1044/

Rastra and Perform Wall • Insulating block forms made from Styrofoam and cement • www.rastra.com • www.performwall.com • Sustainable building products

Agriboard • Structural building panels made from compressed straw • www.agriboard.com • Sustainable building products

Pass on Gas

Michael Welch

Some time ago, Calpine Corporation decided that they wanted to build a liquefied natural gas (LNG) terminal, storage facility, and an accompanying power plant somewhere on the West Coast. About two years ago, they determined that they would try to site the facility on Humboldt Bay in northwestern California. That's my backyard.

LNG is what is in most areas' utility gas lines, except that it's been chilled to the point that the gas becomes liquid, about -260°F (-162°C), and is stored and transported in huge, pressurized and insulated tanks. Liquefying makes larger amounts of gas storable in a given amount of space. Before it is put into our gas lines or used in power plants, it is regassified into its usable form.

LNG Industry Growth

As we started looking into this project and LNG in general, local activists were surprised to learn that Calpine's proposal is one small part of an industry that is trying to grow very quickly, and it is not immediately apparent why that is the case.

Huge energy and construction firms are proposing LNG facilities for nearly every U.S. port where they think they might have a fighting chance for approval, and even some where they don't. Halliburton, Shell, Bechtel, Calpine, ChevronTexaco, ConocoPhillips, BP, Sempra Energy, Mitsubishi, Dow Chemical, Marathon Oil, and more—it's like a who's who of petrochemical and resource extraction companies. There must be some serious money to be made. Shell is predicting that by 2012, the number of these facilities in the world may double to 32. I know that doesn't sound like very many, but these are big facilities, each with at least two, 13-plus-story tanks and gigantic LNG super-tankers docking on a regular basis. Calpine estimated two of these tankers per week in the proposed Humboldt Bay facility.

Plenty of Gas

Right now, there is a lot of unclaimed gas in Asia and in many Third World nations, and the glut is predicted to last for a long time. This is depressing the price of natural gas, which makes it financially worthwhile for companies to extract it, liquefy it, and ship it around the world to energy-thirsty areas like the U.S. and Europe where it commands a high price. Once it arrives at its destination, it is regassified and fed into existing and planned gas lines for use by consumers and the hundreds of new gas turbine power plants that are also planned.

At the same time, it looks like the (once considered vast) Canadian gas fields will be unable to keep up the level of production needed to slake U.S. thirst. According to the industry newsletter, *Anderson's Gas & Oil Connections*, U.S. Energy Secretary Abraham said that U.S. gas demand is expected to rise by half during the next twenty years; and Federal Reserve Chairman Alan Greenspan said that the U.S. must expand import capacity to avoid price swings that hurt the nation's companies.

So, what's the problem if we need it and they've got it? If only it were that simple and nice. Problems run the gamut from health and safety to the economic exploitation of the poor. Starting at the supply end, corporate bidding on gas in developing nations makes it more expensive in those countries, which keeps it out of the hands of those who can't afford the higher prices. Those countries would like to increase their industrial development to help get beyond poverty level and currently need the gas to do so. Yet the multinational corporations that control their supplies would rather sell into more lucrative markets.

Environmental Justice

Also at the supply end, most countries do not have the kind of environmental, health, and safety laws that exist in developed nations. Not only does this keep the price down, making gas more attractive to exporters, but it also has the potential for creating disastrous leaks and ensuing explosions. In January, a pipeline at an LNG plant in Skikda, Algeria, exploded, leaving at least thirty dead and more than a hundred injured. It is still unclear what really happened, but officials say they have ruled out a terrorist act. Those are the same industry officials that continued to claim it was a non-gas-related steam explosion until the truth finally came out from Algeria.

Terrorism is a considerable possibility—at the supply end, during transit, and at the delivery end. But at the supply end, mostly in Third World countries, fewer precautions are taken against these threats, so there is more risk in the producing nations.

However, the increased, post-9/11 security in the developed world, and especially in the U.S., presents another impact. The U.S. Coast Guard sets up exclusion zones around LNG super-tankers as they come into port, while they offload at dock, and as they leave again. In some cases, the exclusion zones disrupt other shipping and movement of smaller private, ferry, and fishing vessels.

Now with increased anti-terrorism security, the exclusion zones have grown in size to the point of being much more disruptive. In the case of Humboldt Bay, any exclusion zone would be larger than the Bay channel, even at pre-9/11 sizes. At two tankers per week minimum, with at least a full day each of berthing and maneuvering, that is a particularly harsh impact on a community that is reliant on tourism and commercial fishing.

Photo by U.S. Coast Guard

The U.S. Coast Guard patrols an exclusion zone around an LNG tanker while it docks.

Kaboom

The biggest fear in communities that are considering siting LNG facilities is the possibility of a fire from some sort of catastrophic failure. The liquefied gas is not flammable until it regasifies, and it takes energy to heat it to that point. So what happens in the event of a spill is that the outer edges of a release are warmed and slowly begin gasification. In the meantime, the liquid pools on top of the water and spreads out just as you might expect any other liquid petroleum product to do.

If a spark ignites the outer, regasified area of the release, an inferno ensues that is further fed by the fuel that is gasified by this new heat source. You end up with a long-burning, widespread flame that can only be fought if the release can be contained to a very small area—pretty hard to do if the pool is on a bay or in some other water port. Firefighters agree that not much can be done to put them out. You can say goodbye to anyone caught by such a conflagration.

Fight On

Seaport communities around the nation are having to fight these unsavory terminal siting plans. Many have been successful because the dangers involved make it easy to rally the public. All have learned from watching what has happened in other communities. The City of Long Beach, for example, made a serious mistake. Their community leaders thought the LNG terminal would be good for the city, and signed some preliminary agreements. They found out too late that they had given up some of their authority over the project. When they decided that they once again wanted to influence it, the applicant went over their heads to the industry-influenced Federal Energy Regulatory Commission (FERC). Now Long Beach's attorneys are fighting tooth and nail to regain some control over the project.

The Long Beach LNG terminal will, if the City is unsuccessful, be the first such facility on the West Coast. Another, offshore facility is moving forward near Oxnard, California. In total, seven West Coast projects were proposed, and all are under community protest.

Learn & Live

In Humboldt County, we were lucky to have watched what other communities went through. Vallejo, California, was successful in stopping a plant because they were smart enough not to sign anything until after feasibility studies had been completed. Here, Calpine wanted an agreement from the City of Eureka for exclusive rights to negotiate (ERTN) for the proposed property, and they wanted a memorandum of understanding from the county that committed to pursuing the feasibility study. For a while, it looked like the city and county were going to give them what they wanted, thinking they could still control the project.

The outraged public convinced the county government to hold off until the City of Eureka dealt with it. Then on March 16, the City of Eureka held a meeting to take public comment on Calpine's requested ERTN. Local organizers had been working hard to inform and educate the public, and then to mobilize folks to attend this meeting.

More than 1,500 people showed up at the meeting, according to a local paper. Sentiment against the plant was huge, and most people were against any negotiation with Calpine at all. One speaker likened Calpine's proposal to "coming home to find a 300 pound gorilla in the living room. You don't need a feasibility study to know if it fits, and you don't even need a desirability study to know if it is wanted. You just want it the hell out of there!" Other speakers suggested that Humboldt County could become a region where large scale renewable energy is welcome, including the installation of commercial wind generators at the proposed LNG terminal site.

Sweet Success

Calpine got the picture, even if the too-easily-influenced politicians didn't. The next day, Calpine sent a letter to the city that said, "We regret to inform you that we are withdrawing our request for an exclusive right to negotiate (ERTN) agreement for the LNG project, and are ceasing all development activities on the project as of today. It is the policy of Calpine not to build projects in areas where there is insufficient community support. Based on feedback received from the local community and public officials, we feel this decision is best for all parties."

Our coalition and community were inspired and instructed by watching what other communities with proposed LNG facilities were doing. We hope our victory is as helpful to others.

Now our coalition is ready to move on to the next project. We really want to find a permanent, nonindustrial solution for the environmentally fragile site that was being considered for this project. And you can bet we will be tapping into the vast community interest revealed by the LNG fight as other nonrenewable projects show up on our doorstep.

Access

Michael Welch, c/o Redwood Alliance, PO Box 293, Arcata, CA 95518 • 707-822-7884 • michael.welch@homepower.com • www.redwoodalliance.org

Humboldt Bay, California LNG info • www.LNGwatch.com

Long Beach, California LNG info • www.lbreport.com/reference/reflng.htm

Efficiency—

Ratio of Energy Out to Energy In

Ian Woofenden

Derivation: From Latin efficere*, to effect.*

In terms of energy generation and use, "efficiency" is the ratio of energy input to energy output. If I put ten units of energy into a device and only get seven units of useful work out, the device is 70 percent efficient. This means that 30 percent of the input energy is lost. This "loss" is usually waste heat.

Losses are inherent in any transfer and use of energy. The goal is to keep these losses to a minimum. But concern about efficiency may vary depending on what sources of energy we're talking about, and what devices.

In the case of solar-electric modules, the quest for higher efficiency sometimes seems a bit misplaced. Sure, we'd all love very efficient modules, and progress in this area of technological development is welcome. But we're dealing with a free and abundant resource—sunshine. It's not as if we're wasting sunlight by not converting it to electricity more efficiently.

What's needed most with PV development is lower cost. If given the choice between cheaper PV modules and more efficient PV modules, I'd take the cheaper ones (assuming the same warranty). Less efficient modules do take up more space on your roof, and require more racking structure. But the fact that today's best mass-market solar-electric panels are "only" about 15 percent efficient is not something to lose sleep over.

It's a similar story with wind turbines. Sure, we want very efficient blades and alternators. But as long as you site your wind generator properly, it will have no shortage of wind, which blows by at no charge. A higher priority is to make durable, long-lasting turbines that we can afford.

The situation is a bit different with hydro turbines, at least in most cases. Often, hydro system owners have a limited amount of head (vertical drop) and usable flow, the two ingredients that make hydro-electricity. So it's important to make the most of the resource. By increasing the efficiency of the turbine, you can make more electricity from the same resource. With sun and wind, you can always make your array or wind turbine larger to catch more of the free and abundant resource. With a hydro turbine, it's the resource that is limited.

Once you've generated the renewable electricity, efficiency becomes *very* important. Renewably generated electricity is not cheap. It makes no sense to waste it with inefficient balance of systems (BOS) components or with inefficient loads.

Batteries are essential in virtually all off-grid RE systems. But there is an efficiency cost. For new batteries, we generally assume that 10 to 20 percent of the energy put into a battery is lost in the electrochemical energy conversion process. That's the price off-grid folks pay for needing energy when they aren't making any. Improvements in storage efficiency would be very welcome, though again, at what cost?

Inverter efficiency varies depending on the load on the inverter and can range from really poor (say, 50%) to quite good (95%). Remember that inverter manufacturers like to advertise the *peak* efficiency, but actual efficiency spans a wide range, depending on the level of energy usage. I've seen battery-based, grid-tie PV systems in which the inverter/battery system eats up 40 percent of the production!

Charge controllers have an efficiency penalty too. You just can't do much with electricity without paying an energy price. But these percentages are generally minor with modern charge controllers, which are typically better than 95 percent efficient.

With all the BOS components, we're looking for electricity out compared to electricity in. With loads, the output takes different forms. We put electricity into a lightbulb and we want light out. Inefficiency takes the form of heat, something we aren't looking for from a lightbulb. An incandescent lightbulb, for instance, is a fairly efficient heater, but a very inefficient source of light. Compact fluorescent bulbs, on the other hand, give the same amount of light for one-third to one-quarter of the energy input of incandescents. Much less energy is wasted in heat.

Every load in your home can have high or low efficiency. Your pump may pump more water per kilowatt-hour of electricity than your neighbor's pump. Your washing machine may use more electricity to wash that load of jeans. Choosing efficient appliances is critical to making the most of your energy, whether you buy it from a utility or make it yourself. See the fine publications of the American Council for an Energy Efficient Economy (www.aceee.org) for information on choosing efficient appliances.

There's still a cost vs. efficiency balancing act with appliances, but the closer you get to the end use, the more important efficiency is. If you use incandescent bulbs instead of compact fluorescents, you'll be spending three to five times as much on solar-electric modules to power them.

Efficiency at the appliance end is much more important than at the generating end of the system, and money invested there will do the most good for your pocketbook and for the environment.

Inefficiencies in a system don't just add up, they multiply. If you use four times the energy to do the work, you'll have four times the losses in the conversion process. Your generating sources will have to make more energy for your inefficient loads, multiplied by the inefficiency of all the conversion components.

So another way to look at efficiency is that the most efficient use of your *own* time, money, and energy is to invest in making your system and loads more energy efficient. This effort put in will be rewarded with increased functionality coming out, at lower cost in the long run.

Access

Ian Woofenden, PO Box 1001, Anacortes, WA 98221 • ian.woofenden@homepower.com

The Chicken House of Mystery

Kathleen Jarschke-Schultze

Chickens walk backwards. Eggs roll uphill. No, nothing like that. Although I am not a carpenter-type, I love to build things. It took me two years to build a chicken coop. I planned, designed, and built it myself. I thought my design would be easy for a novice to build.

Best Laid Plan

The design uses 4 by 8 foot (1.2 x 2.4 m) sheets of 1/2 inch (13 mm) plywood, without cutting them. So the chicken house is 4 feet wide, 8 feet tall, and 8 feet long. It has a ceiling made from a single sheet of plywood. I figured that by using these dimensions, I would avoid having to make a lot of cuts with a saw. I am absolutely no good at cutting straight lines—not with a handsaw, a circular saw, nor with a jigsaw.

