home power

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The Stone-Guevara family brings their straw bale dream home to life.

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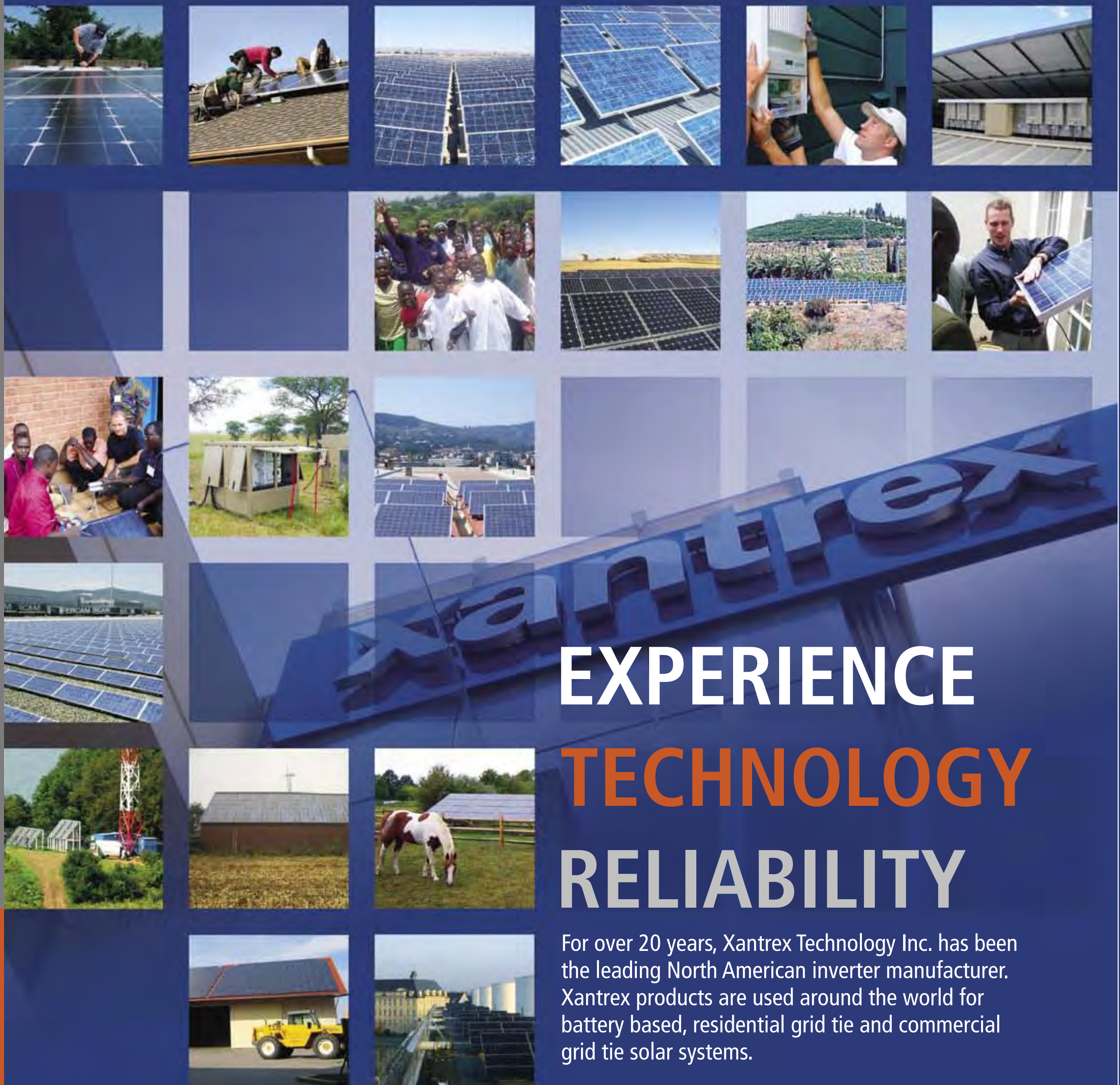
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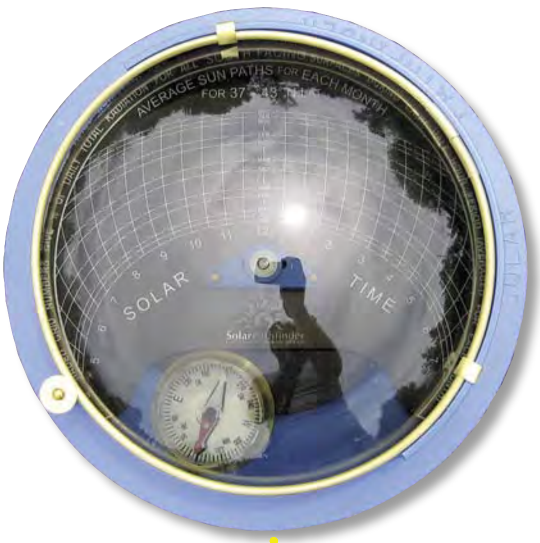
October & November 2006



On the Cover
The Stone-Guevara family in front of their passive solar, straw bale home in Carbondale, Colorado.
Photo by Steve De Micoli

Regulars

Think Locally, Act Globally

Mounting U.S. trade deficits and climbing petroleum costs due to increasing demand and decreasing supply are strong indicators that worldwide resource exchange is both the backbone and the Achilles' heel of a global economy. Although resources have been redistributed between continents for centuries, never before in history has this exchange occurred with such speed, or been so dependent on finite fuel resources. Widespread consequences like pollution and climate change remind us that resource exchange and consumption affects us in ways that span continents.

We typically use the phrase "the bottom line" to reflect the financial value of a product, service, or commodity. In the short term, we in the developed world have benefited from inexpensive products and materials manufactured in developing countries, where labor costs are low and environmental regulations are few, and cheap petroleum allows for quick and inexpensive transport of these products to market. But there's a growing awareness that the *real* bottom line is not based on economics alone, but a combination of factors, including the total amount of energy required to manufacture a given product and deliver it to your doorstep. This is a product's *embodied energy*, the amount of energy required to fabricate a specific material or product, which accounts for all energy inputs, from raw material extraction, to transport, manufacture, assembly, and installation.

Even though renewable energy equipment like solar-electric (photovoltaic; PV) modules are often manufactured far from their point of use, they make electricity from infinitely renewable (and local) resources. And while their manufacture and transport is a material- and energy-intensive process, a PV module's energy "payback" time is typically a mere two to four years, depending on the module type and location. PVs are a net energy producer, and over an estimated operational lifespan of 30 to 50 years they will generate many times more pollution-free energy than was used in their manufacture and transport. And they do it right on your rooftop. That's about as local as it gets.

—The *Home Power* crew

Think About It...

"Efficiency can save 75 percent of America's electricity at lower cost than making it at existing power plants."

—Amory Lovins, 2006, Rocky Mountain Institute

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Legal: *Home Power* (ISSN 1050-2416) is published bimonthly for $24.95 per year at PO Box 520, Ashland, OR 97520. Periodicals postage paid at Ashland, OR, and at additional mailing offices. POSTMASTER Send address corrections to Home Power, PO Box 520, Ashland, OR 97520.

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Ask the EXPERTS!

Battery Wiring

Does it make a difference where you connect your inverter to the battery bank? Do I connect to the last or first battery or batteries, or one in the center of the bank? Also, if I am hooking up two inverters, what's different? I have the same question on how to wire input from solar-electric modules to a battery bank. Great mag—keep it up. Thanks,

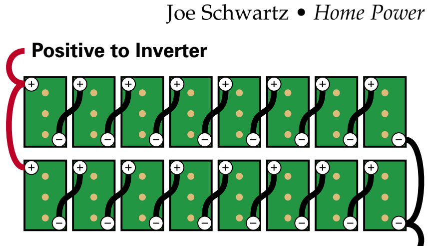
Glen Grace • via e-mail

Hello Glen, The standard installation practice is to terminate battery-to-inverter cables at opposite corners of a battery bank that has more than one series string of batteries. This wiring configuration helps balance out charge/discharge rates between the individual series strings. In this case, a picture is worth a thousand words—see the illustration below. Also, always check the combined voltage of each of your battery series strings if there is more than one before connecting them in parallel. And check the voltage of the completely wired battery bank before connecting battery-to-inverter cabling to make sure the voltage is compatible with the inverter and that no wiring errors were made.

If you're running more than one inverter, you may need to run separate battery-to-inverter cables for each inverter, and terminate the cabling at the points on the battery bank described above. Some high-voltage (48 VDC) dual-inverter installations require only one pair of cables, and battery-to-inverter wiring is terminated at bus bars inside the DC breaker panel. Check your particular inverter's installation manual for required cable length, ampacity, and configuration specifications.

In battery-based systems, PV array output conductors should always be routed through properly sized breakers both before and after the charge controller. This configuration provides overcurrent protection, and allows you to electrically isolate the charge controller if servicing is required. The charge controller output wiring will either be terminated at the positive and negative bus bars in the DC breaker enclosure, or if your system does not have a centralized DC panel, the PV cabling can be terminated directly at the battery bank at the same points mentioned above. Best,

Joe Schwartz • *Home Power*



Parabolic Collectors

Have you published any articles comparing parabolic solar hot water collectors to conventional flat-plate and tube collectors? Why are there no parabolic trough collectors for home water heating on the market? Is there some inherent flaw to them? Thanks,

Grant Jobb • via e-mail

Hi Grant, That's a good question because at one time, parabolics were somewhat popular. Thousands of parabolic trough systems were put on U.S. homes in the 1980s. These were three- and four-collector systems. Each trough was 2- by 8-feet with a 1-inch ID target tube, giving them a concentration ratio of about 22 suns. Most were installed with a south orientation, operating on an east-to-west daily track.

All of these systems failed for two main reasons. Either the tracking control failed to operate correctly or the mechanical linkage that tracked the collectors became fouled with ice, dirt, or grime, and broke or froze. The control and linkage problems can surely be solved with technology, but these systems cost US$5,000 to $6,000, and flat-plate systems of the same size were installed for half that cost or less. Parabolic systems are too complex and expensive to compete with flat-plate collectors in making 140°F domestic hot water. The troughs only existed as a tax credit product that was sold in high-pressure "seminars" or by slick salespeople called "in-home closers." In the last twenty years, the troughs have disappeared completely from the residential solar marketplace. Cheers,

Chuck Marken • AAA Solar

Solar Hot Water Maintenance

I have a PV-pumped solar hot water system on my house that uses propylene glycol as an antifreeze. How often should it be changed? Several people on solar online groups claim that I don't need to buy expensive propylene glycol made just for solar hot water systems, but that I can use inexpensive RV antifreeze available locally. The RV antifreeze is propylene glycol, and has anticorrosion additives, and supposedly safe for copper. What do you think? Thanks,

Doug Kalmer • Lutts, Tennessee

Hi Doug, Heat is the enemy of glycol solutions, and excessive heat will turn the solution various shades of brown. Dark brown is usually bad news and a good indication that the glycol needs changing. The more expensive propylene glycol concentrates like Dowfrost have buffers (aluminum hydroxide is one) that prevent the glycol from turning acidic. All the glycols I am familiar with are called "inhibited" because of the buffers they contain. The buffers in different propylene glycols are rated from about 280°F to 325°F. I don't know if all RV antifreezes have the necessary buffers for protection, since they are not normally subjected to elevated temperatures. If they aren't advertised as inhibited, you should check with the manufacturer to ensure buffers have been added.

I use litmus paper to test propylene glycol solutions. It just takes a drop or two on the 1/4-inch strip to get a good reading. I use paper that changes color at a pH between 6 and 8. Concentrated propylene glycol has a pH above 9, and when mixed with an equal amount of water, a pH of about 8. When the pH of the solution falls below 7, it needs changing. Since litmus paper is not an exact reading, I recommend changing it when the paper shows a pH of 7.4 or less. If your system is operating OK, propylene glycol solutions can easily last ten years or more before changing them. I test a few systems each month and most, by far, are above pH 7.6. It is a good idea to test the solution every year or two.

I get my litmus paper from a local chemical supply store—enough for five to ten years at my usage level costs about US$12. For people testing their solution once a year, a roll will easily last a lifetime. Cheers,

Chuck Marken • AAA Solar

Solar Angles

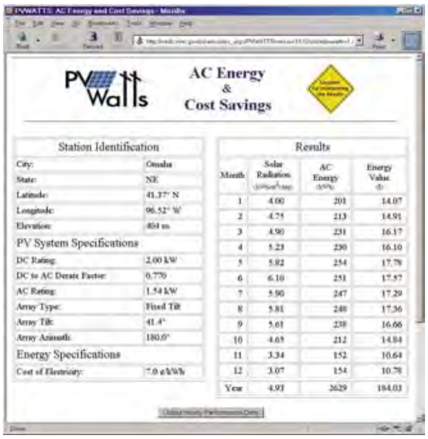
Where can I get information that relates the latitude of a place on Earth with the seasonal changes (winter & summer) for the height of the sun over the horizon

when it reaches its zenith? My question has to do with the seasonal orientation of an adjustable PV module, or the selection of a two-axis versus a one-axis autotracker. Thanks a lot,

Hector L. Gasquet • Austin, Texas

Hi Hector. Check out the calculator at http://rredc.nrel.gov/solar/codes_algs/PVWATTS. It lets you compare the output of fixed mount, single-, and dual-axis trackers.

Michael Welch • *Home Power*



Transforming a Home

I have been searching the Web for a really good step-by-step guide to explain either how to transform an on-grid house without a renewable energy (RE) system to an off-grid house with an RE system. I would like to use a combo system with solar, wind, and hydro. I am not currently a homeowner, but I would like to begin planning now.

Rich Metschke • via e-mail

Hi Rich, Such a guide would be very difficult to write, since homes, needs, equipment, location, homeowner preferences, and installations all vary so widely. I highly recommend that as you begin looking at land, or buying or building your home, you start consulting with a reputable local installer of RE systems.

Your position is good because you are thinking of building from scratch, and even shopping for property from scratch. This creates an added benefit of choosing property with good resources—solar exposure, wind exposure, hydro potential, or some hybrid combination.