Attached to the chicken house is an 8 by 8 foot varmint-proof chicken run made out of chicken wire. A corrugated metal roof covers both the structure and the pen. For the roof supports, I sank 12 foot (3.7 m), pressure-treated 4 by 4s, 2 feet (0.6 m) down into concrete. I figured the roof pitch from the 10 foot (3 m) height at the end of the chicken run to the 8 foot (2.4 m) level of the chicken house would be enough to shed water and snow.

I planned to have an attached nest box at the back of the coop. That way I could collect eggs without having to enter the coop. I bought 16 foot (4.9 m) joists for supporting the roof, figuring there would be enough of an overhang at the coop to cover the protruding nest boxes and protect them from the rain and snow.

I placed the chicken coop right next to our garden. We have a 6 foot (1.8 m) tall fence around our garden to keep the deer out. I wanted a chicken "tunnel" from the coop into the garden. That way the chickens could enjoy the freedom of ranging in the garden during the seasons when we were not actively gardening.

For my chicken dream house, I wanted a door into the wire chicken run. I also wanted a separate door (for people) into the plywood chicken house. The door into the house had to be accessible without having to enter the run. This meant I needed another door for the chickens to get from the house to the run—a door that I could open and close from the outside. That way I could clean the run or the house with the chickens in or out, as I preferred. I figured I had thought of everything.

House of Mystery

I call it the House of Mystery for several reasons. First, there is not a square corner in the whole building. I tried, and I really tried, but accurate measuring evaded me. I actually (and this is true, I swear) measured a board and cut it three different times, and it was *still too short.* I had to use it in another place. When I build, jokes come true.

I planned for the 16 foot roof joists to give me a 3 foot (0.9 m) overhang at the bottom of the pitch. This did not happen. The pitch ate up some length (who knew?), and the protruding nest box gets the full brunt of the rainwater falling from the roof. This winter, I stapled tarpaper over the nest box lid to fend off the water.

My friend, who has asked that his name not be associated with the Chicken House of Mystery, came to help me put on the metal roofing. I hate heights. I don't even like being up on a ladder. So Friend came to put the roof on.

He saw that I had built with every board straight up and down—no bracing whatsoever. He kind of freaked out and spent a good part of the morning cutting and attaching cross bracing throughout the structure. When he felt it was safe, he climbed up and attached the roof tin for me.

Friend placed the tin panels in straight lines along the roof rafters, overlapping them by one corrugation, starting at one side of the roof and finishing at the other. Because the building is not square, when he came to the last bit of roof, the straight-sided panel did not cover the whole roof of the cockeyed chicken house. There was a wedge-shaped gap that was 5 inches (13 cm) across at the widest part.

After Friend left, I cut a wedge of old greenhouse fiberglass to overlap the tin and cover the gap. I stood at the top of our fruit ladder to attach it, and I was terrified. Frankly, between my lack of carpentry skills and my fear of heights, it's a mystery how I finished this project to the extent that I have.

The Poultry Palace

My coop began to get a little personality. I cut a crooked opening in the back of the chicken house, and used the piece I cut out to make a crooked door. It fit perfectly. I bought some old glass doorknobs at a yard sale, and I used those on the door.

Above the nest boxes, I incorporated a small, old, stained glass window. Above that, I framed in the bathroom window that we had replaced with a double-paned one in our house years ago. In the summer, I can open it to ventilate the chicken house. I covered the window opening with quarter-inch hardware cloth. The cut piece fits just where a screen would. I bought a gallon of paint for US$5 because it was tinted wrong. So the Palace is dark green now.

A good deal of my enjoyment of building comes from trying to use as few new parts as possible. Used hinges, doors, windows, latches, scraps of plywood, and 2 by 4s all found their way into my architectural creation. Here is something I learned a long time ago though—new chicken wire is worth the cost. You can never get old, used, bent chicken wire back into usable condition.

We had an old glass door from a broken-down greenhouse, and I used that for the door to the run. That was an easy door to attach. I made a small chicken door, attached eyebolts at the top, and strung them through with antenna rope. I used deck screws to attach some scraps of plywood next to the opening. The door uses these plywood rails as guides. By pulling the rope, I can raise and lower the door hatch from outside the coop.

My sister gave me an old wooden ironing board in a cabinet. I attached it to the wall inside the chicken run. I leave a knife out there on top of the cabinet. So now I can take garden debris into the coop, lower the wooden ironing board to a comfortable height, and chop it into chicken food. Boy, is that handy.

For the chicken tunnel, I took a square tomato cage and wrapped it twice over with 1 inch (2.5 cm) chicken wire. I secured a piece of plywood on the bottom of the chicken wire wall facing the garden. I cut a not-too-crooked door the size of the tunnel opening in the plywood. With hinges attached at the bottom of the cut-out piece, it became a little ramp into the tunnel. When I close the ramp, it has a spring-loaded hook and eye at the top to secure it. I am very proud of the tunnel. It works quite well.

The roosting poles are attached diagonally in one corner of the chicken house. There are four roosts, each progressively shorter and higher. I spread cedar shavings in the nest boxes and the floor of the chicken house. Then when I clean out the coop poop, it all goes right into my homemade, rotating barrel composter.

The Chickens

I got my first three chickens from a friend. They were a big rooster, Elvis, and his two young protégés, Priscilla and Penny. I had them for a while when Priscilla succumbed to MCD—better known in novice circles as Mystery Chicken Death.

So I got chicks at the local feed store and raised them. Even when the chicks got to be adolescents, Elvis and Evil Penny would not tolerate them. There was much pecking and attacking whenever I tried to mix them. The attacks happened even if I introduced just Elvis or just Evil Penny.

I sent Elvis and Evil Penny into exile at my father's house. I heard that Evil Penny had died and now, two years later, Elvis lies around the yard in the sun with his two dog buddies, Old Peter and Daisy. My father swears Elvis is a dog with feathers.

Kathleen's Chicken House of Mystery.

Two of my remaining hens died—one from MCD, and one from DOG. The less said here, the better. I saw an ad for laying hens, so I bought some. They were adolescents when I got them. Several turned out to be roosters, so now I have the Three Amigos. For a while, I had only two hens and the three roosters.

This spring, I saw another ad for laying hens. I called and explained that I only wanted laying hens. I had more than enough roosters. I did not want to raise chicks and have more roosters. The woman explained that the hens she was selling were pullets. A pullet is a chicken that has just started laying and has not reached its first molt (feather shedding). Perfect. I got eight Red Leghorn pullets.

Simple Pleasures

I still have some fine-tuning to do on the Chicken House of Mystery. My chickens do not seem to mind though. I have fashioned a chicken courtyard outside the tunnel so we can garden unmolested. I get plenty of eggs now, with enough surplus to sell a dozen a week to my neighbors.

My biggest rooster, Simon, is getting a bit pushy, so there may be a coq au vin in his future. Even though they have tiny putty brains, I really like chickens. You know, I once did see one of my chickens walking backwards.

Access

Kathleen Jarschke-Schultze is composting chicken manure and eating homegrown eggs at her home in Northernmost California. c/o *Home Power* magazine, PO Box 520, Ashland, OR 97520 •
kathleen.jarschke-schultze@homepower.com

Errata

The rating of the array disconnect in the Tech Specs sidebar on page 47 in HP100 *was incorrectly listed as 250 VDC. The correct rating is 600 VDC when wired to break the DC load twice, as was done in this system.*

Oops!

On page 126 of *HP100*, you have a lovely diagram illustrating Perihelion and Aphelion. It states that Perihelion is 147.5 million *miles* and Aphelion is 152.6 million *miles.* Even if this glaring mislabeling was not immediately noticed by your readers, the avid *Home Power* reader would note that on page 71 of the same issue, Bob Yoesle stated the sun's distance from the earth is "about 92.8 million *miles.*"

Further reading of Bob's article clarifies the apparent discrepancy. Bob says, "about 92.8 million miles or 150 million km." Oops—the illustration on page 126 should have been labeled Perihelion is 147.5 *kilometers* and Aphelion is 152.6 *kilometers.*

Other than that minor and humorous oops, I love *Home Power!* Your magazine has lead me and my wife from vague lack of knowledge a few years ago to moving into our own off-grid, passive/active solar home later this month. Keep up the great work. Grey Chisholm, Madrid, New Mexico • GreyChis@who.net

Hi Grey, Thanks to you and others (including Bob Yoesle) for pointing out our labeling error. To err is human; to admit it means you better not run for president. Our apologies. The HP *crew*

Advancing RE

I just picked up the 100th issue of *HP* at the library and had to rummage through the attic. I found the first one I got, *HP3.* Wow, what a change! That old newsprint magazine with a handful of pages and a smaller handful of advertisers was a godsend when I found it, back when we were putting our RE system together. Put them side by side, and imagine what our national energy systems would look like if they had advanced at the same pace *HP* has! Good work, folks! Jim Sluyter • csafarm@jackpine.com

Remodeling Queries

Hi all, I recently purchased my first edition of *Home Power, HP99.* I was very impressed with the amount and the broad spectrum of information covered. My family and I live in San Jose, California, and we are beginning the process of either remodeling our home or building a new one. I am very interested in integrating a grid-tied photovoltaic system without batteries into the design and construction of our home. The front of our home faces east, so I'm hoping that I can maximize the use of my roof area by installing PV panels on the east, south, and west sides of the roof. I'm hoping that I will be able to locate an architect who is familiar with PV systems, but any additional help and advice is greatly appreciated.

At a recent home and garden show, I discovered solar shingles and was very intrigued with this concept. Being a licensed electrician and living in an earthquake prone area, I was a little concerned about the number of connections that would be required and the increased probability of a bad connection or having one disconnect because of an earthquake and then having fun in trying to locate it.

I would like to integrate the support structure for the PV panels into the installation of the roof tiles. I hope I can use roof tiles that have a longer life than the PV panels. My professional experience is in the UPS and 48 volt DC power field. I have no solar or grid-tied equipment experience. My apologizes if this topic has been discussed in past issues, but any help, information, personal experiences, and advice would be greatly appreciated in helping me integrate PV into the design of our home. Sincerely, Stan Argiris • icehawk@ix.netcom.com

Hi Stan, I strongly recommend you begin working right away with a local, reputable installing dealer of RE equipment. He or she will be able to lead you and your architect in the right direction in each of your concerns. There are a number of excellent RE companies in the Bay Area. Check our RE Directory on the Web site, and our new directory of installers in the back of the magazine.

As for architectural design, the larger you can make the south-facing roof, the better. While good amounts of energy can be obtained by mounting arrays facing east and west, south is the best choice to maximize your KWH/cost ratio. One thing you do not mention is solar hot water. This should be considered, for sure. Many folks find that solar H_2O, sometimes combined with hydronic heating as well as domestic hot water, will pay off much faster than PV.

I agree with your thoughts about the PV shingles. Connections, cost, and unknown longevity are real factors in such a choice. Tiles are a good choice for the roof system under your PV panels. In fact, special PV mounting brackets are made for just this type of installation. But once again, you should consult with your installer and dealer before choosing. Good luck with your RE project, and remember to take plenty of notes and photos for your Home Power *article! Michael Welch • michael.welch@homepower.com*

Embodied Energy

Dear Editor, In the natural building article in *HP99*, there is a table indicating embedded energy values for various natural building materials. I see that straw bales are listed as having the lowest embedded energy—lower even than earth! I am curious to know how the authors compiled this information, and I am dubious that the value for straw is correct when the true cost of the material is considered.

The vast majority of straw available in industrial nations such as the U.S. is the product of an incredibly energy (and chemical) intensive, soil and ecosystem-destroying, completely fossil fuel dependent mechanized agricultural process. Have all these costs in production of straw bales been factored in to the embedded energy value listed for straw? How about transportation costs when straw bales are not a local resource?

Straw bales are one of a variety of alternative building materials. It is important that natural builders and natural building advocates tell the whole truth about the costs of materials they use and recommend. If the high ecological costs of industrial agriculture are not included in the embedded energy calculations for straw bales, we are only cheating ourselves. Sincerely, John Schinnerer • john@eco-living.net

Hello John, You bring up some excellent points that stress the difficulty in calculating embodied energy of building materials. The embodied energy coefficients we mentioned in the article are based on a 1983 study conducted by the New Zealand Energy Research and Development Committee, updated in 1997 by the Building Research Association of New Zealand. This study has long been used worldwide as a reference document on embodied energy. Nevertheless, estimates of embodied energy can vary greatly depending on how the assessment is done. While straw bales are inherently low in embodied energy, as you point out, most have been sprayed with fertilizers and pesticides, produced by fossil-fueled machinery, tied together by plastic twine, and may end up being transported over hundreds of kilometers. This can add significant amounts of embodied energy to what is a fundamentally low energy material.