Also, planning a house from the beginning, and integrating energy efficiency measures and passive solar heating (or cooling, depending on your climate) gives you a big advantage. Design variables as simple as orienting your home, sizing and placing windows properly, providing correctly sized overhangs on your eaves, boosting insulation levels, and integrating thermal mass can greatly reduce the amount of supplemental energy needed to make your home comfortable.

Remember, energy saved is energy that doesn't have to be created in the first place. This will save you three to five times the money on an RE system, and create a home that is naturally comfortable.

I suggest picking up a book on passive solar design to learn the basics, and then finding an architect in your area who specializes (not just dabbles) in energy-efficient and solar design. With a properly designed home on the right site, the RE system you choose will be icing on a very good cake. Have fun,

Ben Root • *Home Power*

Battery Charging Rates

Is there some sort of a standard maximum charge rate for flooded lead-acid batteries? Someone mentioned not wanting to take them beyond a C/10. What's the rationale for that? I'd rather hit them hard and fill them up quickly while my generator is running. Thanks,

John Bartlett • Exeter, New Hampshire

Hello John, The maximum recommended rate is C/5 (a charge rate in amps of one-fifth the overall battery capacity in amp-hours), but only when the cells are between 10 and 85 percent state of charge (SOC). After the cells reach 85 percent SOC, then a C/10 is the maximum. After cells reach 95 percent SOC, between C/20 and C/15 is recommended. Having said this, I rarely charge faster than a C/10.

The reason for the maximums is heat. Higher amperage means more heat, particularly when the cells are getting fully recharged. Thermal cycling wears the plates and sloughs off material.

Finally, it's always a good idea to get charging specifications from the manufacturer of the particular model of battery you're running. Battery specific charge rates, and bulk, absorption, float and equalization setpoints and times will all lead to better battery longevity.

Richard Perez • *Home Power*

Hydro Vent Correction

I read the question by Darryl in *HP114*, who asked about a siphon problem. Bob-O's answer suggested installing an "air purge valve" to solve the problem.

Not so fast. The part of the pipeline that forms the siphon above the water level is under negative pressure. The only way to remove the air is to pump it out (creating a greater negative pressure outside the pipe). And yes, the way to do this is to use a cheap hand vacuum pump. Pockets of air that occur below the headwater level, but in high spots in the pipe, can be kept out using Bob-O's suggestion. Regards,

Paul Cunningham •
Energy Systems & Design

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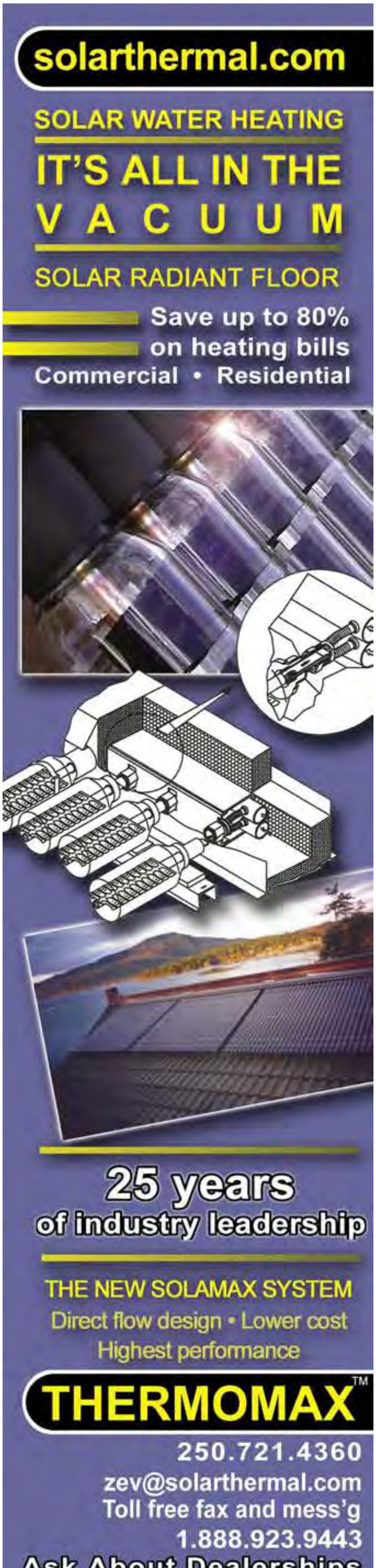

Keep Cool with CFLs

Dear *Home Power*, I've been using compact fluorescent lights (CFLs) for a number of years now. One of the things I've noticed is that I not only save energy due to the lower wattage compared to incandescents, but also, because they don't produce as much heat, my air conditioner runs less. This also saves energy.

Living in Texas with temperatures regularly exceeding 100°F, an air conditioner is a must for sanity. By not cooling the standard lightbulbs, the air conditioner only cools the brutally hot air. Proper home design, insulation in the walls, and quality windows help as well. Thanks for a great magazine!

Stephen Bachofen • Austin, Texas

Renewable Train

Last fall, I spotted this train (pictured below) heading northbound through Crowley, Texas, southwest of Fort Worth. There were at least 20 to 30 pairs of blades. Awesome!

Jim Duncan •
North Texas Renewable Energy Inc.

Electric Vehicles Dead?

As an automotive engineer, I'd like to build on Shari Prange's rebuttal of the "EV Death" letter in *HP114*. The letter writer was misinformed in stating that "the overall well-to-wheel energy efficiency of an EV is a net loss to the environment." The environmental advantages of battery-electric vehicles (BEVs) over conventional internal combustion engine vehicles (ICEVs) are well established.

Numerous researchers have studied total cycle energy usage in detail. When reading their work, I find it helpful to consider "well-to-wheels" energy flows in two distinct segments: "well-to-retail" and "retail-to-wheels." This separates the losses controlled by energy vendors from the losses and ultimate usage controlled by vehicle owners. Given the broad spectrum of energy sources and vehicles, it's obvious that the possible combinations of specific comparisons quickly become unwieldy. But I'll confidently defend this general rule: The well-to-retail efficiency of gasoline is roughly double the well-to-retail efficiency of fossil-fuel-based (typically coal or natural gas) electricity. The ICEV gets a 2:1 head start.

The tide turns at the retail sale. Retail-to-wheels efficiencies for low-tech hobbyist BEVs are more than double those of comparable ICEVs. Modern BEVs, with smarter chargers and better motors/controllers, have about a 4:1 advantage. Thus, the worst-case scenario for BEVs is a tie in the well-to-wheels energy race. The best BEVs use about half the total cycle energy of comparable ICEVs.

Total cycle emissions studies paint an even brighter picture. Over their full lifetimes, almost any BEV is cleaner than almost any ICEV, even where power plants are relatively dirty. Hundreds of stationary power plants are far easier to keep clean than hundreds of millions of mobile vehicles. If emissions-related repairs are required, the social justice questions surrounding financial responsibility are almost moot with BEVs—utilities spread repair costs among all of their customers, whereas the owner of a smoking '72 Buick chooses between a ring job and rent. Power plant upgrades immediately upgrade all BEVs on the grid, while advances in automotive design take more than a decade to fully penetrate the fleet.

Other factors certainly deserve consideration. Emissions aren't just lowered in a shift to BEVs; they're often exported to hapless downwind communities too. With PV or wind, efficiency isn't the important number—cost is. Increased coal usage will further damage Appalachian environments, and though silk-suited shills claim otherwise, Appalachian economies. (Nobody ever moved to a coal town to improve their odds of marrying a millionaire.) BEV range is problematic, though experience has shown it to be less so than most people imagine. Hybrids, my area of professional


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expertise, open a huge design space beyond conventional ICEVs and BEVs. And, as with everything in the real world, "your mileage may vary."

But, despite that variation, and because the real world is awash in mis- and disinformation, it behooves us all to examine at least a few solid, quantitative facts before we parrot fuzzy, qualitative platitudes. In the presence of honest data, honest analysis strongly supports BEVs.

Dave Erb • Upper Arlington, Ohio

Thanks for a very cogent discussion of BEVs versus ICE vehicles in terms of energy efficiency and emissions. I would like to expand on one point—your reference to BEV emissions being exported to other communities. You are referring to the concept that, even with nighttime charging, a large number of EVs in the fleet would require power plants to burn extra fuel at night to charge the cars (operating the generators at a higher level than they do now), and these power plants are likely not in the same communities that would benefit from the reduced daytime automotive emissions. This is a subtle and complex issue.

My understanding, from utility spokespersons, is that smaller fluctuations from peak demand to minimum demand would allow the generators to operate more efficiently, as the process of spooling them up in the mornings and down again in the evenings is inherently wasteful. I admit I am not sure how the increased operating efficiency balances against the increased plant emissions.

However, gas refineries also export emissions. So we would also need to factor in the reduced refinery emissions due to the vehicles that have shifted from gasoline to electricity. Even in the most optimistic projections, it would take years to get large numbers of BEVs into the fleet mix. If we are simultaneously working toward cleaner power generation, the overall effect should be a positive one.

Shari Prange • Electro Automotive

Hybrid Doubts

Dear Folks at *Home Power*, I feel compelled to comment on Andy Kerr's article in *HP113* on how good hybrids are. You can cite all the data you want to support hybrids, but a simple fact still can't be denied. The Geo Metro has far exceeded the fuel economy of any hybrid on the market today, but is no longer sold in the good old U.S. of A.

I bought a new Geo back in 1991, and got an amazing 48 mpg in the city and 60 mpg on the highway. When you figure in the cost of a hybrid vehicle and the replacement cost of the batteries in actual miles traveled, I doubt that you will come up with a figure equal to the cost of driving a Geo Metro. My Geo cost a bit more than US$7,100 in 1991, including tax and license.

I would be willing to bet that when the hybrids' batteries begin to lose their ability to hold a charge, the vehicles will rapidly lose their appeal, due to the cost of battery replacement and labor to change them out. There are automobiles all over the world that can get 75 to 100 mpg, but we here in the United States are denied access to them. Our auto manufacturers really have their heads in the sand. Sincerely,

Tom LaRosa • Port Angeles, Washington

Hi Tom, You are absolutely right. We could have affordable cars with much better fuel economy in this country, if there was a will to do it. This means both on the part of the manufacturers to build them, and on the part of the truck- and SUV-loving public to buy them. As long as hybrids are not chargeable from sources other than gasoline, their benefits are limited to improved mileage and emissions compared to the other vehicles on the market.

You are also right about the battery packs. At Electro Automotive, we are getting numerous inquiries from owners of 2000 Insights with dying battery packs who want to convert them to pure electric vehicles.

Shari Prange • Electro Automotive

Hi Tom, While I generally concur with your analysis about the American automobile industry, you seem to be arguing that the only car anyone would ever need is a Geo Metro. I used to own an '87 Honda CRX HF, which averaged 55 mpg. Though it had very low clearance and could only carry two passengers, it served my needs at the time.

All automobiles are not equal in serving one's needs. Your choice of car is based on what you are going to use it for. Today, my work requires me to drive off-pavement on substandard roads with a bunch of camping gear. Four-wheel drive is a necessity.

My goal for society is to have the highest fuel economy for any given vehicle, and the smallest vehicle to meet the need. If you drive enough miles each year, any vehicle that is hybridized—be it a Geo Metro or a Hummer—is a better deal for the owner (and always better for the Earth).

In my analysis, I factored in the cost of potential battery replacement. My analysis assumed the cost of gas at US$2.50 per gallon. It's now US$3 per gallon. Changing out batteries probably won't be any different from major engine work that most 15-year-old cars like yours periodically require. A hybrid gasoline engine will last longer because it doesn't run all the time the car is running (as I noted, the oil must be changed half as often).

Andy Kerr • The Larch Company

Courtesy Philip von Haken

Lending Problem

I have found a slight problem with your magazine—it doesn't have a "return to owner" label on it. Every time I talk about your magazine and renewable energy, somebody wants to look at the mag, and it never returns to me. Any suggestions? Thanks for a good job.

Mike Dalton • Agate, Colorado

Hi Mike, When I faced this dilemma early in my RE days (and this was before I began working with Home Power), I solved it by buying five copies of each issue, so I had four to pass out to interested neighbors, friends, and relatives. This simple practice led to a lot of people following up on their interest in renewable energy. Share the knowledge!

Ian Woofenden • *Home Power*

Greening Schools

I am an elementary school teacher, and I'm interested in getting my school to look into becoming a "green" school. I have some experience with electronics in a past career, but I need more information before I take the school and myself down that path. Can you recommend any unbiased organizations that might lead me toward my goal? Sincerely,

Dan Schmidt • Baltimore, Maryland

Dear Dan, An amazing group of environmentally focused educators have created curricula textbooks and a quarterly magazine just for teachers like you. The group is called Green Teacher and their textbooks are filled with hands-on activities for students of all ages. The titles are as follows: *Teaching Green: The Elementary Years*; *Teaching Green: The Middle Years*; *Greening School Grounds*; and *Teaching about Climate Change* (available from New Society Publishing, www.newsociety.com). The books also can be purchased at SEI's online store (www.solarenergy.org/resources/store.php).

Additionally, you can subscribe to Green Teacher magazine at www.greenteacher.com/orders.html. The U.S. Department of Energy also publishes guides for green schools (www.nesea.org/buildings/greenschoolsresources.html).

Interest in implementing Earth-conscious curricula and classroom projects seems to be growing every day. Thanks for believing that kids can make a difference! I hope this information helps. Knowledge is power!