However, in the United States each year, more than 200 million tons of waste *straw is produced. Since straw is a waste product that cannot be used for feed like hay, much of it is burned at the end of the season. Some researchers do not to include the embodied energy of the production and cultivation of straw, since straw is just a by-product of the primary plant. It's similar to not including the embodied energy of the manufacture of tires in an Earthship, since the tires are being recycled. We also must remember that the burning of waste straw emits large amounts of carbon monoxide and nitrous oxide into the air. Using straw bales reduces the poisonous gases in the air. Also, the straw left over from building can be used as mulch so that, overall, there is minimal real waste from using the material.*

The reason that the embodied energy of straw bales is lower than that of the earthen technologies is the fact that (assuming the straw is grown relatively locally) earth takes a lot of energy to move. It also requires energy to press into blocks or ram into forms. Also rammed earth is often stabilized with cement, a very high embodied-energy material. For information on how the New Zealand organizations came up with the embodied energy coefficients, you can download their report at www.arch.vuw.ac.nz/cbpr/embodied_energy/files/1995.pdf

Keep in mind that figures often quoted for embodied energy are broad guidelines only, and should not be taken as exact. What is important to consider are the relative relationships. Try to use materials that have a lower environmental impact, and work best for your location, climate, and needs. The bottom line is, it's hard to argue that both earth and straw aren't among the greenest of building materials. Laurie Stone, Solar Energy International

Getting Started in the RE Business

The purpose of this letter is to seek out information on how to get started in the renewable energy business. I have always been interested in alternative energy sources, and would like to have my own business some day. I assume that I'll need to work with a licensed contractor for a few years before starting out on my own. However, my question is more specific. What are the steps in the process of going from novice to contractor? Also, what experiences can one use toward that goal of being an RE contractor? For example, my father had his own electrical contracting business, and I worked for him until I started high school. I worked as an electronic technician for more than ten years after high school. While working as a technician, I attended the university and earned a BSEE degree. How much of this experience could I use?

I would appreciate any information or links to information about starting an RE contracting business. I think it is important that we try to make people aware of RE alternatives to coal-fired power. Thank you and have a great day. Bob Norstebon • bnorstebon@yahoo.com

Hi Bob, It sounds to me like you are already well on your way. Each state has different requirements for electrical contractors. My state has a separate category for solar-electric contractors. You may already have enough or part of the experience needed to get your contractor's license, and certainly working as an electrician with your dad should help quite a bit. Often when a novice electrician-wannabe contacts me, I will recommend community college home wiring courses as a starting point, but it seems to me you are already beyond that point.

So the next step would be to get training specific to our industry, and I highly recommend either Solar Energy International (www.solarenergy.org) or the Midwest Renewable Energy Association (www.the-mrea.org). There are also some schools out there, like San Juan College (www.sanjuancollege.edu) and Appalachian State Univ. (www.tec.appstate.edu). Check our RE Events pages for more workshops. You should also see Richard Perez's column in HP89 *about working in the industry. Michael Welch • michael.welch@homepower.com*

Edison & Westinghouse

Hello *Home Power* crew, May I start by saying that I love the mag and all that other patting you on the back stuff. I read with pleasure your *Independent Power Providers* column in *HP99*. Local, or distributed, generation was Edison's thought when he first started producing electricity use and generation products. It was Westinghouse who fought for central generation and long distance transmission of electricity. This was due to the nature of each system. DC does not lend itself to long transmission runs and is better produced locally, whereas AC can be transmitted over vast distances with ease. These two men battled over what system was better for the public.

A classic example of this battle was over which system should be used for the execution of prisoners in the electric chair! A lengthy court battle was fought, with each man portraying his system as safer, and stating that the other's should be used. Westinghouse would *not* provide the generator to be used on such an inhumane piece of equipment. Edison eventually lost the battle and Westinghouse reigned supreme, although his win may have been due to his associations with big business and government. It is my belief that Edison had it right. If we had followed his ideas, we would have been able to adopt renewables sooner and not be where we are today. An article on these two men and their associations would be a great read! Regards, Matt Elder, Toronto, Ontario, Canada • matthewe@ca.ibm.com

Hi Matt, Thanks for the compliments. It would be cool to publish a short history of the grid, including the Edison vs. Westinghouse story, though it is just a bit far afield from the kind of articles we usually publish. How about it, readers, anyone up for writing this piece? Michael Welch • michael.welch@homepower.com

Congratulations on #100!

Hi, Just wanted to congratulate *Home Power* for your first 100 issues. *HP* has been a great reference, before, during, and after installing my home power system. As a matter of fact, I'm using your article on RE myths in my lecture about renewable energy next week! Thanks, Bill Coburn • wcoburn@clemson.edu

Financing RE Homes

Dear *Home Power*, I just ran across your Web site while in search of some information. My wife and I are considering the feasibility of purchasing property where we would build an off-grid home. What construction loan financing options are available? If all works out, our plan is to begin with an LP-powered generator and a bank of batteries, and as finances allow, migrate to PV panels and a wind generator. So far we are learning that the local mortgage lenders are not comfortable (that's an understatement!) with this type of construction. Thanks in advance for your assistance! Sincerely, Eric and Raquel Mead, Duluth, Minnesota

Hi Eric & Raquel. We are working on an article about RE home and system financing. Many conventional loan companies accept the use of a generator as normal, but I am not so sure what they will think of those batteries. You might be better off financing the entire PV system with your construction loan.

I usually recommend that folks take a look at local institutions, like credit unions and local banks or savings and loans. They can often add the personal touch and make loans on projects outside of the norm. There are also federal programs developed through Million Solar Roofs that can add extra amounts into conventional mortgages. Check them out under loan programs at www.dsireusa.org. Michael Welch • michael.welch@homepower.com

PV Mathematics

Greetings, I just started receiving your magazine, and I guess I need a bit of a refresher on electricity. When a unit such as a PV panel is rated for 120 watts and 24 volts, how many watts does it produce that I can actually use in my home (running on the standard 120 volts)? I calculate 5 watts per hour, which doesn't seem like nearly enough, even in a multiple array, to be able to cover the electricity needs for a house or to be anywhere near financially viable compared to utility electricity.

I'm a residential designer trying to convince my clients to use more home-based, renewable energy sources. Could you publish (or send me) a brief primer explaining the basics of such systems (with calculations) so I can better understand and compare systems described in your regular articles? Thanks, Jeff Haines • hainesfour@yahoo.com PS—Most of my family is trying to get ahold of my magazine to read it when I'm done, so clearly, it's valuable and captivating reading.

Hi Jeff, You're a bit mixed up in your calculations, so you're getting bad answers. Watts are watts, no matter what the voltage. So in a perfect world, with no inefficiency, a 120 watt, 12 volt PV module in full sun for one hour will run a 120 watt, 120 volt AC lightbulb for one hour. See Michael's response below for the real world reality, but it's good to get off on the right foot with the math. The module in my example above will have generated 120 watt-hours in that hour. If the sun shines for ten hours, it will generate 1,200 watt-hours (1.2 kilowatt-hours). "Watts" is a measure of energy generating capacity or instantaneous usage. "Watt-hours" is a measure of energy generated or used. Ian Woofenden • ian.woofenden@homepower.com

Hi Jeff, There are three major factors involved (but lots of others that also need to be determined too): 1. Size of array. 2. Amount of sun available. 3. Efficiency of system. For a 100 percent efficient system, you would multiply the array size in watts times the number of average peak sun hours. So, in my neighborhood for a 1,000 watt system: 1,000 x 4 hours of sun equals 4 kilowatt-hours per day average.

No system is perfectly efficient. For a batteryless, utility-intertie system, you can figure on about 70 to 75 percent efficiency (ballpark), which would bring my example system down to about 2.9 KWH per day average. A battery-based system will add even more inefficiency, all depending on the size and your usage. For a lot of info related to the rest of your concerns, see the article on investing in a solar-electric home in HP100.

But also remember that the cheapest energy is energy that never needs to be produced, so cut back on usage where possible. For every dollar spent on increasing efficiency and conservation, you will save three to five dollars on the cost of your solar-electric system. Michael Welch • michael.welch@homepower.com

Energy Use of Computers

Hi Joe, I called Apple looking to answer this question, then Real Goods and Backwoods, and finally got routed to you. You guys use Macs there, I understand. I'm running an iMac with a 700 MHz processor and a 15 inch CRT screen, and it's eating energy like a hungry teenager. I'm a journalist and the computer is on for eight hours a day, and probably four or five of that time it's asleep. Do you know what the electrical draw might be for this unit? We've got to do something about the draw, and I'm thinking about replacing it with a newer 15 inch iMac with a gig processor, G4, and the flat screen. Question is, roughly what will this represent in the net power differential between the two models? Cut it by half to 75 watts? Thanks much if you can be of any help. Rob Lyon • rob@lyonexpeditions.com

Hello Rob, We have an older 15 inch CRT iMac, 500 MHz processor, and it draws 87 watts running and 32 watts in sleep mode. We have a 17 inch LCD iMac, 800 MHz processor, which draws 45 watts running and 4 watts in sleep mode. I run a 15 inch LCD Mac Powerbook, 1 GHz processor, which draws 24 watts running and 3 watts in sleep mode. Laptops are almost always the best option when it comes to low energy consumption. They also have a built-in uninterruptible power supply (UPS)—the laptop's battery—to keep you running when the grid isn't. Best, Joe Schwartz • joe.schwartz@homepower.com

Fuse Sizing

Dear Editors, I agree with Joe Schwartz's fuse suggestions in *HP100*, page 138, in response to Tim Maxwell's letter "Fuse Sizing & Placement." But I think more needs to be said about sizing. Whatever its measured amperage, any alternating current periodically becomes zero. The current alternates from one direction to the other. When current is zero, any spark inside a blown fuse will extinguish itself. This means a faulty alternating current is relatively easy to shut down, since it's normally stopped part of the time anyway.

Confusingly, DC fuses carry two different ratings. I'm looking at one right now labeled both "10 A" and "10 kA." Perhaps the "multi-thousand amp" fuse rating Tim was looking at was the AIC or "amps interrupting current" rating, not the blow rating.

In DC circuits, if a fuse blows, its melted parts may well continue to carry a current. If a current is large enough, it won't stop merely on account of the fuse blowing. A DC fuse has to be designed to not only blow, but to fall apart with a large internal gap, to stop further activity. The initial blow rating of a DC fuse or circuit breaker might be 20 amps, but the same fuse might carry a 10,000 AIC rating. This means that the fuse will blow when subjected to 20 amps for a short while, but having done so, the fuse will not support an internal arc, if the current that blew it was less than 10,000 amps.

On Tim's other point, as to which way electrons flow, it depends on which college you went to. When I was at Georgia Tech, we learned that the fellows at Purdue had current figured out all backwards. One school thought that the plus terminal signified a high voltage potential just swarming with electrons ready to leap forth at the first hint of a complete circuit. The other school thought that since electrons were negatively charged, they hung around the minus pole of a battery, and disembogued [*Ed: That's college-ese for "boogied."*] from there. I forget now which school was which, since it doesn't matter from the standpoint of circuit analysis, or energy flow, or anything else. Take your pick. Hope this helps, Joel Chinkes • solarbozo@escapees.com

Community Question

I have only recently subscribed to *Home Power* magazine. However, I have had a desire for most of my adult life to be more self-reliant and to live a more environmentally aware and less impacting lifestyle. I have only thought about that lifestyle, and tried to keep up with the technology that would allow me to live it, over the past twenty years or so. I now have the freedom to make that desire a reality. I am writing to you to start a process of learning and discovery that I hope will lead to a more fulfilling and self-reliant way of life.

For a little background, let me say that I am about five years out from retirement. I am a landscape architect and I have worked most of my career for one government agency or another doing design, planning, and environmental work. I thought that I was doing something worthwhile—now I know better. I am not a survivalist, back-to-the-lander or New Age crystal collector, although I can understand why those groups have become what they are. I believe I have the skills to make a part of a self-reliant lifestyle work. I can do basic framing and finish carpentry, I understand single-phase electrical residential wiring, basic plumbing, general agriculture, and I have skills in site design and construction. I plan to build my own home. Also, I can still read and learn. With thought, more education, and some experimentation, I believe I could go off-grid without trauma and I believe that I would have a better life than I have now living on my 3.5 all-electric acres.

The reason I am writing to you is that my plan involves finding other people who want the same thing—a self-reliant life insulated from the impacts of decisions made by others. I am at a loss in this regard. I am not interested in being a hermit, nor do I seek a communal living arrangement. What I am interested in doing is forming or helping to form a land cooperative or intentional community where people like myself can join together, pool our financial resources and our skills to purchase a large block of land and build a community based on self-reliance, respect for nature and each other, and cooperation.

I had hoped to return to Oregon to work on this idea, but I may have to remain here in Arkansas because of the cost of living in Oregon. And I don't have enough time to fix up and sell several more houses before I can retire. Time waits for no man. But the Ozarks of northwest Arkansas are very beautiful, and land is still fairly inexpensive, so it makes sense to look here as well.

Can you point me to any organizations, movements, or groups that might assist in making this rather drafty plan come together? I know about cohousing, and there are some intentional communities here and in Oregon, but none fit the pattern that I have set out. I had hoped, since you and your publication seem to be in the forefront of what I believe will be a substantial movement away from centralized energy, that you might have some suggestions. If you do, I would very much like to hear them. Thanks for listening. Hope to hear from you soon. Robert Flowers, Royal, Arkansas • rkmousie@juno.com

Hi Robert, One resource you should check out is Communities *magazine, an* HP *advertiser. I think the answer to your dream is to start networking to find kindred spirits. Best of luck, and keep us posted on your progress. Ian Woofenden • ian.woofenden@homepower.com*

Tanks & Pumps

Hi *Home Power*, Thanks for the great magazine. I've been reading every issue for a couple of years now and have enjoyed every one. I have two things on my mind. First, I have a simple solar hot water system I installed on my house that I have a question about. I live in Florida, so I don't have to deal with antifreeze or heat exchangers. My system uses a solar powered "el Sid" pump to circulate water right out of my standard 40 gallon gas heater (which I usually leave off) to two collectors on the roof. It has been on-line since last September. I was pleased that it continued to provide me with ample hot water up to mid-November when the sun got too low to clear the trees. I was able to go back on-line with it February 15th, which was not bad.

As you may have guessed by now, all is great except I could use more storage. My tank is hot by 11 AM, and then the hot water just goes 'round and 'round. If we use much hot water in the evening, it starts to run a little cool. I thought of getting another 40 gallon electric heater (which is cheap) and putting it in series with my existing system. Well, it sounds easy enough, but when I started drawing it out on paper and dealing with all the ins and outs and factoring in the cold sides and the hot sides, it got real complicated! Has there ever been an article where this was done? Is it possible?

The other thing I wanted to get off my chest is the high price of some renewable energy equipment. If we are to have success in persuading the general public to use RE, the prices must be somewhat reasonable. One item in particular is the "el Sid" pump I mentioned earlier. I shopped many suppliers and could do no better than $200! I could not believe the cost of this little pump that you can hold in the palm of your hand. I even took it apart and looked inside for some super high tech, gold-plated parts. I didn't see anything worth that kind of money! This thing should have cost $60 to $80 max. What gives? Tom Wechter • thomaswechter@aol.com

Tom, putting a solar storage tank in series, upstream of a water heater is fairly simple. You are right about using a conventional electric water heater as a solar storage tank. Just ignore the elements. Typically, your cold water feed would go into the storage tank's cold water port on top. The storage tank's hot out port would then plumb to your water heater's cold in port, thus putting them in series. The collectors are fed water from the boiler drain valve port on the bottom of the storage tank, and would return to it at the T&P valve port on the top. This is a common setup and would allow you to turn the gas water heater thermostat way down. You could also plumb it with valves to bypass the gas heater when you want. If your present collector set-up is heating everything up by 11 AM, I would suggest you step up to an 80 gallon storage tank.

On the matter of the pumps, it's an economy of scale. For instance, for every 100 AC pumps sold, there is only 1 DC pump sold. With this small market share, the DC manufacturers have to charge more to stay in business. Hope this helps, Smitty • smitty@aaasolar.com

RE happenings

INTERNATIONAL

Solar On-Line (SóL) Internet courses on PV, green building, & international development. SóL, PO Box 217, Carbondale, CO 81623 • 720-489-3798 • info@solenergy.org • www.solenergy.org

Solar Energy International online courses: PV Design, & Solar Home Design. Info: see SEI in Colorado listings.

CANADA

Alberta Sustainable Home/Office, Calgary. Open last Sat. every month 1–4 PM, private tours available. Cold-climate, conservation, RE, efficiency, etc. 9211 Scurfield Dr. NW, Calgary, AB T3L 1V9 • 403-239-1882 • jdo@ecobuildings.net • www.ecobuildings.net

COSTA RICA

Feb. 21–27, '05; Homebuilt Wind Generators workshop, Fundacion Durika, Costa Rica. Build wind generators from scratch with Hugh Piggott. Info: see SEI in COLORADO listings. Coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Mar. 7–13, '05; RE for the Developing World—Hands On, Rancho Mastatal, Costa Rica. Solar electricity, hot water, & cooking; & other RE technologies. Info: see SEI in COLORADO listings. Coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

GERMANY

Jun. 1–4, '04; International Conference for RE: Bonn 2004. Business forums, presentations, exhibits. Info: Mr. Joest, +49 (0) 30 7261656 43 • joest@deutsche-energie-agentur.de • www.deutsche-energie-agentur.de

Jun. 24–26, '04; INTERSOL 2004; Freiburg, Germany. Solar energy industry exposition & conference. Info: Solar Promotion GmbH, PO Box 100 170, D-75101 Pforzheim • ++49 (0) 7231 / 35 13 80 • dufner@intersolar.de • www.intersolar.de

Oct. 21–24, '04; RENEXPO 2004; Augsburg. Hydro power, decentralization, biofuels, solar, biogas, energy-efficient construction. Info: Erneuerbare Energien Kommunikations und Information Service GmbH, Unter den Linden 15 • 72762 Reutlingen, Germany • +49 (0)71 21-30 16-0 • Fax: +49 (0)71 21 - 30 16 -100 • redaktion@energie-server.de • www.energy-server.com

ITALY

Sep. 30–Oct. 2, '04; Eolica Expo Mediterranean; Rome. Expo & conference on utility-scale wind power. Info: Solar Energy Group, Via Antonio Gramsci 63, 20032 Cormano (MI), Italy • +39 0266301754 • info@eolicaexpo.com • www.eolicaexpo.com

KENYA

Jun. 19, '04 in Kisumu; Sep. 18, '04 in Mombasa; & Dec. 18, '04, place TBA. Regional energy fairs. Info: Solarnet, PO Box 76406-00508, Nairobi, Kenya • 254-20-572656, 565027 • david@solarnet-ea.org • www.solarnet-ea.org

NICARAGUA

Jul. 19–30, '04 (again Jan. 3–14, '05); Solar/Cultural Course. Managua. Lectures, field experience, & eco-tourism. Info: Richard Komp • 207-497-2204 • sunwatt@juno.com • www.grupofenix.org

UNITED KINGDOM

Jul. 9–11, '04; RE Weekend Course; Centre of Continuing Education, Univ. of Wales, Aberystwyth. Overview of technology, solar electricity, solar water heating , wind power, microhydro, biomass, & their applications & design. Info: Green Dragon Energy • 01654 761 570 • dragonrg@talk21.com • Register: Centre for Continuing Education, Univ. of Wales, 10-11 Laura Place, Aberystwyth SY23 2AU • 01970 622 677 • bff@aber.ac.uk

U.S.A.

American Wind Energy Assoc. Info about U.S. wind industry, membership, small turbine use, & more. www.awea.org

Info on state & federal incentives for RE. North Carolina Solar Center, Box 7401 NCSU, Raleigh, NC 27695 • 919-515-3480 • www.dsireusa.org

Ask an Energy Expert: online or phone questions to specialists. Energy Efficiency & RE Network (EREN) • 800-363-3732 • www.eere.energy.gov

Stand-Alone PV Systems Web site: design practices, PV safety, technical briefs, battery & inverter testing. Sandia Labs • www.sandia.gov/pv

ARIZONA

Scottsdale, AZ. Living with the Sun; free energy lectures, 3rd Thurs. each month, 7 PM, City of Scottsdale Urban Design Studio. Dan Aiello • 602-952-8192; or AZ Solar Center • www.azsolarcenter.org

CALIFORNIA

Jun. 12–13, '04; 25th Annual Health & Harmony Festival; Sonoma County Fairgrounds, Santa Rosa. RE, music, arts, green living expo, eco-village, lectures, & more! Info: H&H Festival, PO Box 7040, Santa Rosa, CA 95407 • 707-575-9355 • info@harmonyfestival.com • www.harmonyfestival.com

Aug. 14, '04; Southern California RE Expo; Pomona, CA. RE booths, workshops, & demonstrations. Info: Solatron Technologies, Inc., 888-647-6527 • www.socalenergyexpo.com

Aug. 23–24, '04; Solfest RE & Sustainability Fair; Hopland, CA; Exhibits, workshops, music, speakers. Info: 707-744-2017 • www.solfest.org

Arcata, CA. Campus Center for Appropriate Technology, Humboldt State Univ. Workshops & presentations on renewable & sustainable living. CCAT, HSU, Arcata, CA 95521 • 707-826-3551 • ccat@axe.humboldt.edu • www.humboldt.edu/~ccat

Ongoing workshops, including beginning to advanced PV, wind, hydro, alternative fuels, green building techniques, & more. Real Goods SLI, 13771 S. Highway 101, Hopland, CA 95449 • 707-744-2017 • sli@solarliving.org • www.solarliving.org

COLORADO

Jun. 25–27, '04; Colorado RE Conference; Denver Univ. Sessions & workshops for home, business, & local leaders. RE & energy efficiency experts. Info: CO RE Society, info@cres-energy.org • www.cres-energy.org

Jul. 19–23, '04; Biodiesel Workshop, Carbondale. Info: See SEI below

Sep. 27–Oct. 5, '04; Sustainable Resources 2004: Solutions to World Poverty; Boulder. Grassroots conf. on sustainable development, technology, & use of resources. Info: Sustainable Resources Conference, 717 Poplar Ave., Boulder, CO 80304 • 888-317-1600 or 303-998-1323 • info@sustainableresources.org • www.sustainableresources.org

Camp-Us; RE camp for teens. Jul. & Aug. sessions. Lectures, labs, hiking, & more. Apprenticeships available, campers & volunteers wanted. Info: Ed Eaton, Our Sun Solar, PO Box 1876, Paonia, CO 81428 • 970-948-5304 • hareef99@yahoo.com • www.youthcamp-us.org

Carbondale, CO. SEI hands-on workshops & online distance courses on PV, solar pumping, wind power, micro-hydro, solar H2O, alternative fuels, green building, women's courses, & online distance courses. Solar Energy International, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

ILLINOIS

Aug. 7–8, '04; 3d Annual IL RE Fair; Ogle County Fairgrounds; Oregon, IL. Exhibits, workshops, & booths. Info: IL RE Assoc. • 815-732-7332 • www.illinoisrenew.org

IOWA

Jun. 5, '04; PV Workshop; Cornell College, Mt. Vernon, IA. See below for IRENEW access.

Jul. 24–25, '04; Solar Domestic Hot Water Workshop; Garrison, IA. See below for IRENEW access.

Sep. 11–12, '04; 13th Iowa Energy Expo, Prairiewoods Franciscan Center, Hiawatha, IA. Workshops, exhibits, Electrathon, alternative vehicles, straw bale building, passive & active solar, biomass, & solar-powered music. See below for IRENEW access.

Prairiewoods & Cedar Rapids, IA. Iowa RE Assoc. meets 2nd Sat. every month at 9 AM. Call for changes. IRENEW, PO Box 3405, Iowa City, IA 52244 • 563-432-6551 • irenew@irenew.org • www.irenew.org

KENTUCKY

Mt. Vernon, KY. Appalachia: Science in the Public Interest. Projects & demos in solar electricity, solar hot water, gardening, sustainable forestry, more. ASPI, 50 Lair St., Mt. Vernon, KY 40456 • 606-256-0077 • solar@a-spi.org • www.a-spi.org

MICHIGAN

Jun. 17, '04; Introductory RE Seminars; Dimondale, MI. Three seminars: Solar H_2O & Space Heating, PV Systems, & Wind Systems. Info: Great Lakes RE Assoc. • 517-646-6269 • info@glrea.org • www.glrea.org

Jul. 17, '04; Intermediate PV; Dimondale, MI. In-depth PV systems & how they work. Info: See GLREA above.

Urban Enviro Discussion, Ferndale, MI. 2nd Wed. each month, 7 PM. Sustainability, energy efficiency & conservation, RE, & green building. Potluck. The GreenHouse, 22757 Woodward #210, Ferndale, MI 48220 • 313-218-1628 • www.hometown.aol.com/ecadvocate

Intro to Solar, Wind, & Hydro. West Branch, MI. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com

MINNESOTA

Jul. 23–25, '04 (again Jul. 30–Aug. 1); Straw Bale Construction workshop; St. Cloud. Info: see MREA in Wisconsin listings.

MONTANA

Jul. 10, '04; Sustainability Fair 2004; Livingston, MT. Vendors, workshops, demonstrations, & "Sustainable Office," to showcase sustainable building & RE. Food, education, kids' activities. Info: Corp. for the Northern Rockies • info@northrock.org • www.northrock.org

NEW JERSEY

Jul. 11–14, '04; Harvesting RE from Agriculture; Rutgers Univ., Bordentown, NJ. Sponsors: NE Branch of American Society Agronomy, & Soil Science Society America. Info: Joseph Heckman • heckman@aesop.rutgers.edu • www.ecocomplex.rutgers.edu/nebasa

NEW YORK

Jun. 19–20, '04; Great Hudson River Revival 2004; Croton-On-Hudson, NY. RE-powered environmental & music festival, with hands-on solar installation. Info: Hudson River Sloop Clearwater, 112 Little Market St., Pouhgkeepsie, NY 12601 • 800-67-SLOOP • office@clearwater.org • www.clearwaterfestival.org

Jun. 23–24, '04; RE Finance Forum; New York City. Document RE finance opportunities, inform the financial community, & bridge the gap between the US and European RE finance. Info: www.euromoneyenergy.com/energy.asp

Jun. 26–Jul. 3, '04; Natural Building Colloquium; East Bath, NY. Exhibition, workshops, presentations, & lectures on natural building & sustainable technologies incl. RE. Info: Gaiatecture Design • 585-624-2540 • gaiatecture@hotmail.com • www.gaiatecture.com

NORTH CAROLINA

Saxapahaw, NC. How to Get Your Solar-Powered Home. Call for dates. Solar Village Institute • PO Box 14, Saxapahaw, NC 27340 • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OHIO

Jul. 25, '04; Green Energy Ohio Summer Solar Social; Glacier Ridge Metro Park, Columbus, OH. Educational & festivities, visit RE systems, solar activities. Info: Green Energy Ohio, 866-GREEN-OH • geo@greenenergyohio.org • www.GreenEnergyOhio.org

Oct. 2, '04; Green Energy Ohio Solar Tour. Sustainable, energy efficient, & RE technologies at homes, businesses, & public places. Guidebook. Info: See GEO above.

Nov. 9–10, '04; Ohio Wind Power Conference; Cleveland. Educational seminar on wind development for Ohio & Lake Erie. Info: See GEO above.

OREGON

Jun. 19, '04; Tour of Solar Water Pumping Installations, John Day, OR. Info: EORenew, PO Box 485, Canyon City, OR 97820 • 541-575-3633 • info@solwest.org • www.solwest.org

July 21–23, '04; Pre-SolWest Installation Workshop: Solar Hot Water, John Day, OR. Info: See EORenew above.

Jul. 10–14, '04; SOLAR 2004; Portland. American Solar Energy Society national conference. Info: ASES • 303-443-3130 ext.103 • www.ases.org • bchowe@ases.org

July 23–25, '04; SolWest RE Fair, John Day, OR. Exhibitors, workshops, Electrathon racing, music, & more. Info: See EORenew above.