Soozie Lindbloom •
Solar Energy International

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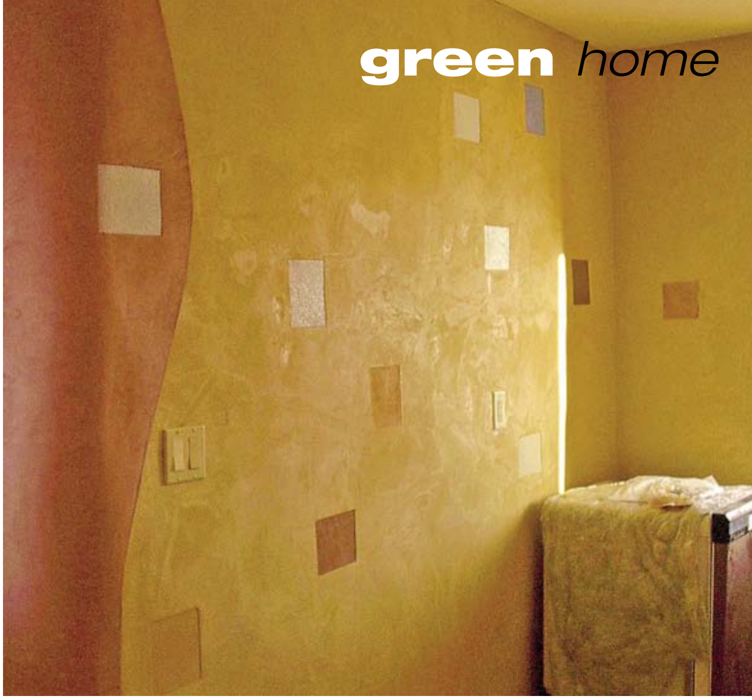
High-performance windows, forest-friendly lumber, and earthen plasters give this home its ecofriendly edge.

choosing ecological materials

The seemingly simple act of building a home can have a multitude of impacts, such as resource depletion, energy and water use, greenhouse gas emissions, and waste generation. When my husband Anibal and I decided to build our dream home, we wanted to limit our contributions to these problems by making it as energy and resource efficient as we could, while still sticking to our budget. The bottom line? With careful attention to the details and a little bit of research, we built a high-performance, beautiful, and efficient home that will consume a fraction of the energy and resources used by the average American home.



Natural plaster color samples integrated into the wall become decorative elements in the rear entryway.

Walls & Foundation

In our Colorado climate of hot summers, cold winters, and almost nonexistent humidity, using straw bales for wall insulation seemed like a perfect choice. Straw bales are nontoxic and good insulators (estimates for straw-bale wall systems range from R-27 to R-33, according to Oak Ridge National Laboratory). We sourced the material locally, buying our straw from a farmer in southern Colorado who bales specifically for straw bale homes.

Straw bale construction.

Lime plaster forms a protective exterior skin on the home.

Steve De Micoli

The sculptability of earthen plasters accommodates artistic whimsy.

Building an energy and resource efficient home also meant using materials with low embodied energy. Our first challenge was that we wanted a basement, and traditionally that means pouring a lot of concrete. Unfortunately, Portland cement production is one of the most energy intensive of industrial manufacturing processes. According to *Environmental Building News (EBN)*, including direct fuel use for mining and transporting raw materials, every ton of cement requires 6 million Btu for production, and releases 1.25 tons of carbon dioxide into the atmosphere.

To minimize our concrete use, we decided to construct the basement walls with insulated concrete forms (ICFs), hollow foam blocks or panels that can be used to form a building's exterior walls or foundation. The hollow blocks are filled with reinforced concrete, resulting in a wall that is exceptionally strong, energy efficient (boasting an R-value between R-40 and R-50), quiet, and durable. ICFs use about 30 percent less concrete than a traditional poured foundation.

Extra Insulation

Even though the home's walls are straw bale, we still needed insulation in the roof. We originally wanted a roof constructed of structural insulated panels (SIPs)—premanufactured

Building a post-and-beam straw bale home allowed us to use less wood in the home's construction. We used mostly manufactured (also known as engineered) wood products, in which pieces from smaller-diameter, faster-growing trees are laminated together to create structural members. The dimensional lumber was regular hem-fir from the local lumberyard. All of the doors are made from pine certified by the Forest Stewardship Council (FSC), a nonprofit organization that sets criteria and standards to guide sustainable forest management practices.

Pouring the adobe floor.

Steve De Micoli

Passive solar design paired with an open floor plan minimize the home's need for supplemental heating.

Thick, straw bale walls help keep the house cool in the summer and warm in the winter.

panels that consist of two sheets of rigid structural facing bonded to an insulating core. SIPs offer good insulation (R-values range from R-15 to R-45, depending on the panel thickness) and greatly reduced air infiltration. But their cost didn't fit within our budget, so we considered other options.

Our second choice was either sheep's wool or recycled cotton insulation, both of which were also outside of our budget allotment. So we chose cellulose insulation, which is made primarily from recycled newspaper. One hundred pounds of cellulose insulation contains 80 to 85 pounds of recycled newsprint. The remainder is usually ammonium sulfate or boric acid, which acts as a fire and pest retardant. The cellulose insulation was professionally blown in, resulting in an average R-value of R-52, a bit above the U.S. Department of Energy's recommended value of R-49 for our location in the Colorado Rockies.

Going Green

Building green encompasses a range of considerations, from a material's embodied energy to its energy efficiency and durability. Consider these criteria in your search for greener products.

Low embodied energy. Embodied energy is the energy used to extract, manufacture, transport, and dispose of a product. Many conventional building materials have high embodied energy. In this age of global warming, species extinction, and resource wars, selecting materials that consume the least amount of energy helps reduce your ecological footprint and improve your home's overall energy efficiency.

Local materials. When possible, buy local materials—this can strongly influence a product's embodied energy. The energy consumed in shipping a "green" material long distances often compromises the energy savings gained by using it, and sourcing materials locally can often be one of the "greenest" things you can do.

Nontoxic products. Many building materials, such as particleboard, and paint, contain toxins such as formaldehyde or volatile organic compounds (VOCs), which can be harmful to human health. Choosing nontoxic products can support better air quality inside the home, and eliminate the hazards associated with the manufacture, use, and disposal of toxic chemicals.

Recycled content. Reusing materials keeps them out of the landfill and lessens the stress on virgin resources. Many building products incorporate recycled materials such as recycled newsprint (cellulose insulation), glass cullet (tiles), and postconsumer recycled paper (composite countertops and insulation). Check your local phone listings for used building materials centers, such as Habitat for Humanity's ReStores (www.habitat.org), or check out local online communities like the Freecycle Network (www.freecycle.org).

A "truth window" in the wall reveals the straw bales inside.

Natural materials. Natural, nontoxic materials, such as earthen plaster and straw, can offer the benefits of low embodied energy and can support good indoor air quality. Compared to synthetic products, they also can produce a warmer, more inviting space.

Energy efficiency. Select Energy Star-rated appliances for your home, which offer improved energy savings, and use compact fluorescent lightbulbs instead of incandescents. Besides these more obvious choices, a home's energy efficiency also relies on its design and the qualities of materials used. The straw bale walls of our home have high R-values, which significantly reduce the need for supplemental heating and cooling, especially when combined with the insulated concrete forms for the foundation, the cellulose insulation in the ceiling, and the home's passive solar design.

Of course, if you're building a new home, the greenest thing to do in terms of energy efficiency and materials use is to build small. Today's average American home has swelled in size—from 983 square feet in 1950 to 2,349 square feet—while family size has decreased.

Performance/Durability. There's not much use in choosing a green product if it doesn't perform satisfactorily, or if it doesn't last long and needs to be replaced in just a few years. Choose durable, low-maintenance materials that are well suited to the task.

Cost. Many green building materials and technologies have higher upfront costs, but offer significant long-term savings because of their improved performance and higher energy efficiencies. In many cases, such as investing in high-performance windows and Energy Star appliances, you'll be dollars ahead in the long run if you are willing to spend a bit more upfront—especially as energy prices escalate.

Efficient Windows

Most of our windows are double pane with a low-emissivity (low-E) coating on the glazing. For our application, we wanted a coating that would reduce heat loss through the windows in the winter and reflect infrared heat radiation back into the room.

Our north-facing windows from Alpen Glass incorporate Heat Mirror, a wavelength-selective, thin-film technology that provides transparency and infrared reflection, screens ultraviolet rays, maximizes daylighting, and slows heat transfer. The two airspaces created by the suspended film further increase the windows' insulation. On a cold winter day, if you put your hand on the inside of the windows with and without Heat Mirror, you can really feel the difference.

The author's husband Anibal makes a cut into the straw bale walls.

Flooring

To capture and store incoming solar energy, we also needed to incorporate thermal mass into the house. Many passive solar homes use concrete for their floors, which has high thermal mass. However, because one of our goals was to minimize concrete use, we needed a different material.

I found a Colorado company, Mudcrafters, that creates beautiful earthen floors. Our adobe floor is inviting, nontoxic, and incredibly beautiful. The floor is composed of clay, sand, and small amounts of straw, and is sealed with several coats of linseed oil and BioShield plant-based wax, resulting in a durable finish that's easy to clean with a vegetable-oil soap.

We used engineered bamboo flooring in the rest of the house. Bamboo is strong and dimensionally stable. It is quick growing, maturing in three years, and regenerates without the need for replanting. Traditionally, bamboo has required minimal fertilization or pesticides. A couple of drawbacks to bamboo flooring is that it is imported from Asia, which increases its embodied energy, and that a formaldehyde binder is still used in the product (our floors, from Hanlite, have a very low formaldehyde content compared to other products).

Laura Bartels and Cindy Smith apply lime plaster. The final coat will be colored with mineral pigments.

Steve De Micoli

Countertops & Cabinets

Being an avid cook, I was very excited to have a new kitchen. Choosing cabinets was easy—local cabinetmaker Peter Ware handmade all of our cabinets from spalted soft maple, which some people consider "waste" wood. We think the unique patterning in the wood lends a special beauty to the cabinets.

That left the more difficult decision of what to build the countertops from. Today, many beautiful and durable countertops made from recycled materials are available. We chose PaperStone—a recycled paper product manufactured by KlipTech Composites, made with a minimum of 50 percent postconsumer recycled paper and water-based resins. PaperStone countertops are stain resistant, repairable, and heat resistant to 350°F. Originally marketed and used for outdoor skateboard surfaces, this durable, U.S.-made material has an appearance similar to soapstone. Since purchasing my countertop, KlipTech has developed an FSC-certified product made with 100 percent postconsumer recycled paper.

Interior & Exterior Finishes

Laura Bartels of GreenWeaver Inc. applied earthen plaster from recipes she created with local clays and pigments to most of the interior walls. We added mica to the plaster in the bathrooms to make those walls stronger and more water repellent. For our son Camilo's room, we opted to use lime plaster for its durability and ability to withstand some scrubbing, which will come in handy if he decides to go wild with his crayons.

We sealed all the wood in the house with plant-based paints from BioShield and other no- or low-VOC (volatile organic compound) paints and stains. Even though these products can be more expensive than conventional paints and stains, their fewer environmental and human health impacts are well worth it. Many conventional paint and coating products off-gas VOCs, which can cause a variety of health problems, including nausea, dizziness, irritation of the eyes and respiratory tract, and more serious illnesses. Even some "low VOC" paints still contain ingredients such as ammonia, formaldehyde, crystalline silica, acetone, fungicides, and bactericides.

For an exterior finish, many people like to use a cement-based stucco on their straw walls. While we like stucco's Southwestern look, we wanted to avoid the cement for a couple of reasons. One, the embodied energy mentioned earlier. But also, straw bale walls perform best when they allow vapor permeability. Cement can trap moisture in the walls, which can lead to rot and mildew in the bale walls. So we chose a lime plaster, which lets water vapor escape, is extremely strong and durable, and provides great protection, even in rainy climates where driving rains are common.

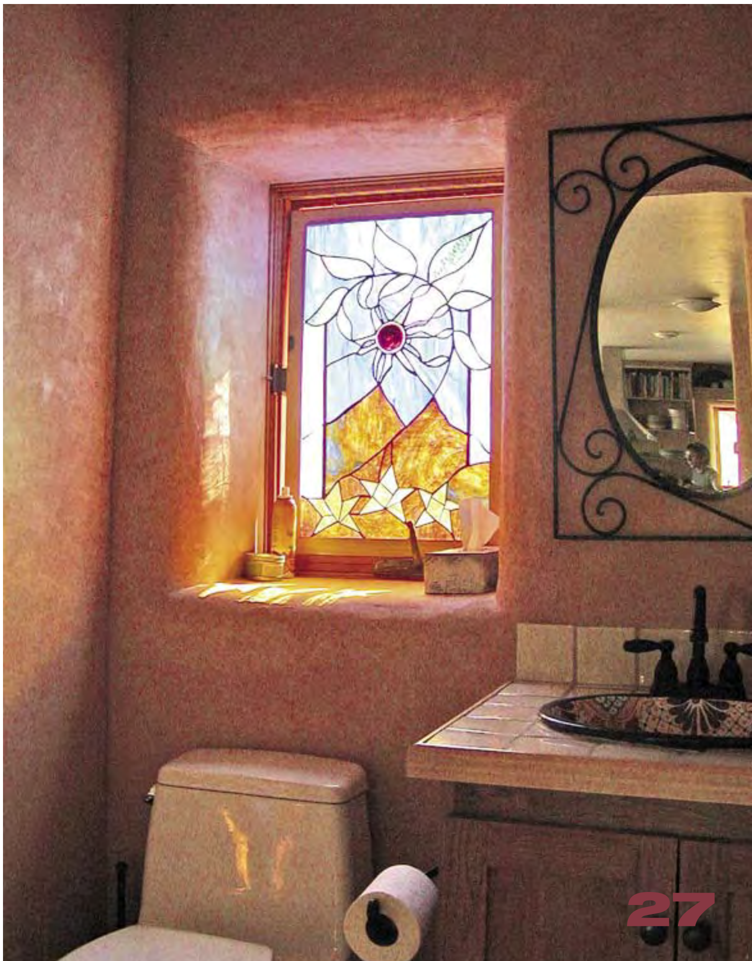
A Good Lid

We wanted to avoid asphalt shingles, which are petroleum-based, generally unrecyclable (in most areas), and compared to other roofing materials, relatively short-lived. We considered Eco-Shake shingles, which are made out of 100 percent recycled materials (reinforced vinyl and cellulose fibers) and warranted for 50 years. But we finally decided on a metal roof, which would suit our future plans for rainwater catchment and installing Uni-Solar solar-electric (photovoltaic; PV) laminates.

The End Result

Producing our own clean energy is just as important as using natural, recycled, energy efficient, and nontoxic materials. Our next steps are to install a 1- to 2-kilowatt PV system and a two-collector solar hot water system. We have the house wired and plumbed for both of these systems, and are just waiting for our bank account to be replenished before we tackle these projects.

Natural lighting and low-flow fixtures in the bathroom offer energy and water savings.



For us, a "green" home is one that impacts the environment as little as possible. What we ended up with is a beautiful, healthy, and efficient home that turned out better than we had ever imagined. Although there are some things we probably would have done differently if we weren't on a budget, we are overwhelmingly happy with the result.

Access

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GreenWeaver Inc. • 970-379-6779 • www.greenweaverinc.com • Earthen plaster

Jeff Dickinson, Energy & Sustainable Design • Phone/Fax: 970-963-0114 • www.energyandsustainabledesign.com • Architectural assistance

Keith Brand, Terralink Structures • 970-379-8002 • www.terralinkstructures.com • General contractor

Mudcrafters • 719-256-4197 • www.mudcrafters.com • Earthen floors

Green Products Sources & Information:

Alpen Glass • 800-882-4466 or 303-530-1150 • www.alpeninc.com • High-performance windows

BioShield Paint Co. • 800-621-2591 • www.bioshieldpaint.com • Plant-based paints & finishes

Building for Health Materials Center • 800-292-4838 or 970-963-0437 • www.buildingforhealth.com • Plant-based paints and finishes

Energy Star-rated products • www.energystar.gov

Forest Stewardship Council • 202-342-0413 • www.fscus.org

KlipTech • 360-538-9815 • www.kliptech.com • PaperStone countertops

Sierra Pacific • 800-824-7744 • www.sierrapacificwindows.com • Windows

SolSource • 303-297-1874 • www.solsourceinc.com • Bamboo flooring

U.S. Dept. of Energy's Zip Code Insulation Program • www.ornl.gov/~roofs/Zip/ZipHome.html • Calculates the most economic insulation levels for your home

U.S. Dept. of Energy Recommended Insulation Values • www.eere.energy.gov/consumer/tips/insulation.html • Map of recommended R-values for various regions

Choose the Right Site

To Maximize Your Solar Investment

Tehri Parker

For maximum output, solar-electric (photovoltaic; PV) modules or solar thermal collectors need to be located where they receive the most sunshine. Ideally, hills, trees, buildings, or other obstructions shouldn't shade a system site at any time during the year, so figuring out the best place to install a system can be tricky. The good news is that the Solar Pathfinder is one tool you can use to ensure that your system is sited correctly to get the most out of your investment.

Even the best system equipment on the market and a highly trained installer can't compensate for poor solar exposure. PV systems are extremely sensitive to shading, and even a small amount of shade can reduce a system's performance. Although solar water heating systems are less sensitive to shading, they are still affected by even partial shade.

How It Works

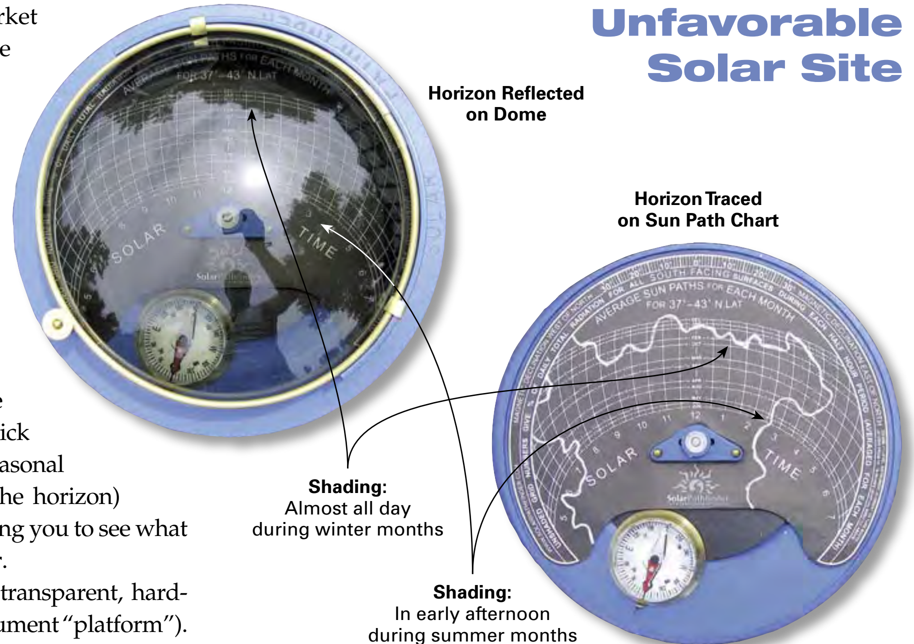
The Pathfinder is an easy-to-use tool that accurately measures the shading of any site over the course of a year—in just one quick visit. Its unique design accounts for the seasonal changes of the sun's altitude (angle above the horizon) and azimuth (its path through the sky), allowing you to see what could shade your system throughout the year.

A key component of the Pathfinder is a transparent, hard-plastic dome set on top of a solid base (the instrument "platform"). The user looks down onto the dome to see a panoramic view of the site reflected on the dome's surface. All of the obstacles to sunshine at that location can be clearly seen in this reflection.

A paper sun-path diagram, which shows the sun's route through the sky for every month of the year and every hour of the day, is placed underneath the dome. Slots in the side of the dome allow the user to trace the outline of the reflected obstacles onto the diagram, revealing exactly what obstacles will shade the selected site and when.

The complete Pathfinder kit contains the plastic dome, instrument platform, tripod legs, base section, sun-path charts for various latitudes, and comprehensive user instructions. All of this is housed in a very lightweight and durable plastic carrying case.

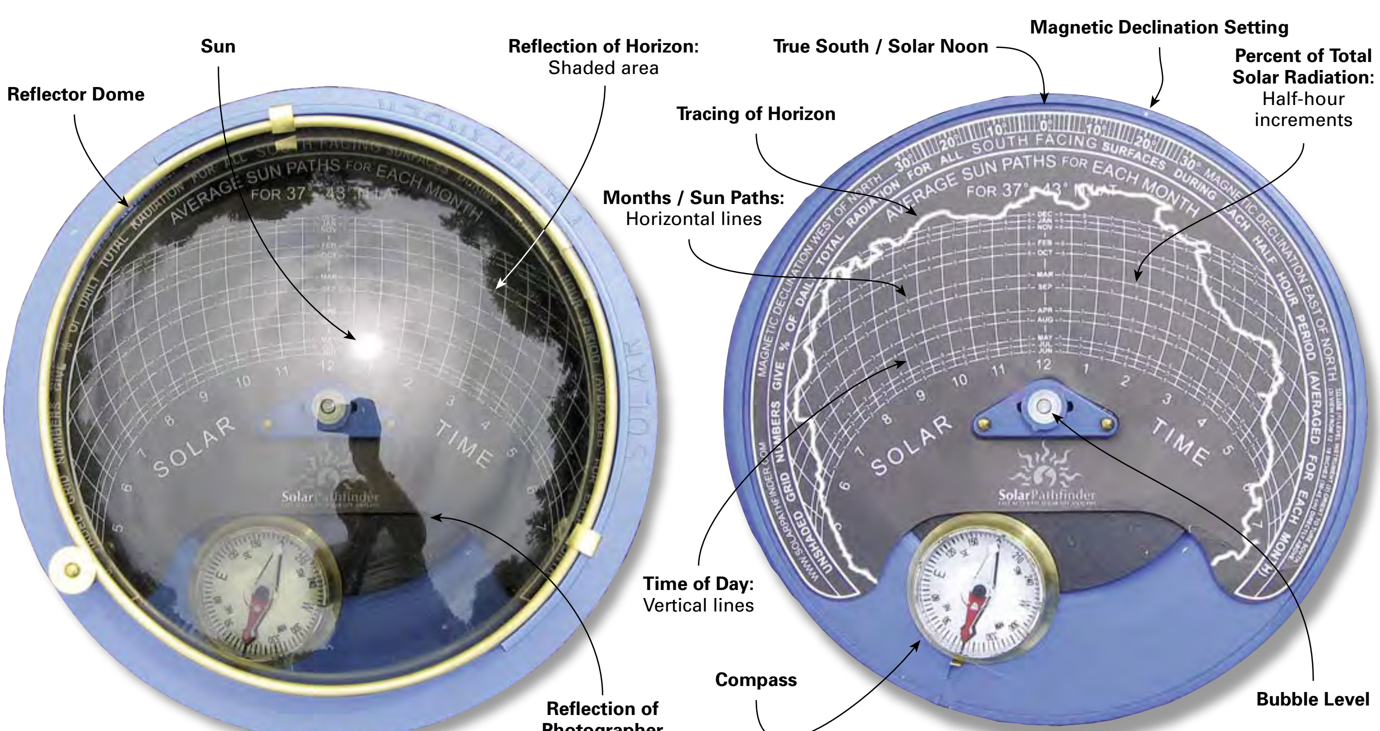
Unfavorable Solar Site



Getting Started

The Pathfinder setup is quick and easy, and usually takes just a few minutes. Start by securing a paper sun-path diagram to the instrument platform. Align the triangular hole in the center of the chart with the raised bubble level, and push down. The bubble level base holds the chart in place, so it doesn't move while you're conducting the site analysis.

Favorable Solar Site



A Smarter Solar Assistant

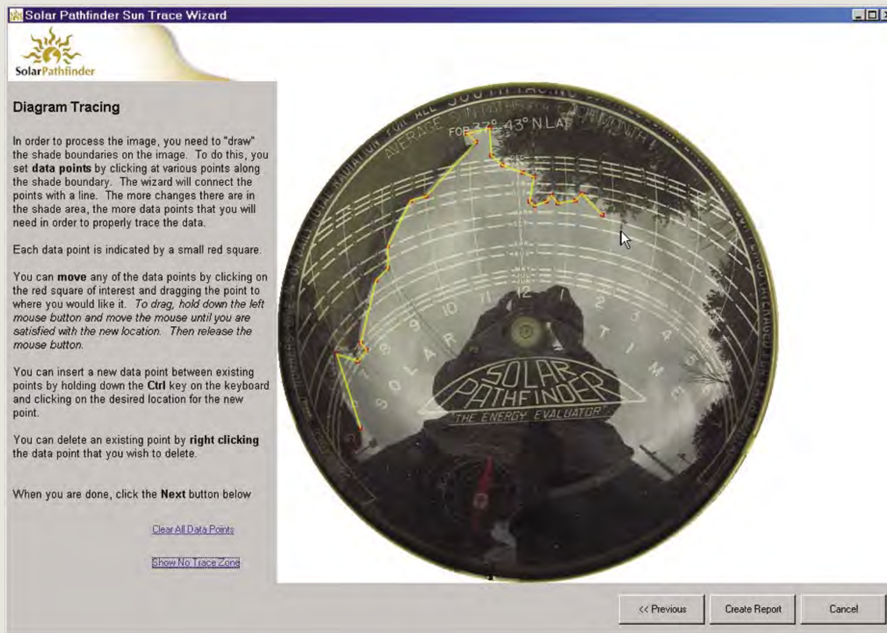
If you want an even more precise analysis of a site's solar resources, as well as the ability to subject data you collect in the field to various "what-if" scenarios, Solar Pathfinder now offers its Assistant software. Paired with the Pathfinder and your own digital camera, this software allows you to analyze site data and determine with accuracy the best siting of a PV system.

After setting up the Pathfinder at the site, you'll use your digital camera to take a photo of the reflected pattern on the Pathfinder's dome, instead of manually tracing the pattern on the paper chart. Assessing various locations on the site is as simple as moving the Pathfinder and snapping more photos. And once you've finished your fieldwork, you can analyze the data at your leisure on your computer.

The Assistant software works with any modern Windows operating system; I installed mine very easily on Windows XP Pro (sorry, there's no Mac version yet). Once you've installed the software and taken your first Pathfinder photo, you're ready to go.

Start the program and import the photo using standard "Open" dialog boxes. The first time you use a particular camera, you will need to calibrate the program, since camera lenses can vary quite a bit. Simply follow the instructions to mouse-click on a few specific reference points in the imported photo. Done once, camera calibrations can be saved for future uses of the specific cameras.

Next, set the reporting parameters, including zip code (which accesses the proper insolation data), proposed system size, derate factor (for system efficiency), azimuth (orientation of array), and the cost of grid electricity. Then calibrate the size and orientation of the photo by clicking on the compass and bubble level in the imported photo. Finally, trace the edges of the pattern reflected on the dome by clicking the mouse on points that represent the outline.



Mouse-clicking to trace the horizon line using Solar Pathfinder's Assistant software.

Once you've finished tracing, you can easily generate a report. This report includes data similar to that shown by the well-known, online PVWATTS calculator (see Access), except the Assistant knows how to subtract just the right amount at just the right times of the year to give an accurate description of the available energy at that site. The report and traced outline can be saved for further "what-if" analyses, and printed for your use or to share with potential customers.

The software contains a large data set on solar energy insolation for locations throughout the continental United States. Entering your site's zip code is usually enough to tell the Assistant what data set to use, although you can override this set with data you enter. The data can be further manipulated by adjusting the parameters and generating new reports to reflect the changes.

I was a beta tester for the Assistant, and think that it is a great addition to the Solar Pathfinder. Renewable energy installers will find it especially helpful in accurately estimating the performance that their customers can expect from a PV array. The Solar Pathfinder Assistant is a valuable customer education and sales tool, and a good investment at US$89 ($69 with Pathfinder purchase).