Sep. 18, '04; Solar Cookery Equinox Extravaganza & Potluck; Morning Hill Forest Farm, Seneca, OR. Info: See EORenew above.

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10 weeks, 14 interns per quarter. Aprovecho Research Center, 80574 Haxelton Rd., Cottage Grove, OR 97424 • 541-942-0302 • apro@efn.org • www.efn.org/~apro

PENNSYLVANIA

Penn. Solar Energy Assoc. meeting info: PO Box 42400, Philadelphia, PA 19101 • 610-667-0412 • rose-bryant@erols.com

RHODE ISLAND

Jun. 5, '04; RI Sustainable Living Festival & RE Expo; Coventry, RI. Exhibits, vendors, artists, kids' stuff. Info: Apeiron Inst., 451 Hammet Rd., Coventry, RI 02816 • 401-397-3430 • info@apeiron.org • www.apeiron.org

TEXAS

Sep. 24–26, '04; Texas RE Roundup & Green Living Fair; Fredericksburg, TX. Speakers, workshops, demos, family activities, alternative vehicles, & natural food. Info: 877-3ROUNDUP • www.theroundup.org

El Paso Solar Energy Assoc. meets 1st Thurs. each month. EPSEA, PO Box 26384, El Paso, TX 79926 • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group: e-mail for meeting times: HREG • hreg@txses.org • www.txses.org/hreg

VERMONT

Jul. 10–11, '04; SolarFest RE festival; Green Mt. College, Poultney, VT. Solar stages, workshops, vendors. Info: 802-287-9135 • www.solarfest.org

WASHINGTON STATE

Oct. 16, '04; Intro to RE; Guemes Island, WA. Solar, wind, & microhydro for homeowners. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 18–23, '04; PV Design & Install Workshop, Guemes Island, WA. System design, components, site analysis, system sizing, & a hands-on installation. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

Oct. 25–30, '04; Wind Power Workshop with Mick Sagrillo, Guemes Island, WA. Design, system sizing, site analysis, safety issues, hardware specs, & a hands-on installation. Info: see SEI in COLORADO listings. Local coordinator: Ian Woofenden • 360-293-7448 • ian.woofenden@homepower.com

WISCONSIN

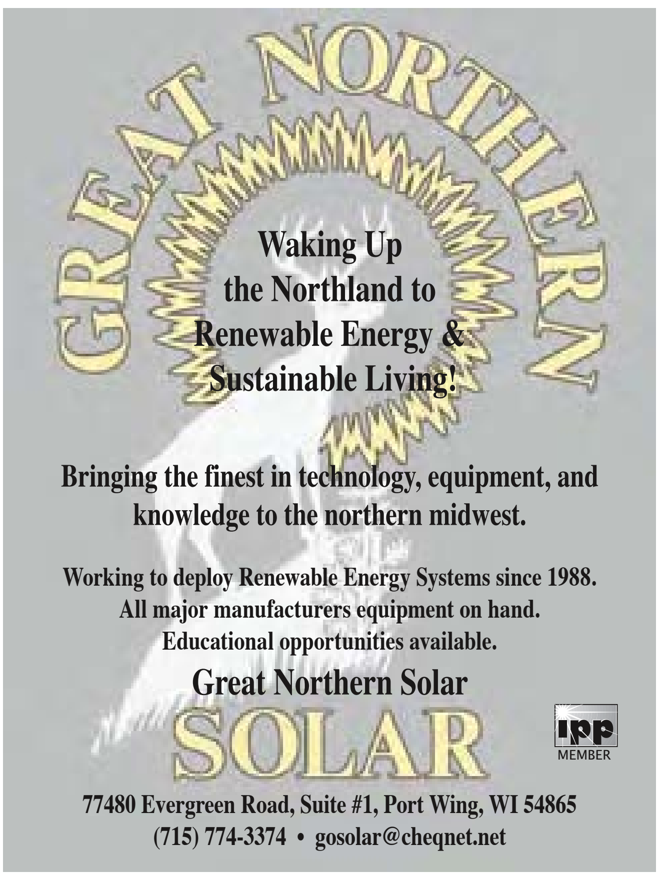
June 18–20, '04; RE & Sustainable Living Fair (aka MREF); Custer, WI. Exhibits, workshops on solar, wind, water, green building, alternative fuels, organic gardening, energy efficiency, & healthy living. Home tours, silent auction, Kids' Korral, entertainment, keynote speaker. See below for MREA access.

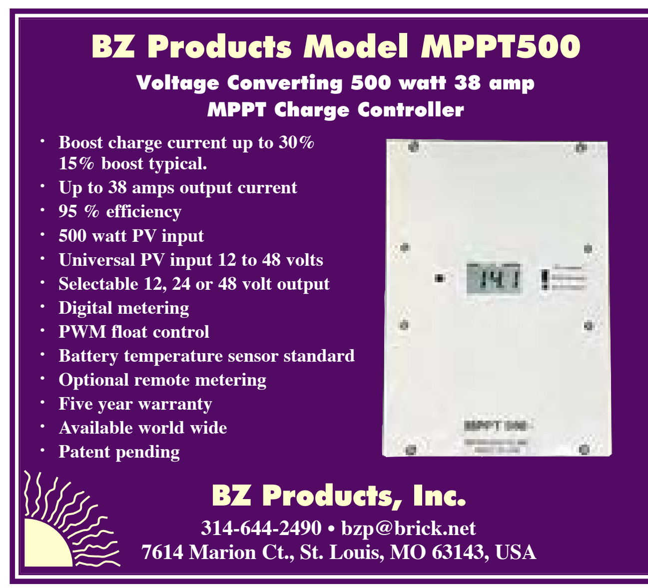
MREA workshops: Jun. 5–6, Ashland, WI, Basic PV; Jun. 12–13, Ashland, WI, Int. PV; Jun. 12–17, Custer, Women's PV; Jul. 17–23, Custer, Adv. PV; Jul. 23–25 (again Jul. 30–Aug. 1), St. Cloud, MN, Straw Bale Constr; Sep. 19–25, Custer, Tilt-Up Tower Wind Install. Also, Alternative Construction, Solar Domestic Hot Water, & Solar Space Heating. Info: MREA, 7558 Deer Rd., Custer, WI 54423 • 715-592-6595 • mreainfo@wi-net.com • www.the-mrea.org

Send your renewable energy event info to happs@homepower.com

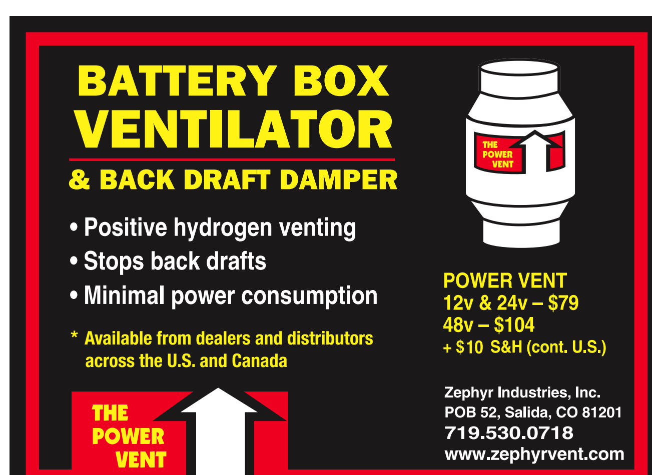

ADVANCED COMMUNICATION SOLUTIONS INC.
"Keeping you connected to your world"
Satellite Phones / Radio-telephones / Home Cellular
Cellular Amplifiers & In-Building Repeater Systems
Antennas / Long-range Cordless Phones / RF Cables
Globalstar
Satellite Phones
CellSocket
VOYAGER
MAXRAD
EnGenius
ANTENEX
Prescott Valley, Arizona • (928) 772-7515
www.advanced-comm-solutions.com


Camp-Us
A Renewable Energy Camp for Teens
8-Day sessions learning about:
• Solar, Wind, and Water Power
• Green Building and Community
• Solar Cooked Organic Meals
• Hiking, Rafting, and Tours
For fees, schedules, and info:
www.youthcamp-us.org
hareef99@yahoo.com
Ed Eaton, PO Box 1876, Paonia, CO 81428
Tel. 970-948-5304


GREAT NORTHERN
Waking Up the Northland to Renewable Energy & Sustainable Living!
Bringing the finest in technology, equipment, and knowledge to the northern midwest.
Working to deploy Renewable Energy Systems since 1988.
All major manufacturers equipment on hand.
Educational opportunities available.
Great Northern Solar
SOLAR
ipp MEMBER
77480 Evergreen Road, Suite #1, Port Wing, WI 54865
(715) 774-3374 • gosolar@cheqnet.net


BZ Products Model MPPT500
Voltage Converting 500 watt 38 amp MPPT Charge Controller
• Boost charge current up to 30% 15% boost typical.
• Up to 38 amps output current
• 95 % efficiency
• 500 watt PV input
• Universal PV input 12 to 48 volts
• Selectable 12, 24 or 48 volt output
• Digital metering
• PWM float control
• Battery temperature sensor standard
• Optional remote metering
• Five year warranty
• Available world wide
• Patent pending
BZ Products, Inc.
314-644-2490 • bzp@brick.net
7614 Marion Ct., St. Louis, MO 63143, USA


SIMMONS Natural Bodycare
Off the grid since 1980
Make every day special
The natural ingredients of our products get their energy from the sun
simmonsnaturals.com
42295 Hwy. 36, Bridgeville, Ca 95526


BATTERY BOX VENTILATOR
& BACK DRAFT DAMPER
• Positive hydrogen venting
• Stops back drafts
• Minimal power consumption
* Available from dealers and distributors across the U.S. and Canada
THE POWER VENT
POWER VENT
12v & 24v – $79
48v – $104
+ $10 S&H (cont. U.S.)
Zephyr Industries, Inc.
POB 52, Salida, CO 81201
719.530.0718
www.zephyrvent.com

Thermal Mass

Hi Richard and crew, Happy (100th) birthday! I live in a 1950s chalet-style house, with solid internal walls connected to a solid floor, leading to an outside double garage with a wide drive. The house is cold for the whole year, except during a hot summer when it overheats. It is poorly designed and built, so I am not a fan of thermal mass, because badly thought out design can result in the mass acting as a heat sump and drawing warmth *out* of a house. So I was interested in the article on your place, and in particular the thermal mass of the floor. Please tell me how you separated the outside wall from the internal floor, and how you designed the support, and insulated the floor. Thank you for *Home Power* magazine, and continue with all those great articles. Steve Rainbird • sandj@matapan.freeserve.co.uk

Hello Steve, As you've experienced, high thermal mass can indeed be a liability, rather than an asset, in poorly designed buildings. Two of the most important requirements related to the design of high mass structures is to keep the mass shaded during the cooling season, and to limit unwanted heat transfer from the mass during the heating season.

Shading the mass during the warm months can easily be accomplished with appropriately sized roof overhangs that block the high summer sun from entering the building. Window shades can accomplish the same thing, but require daily operation. For effective wintertime heating, a building's thermal mass should be insulated from both the earth below it, and any other surfaces in contact with the outside air. Here are the construction details of the thermal slab we built up at Home Power *Central.*

The weight of the building's walls, roof, and snow load is supported by a perimeter footing that is 18 inches wide and 18 inches high. An additional concrete stem wall was poured on the west end of the foundation to accommodate the sloping grade of the building site. This footing was poured first, and allowed to cure before we continued. The inside of the perimeter footing was wrapped with 2 inch, high density rigid foam insulation, commonly referred to as "pink board." This insulation created a thermal break between the load bearing footing and the soon to be poured thermal slab. Next we leveled the area inside of the footing with sand, which was then compressed. Four inches of high density rigid insulation was laid over the sand. At this point, we had a form for the slab that was insulated from both the building's perimeter footing, and the earth underneath the slab.

Four-inch-square road wire was laid down on top of the rigid insulation. High temperature PEX tubing was then affixed to the road wire. This tubing is used to distribute the hot water collected by the flat plate collectors on the building's roof. To increase the strength of the slab, the concrete supplier added fiberglass to the mix. The finished slab is six inches thick and very well insulated. Joe Schwartz • joe.schwartz@homepower.com

Tracking Solar Thermal Collectors?

I have made a flat plate, hot water solar collector. I live in Minnesota, about an hour north of Minneapolis-St. Paul. I am considering adapting my panel so that it tracks the sun during the winter months. Would this be a great enough benefit to make it worth the trouble? Any advice or insight you can offer would be appreciated. Wally Nielsen • JPGPR@aol.com

Hi Wally, For photovoltaics, to track or not to track is a question mostly of personal preference and the specifics of your site and system. See Richard Perez's article in this issue for more details. With solar water or air heating, it is usually a lot easier to answer the question with a "no," because generally solar thermal panels are more bulky and heavy than PVs, and it is more difficult to make a flexible plumbing connection than a flexible wiring connection. I think you would be better off with a second panel than spending time, resources, and money on developing a tracking system. Michael Welch • michael.welch@homepower.com

Hello Wally, Michael is right on about the tracking question for solar heat collectors. In addition to the cost and hassle of the tracker (flex piping, heavy duty large frame, cable or screw drive mechanism, and electronics), future maintenance of the more complex system is also a big factor. Maintenance (or lack of it) is what has caused the abandonment or alteration of more than 95 per cent of the residential tracking solar heating systems installed in the last two decades. I'll second Michael's advice that you would be happier in the long run to add more square footage of collector surface area. Chuck Marken • chuck@aaasolar.com

Tapping a Battery Bank

Hi, I have a question regarding my 24 volt battery bank. I have eight Trojan T-105s running a Trace 3624 and a Prosine 1800. My question is, would it hurt the battery bank to take 12 volts from one battery string while the main inverters are taking 24 volts? What problems would this cause? Thanks, John Lee • johnlee628@yahoo.com

Hello John, Don't do it! This will lead to imbalance within the battery pack—unequal states of charge between the batteries. Many have tried this in the past and it always leads to early battery demise. If you must have 12 volt electricity from your bank, either get a battery equalizer to tap your bank, or get a DC-to-DC converter to step the voltage down. (See the article in HP98.*) Richard Perez • richard.perez@homepower.com*

Mounting PVs

I have a question about solar anything installed on a roof vs. separately on the ground. I have never seen a roof that did not eventually need repair or replacement. If you mount solar panels or collectors on your roof and the roof decides it's time to leak, how do you repair it? What is the standard installation? 1. Mount collectors into the roof, not on it; it acts as the weatherproof portion and no extra shingles are used under it? 2. Mount collectors over the shingles (stood off if necessary)? How do you walk on a roof that has solar shingles on it like the Kyocera roof shown on the back page advertisement of *HP100*? Inquiringly, Warren • Warren_L1@Netzero.Com

Hello Warren, Pole or ground-mounted PV arrays are common in rural areas, and roof leaks are not an issue as a result. Most suburban/urban sites do not have unshaded locations for this type of mounting, and roof mounts are the standard. Also, *roof-mounted arrays typically have less of a visual impact. This is an important consideration for PV systems that are installed in densely populated areas.*

The condition of the roofing material needs to be evaluated before roof-mounted arrays are installed. Some roofing materials, like tile and metal, are very long lived, and don't present much of a problem related to PV arrays. But asphalt roofing does need to be replaced periodically. The smart thing to do is to replace the roofing with a high quality (40 year) asphalt roof before the array is mounted. Here in Oregon, the Energy Trust of Oregon (ETO) administers PV incentive money. If the roofing is nearing the end of its lifetime, they require it to be replaced before incentive money is available for the system in question.

I spent several years in the construction trades before I became involved in the renewable energy industry. Properly installed roofs don't leak. If roofing materials are poorly installed, ridges, valleys, and flashing around skylights and vent pipes are almost always the problem areas, not the open roof space where PV arrays are mounted.

Currently, the most common building integrated PV material is the laminate manufactured by UniSolar. These laminates are adhered directly to standing seam metal roofing. Roof leaks are not an issue in these installations. PV arrays made of individual modules on stand-off racks are more common. As long as the roof penetrations required by this type of mounting are properly sealed, roof leaks are not an issue.

The worst-case scenario is that an asphalt or wood shingle roof needs to be replaced, and the PV array needs to be removed to accomplish this. The PV installer (not the roofer!) should remove the array, and reinstall it after the new roof surface is in place. In some instances, roof integrated flashing is used to seal the mounting feet of the PV rack. Once the mounting feet are in place, the roofing contractor will install the required flashing, and the PV installer will finish the job. The homeowner will need to pay for this service, but considering it will likely only be required once at most during the lifetime of the system, the relative cost is minor.

If the roof surface under a PV array needs to be accessed for repair, individual PV modules can be removed where necessary. It's never a good idea to walk, even on the edges, of an installed PV array. Best, Joe Schwartz • joe.schwartz@homepower.com

One Tank or Two?

Mr. Marken, With reference to your *HP96* article on one-tank SDHW modification, you stated that a two-tank system would be more efficient. Is this only because of the greater volume of water, or am I missing something? I plan to install a solar preheater (closed loop using a heat exchanger) in line with my on-demand propane-fired water heater. I am limited in head room (crawl space) to 40 gallon tanks, but I would like to use two or more tanks. If I have extra heat, a hydronic loop would bleed off extra energy. The question: How would you set up for the two-tank system you mentioned? I was considering using the two tanks plumbed in parallel. Best Regards, Brian Spilsbury • brian.spilsbury@sympatico.ca

Hello Brian, The benefits of having two tanks (storage and water heater) piped in series is three-fold, one of which you mention. The larger volume (assuming it's heated) will carry a family through longer periods of reduced sunshine. The second benefit is an increased "stratification," so to speak, of the water—this is beneficial because the less you mix the hot with the cold—the more really hot water is available for demand. Two tanks of equal size is a good configuration for the limitation of mixing hot and cold. The third benefit is that it is very difficult to tell when the solar collectors will be able to heat the tank. This can be approximated with a timer for day and night, but during the day, clouds can limit the solar hot water production.

If only one tank is used, how does the conventional water heater thermostat know that the sun will soon be heating the tank? It cannot know and therefore will energize the element or turn on the burner, much of the time needlessly and wastefully. If two tanks are used, there is no conventional element or burner in the solar tank, and this will never happen. Two tanks will normally give twenty to thirty per cent better performance than a single large tank system.

As to your installation, the instantaneous water heater is taking the place of the thermostat and second tank (water heater) in systems described above—the third benefit doesn't exist if both tanks are storage only. I would imagine your main concern is the daily cycle of solar hot water and how well it meets demand. Since the instantaneous backup is in place, the parallel piping is fine if you have enough collector surface area to heat the total volume of two tanks on a daily basis. If not, you will probably be better off with the tanks in series. Best to you, Chuck Marken • chuck@aaasolar.com

Pedal & Steam

Greetings, I have two questions: Are there any good, tested products that will produce electricity and charge a battery bank via bicycle power? Second, how about steam power? I live off the grid in north Idaho, where we have long, dark winters. We heat entirely with wood, and as I watch all that energy go up in smoke, one can't help but wonder about the possibilities. Could you shed some light on steam or other alternatives for capturing all those BTUs going up the pipe? We now use a generator during the winter months for charging, but there's got to be a better way. Thanks. Great publication. William • herring@icehouse.net

Hi William, We've run several articles on bike generators over the years, and I've played with some home-built, pedal generators. Don't get your hopes up. My conclusion is that pedal generators are a good advertisement for PVs. A person in good condition can put out 75 to 100 watts continuously on a well designed pedal generator. That's not very much for most home systems. A 100 watt PV module does that every time it's sunny. How many hours a day do you want to pedal?

We've run at least two articles on steam-electric systems, authored by Skip Goebel (Sensiblesteam@aol.com). You can search for and order the back issues on our Web site. Synopsis: you need to have a use for the heat to make it worthwhile, and you need to monitor the system closely. But it is possible, though the equipment is not cheap (expect to invest at least a few thousand dollars, or do a lot of homebrewing). Also, steam can be dangerous, so please do your research before you start experimenting. It's been on my mind for several years to try to do something along these lines myself. Best, Ian Woofenden • ian.woofenden@homepower.com

readers' marketplace

HYDROELECTRIC SYSTEMS: Pelton and Crossflow designs, either complete turbines or complete systems. Assistance in site evaluation and equipment selection. AC Systems for standalone or grid interconnect operation. Manufacturing home and commercial size turbines since 1976. Send for a free brochure. Canyon Industries Inc., P.O. Box 36 HP, Deming, WA 98244, 360-592-5552. e-mail: citurbine@aol.com web page: canyonhydro.com • HP10102

EARTH SHELTERED HOMES This definitive manual by noted authority Loren Impson features detailed building instructions for amazingly affordable and practical Ferro Cement Domes. Only $15 from Loren, 71 Holistic, Mt. Ida AR 71957 www.2BbyD.com • HP10103

COSOLAR.COM discount prices from Colorado Solar Electric. New Shell SQ80 in stock $328. OutBack Inverters in stock 1-800-766-7644 • HP10104

SINGLE AND DUAL AXIS SOLAR TRACKER CONTROLS up to 48V and 5A output. www.theanalogguy.com • HP10105

WIND TURBINES! Best prices nationwide. Bergey & AWP. www.pineridgeproducts.com 406-738-4284 • HP10106

SURPLUS INDUSTRIAL BATTERIES: Save up to 70% on unused military and industrial batteries. Many types and sizes, super H.D. Factory crated. Also chargers, wind and solar equipment, new and used. D.P.S.D. Inc. 3807 W. Sierra Hwy. #6, Acton CA 93510. 661-269-5410. Fax 661-269-1303. • HP10107

ALMOST FREE SOLAR POWER! Cheap (under $500) DIY systems for home, cabin, rv. PowerFromSun.com • HP10108

POWERPULSE® SULFATION BUSTERS endorsed by R. Perez! 12V $69.95 free UPS. 800-222-7242 for other models/wholesale prices. email: abrahamsolar@hotmail.com Siemens 40 watt: $170! Ask about other surplus modules or any energy gear. Veteran Colorado equipment broker; happy clients since 1984. • HP10110

VARI-CYCLONE: DC powered ceiling fan, 40% more airflow with no increase in power consumption. For more info contact RCH Fanworks, the #1 manufacturer of DC powered ceiling fans, 2173 Rocky Crk. Rd. Colville, WA 99114 PH: 509-685-0535, email: info@fanworks.com, Web: www.fanworks.com, Dealer inquiries welcome. • HP10125

VIDEOS AVAILABLE: NEW-"GUERILLA SOLAR INSTALL", "Introduction to Solar Electricity", "Introduction to Solar Pool Pumps", "How To Solar Installation Video" VHS and DVD www.igotsolar.com • HP10111

ECOMALL: The largest environmental portal of earth-friendly companies and resources. Renewable energy companies, news and information. www.ecomall.com. To advertise, call 845-679-2490. • HP10112

LARGE GAS REFRIGERATORS 12, 15 & 18 cubic foot propane refrigerators. 15 cubic foot freezers 800-898-0552 Ervin's Cabinet Shop, 220 N County Rd. 425E., Arcola, IL 61910 • HP10113

XXXXXXXXX UNI-SOLAR XXXXXXXXXX XXXXXXXXX 64 Watts $319 XXXXXXXXX New 105AH AGM 12V batteries-Reg $185, Sale $75. TraceX SW5548 (GTI unit) $1995. Ex 2KW inverter SB $850. Buy, sell New/Used 760-949-0505 • HP10114

HONDA GENERATORS - 1000 to 10,500 watts. Fast shipping and great prices! www.hayesequipment.com 1-800-375-7767 • HP10115

NICAD CELLS FREE. Edison 1.2v ED-240 cells. Have 40 that I would like to find a good home for. In need of reconditioning, see early HP articles for info on that. Must pick them up in VT. Call David Palumbo 802-888-7194 • HP10116

DC SUBMERSIBLE WELL PUMPS. Complete, ready to install. $187 includes IMMEDIATE FREE SHIPPING. Visit www.nemopumps.com or call 1-877-684-7979 • HP10117

I AM A SOLAR WHOLESALER looking for retailers to carry my solar electronic and hobby goods. Phone # 916-486-4373. Please leave message. • HP10118

TELLURIDE COLORADO: Off the Grid Properties! Hot Springs, Riverside, solar powered homes, large and small ranches. Find your own place in the sun with the only solar powered real estate office in Colorado. T.R.I. (970) 728-3205 1-800-571-6518 www.solarrealty.net • HP10119

EDTA RESTORES SULFATED BATTERIES. EDTA tetra sodium salt, $12/lb. plus $5 S&H for 1st lb. plus $1 S&H for each additional lb. Trailhead Supply, 325 E. 1165 N., Orem, UT 84057, (801) 225-3931, email: trailheadsupply@webtv.net, info. at: www.webspawner.com/users/edta. • HP10120

RADIO/TELEPHONES Voice-Fax-Web 1-8 lines 20mi. CELLULAR Antenna pkg improves access 208-263-9755 PDT • HP10109

SOLAR ELECTRIC INC. Lowest prices under the sun! 5555 Santa Fe St #D, San Diego, CA 92109; 800-842-5678, www.solarelectricinc.com • HP10121

www.LOWESTCOSTSOLAR.com Do it Yourself! PV Panels, Wind Turbines, Charge Controllers, Kits BEST PRICES, ONLINE SUPPORT • HP10122

SOLAR HEATERS FOR SALE! Get free heat from the sun for your home, office, garage, etc. Visit us today at www.hotboxsolar.com or by phone at 1-607-481-0992. HotBox Solar. 263 Glenwood Ave. Elmira Heights, NY. 14903 • HP10123

FOR SALE-40 SECLUDED ACRES, no restrictions, 3BR 2B 16X12 shop, property taxes are $90/yr,solar tracker poles etc remain on property,$100,000 many pictures & info at www.empyrean-eye.com • HP10124

SURVIVAL UNLIMITED.COM - Emergency Preparedness & Survival Supplies. Wind Power from 439.00+. Many great products & prices! 1-800-455-2201 www.survivalunlimited.com • HP10126

PHOTOWATT DROPSHIPPED FROM FACTORY DIRECT TO YOU, $3.30 PER WATT, 25 yr warranty. Minimum order 10 modules. Contact Sun @ 305-381-6166 • HP10127

DANBY PROPANE 8 cu. ft. refrig. freezer $800 shipped direct from factory. Call Sun 305-381-6166 • HP10127

KUBOTA DIESEL GENERATOR Low Boy 6.5 KW, super quiet, only 64 DCB. Only $3,550. Call Sun 305-381-6166 • HP10127

AIR LAND 403 $349 305-539-0403 • HP10127

REMANUFACTURED INVERTERS, LARGE INVENTORY, UP TO 55% OF LIST, with factory warranties, all brands, all sizes. Call Sun at 305-536-9917 Can be drop shipped from factory. • HP10127

CONVERT WOOD TO ELECTRICITY: Steam engine powered generator sets http://www.geocities.com/steamgen/ 918-520-7711 or wjjcg7@cox.net 2827 N. Kingston Ct. Tulsa OK 74115 • HP10128

Readers' Marketplace Rates

Rates: 25¢ per CHARACTER, include spaces & punctuation. $20.00 minimum per insertion. All Readers' Marketplace ads are published in both the print and web versions. Please send a check or Visa, Mastercard, American Express, or Discover card data with ad. Please, no money orders. We do not bill Readers' Marketplace ads, they must be paid for in advance of publication. Your cancelled check or credit card bill is your receipt.