—Michael Welch

Solar Analysis Report

Report Title	Sweet Home Ground Mount
Image File	PICT1378.JPG
Report Date	Friday, May 05, 2006
Declination	15d 41m
Latitude/Longitude	40.564 / -123.936
Analysis Site	ARCATA, CA, Zipcode: 95521
Weather Station	ARCATA, CA, Elevation: 69 m
Station/Site Distance	30.22 miles
Array Type	Fixed
Tilt Angle	40.56 degrees
Cost of Electricity	13 cents/kWhr
DC Rate	1.00 kW
Derate Factor	0.77
Azimuth (180 = south)	180.00 degrees

Month	Exposure % Ideal/Effective	Solar Radiation (KWH/m^2/day)	Energy Value ($)
January	27.6%/27.6%	0.86	$2.58
February	42.0%/42.0%	1.49	$3.99
March	85.6%/85.6%	3.76	$11.35
April	90.7%/90.7%	4.94	$14.39
May	95.7%/95.7%	5.22	$15.68
June	95.7%/95.7%	5.00	$14.31
July	96.9%/96.9%	5.34	$15.75
August	93.5%/93.5%	4.67	$13.61
September	86.8%/86.8%	4.40	$12.53
October	50.3%/50.3%	2.09	$6.08
November	30.1%/30.1%	1.07	$3.09
December	16.6%/16.6%	0.53	$1.58
Totals	**67.6%/67.6%**	**39.38**	**$114.92**

Next, adjust the platform (with diagram in place) to account for the magnetic declination, the angle between true north and magnetic north. Due to metallic elements below the Earth's surface, compasses do not normally point to true north, but to *magnetic* north. To adjust the Pathfinder for this variable, find your location on the magnetic declination map in the instruction booklet or, for the most accurate declination figures, visit the Web sites listed in the manual. The map shows the declination of a site as either a positive or negative number of degrees. Unlock the instrument platform and rotate the chart holder the appropriate number of degrees, which are clearly labeled on the perimeter of each sun-path diagram, and then lock the platform again.

The next step is to set up the Pathfinder at the system's proposed location. Insert the ends of tripod legs into the base section of the Pathfinder, and place the platform on the base. Rotate it until the compass needle aligns with magnetic north. Then adjust the telescoping legs and level the unit by eyeing the bubble level. Place the plastic dome on top, and you are ready to go.

Site Evaluation

The Pathfinder makes it easy to compare several locations at your site for their solar suitability. Simply take your Pathfinder to each locale, set it up as described, and peer into the dome. Use the white pencil that comes with the Pathfinder to trace the outline of the objects reflected on the dome directly onto the sun-path diagram. Quick, preliminary "spot tests" to identify sites that would benefit from a tracing analysis can be performed by carrying the unit around without its legs .

For the most accurate results, the Pathfinder should be placed in the exact location of the proposed solar array. For a roof-mounted system, this will entail climbing onto the roof. To site a system to be placed on a tall pole-mount or for a house that has not yet been built, a ladder or scaffolding can be used to simulate the correct elevation. If it is not feasible to place the Pathfinder at the exact elevation of the proposed system, the next best option is to use the angle estimator spreadsheet on the Solar Pathfinder Web site (www.solarpathfinder.com/formulas.html). However, using the angle estimator tool is time-consuming because each obstacle on the horizon must be measured separately to compensate for its distance from the Pathfinder. If a home's proposed site looks good at ground level, generally solar access will also be as good—or better—at the pole or roof level.

After you have diagrams from two or three potential locations, it is time to interpret and compare the data. Each sun-path diagram has twelve arcs, one for each month, which represent the sun's path across the sky. Vertical lines, or rays, mark solar time in half-hour increments. Each half-hour increment, for each arc, is given a number that represents the relative solar energy, or radiation, that is available at that time. The numbers increase as they approach noon, when the most solar energy is available. The numbers along each sun-path arc add up to 100 percent, the total amount of potential solar energy available.

To find the percentage of solar energy that is available at each of your chosen locations, simply add up the numbers

Using a white grease pencil to trace the horizon line under the Solar Pathfinder's reflective dome.

along each arc in the *unshaded* part of the diagram. For example, see the site tracing at the bottom of page 31. A solar array placed in this location would receive 57 percent of the total available energy for the month of December (6+7+8+8+8+7+7+6=57); 43 percent of the potential energy would be lost due to shading.

Comparing the charts from the different locations will show which has the best solar potential. In general, look for the location that has the highest percentage of solar energy available, is unshaded each day from 9 a.m. to 3 p.m. (the hours with the greatest solar potential), and has no shading during these hours in the winter, when every minute of sunshine makes a difference.

The Solar Pathfinder comes with a 34-page instruction manual, complete with all the charts you need to set up and interpret the results of your site analysis. Visual learners might want to purchase the demonstration DVD (US$10), which gives a quick overview of how to set up and use the Pathfinder. And if you still need more information, you can visit the Web site.

If you crack the plastic dome or need more sun-path diagrams, you won't need to buy a whole new Pathfinder. From new charts to bubble levels, all of the essential replacement parts are available.

Seventeen years ago, *Home Power* praised the Pathfinder as the best tool for solar site analysis. And although the price has increased since then, at US$250 it's still a good deal when you're considering maximizing your return from investing in a solar energy system.

Access

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Solar Pathfinder • 317-501-2529 • www.solarpathfinder.com

PVWATTS calculator • http://rredc.nrel.gov/solar/calculators/PVWATTS

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Solar Tracking

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>>> www.LORENTZPumps.com

Eight Years of Solar Electricity

David Boyce

Lee, Maya, Eric, and Karl—and the 1.35 KW solar-electric array mounted on their home's rooftop—take in some sunshine.

The looming smokestack of an 80-year-old coal-burning power plant just over a mile from our home drove our decision to create our own clean energy. That was about fifteen years ago, and the birth of our son Karl in 1994 clinched it. Although we had always been environmentally conscious and active in our neighborhood, we decided it was finally time to put our money where our mouths are, for our children's health. So in 1997, we set out to install a renewable energy (RE) system in St. Paul, Minnesota.

Education

We discovered early on that wind energy is problematic in the city because of the lack of space for a tower. But we still wanted to replace that coal-fired electricity. So first we went to a two-day class on solar electricity (photovoltaics; PV) taught by Chris LaForge of Great Northern Solar and sponsored by the Midwest Renewable Energy Association (MREA). At Chris's suggestion, we went to the MREA's energy fair, just outside my wife Lee's hometown of Stevens Point, Wisconsin.

Going to an energy fair for the first time is like stepping into a time warp into the future. We were in awe. Wind generators and PV modules and composting toilets and everyone with the same attitude—we can make a better, cleaner future for our children and the planet. After attending all sorts of workshops at the energy fair, we had a good idea of what we wanted—as much PV as we could afford.

Lee and David with the solar-electric array, which generates more than half of their home's electricity.

and Counting...

Efficiency

The decision to install a 1.35 kilowatt (KW) solar-electric array was ultimately determined by our roof size and our pocketbook. Because we could only afford that much, we focused on reducing our energy consumption to get better use of our PV dollar. At the time, we had a full-size, upright freezer, an old fridge that wouldn't close properly, even after I replaced the door seal, and we didn't pay much attention to turning off lights and appliances when we weren't using them.

We gave the freezer to some friends (yes, they are still friends and still using the freezer), decided to replace the fridge, started turning off lights, put in energy-saving compact fluorescent lightbulbs where we could, and put our "phantom loads" (TVs and other appliances that consume energy, even when switched "off") on power strips so we could turn them off completely. After those changes, we were down to 5 KWH a day during the summer—less than one quarter of the consumption of a typical American home, and one half to one third of what we'd used in the past. We were ready to make the most of our investment in solar electricity.

David pumps biodiesel into his Mercedes 240D from his home fueling station.

We decided to get a superefficient refrigerator, since this is generally the largest home load after space and water heating, and air conditioning. We purchased a 19-cubic-foot (0.54 m^3) Sun Frost RF19, the largest they make, because we thought we wanted all that freezer room after losing our full-size freezer. If we had it to do again, we would get the more conventionally sized RF16.

The author's son Karl keeps an eye on the PV system's performance with the Brand Electronics energy meter mounted on the dining room wall.

When we were trying to make the refrigerator decision, I compared the Sun Frost to the least expensive refrigerator at our local appliance store. The nearly US$2,000 more we would pay for the Sun Frost would be saved immediately from the reduced number of PV modules we would need to power it. Each day after that, we would save more money because of its efficiency. In the last several years, mainstream refrigerator manufacturers have made significant strides in improving efficiency and reducing electrical usage, and many of these appliances now deserve a closer look.

Battery-Based

Chris recommended going with a 24-volt system, which at the time (1997) was not unusual for a grid-tie system, believe it or not. Today, many batteryless grid-tie PV systems operate at close to 600 volts DC, and 48 volts is the most common voltage for a home-scale battery-based system.

At Chris's suggestion, we purchased eighteen, 75-watt Siemens, single-crystal solar-electric modules. At the time, these were considered to be big modules. These days, 150- to 200-watt modules are a common sight. Larger modules lower manufacturing and material costs, and result in quicker system installation.

We also knew that we wanted battery backup, even though we were going to be grid tied. Our feeling was then, and remains today, that we wanted a way to use our PV array if the grid went down. We picked the Xantrex SW4024 inverter (formerly Trace), which was state of the art at the time, and four Interstate L-16s for our battery bank.

Based on our lot, trees, and a busy, urban neighborhood, we decided to put the modules on our roof. We mounted the modules on manually adjustable racks that allow the angle of the modules (22, 45, and 60 degrees for our location) to be changed seasonally to maximize system output. While it's a bit of a hassle, seasonal adjustment increases the output of the array by about 5 percent annually, and in the deep of winter, the steep angle helps snow fall off the modules.

Installation

Ten years ago, most electrical inspectors had never seen a renewable energy system, and "early adopters" were often in for a challenge. After speaking with our local plan-checker, I thought we were ready for installation. Unfortunately, we were speaking different languages. The first time Chris arrived to install the system, he was told we lacked a flashing detail and an engineering plan. We have a house built in 1925, in beautiful shape, but far from modern-day code when it came to rafters. It cost us two weeks and several hundred dollars to find an engineer to specify how to strengthen our roof to support the additional weight of the PV modules and racking.

We also had an old fuse box that had to be replaced with a new breaker panel. A full day's pay to an electrician was added to the bill. But having an old house has its good side too. Ours has a clothes chute, an internal chase that runs from the attic to the basement. This turned out to be the perfect way to run the PV wiring and conduit from the array on the roof to the inverter in the basement.

The first three days of installation were spent reinforcing the rafters on the south side of the roof according to our engineering plan. Three days in a hot attic is not fun. That ended my labor contribution, and I left the rest to Chris and his crew.

Home Loads

Item	Watts	Hrs. / Day	Days / Wk.	Avg. WH / Day
Furnace blower (winter)	1,200	1.00	7	1,200
Sun Frost RF19 fridge	80	10.00	7	800
Dining room lights	84	3.00	7	252
Microwave	1,650	0.30	4	283
Kitchen lights	90	3.00	7	270
Clothes dryer (gas)	300	1.25	5	268
Bedroom lights & fans	150	1.00	7	150
Family room lights	100	2.00	4	114
Staber clothes washer	150	1.00	5	107
TV/VCR/DVD	90	2.00	4	103
Microwave (standby)	4	24.00	7	96
Cordless phone	4	24.00	7	96
Coffee maker	1,100	0.10	5	79
Toaster	800	0.10	5	57
Laptop computer	25	1.00	7	25
			Total Avg. WH Per Day	4,608

Before we started installing the system, I had created a hatch from our attic onto the roof. I wanted a better way to get on the roof than the 24-foot (7.3 m) ladder I had been using, knowing I was going to be adjusting the module angle four times a year. With the hatch, I could climb a short ladder into the attic and then take a couple of easy steps onto the roof. As it turns out, the hatch was a necessity because the lumber to beef up the roof wouldn't have fit into the attic any other way. Changing the module angles and clearing off the occasional stubborn snow is made much easier and safer with the hatch as well.

A few days after we finished the work in the attic, we had our system up and running. There is nothing quite like that first moment when the reality of photovoltaics hits you—electricity from sunlight—it's truly *magic*! We got to see our meter spin backwards for a few months. Then the utility installed a digital meter that isn't as fun to watch. What was fun was the first time the meter reader came by after the installation. His reading device wouldn't accept the number he fed into it, but just beeped and gave him an error message because our usage was too low.

The Xantrex inverter, which converts DC electricity produced by the PV modules into typical household AC electricity, has worked flawlessly for the past eight years.