Help us prevent fraud! Home Power Readers' Marketplace ads from individuals must supply serial number(s) for equipment being sold. Businesses must supply published phone number(s) and physical address. While Home Power is doing everything we can to prevent fraud, we can assume no responsibility for items being sold.

installers *directory*

Do you want a renewable energy system, but don't want to install it yourself? You deserve a system that meets your expectations and budget! A renewable energy professional will design and install a safe, code-compliant system, and offer you service and support after the sale. Check out the state-by-state installer listings below.

Home Power **does not guarantee the quality provided by the businesses listed below—please shop carefully, request references and certifications, and compare.**

Canada

Energy Alternatives, Serving Canadians for over 20 years, is a full service energy systems contractor with a team of professional installers throughout Canada. We offer expert consultation and design services, turn-key installed systems or DIY kits. Extensive product inventory for fast delivery. Please visit www.EnergyAlternatives.ca to learn more about our products and services. Call 800-265-8898

Alaska

Remote Power Inc Greg Egan, President. Licensed electrician since 1982. Outback certified field service technician. MREA trained wind system installer. Design, installation & service of wind, pv, & hydro systems. Bush jobs no problem. Large inventory of inverters, pv panels, efficient appliances, etc. at our shop near Fairbanks. Call (907) 457-4299 or 1-888-257-3639. www.remotepowerinc.com

California

Akeena Solar is the nation's largest residential solar electric installer with two NABCEP-Certified PV Installers on staff. Our design/build services coupled with our complete financial analyses, based on actual site conditions, support our growing list of satisfied customers in making the switch to clean reliable energy. Serving CA, NJ, MA, RI, CT, & NY. Visit www.akeena.net or call 888-akeena-8

Electron Connection Licensed in CA and Oregon. NABCEP Certified installer. Serving northernmost California and southern Oregon. PV, wind, microhydro installs. (800) 945-7587 email: bob-o@electronconnection.com, www.electronconnection.com

Empower Energy, Southern CA. We design, sell, install, & service high quality residential & commercial solar, wind, & hydro systems. Specializing in grid-tied & remote stand alone systems in any part of CA. Make renewable energy a part of your home, ranch, or business. Lic. in CA since 1995, (#711993). Cert. SMA & Sharp installer. 818 222-8700, toll free 800 494-2366, EmpowerEnergy.net, Info@EmpowerEnergy.net.

Feather River Solar Electric Bill Battagin of Taylorsville has been designing, installing and servicing renewable energy systems since 1982. PV, micro-hydro, hybrids; grid intertie or stand alone systems. CA Elect.l Lic. # 681552, Outback Cert. Tech. We live and work with RE. Serving Plumas, Lassen, Sierra, Butte Cos. 530.284.7849 frenergy@psln.com, www.frenergy.net

Horizon Industries, San Diego Calif solar showroom, retail installation: Horizon Industries has been servicing, designing and installing solar hot water, solar pool heating, and solar electric on and off grid systems in San Diego county since 1984. Our showroom is at 120 N. Pacific #G7, San Marcos, (760) 744-1001.

Offline Independent Energy Systems, Since 1983. An electrical contracting co., we specialize in utility intertie (with state rebate & net metering) & off grid systems. Owned & operated by Don & Cynthia Loweburg in Central CA East of Fresno. We run our home & business with solar electricity. POB 231, North Fork, CA. 93643, (CA lic# 661052) ph 559 877 7080, fx 559 877 2980, ofln@aol.com www.psnw.com/~ofln

California, cont.

Solar Electric Inc.
5555 Santa Fe St. #D,
San Diego, CA 92109-1602 USA
1-800-842-5678 TOLL FREE, 1-877-842-5678 TOLL FREE FAX
858-581-0051, 858-581-6440 fax
solar@cts.com http://www.solarelectricinc.com

Colorado

Burnham-Beck & Sun, Solar & Wind Energy Systems. Located in Fort Collins, Colorado, we make site evaluations, system designs, and installations in Northern Colorado, Southern Wyoming. We drop-ship equipment anywhere in the US. Retail products include PV modules, wind turbines, inverters, batteries, efficient appliances. 970-482-6924. mailto: BurnhamBeckSun@aol.com. www.burnhambeck.com

Solar Solutions Ltd. provides photovoltaic, wind & hybrid power systems & components for stand alone systems, grid tied, RV's & remote water pumping. Committed to providing the highest quality service & customer satisfaction. A proud member of Colorado SEIA and a lifetime member of the Colorado RE Society and ASES. Xantrex Certied Dealer. 888 44solar or 888 447-6527 www.solarsolutions.com

Florida

ECS Solar Energy Systems (tel) 352-377-8866 www.ECS-solar.com / tom@ECS-solar.com We service FL, the Caribbean and the Southeastern U.S. FL's first solar contractor since 1977. Solar pool heating, hot water, and electric systems –commercial & residential. Solar lic. # CVC056643 Florida state certified for "grid-connected" systems. Contact us now to receive a free solar informational booklet.

Maine

Independent Power Off-grid installations anywhere in Maine. Solar, Wind, Generators. Reliable independent power systems installed by an expert. Full service and support. 207-946-4444 www.independentpowermaine.com.

Michigan

Backwards to the Future Ltd, installing, designing and supplying solar equipment since 1986. OEM supplier of evacuated tube heat pipe technology for DHW & hydronic heating. Systems building integration by joint venture with registered architect. State licensed residential builder & solar mechanical contractor. POB 409 Fennville MI 49408
tel: 269 2366179 email: info@BTFsolar.com www.BTFsolar.com

S.U.R. Energy Systems, LC is South East Michigan's premier provider of wind, solar electric, and solar thermal systems. Any combination of design, sales, and installation. "Do it yourself" assistance to custom turnkey systems. We do power point seminars. Willing to travel. VISA, MC www.sur.biz sales@sur.biz 734.913.9944

Montana

Oasis Montana Inc. designs, sells & installs renewable energy power systems in western Montana and also offers efficient and gas appliances. Our technician Dan Healy is NABCEP certified for PV installations. Toll-free 877-OASISMT or 877-OASISPV web sites: www.oasismontana.com www.grid-tie.com www.PVsolarpumps.com
E-Mail: info@oasismontana.com

Montana, cont.

Planetary Systems, Inc. In business 10+ years. Sales/design/installation of complete RE electrical, water & hydronic heating systems. Our patented RE "Power Package" simplifies installation & reduces costs. Can be shipped nationwide & installed locally. CAD schematic system drawings/technical support provided. Xantrex Certified Dealer. Phone (406) 682-5646, www.planetarysystems.com

Nevada

Alternative Energy Solutions, Reno, Nevada. We design, sell, install and service PV, wind, off grid and grid tie RE systems, Nevada State Licensed and Bonded Contractor, Xantrex / Trace Authorized Service Center, Xantrex Certified Dealer, Outback Factory trained field service technicians and Certified Uni-Solar field laminate installer. 775-857-1157 toll free 1-866-491-SOLR

New Hampshire

Sunweaver Incorporating innovative technologies for power, water and heat. Encouraging knowledge and direction towards resource responsible solar living. Installing in New England and the Carribean since 1985. www.sunweaver.org. mailto: info@sunweaver.org 603-942-5863 Showroom hours: Monday-Saturday 11am-6pm

New Jersey

Akeena Solar is the nation's largest residential solar electric installer with two NABCEP-Certified PV Installers on staff. Our design/build services coupled with our complete financial analyses, based on actual site conditions, support our growing list of satisfied customers in making the switch to clean reliable energy. Serving CA, NJ, MA, RI, CT, & NY. Visit www.akeena.net or call 888-akeena-8

New Mexico

Positive Energy Inc. High quality renewable power systems. Licensed, bonded, and insured electrical contractor serving Santa Fe and northern NM. Owner Allan Sindelar is NABCEP certified and is a certified dealer/installer for Xantrex, Outback, and Sunnyboy. 505 424-1112. E-mail: info@positiveenergysolar.com. Website: www.positiveenergysolar.com

New York

Daystar Energy Systems We're making it easy to choose renewable energy. Unparalleled pricing guarantee, exceptional installation service, and backed up with a comprehensive warranty. Not your average installer, ask about our Sweat Equity and Referral Incentive Programs. Putting customers first in NY and NJ. Call Desi 585-224-9105 www.daystarenergysystems.com

Suntric Renewable Electric Systems, Experienced, qualified installers of photovoltaic, wind, and micro-hydro stand alone systems. Located on the western end of the Adirondack Park in northern New York State. Site evaluations, design consultations, sales and service. Off grid since 1976. Edwin & Pamela Falk, 6920 Abbey Road, Lyons Falls, New York 13368 • 315-348-6893

Oregon

Electron Connection Licensed in CA and Oregon. NABCEP Certified installer. Serving northernmost California and southern Oregon. PV, wind, microhydro installs. (800) 945-7587 email: bob-o@electronconnection.com, www.electronconnection.com

Ohio

Third Sun Solar & Wind Power, Ltd. is Ohio's leading renewable energy contractor. Complete design and installation of off-grid, utility tied, PV and wind systems in OH, KY, IN, IL, MI, PA, WV. Owner Geoff Greenfield is NABCEP Certified Solar PV Installer. We are committed to excellent customer service & the highest quality systems. www.third-sun.com. (740) 597-3111.

Pennsylvania

www.
windturbine-1
.com

Appalachian Wind Systems, LLC has been serving PA, WV & MD for 6 years. Distributor for Cyclone wind turbines, Synergy wind turbines, Sun solar panels, LED lighting, stand alone & grid tie inverters and other products. Site evaluations and financial analyses. We also sell, service & install 10–60 meter NRG meteorological towers & first stage wind analysis. For more information, call 724-452-0326

South Carolina

SC Solar designs/installs PV systems—residential, US military, solar lighting, water pumping, traffic management power systems. Solar thermal & micro hydro. Custom UPS systems for off grid. Installation area: NC, SC, VA, GA, TN, & Mexico. For more info & credentials: 803-802-5522 www.scsolar.com CCR# & Cage Code #1SLJ5.

Texas

Meridian Energy Systems specializes in the design and installation of high quality solar and wind energy systems throughout the State of Texas...and beyond. Factory trained technicians and NABCEP Inaugural Certificant on staff. Visit our website www.meridiansolar.com or call toll-free: 888-477-3050

NTREI ☆

North Texas Renewable Energy Inc. North Texas' premier solar and small wind energy service. Complete system design and installation. Available service contract Independence–Reliability–Conservation. Jim Duncan answers@NTREI.com 817.917.0527

Vermont

Independent Power & Light

Independent Power & Light serving Northern Vermont since 1988. David Palumbo designs, sells, and installs solar electric systems. NABCEP Certified installer, Outback Power Certified Field Service Tech. Specializing in efficient off grid homes. Phone: 802-888-7194, e-mail: IP&L@sover.net, www.independent-power.com

Vermont Solar Engineering has provided the finest in renewable energy throughout New York and New England, since 1991. We design, install, and support solar electric, wind electric, and solar hot water systems. K. Herander, NABCEP™ certified installer. Xantrex Certified Dealer. NYSERDA eligible installer. Vermont Solar and Wind Partner. www.vermontsolar.com 1-800-286-1252

Washington

Puget Sound Solar, We design, sell, install & service solar electric & solar hot water systems in the Puget Sound region. Licensed contractor for 30+ years. Solar site assesments, pinpoint heat loss calculations & whole house energy design. WA cont. lic# PUGETSS973KR. See our website www.pugetsoundsolar.com. (206) 706-1931 jeremy@pugetsoundsolar.com

SolarWind Energy Systems, LLC P.O. Box 1234, Okanogan, WA 98840 (509) 422-5309 www.solar-wind.us WA Cont. # SOLARES983RQ. Serving Eastern WA & Northern ID grid-tied & off-grid RE systems. Solar PV, wind, solar hot water, remote stock watering. Design, installation, service, maint. Solar Energy International (SEI) trained. Lic. & bonded. bclark@solar-wind.us or jmartin@solar-wind.us

Sound Power Design • Site Surveys • Installation • Service. Contractor Reg. # SOUNDPI983NW www.soundpower.us phone 425-844-8748 fax 425-844-8928 Licensed, bonded, insured electrical contractor. Renewable energy specialist. We will travel anywhere in Washington to install PV, wind, and microhydro systems.

Wyoming

Creative Energies Wyoming's premiere full-service RE company. Solar & wind power for remote cabins, homes & ranches, utility grid-tied solar & wind power, solar hot water & heating, solar water pumping & passive solar home design. We custom design a system that fits your needs & budget. Trace certified dealer. Phone/fax: 307-332-3410 toll free 866-332-3410 info@creativeenergies.biz www.creativeenergies.biz

RE Installer? Get Listed.

Our readers continue to look to *Home Power* for referrals to RE installation professionals in their area.