PV System Costs*

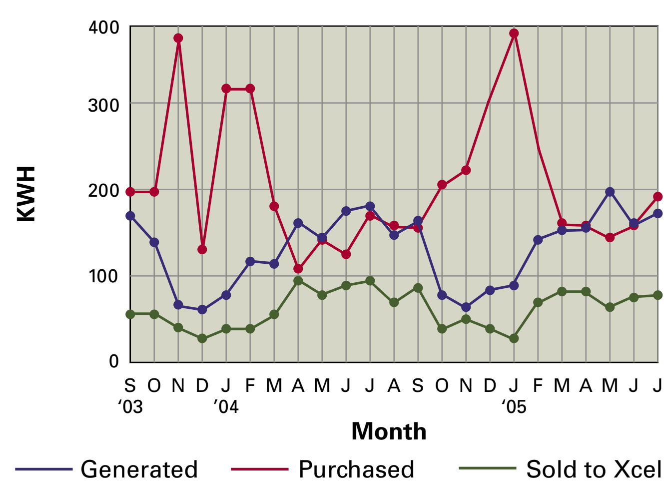
Item	Cost (US$)
18 Siemens SP75 modules	$7,477
Xantrex SW4024 inverter/charger	3,345
3 Direct Power PV racks	1,910
4 Interstate L-16 batteries	730
Xantrex ground fault protector	550
Misc. conduit, wire, etc.	489
Xantrex C40 charge controller	197
Battery disconnect, 250 A	285
Brand Electronics 20-CTR AC power meter	249
E-meter amp-hour meter	191
Shipping	150
Array disconnect, 60 A breaker	127
PV combiner box	124
2 Xantrex inverter cables	75
12 Fuses, RK-5	54
Fused AC disconnect, 30 A	39
3 Battery interconnect cables, #2/0	23
Ground rod & clamp	13
PV interconnect wire, #10	13
Total	$16,041

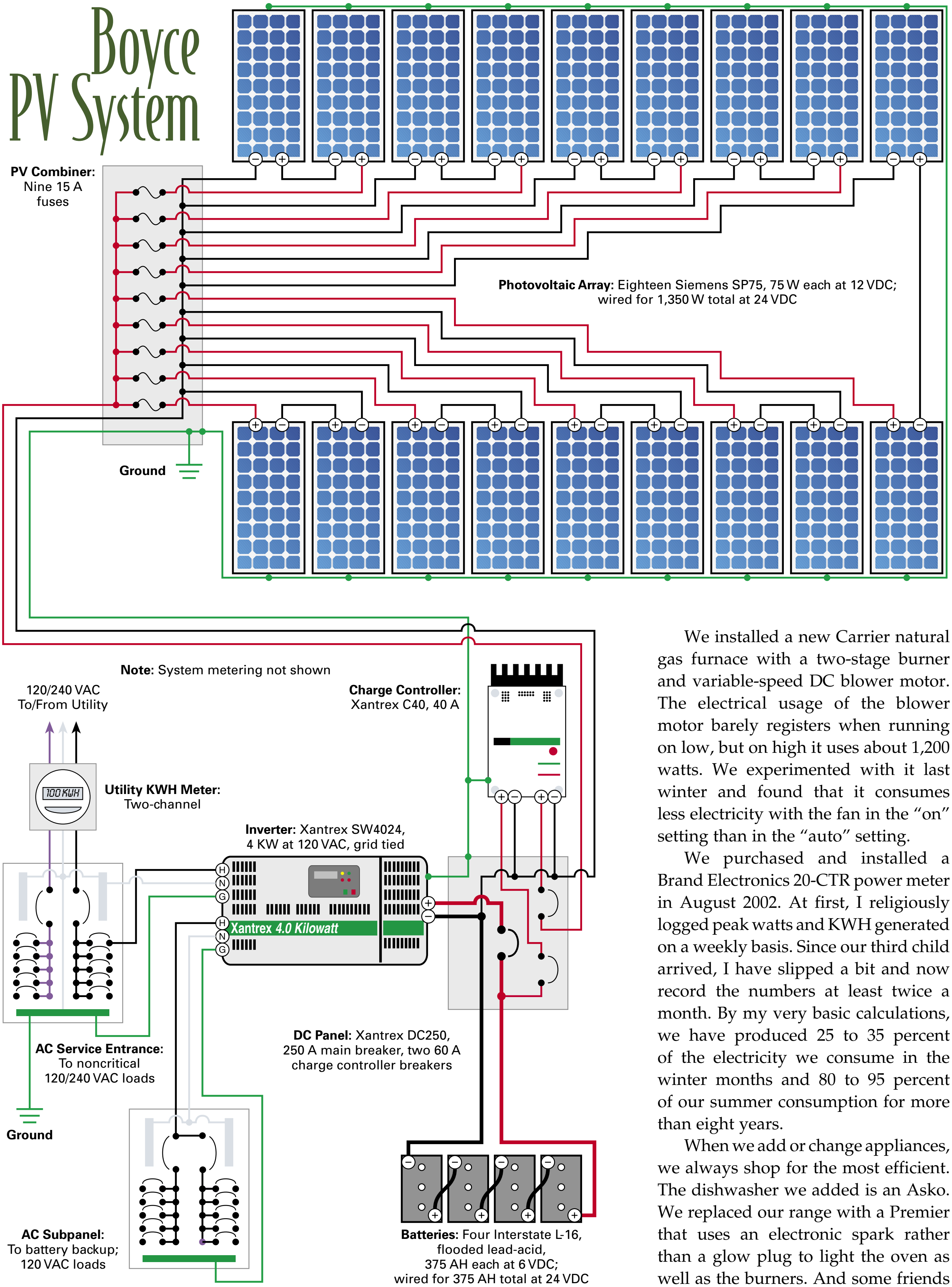
*1997 prices

Performance

I started keeping track of our net utility electricity usage when we installed the system. During the first five months, May through September 1998, we generated more electricity than we consumed. Then we had more children, had friends and relatives stay for extended periods, and bought an electric car. The furnace and the lighting add significantly to our electric load during the winter—at the same time that there is less sunlight. Our data collection from the first four years showed large peaks of net usage during the winter months.

System Performance





We installed a new Carrier natural gas furnace with a two-stage burner and variable-speed DC blower motor. The electrical usage of the blower motor barely registers when running on low, but on high it uses about 1,200 watts. We experimented with it last winter and found that it consumes less electricity with the fan in the "on" setting than in the "auto" setting.

We purchased and installed a Brand Electronics 20-CTR power meter in August 2002. At first, I religiously logged peak watts and KWH generated on a weekly basis. Since our third child arrived, I have slipped a bit and now record the numbers at least twice a month. By my very basic calculations, we have produced 25 to 35 percent of the electricity we consume in the winter months and 80 to 95 percent of our summer consumption for more than eight years.

When we add or change appliances, we always shop for the most efficient. The dishwasher we added is an Asko. We replaced our range with a Premier that uses an electronic spark rather than a glow plug to light the oven as well as the burners. And some friends

Tech Specs

Overview

System type: Battery-based, grid-tie PV

Location: St. Paul, Minnesota

Solar resource: 4 average daily peak sun-hours

Production: 114 AC KWH per month (average)

Utility electricity offset: 52 percent (annual average)

Photovoltaics

Modules: Eighteen Siemens SP75, 75 W STC, 17 Vmp, 12 VDC nominal

Array: Nine, two-module series strings, 1,350 W STC total, 34 Vmp, 24 VDC nominal

Array installation: Direct Power & Water RGM mounts installed on south-facing roof, seasonally adjusted to 22, 45, and 60 degree tilt angles

Energy Storage

Batteries: Four Interstate L-16, 6 VDC nominal, 375 AH at 20-hour rate, flooded lead-acid

Battery bank: 24 VDC nominal, 375 AH total

Balance of System

Charge controller: Xantrex C40, 40 A, PWM, 24 VDC nominal input, 24 VDC nominal output

Inverter: Xantrex SW4024, 24 VDC nominal input, 120 VAC output

System performance metering: E-Meter battery monitor, Brand Electronics 20-CTR AC power meter, utility KWH meter

gave us their used Staber clothes washer when it needed a minor repair because they knew we would use it.

Our concern about efficiency and sustainability extends to other areas of our life as well. For transportation, we purchased an electric car that I am slowly improving. We needed a bigger vehicle for our family, so we purchased a Ford station wagon that burns E85, a blend of 85 percent ethanol and 15 percent gasoline. And I found an old diesel Mercedes that I am fueling with 100 percent biodiesel from the Twin Cities Biodiesel Co-op.

Easy Living

Living with this system is easy most of the time—and difficult for 45 minutes, four times per year, when I adjust the angle of the modules. Although adjusting the tilt of your modules isn't absolutely necessary, we're interested in maximizing the output of our system. On a daily basis, the system runs itself without trouble.

Several years of flawless operation ended with the failure of one of the batteries. It was my fault for getting lazy with maintenance. I had purchased and installed a pulsating desulfator and became less frequent with my equalizing charges. A few minutes of analysis showed me which battery was dead, and after a frantic call to Chris, I was able to put together a "patch" so that our whole house would continue to operate until new batteries could be delivered. We replaced the entire battery bank rather than just the single battery so that the batteries would all be the same age. The local Interstate dealer delivered the batteries all the way to the battery box and removed the old ones as well.

Another interesting thing I discovered during this episode was that the wiring on the AC side of the inverter had loosened. Tightening it again was simple enough, but it made me wonder how it could have happened. I think an annual tightness check is in order.

Changing the angle of the modules is the only difficult part of the maintenance of our system. It involves removing bolts on both legs of each of the three racks and then switching or adding legs to make the correct angle. I purchased a rope and harness after a couple of slippery visits to a snowy roof. Occasionally in the winter, snow sticks to the modules, even though they are set at 60 degrees. I

The Boyce family enjoys knowing that their electricity is clean and green.

usually just wait for a sunny day to see if the snow will melt off. If it doesn't, I go up with a squeegee and brush it off. This happens maybe once or twice during the winter.

Sunny Future

More modules are on the wish list to get our annual production above 100 percent usage. Finding the space for them may be tough. We also plan to install a solar domestic hot water system. We recently had to replace our ancient water heater, so we installed a Bosch Aquastar tankless heater. The solar-capable model monitors and adjusts to incoming water temperature. Once we get the full system installed, if the water has already been heated by the sun, the gas heater won't fire up.

Each month is different in terms of our electricity production. I really notice prolonged cloudy periods, but some months are great when you don't expect it. Last April, normally a rainy month here, we had lots of sun, and produced more than 92 percent of our electricity, pollution free, from the sun. Now when we drive by the coal plant down the road, our kids shout, "We don't need your dirty electricity—we get ours from the sun!"

Access

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Christopher LaForge, Great Northern Solar, 77480 Evergreen Rd., Ste. 1, Port Wing, WI 54865 • 715-774-3374 • gosolar@cheqnet.net • RE systems dealer & installer

David Morris, PA, 6940 Ticonderoga Tr., Eden Prairie, MN 55346 • 952-934-0351 • Structural engineer

Product Manufacturers:

Asko • www.askousa.com • Dishwasher

Bosch •www.boschappliances.com • Tankless water heater

Brand Electronics • 888-433-6600 or 207-549-3401 • www.brandelectronics.com • Digital power meter

Direct Power & Water • 800-260-3792 or 505-889-3585 • www.directpower.com • PV mounting racks

Interstate Batteries • www.interstatebatteries.com • Batteries

SolarWorld (formerly Siemens) • www.solarworld.de/sw-eng/products • PVs

Staber Industries • 800-848-6200 or 614-836-5995 • www.staber.com • Washing machine

Sun Frost • 707-822-9095 • www.sunfrost.com • Refrigerator

Xantrex • 604-422-8595 • www.xantrex.com • Balance of system components


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Harmony with Nature
DC Power Systems
AEE Solar
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Sun Pumps
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Global Cooling

A blanket of atmospheric greenhouse gases, mostly carbon dioxide (CO_2), is what keeps our planet warm and habitable. But our dependence on fossil fuels for everything from home heating to fueling our vehicles is getting us into trouble, as burning fuel releases excessive amounts of CO_2 and other pollutants into the air. These added gases are making the blanket too thick—kind of like leaving the winter quilt on the bed during the summer months. And this warm-up is melting polar ice, raising sea levels, and changing weather patterns around the world.

So how can you change the world—for the better? Check out these sources we've put together. Educating yourself is the first step—then we can all work together toward the solutions.

A Must-See Movie

▶ *An Inconvenient Truth* by Al Gore. Both a feature movie and a book, *Truth* is aimed at people who might not otherwise be exposed to climate change info. Yet there is enough in it to satisfy even the most seasoned activist. If you do nothing else to learn about climate change, see this movie. See www.climatecrisis.net. For show times: www.fandango.com/moviepage.aspx?mid=95961.

Recommended Reading

▶ *The Heat Is On: The Climate Crisis, the Cover-Up, the Prescription* by Ross Gelbspan (278 pages, US$16, www.heatisonline.org). The first widely distributed "wake-up call" about global warming, this book was first published in 1995, and is still pertinent. It explains the real science behind global warming, the suppression of the science, and how fossil-fuel lobbyists financed that cover-up.

▶ *Boiling Point: How Politicians, Big Oil and Coal, Journalists, and Activists Are Fueling the Climate Crisis—And What We Can Do to Avert Disaster* by Ross Gelbspan (254 pages, US$22, www.heatisonline.org). The subtitle pretty much sums it up. Gelbspan has been an editor and reporter for the *Boston Globe*, and participated in a Pulitzer Prize-winning series while there.

▶ Three books by Richard Heinberg are of related interest. *The Party's Over* (288 pages, US$17.95), *Power Down* (288 pages, US$16.95), and *The Oil Depletion Protocol: A Plan to Avert Oil Wars, Terrorism, and Economic Collapse* (208 pages, US$16.95, all from www.museletter.com) all discuss the diminishing oil supply and what it will mean to be part of a post-oil world.

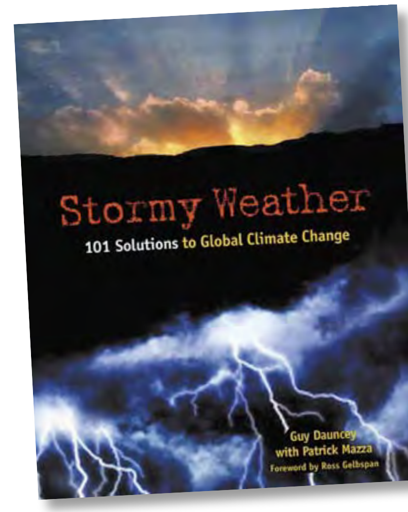
▶ *Can We Still Avoid Dangerous Human-Made Climate Change?* by James Hansen, director of the NASA Goddard Institute for Space Studies (42 pages, available at www.homepower.com/promisedfiles). The answer is yes! This excellent and eye-opening presentation includes the summary, "The Earth's climate is nearing, but has not passed, a tipping point beyond which it will be impossible to avoid climate change with far-ranging undesirable consequences."

The Solutions

▶ *Stormy Weather, 101 Solutions to Global Climate Change* by Guy Dauncey (271 pages, US$19.95, www.earthfuture.com). The ultimate one-stop source for what can be done to halt human-caused climate change, this book covers everything from solar and energy efficiency to political activism and carbon taxes.

▶ *Consumer Guide to Home Energy Savings* by Wilson, Thorne, and Morrill (247 pages, US$8.95, www.aceee.org). This handy book, now in its eighth edition, compares operating costs and energy efficiencies of most models of modern appliances, and is full of energy-saving tips. Check out an abbreviated version on the ACEEE Web site.

▶ *Kilowatt Ours* DVD or VHS by Jeff Barrie presents the solutions to coal-based energy production (65- or 35-min. DVD versions, US$95, www.kilowattours.org). This educational film is not about global warming per se, but rather the other environmental and health problems associated with coal energy—and how conservation, efficiency, and renewable energy are the ultimate answers. You'll be shocked to discover how devastating our reliance on coal really is.