For more information or to get your business listed in *HP's* installers directory, e-mail advertising@homepower.com or call 541.512.0201.

advertisers *index*

Coming Next Issue:

Wind Turbine Sizing Demystified

1920s Farmhouse Goes Fossil-Fuel Free

Start Smart—Assessing Your Home Energy Needs

Hugh Piggott, author of the upcoming article on wind energy.

home power

The Hands-On Journal of Home-Made Power

Issue 101 June – July 2004

Straw Bale Beauty

Low Impact with High Style

Efficiency Ideas to Match Any Budget

Turning Sunshine into Profit

Hydrogen: Solution or Distraction?

homepower.com

$6.95 US $10.95 CAN

06

7 20336 78082 6

Display until August 1

Power with Style

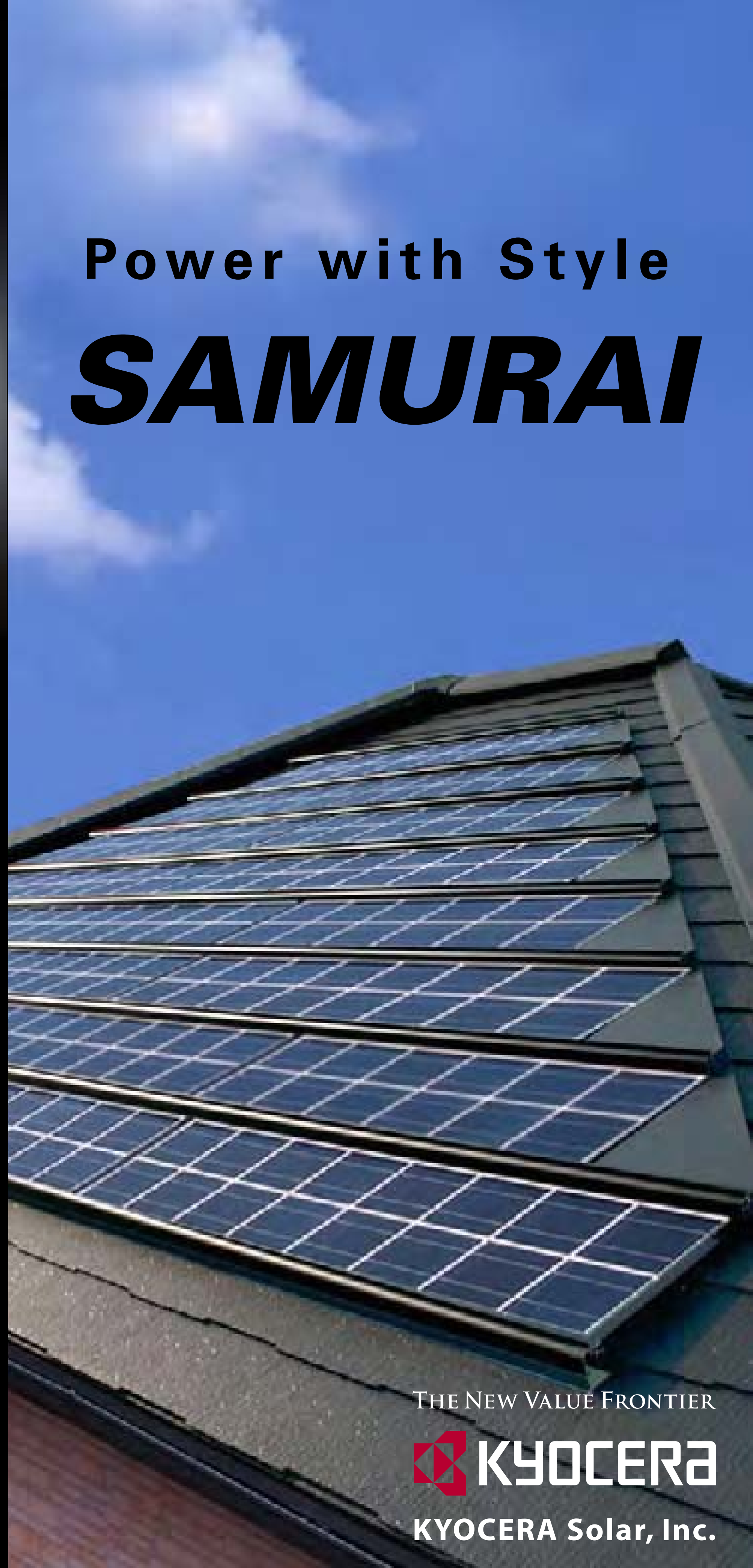
Kyocera introduces a new look in solar energy systems.

This aesthetically integrated photovoltaic system sets a new standard in ease of installation, roof space utilization and beauty. It uses two different size modules and a unique custom racking system to get the most power out of your available roof space while blending into your home's architecture better than traditional solar modules.

Now you can reduce your electric bills without sacrificing your home's elegance.

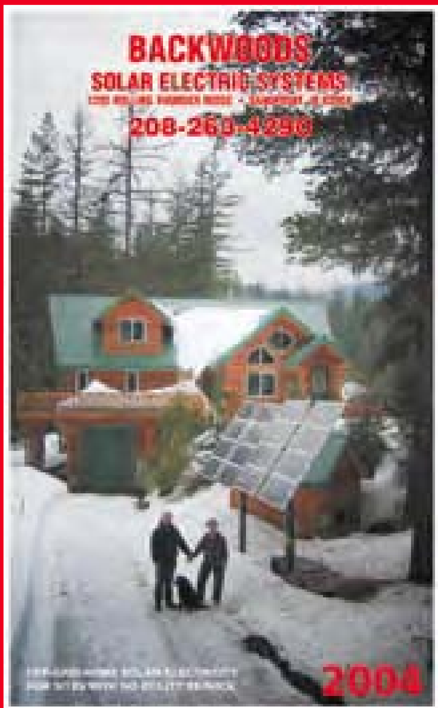
The modules are installed using three types of standard length rails. This eliminates the traditional waiting period while custom mounting racks are made to order. Your installer can have your system installed before most module mounting systems can even be manufactured.

KYOCERA Solar, Inc. Headquarters
7812 East Acoma Drive
Scottsdale, AZ 85260
tel: 480.948.8003 / 800.544.6466
fax: 480.483.6431 / 800.523.2329
info@kyocerasolar.com
www.kyocerasolar.com



BACKWOODS SOLAR ELECTRIC SYSTEMS

FREE 185 PAGE CATALOG/PLANNING GUIDE



A 185 page catalog for home sites where utility lines are not available. One third of the book is educational, to help plan and understand your solar electric system. Call, email, or send the postcard for this free catalog.

Since 1974 our home and business have been entirely powered by equipment in our catalog. We are 2 miles from utility lines. When you call or email, experienced folks personally answer your questions.

BACKWOODS
SOLAR ELECTRIC SYSTEMS

1395 ROLLING THUNDER RIDGE
SANDPOINT, IDAHO 83864

(208) 263-4290, 8 AM to 5 PM Pacific time.
FAX (208) 265-4788

E-Mail: **info@backwoodssolar.com**
Website: **www.backwoodssolar.com**

BACKWOODS SOLAR ELECTRIC SYSTEMS

FREE 2004 CATALOG/PLANNING GUIDE

Mail this card to receive our free catalog & newsletters for a year.

NAME ____

ADDRESS____

CITY ______________________ STATE ________ ZIP ________

PHONE ____

(Some catalogs come back "undeliverable as addressed" - your phone number helps when this happens)

This request is for the 2004 catalog that you may have just received. We would like to avoid accidental duplication. If you know you are on our mailing list and now mean to request a second copy, please write a note here.

Most items in stock here

- Kyocera, Shell, and Unisolar Modules
- Charge Controls and Power Centers
- Outback, Xantrex, Trace, and Statpower Inverters
- Kohler Propane Fuel Generators
- Engine-Alternator 50 amp DC Battery Charger Kit, $775
- Harris Hydropower, Whisper and Bergey Windmills
- Compact Fluorescent and Quartz DC Lighting
- Servel Gas Refrigerator RGE 400 — $1340 includes shipping
- Sun Frost & Sundanzer Refrigerators & Crosley Chest Freezers
- NovaKool small DC Refrigerators & Freezers
- DC and solar powered water pumps
- Aquastar & Paloma Tankless Instant Water Heaters
- Wood-Fired Hot Tub Heater
- Propane Room Heaters, vented, wall mounted
- Gate Opener, solar powered, radio controlled
- Digital multi-test meter, to 10 amp
- Books and videos on solar and hydro
- VISA, MasterCard, American Express, & Discover accepted

Affix First Class Postcard Postage

BACKWOODS SOLAR ELECTRIC SYSTEMS

1395 ROLLING THUNDER RIDGE

SANDPOINT, IDAHO 83864

SUBSCRIBE!

to **HOME POWER** magazine **FAST & EASY** at **www.homepower.com**
or call 800-707-6585, international 541-512-0201, or fax 541-512-0343

Or, complete and mail this form. Enclose payment as a check, money order, or credit card information.
Tape the form closed carefully or use an envelope so your check won't fall out. Allow up to three weeks for your first issue to arrive.

Shipping Information

Name:			
Address:			
City:	**State:**	**Zip:**	**Country:**
Phone:	**E-mail:**		

(Never sold or shared.) (No spam, guaranteed.)

☐ **New Subscription**

☐ **Renewal Subscription**

☐ **Gift Subscription**

☐ **Change of Address**

Old Zip Code

	USA	Canada*	International*
1 Year: 6 issues Save $19.20 off the newsstand price!	☐ **$22.50** Standard ☐ **$43.00** 1st class	☐ **$30.00** Standard ☐ **$43.00** 1st class	☐ **$30.00** Ground ☐ **Call for price** Air
2 Years: 12 issues Save 10% more!	☐ **$40.50** Standard ☐ **$81.50** 1st class	☐ **$55.50** Standard ☐ **$81.50** 1st class	☐ **$55.50** Ground ☐ **Call for price** Air
3 Years: 18 issues Save 15% more!	☐ **$57.50** Standard ☐ **$119.00** 1st class	☐ **$80.00** Standard ☐ **$119.00** 1st class	☐ **$80.00** Ground ☐ **Call for price** Air

HP 101

* Canadian and international orders must be in U.S. funds drawn on a U.S. bank.

$ Subtotal:

Specials add price to subscription above

	USA	Canada*	International*
☐ **Quick Start** With your subscription above, get our six most recent back issues sent to you right away.	☐ **Add $27.50** to your subtotal above	☐ **Add $35.00** to your subtotal above	☐ **Add $37.00** to your subtotal above
☐ **Quick Start +1** Quick Start above, **PLUS** our Solar1—Renewable Energy Basics on CD-ROM sent right away.	☐ **Add $46.50** to your subtotal above	☐ **Add $54.00** to your subtotal above	☐ **Add $56.00** to your subtotal above
☐ **First Year + CD** First-time subscribers only: Subscription, **PLUS** any selection from our CD-ROM library.	☐ **Add $21.00** to your subtotal above	☐ **Add $22.00** to your subtotal above	☐ **Add $23.00** to your subtotal above

☐ Enter number of the Solar CD-ROM to add to special. 1 through 9 currently available.

$ Additional:

Subscription cost plus cost of special **$ Total:**

Billing Information if different from above

Name:			
Address:			
City:	**State:**	**Zip:**	**Country:**
Phone:	**E-mail:**		

(Never sold or shared.) (No spam, guaranteed.)

Payment Information

☐ **Check Enclosed***
☐ **Visa**
☐ **MasterCard**
☐ **American Express**
☐ **Discover**

Card Number:	
Expiration Date:	**CSC Number:****
Signature:	**$ Total:**

* Make checks or money orders payable to *Home Power* magazine.

**The last 3 or 4 digit number on the signature strip on the back of your card. (On the front of American Express cards.)

Energy Survey

The following optional questions about your renewable energy use help us tailor the magazine to meet your needs. All information is kept confidential. We appreciate your input.

I use, or plan to use, renewable energy for:

Now	Future	
☐	☐	All electricity
☐	☐	Most electricity
☐	☐	Some electricity
☐	☐	Backup electricity
☐	☐	Recreational electricity (RVs, boats, camping)
☐	☐	Vacation or second home electricity
☐	☐	Business electricity
☐	☐	Transportation
☐	☐	Water heating
☐	☐	Space heating

My site(s) have the following renewable energy resources:

- ☐ Solar power
- ☐ Wind power
- ☐ Hydro power
- ☐ Biomass
- ☐ Geothermal power
- ☐ Tidal power
- ☐ Other (explain)

Electric utility grid use:

☐ I have the utility grid at my location.

I pay ______¢ for grid electricity (cents per kilowatt-hour).

______% of my total electricity is purchased from the grid.

☐ I sell my excess electricity to the grid.

The grid pays me ______¢ for electricity (cents per kilowatt-hour).

I use, or plan to use, the following renewable energy products (check all that apply):

Now	Future	
☐	☐	Photovoltaic modules
☐	☐	Wind generator
☐	☐	Hydroelectric generator
☐	☐	Battery charger
☐	☐	Instrumentation
☐	☐	Batteries
☐	☐	Inverter
☐	☐	Controls
☐	☐	PV tracker
☐	☐	Engine/generator
☐	☐	Methane digester
☐	☐	Thermoelectric generator
☐	☐	Solar oven or cooker
☐	☐	Solar water heater
☐	☐	Wood-fired water heater
☐	☐	Solar space heating system
☐	☐	Hydrogen cells (electrolyzers)
☐	☐	Fuel cells
☐	☐	RE-powered water pump
☐	☐	Electric vehicle

Feedback

Please write to us here. Tell us what you like and don't like about *Home Power*. What would you like to read about in future issues? Thanks for your attention and support.

☐ It's okay to print my comments as a letter to *Home Power.*

Fold Here

Return Address:

____

____

____

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY MAIL

FIRST-CLASS MAIL PERMIT NO. 49 ASHLAND OR

POSTAGE WILL BE PAID BY ADDRESSEE

HOME POWER
PO BOX 520
ASHLAND OR 97520-9903