Web Resources

▶ Union of Concerned Scientists • www.ucsusa.org/global_warming/science/Fingerprints.html • Sleuthing the human causes of global warming.

▶ RealClimate • www.realclimate.org • Climate science from climate scientists.

▶ United Nations Framework Convention on Climate Change • www.unfccc.int • The international policy mechanism that developed and is charged with implementing the Kyoto Protocol.

▶ RenewUS • www.renewus.org • View a 4-minute online video, *Climate: A Crisis Averted*, which "looks back" from the year 2056 and recounts how ordinary citizens in 2006 took action to demand clean energy and other planet-friendly options.

▶ Green House Network • www.greenhousenet.org • Join the national volunteer speakers network to stop global warming.

▶ Alliance to Save Energy • www.energyhog.org • Interactive Web sites—one for adults and one for kids—on how to improve your home's efficiency.

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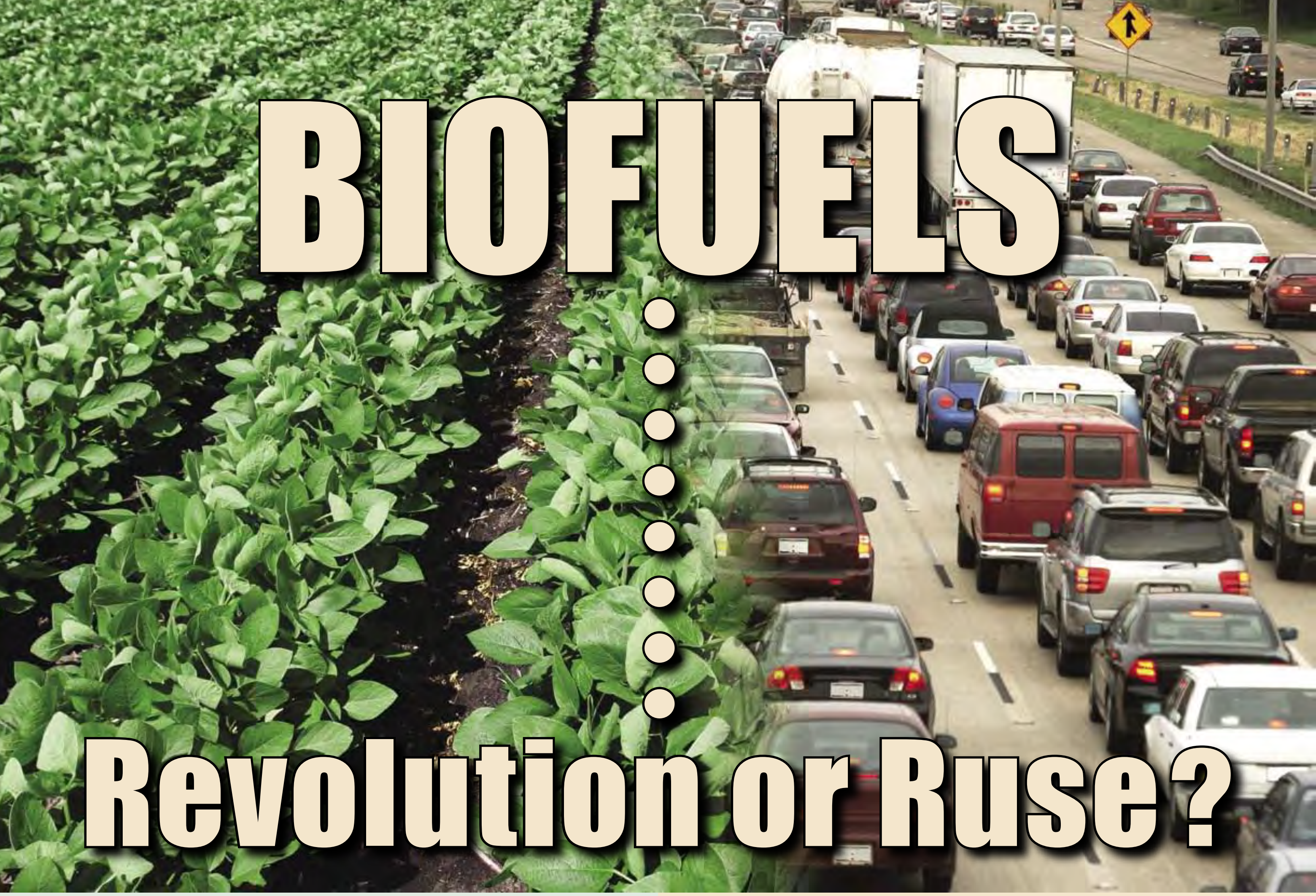


BIOFUELS: Revolution or Ruse?

David Max

Biofuels are concisely defined as "fuels, such as methane, ethanol, and biodiesel, that are produced from renewable resources, especially plant biomass and biobased industrial wastes." The biofuels that gain most of the headlines in the United States are biodiesel produced from soybeans, and ethanol produced from corn. Producing and using biofuels accomplishes multiple goals, including cleaner emissions, domestic energy security, and diversified energy production.

According to the National Renewable Energy Laboratory (NREL), biofuels contain significantly more energy than is used in their production. In contrast, both gasoline and diesel require more energy to produce than they contain.

Net Energy of Fuels

	Energy Out / Energy In	
Fuel	**Ratio**	**Percent Gain/Loss**
Biodiesel	3.20	220%
Ethanol	1.40	40%
Diesel	0.89	-11%
Gasoline	0.85	-15%

Source: NREL

Richard Engel

In his book, *In the Absence of the Sacred*, author Jerry Mander claims that too little critical dialogue in society takes place over the introduction of new technologies. And what dialogue does take place is generally controlled by those with a vested interest in seeing the technology adopted. I'm afraid this scenario is being acted out once again in the realm of biofuels.

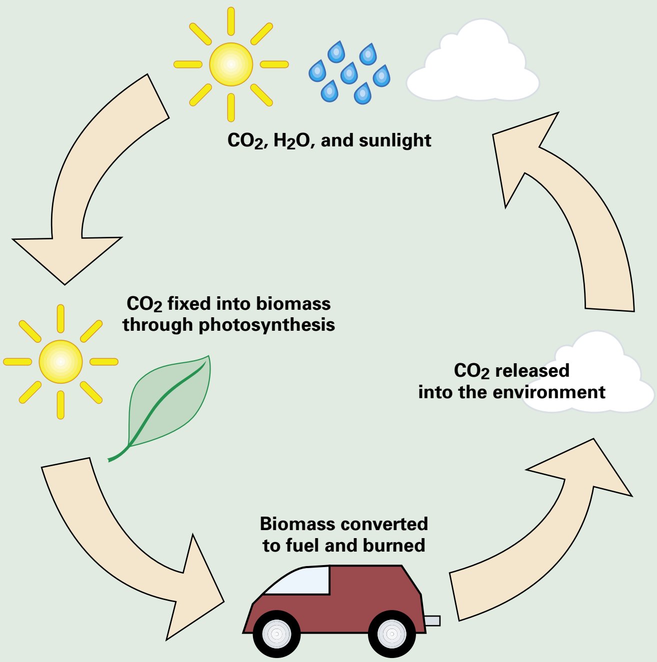
Many agribusiness interests, supported by some well-meaning environmentalists and renewable energy enthusiasts, are promoting biodiesel and other plant-derived fuels as a magic bullet that will enable a smooth transition out of the fossil fuel era. Biofuels certainly can offer some benefits, but serious problems may arise as we start using these fuels on a larger scale.

Much of the dialogue on the sustainability of biofuels derived from "virgin" plant feedstocks begins and ends with the issue of energy return on energy invested, or EROEI. This is the ratio of how much energy a fuel yields to the nonrenewable energy invested to create or obtain that fuel. An EROEI value of 1 means a fuel is just yielding back the invested energy. An EROEI less than 1, where more energy is invested than is derived, is not a sustainable long-term investment.

David Max, continued

Biodiesel and ethanol produce cleaner emissions than their petroleum counterparts. Carbon dioxide (CO_2), carbon monoxide, and particulate emissions are all reduced. Moreover, biofuels are CO_2 neutral—CO_2 released during combustion is equal to CO_2 sequestered by crops and biomass during the growth stage. While current petro-based agriculture emits CO_2 during production, using biofuels for crop production instead would create a completely CO_2 neutral process. None of this beneficial CO_2 recycling occurs when petroleum is burned and extracted.

The Biofuel Carbon Cycle



Unfortunately, existing biofuel production cannot meet transportation fuel demands. Using current feedstocks and production technologies, total biodiesel and ethanol production is less than 4 billion gallons per year. U.S. Department of Agriculture and Department of Energy research suggests that by using highly efficient cellulosic ethanol and planting more efficient forms of biomass, like high-yielding, low-input perennial switchgrass and by using crop residues, 30 percent of the gasoline we consume could be replaced by ethanol. Brazil replaces almost 40 percent of their total gasoline consumption with domestically grown and cheaper-to-produce ethanol from sugar cane.

By combining all available vegetable and animal waste fats, appropriate oilseed cultivation land, and higher yielding crops, present biodiesel production technologies could fulfill 20 percent of our diesel fuel needs. For example, mustard and canola yield higher oilseed per acre than soybeans.

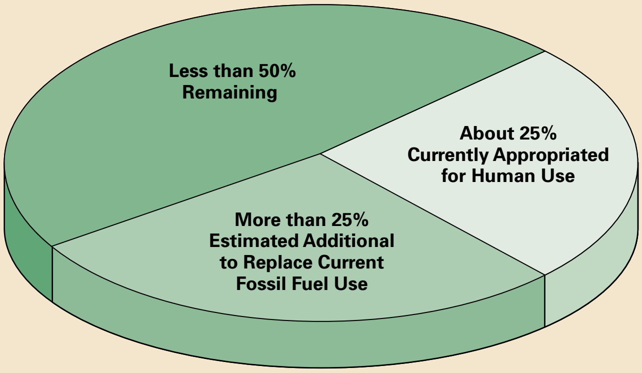
Richard Engel, continued

Prior to 1950, petroleum offered an impressive EROEI on the order of 100. Having retrieved the "easy" oil decades ago, petroleum's EROEI is now about 20 and falling. EROEI for biofuels varies widely depending on the feedstock, the extraction method, and other variables. I've recently seen estimates ranging from about 0.7 (definitely unfavorable) to more than 2 (pretty good). It appears likely that corn-derived ethanol has a favorable EROEI under certain conditions, but overall the energy balance for biofuels remains controversial.

Energy calculations do not tell the whole story about biofuels. Are the planet's non-energy resources—soils, land, water—capable of indefinitely supporting billions of humans dependent on biofuels? Each year, humans consume an estimated 20 to 30 percent of the planet's annual net primary productivity—what plants produce using the sun's energy. This is in addition to our rapid drawdown of the planet's "savings account" of fossil fuels.

Dr. Jeffrey Dukes, Assistant Professor of Biology at the University of Massachusetts–Boston, estimates that transferring our fossil fuel dependence entirely to plant sources would demand more than a quarter of our planet's annual plant growth, meaning that humans would be gulping down more than half of the planet's primary productivity each year.

Global Net Primary Production (NPP) from Photosynthesis



Consider freshwater, already widely predicted to be the most hotly contested resource of the twenty-first century. Humans currently appropriate some 26 percent of the global flows of freshwater, using about nine-tenths of this for agriculture. Could we tolerate a doubling of this resource use?

Global cropland resources may be even more strained, having shrunk by half to 0.23 hectare (about half an acre) per person over the past five decades. Apart from stresses due to population increase, the decline in per capita cropland is

David Max, continued

They are also great rotation crops for grains, improving the soil and breaking up pest cycles. With integrated crop management, the capture of biogas from waste agricultural residues, and wind production farms, we can grow clean energy for both rural and urban populations.

While cleaner emissions are a top priority, so is the efficient and appropriate use of land resources. According to research at NREL, the construction of high-oil-yielding algae farms to produce biodiesel feedstock has the potential to replace 100 percent of the petroleum fuel that we consume, while requiring less than 2 percent of the land space we currently use to produce all agricultural crops combined!

Researchers at the Massachusetts Institute of Technology (MIT) and within private industry are experimenting with methods of growing high-oil-content algae from flue gases emitted by fossil-fueled power plants. Incredibly, the algae reduce CO_2 emissions by 40 percent, and nitrous oxide emissions by 86 percent! Both oil and cellulose can be extracted from the algae, with the potential to produce 15,000 gallons per acre of both biodiesel and ethanol.

It has been said that the United States should be embarking on an "Apollo-like" push to research and finance renewable energy production and next-generation technology advances for efficient energy consumption. The expense and financing needed to construct this network would be enormous, but less than the total the United States has spent in Iraq. It would require innovation and research funding at universities and industry throughout the United States, and would have the potential to employ tens of thousands.

Consider the U.S. diesel passenger vehicle market, which is currently less than 4 percent of the total consumer market. In 1990, Europe's diesel passenger vehicle market was less than 10 percent. By 2005, it had grown to 50 percent. Why the popularity growth? Efficiency. Diesel engines are more efficient than gasoline engines in converting the energy contained in fuel into useable energy for the drivetrain.

Auto manufacturers have begun to see expansive new markets created by huge demand for hybrids and modern turbo-diesels in the wake of diminishing SUV sales. The Ford Expedition is on its way to extinction, and evolution has spawned Ford's first diesel-electric hybrid concept car, the Reflex. Volkswagen's latest prototype, nonhybrid diesel, the EcoRacer, is reported to get 69 mpg! Trucking companies are looking at diesel-hybrid systems that require higher initial investments, but offer significant fuel savings and cleaner emissions.

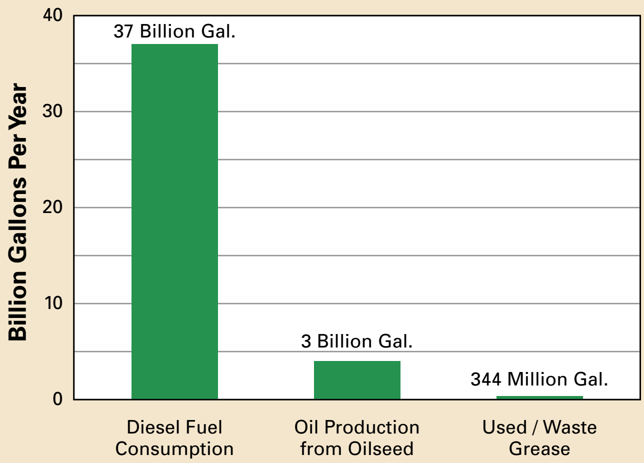
Biofuels hold the potential to offer cleaner emissions while using current fueling and vehicle infrastructure, despite obvious needs for increased efficiencies. Continued innovation in the production and utilization of these valuable resources can add multiple choices to our renewable energy portfolio. This could begin to not only move us away from fossil fuels, but also from fossil-fueled mind-sets.

Richard Engel, continued

driven by the abandonment of 20 million hectares (about 50 million acres) of cropland per year due to soil erosion and salinization. Where these croplands are replaced, it is generally through deforestation. Biofuels farming could greatly aggravate these conditions.

Many people tout biodiesel as a creative way of making use of used restaurant fryer fat. Yet in many communities, this "waste" is already being recovered to make products like soap, industrial chemicals, and animal feed. If such industries lose their feedstock to biodiesel production, they'll just turn to agricultural or petroleum sources, canceling any net gain in waste diversion or resource conservation. Growth potential for waste-derived biodiesel is also very limited. If we turned all of our waste fryer fat into biodiesel, we would meet less than 1 percent of current diesel fuel demand for transportation.

U.S. Diesel Consumption vs. Alternative Oil Supplies



Many biofuels enthusiasts wisely acknowledge that plant-derived fuels cannot replace petroleum on the scale we use today. They foresee biodiesel and ethanol playing minor roles as part of a portfolio of renewable technologies.

This is a healthy outlook, and we need to question biofuels policies that seek to make plant-derived energy a one-to-one replacement for fossil fuels or that send us back down the same road of dependence on unsustainable or imported energy sources. In November 2005, the United States received its first tankerload of foreign biodiesel, made from virgin Ecuadoran palm oil. Weren't we looking for *alternatives* to imported oil?

I'm willing to become a biofuels advocate if some emerging technology like cellulosic ethanol, derived from switchgrass, or algae-derived biodiesel proves feasible and sustainable on a large scale, but for now, I remain a skeptic. In seeking a measured approach to biofuels, I'll close by quoting environmental guru David Brower: "All new technologies should be assumed guilty until proven innocent."

Rebuttal by Richard Engel

During the several weeks since I started researching and preparing for this debate, some interesting experiences in the course of my daily work have got me rethinking biofuels. I participated in a conference call with biofuels researchers and a team who are trying to commercialize algae-derived biodiesel to fuel a major metropolitan bus fleet. I met with a former co-worker now engaged in the same MIT CO_2-capture project David cites. These ideas may someday prove technically and economically feasible, and I support continued biofuels research.

However, we need to keep our expectations realistic. Converting every acre of land in the United States to soybean production would replace barely half of our current gasoline and diesel fuel consumption.

The most important work in transportation energy really needs to happen on the demand side. When I see massive pickup trucks rumbling around town with one occupant and no cargo, many of them sporting pro-biodiesel bumper stickers, I think, "What's wrong with this picture?" We need to shift our emphasis to tried-and-true strategies like ride-sharing, using mass transit, building efficient vehicles, and creating walkable communities. If we put as much effort into these demand-side solutions as we do into clean fuels and other high-tech supply-side approaches, "peak oil" will be nothing to panic over.

A sustainable large-scale program for biofuels would have to:

- Use waste materials (such as crop residues and waste oil) as feedstock. Dedicated agriculture for energy crops produces too many negative impacts, including wildland habitat loss, displacement of essential food and fiber crops, and increased strain on already over-allocated soil and water resources.
- Be domestically based. The additional energy and emissions from transporting biofuels globally may cancel their benefits. Besides, ending dependence on foreign energy is purportedly one of the main drivers for biofuels development.
- Be linked with a serious plan to reduce overall fuel demand using the above strategies, among others.

I don't wish to suggest that there's no future for biofuels. But we must choose our path carefully to ensure biofuels live up to their proponents' claims of sustainability.

Access

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Rebuttal by David Max

There are no magic bullets for replacing fossil fuel infrastructure worldwide. Instead, we must diligently and sustainably create a diverse renewable energy matrix to gradually wean ourselves from our overdependence on oil. Petroleum infrastructure has taken the last 50 to 100 years to create. Given the increasing speed of technological development (production and conservation), it could take another 30 to 50 years to transition to renewable energy resources.

I question the net energy gain/loss studies that Richard quotes; specifically, those that claim biofuel production is a net energy loser. Those studies were largely funded by the petroleum cartel, which has a vested interest in downplaying biofuels.

The agricultural production of biofuels has offered a starting point for the renewable fuel portion of the matrix, although admittedly, growing genetically modified, monoculture crops for biofuel feedstocks might offer less-than-desirable long-term sustainability. In building a renewable biofuel infrastructure, we must consider *all* of our options and, over time, move toward the most sustainable, long-term feedstock production methods. We need methods that not only consider net energy gains, but also the overall impact to our environment, placing economic value on soil and water conservation.

As consensus on world peak oil discoveries draws closer, all options to create locally distributed energy should be critically considered, with preference given to the most economical, sustainable, and cleanest technologies. Before (and after) this debate, I've strived to answer the question of what is truly sustainable. Industry across the globe must begin to move forward in a sustainable pattern. Otherwise, we will soon tip the scales of our own propagation, and that is only if Mother Nature doesn't do it for us first. Biofuels are not without their problems, and we should not throw caution to the wind. But we need good options for today, and also for the day after tomorrow.

Access

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OFF-GRID APPLIANCES
AC or DC?

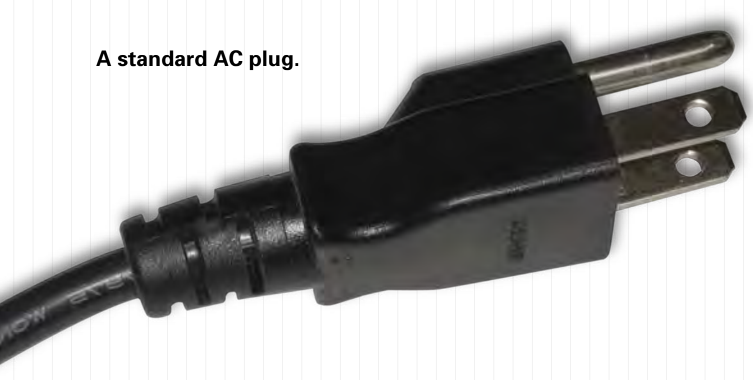
Richard Perez

In the early days of home-scale renewable energy (RE) systems, we all used direct current (DC) appliances. If the appliance didn't come with a cigarette lighter cord, we weren't interested. It wasn't until the mid-1980s that the first reliable inverters became available. Finally, standard "in town," alternating current (AC) appliances could be powered by off-grid RE systems, as long as they were energy efficient.

The efficiency and reliability of modern inverters allow off-gridders to run standard, energy efficient AC appliances.

But inverters brought efficiency losses with them. At low power levels, inverters have a conversion efficiency of between 50 and 80 percent. Higher conversion efficiencies of approximately 90 to 95 percent are achieved when the inverter is operated at about one-third of its rated power or above. DC appliances did, and still do, have one efficiency advantage—no inverter losses. But this advantage is outweighed by numerous disadvantages.

First off, wiring a home for low-voltage DC loads means using larger gauge wire, soldered connections (ideally), and specialized plugs and sockets. All of these components are expensive compared to their high-voltage AC counterparts. Add to this the additional cost of DC appliances (roughly twice that of AC models), and the limited selection and features of DC appliances—the expenses climb even more.



A standard AC plug.

Experience quickly showed us that DC appliances were not typically as reliable or well built as their AC counterparts—this meant even more expense, since the appliances wore out more quickly. For example, consider a blender. The cost of a DC blender was twice that of an AC model, plus the DC blender had only two speeds (on and off), and it had to be ordered from a specialty house by mail instead of being purchased at a local store. The DC blender my wife Karen and I bought died after less than eight months of use.

AC—Advantages & Disadvantages

The main advantage of using AC appliances is standardization. The wiring is standard—inexpensive, conventional house wiring. The appliances are standard, and are available with a wide variety of features. The appliances are designed for regular use, and most are reliable and well built.

The same cannot be said for many DC appliances, which are primarily designed for intermittent use in recreational vehicles. Also, there are many appliances for which there is no DC counterpart to choose from. It was a Macintosh computer and printer that first led us to use an inverter, and enabled us to start publishing *Home Power* magazine in 1987.

The main disadvantage of using AC appliances in off-grid systems is the cost of the inverter and the energy lost due to inverter inefficiency. But modern inverters have an average operating efficiency of about 85 percent, and this may be on a par with the amount of energy lost in low-voltage DC wiring, especially if the wire runs are long or are not terminated properly.

The major wrinkle with AC appliances is that the inverter must function or the appliance will not work. In the early days, a good inverter worked for a year or less before failing. These days, inverter failure is very infrequent. The inverters we use presently at our homestead are well over six years old and have never failed.

When choosing an inverter, only consider sine wave models. Modified square wave inverters produce poor quality electricity that causes motors to run hotter and less efficiently, and can even destroy some appliances.

DC Applications

A few DC appliances still deserve some attention. One is lighting in essential areas (especially the power room), since these lights need to run even if the inverter is not operating. DC refrigerators and freezers are still more efficient than their AC counterparts, but be prepared to rough it a bit. DC refrigerators and freezers generally do not have the convenience options (such as self-defrosting modes, or structured and flexible shelving) that most refrigerator users consider essential.

Low-Voltage vs. High-Voltage Wiring Costs

Wiring your home for low-voltage DC appliances costs significantly more than wiring it for standard 120-volt AC appliances. The main reason is that the higher amperage in low-voltage circuits means wire sizes must be larger. Here's an example. A 120 VAC circuit supplying electricity to a combined load of 1,200 watts will result in 10 amps in the circuit. If this same 1,200-watt circuit were powering 12-volt DC appliances, it would need to be sized to handle ten times the current—100 amps!

If you compare the cost of wiring the above circuit at 120 volts versus 12 volts, the dollar savings quickly become apparent. Let's assume the circuit has a 25-foot wire run, and we're shooting for a maximum voltage drop of 5 percent in the circuit. The 10-amp AC circuit would require #14 conductors, which are rated for 15 amps. You could go to your local hardware store and purchase 25 feet of 14/2 Romex cable for about US$15. The 12 VDC circuit would require #1/0 wire, rated for 150 amps, and cost about US$150—assuming you could find it locally. Wiring at 120 volts would save you US$135 in wire costs alone.

DC circuits will result in additional expenses. Higher amperage breakers are more expensive, as are receptacles (outlets) and switches rated for DC. The ground-fault protection required in kitchens, bathrooms, and garages can also be an expensive hurdle for DC circuits. Finally, large-gauge wire can be difficult to work with, especially when turning corners in wall framing or conduit.

Cigarette lighter plugs—the de facto standard for DC appliances.

The only applications where using only DC makes real sense is in very small cabins and mobile systems—if you want to power a couple of lights and a boom box, for example. But even these situations can often benefit from an inverter and AC appliances. The key issue here is size. If the dwelling is very small in physical size, then the heavy DC wiring runs will be short, efficient, and relatively inexpensive. Otherwise, use an inverter and conventional AC wiring.

If using DC appliances, you normally have two choices—12 VDC or 24 VDC. Most 12 VDC appliances are made for intermittent use in recreational vehicles and boats. In continuous use in a home RE system, these appliances can fail in less than a year.

In my experience, 24 VDC appliances tend to be better made, but they can be difficult to find and expensive. Lighting is a good example. While 12 VDC lighting abounds (mostly because of RVs), there are not as many choices in 24 VDC lighting. Pumps, motors, and specialty DC refrigerators are available in 24 V, though there are more choices in 12 V. Today, most modern stand-alone RE home systems are 48 VDC nominal, which severely limits your options for DC appliances.

Some electronic circuits will convert 24 VDC (or even 48 VDC) to 12 VDC, and some power supplies will convert 120 VAC to either 12 or 24 VDC. But these circuits and supplies take an efficiency cut on the energy moving through them. It's best to use the energy directly from the DC system if you are considering DC appliances.

Here at our home on Agate Flat, we moved to almost all-inverter operation about fifteen years ago. The only two remaining DC appliances at our homestead are our venerable Sun Frost RF19 refrigerator–freezer (which refuses to die after 17 years of reliable service), and our ham radio gear, which is designed to use 12 VDC.

Other than these two uses, everything is powered from 120 VAC via our inverters. We have had no outages—our electricity has been reliable and constant. And we love being able to waltz into the local department store and buy whatever energy efficient appliance we want. We'd never go back to the DC days.

Access

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Six solar collectors mounted on the Blaylocks' family room roof provide almost all of the household's hot water needs.

Solar Heating in the North

Forrest E. Blaylock

Can solar heating work in Green Bay, Wisconsin? Although it's a place better known for the Ice Bowl, the frozen tundra, and watching the Green Bay Packers play football in an open stadium in the snows of December, I was confident that it would work. So in January 2004, I started planning the installation of a solar hot water system on my residence.

At the time, Wisconsin's Focus on Energy program allowed residential homeowners residing within a participating utility's service area to receive a cash-back reward for 30 percent of the cost of the installation of a solar hot water system (with a US$3,000 maximum), so my timing was perfect.

I filled out the application and cover letter, complete with an equipment cost-estimate worksheet and information on all of the major components. I had estimated the project costs to be US$6,000. At 30 percent, the cash-back reward would be US$1,800—definitely worth the effort and wait.

Sizing the System

I did a lot of research on the Internet to learn about the proper sizing of a solar hot water system. One site that I recommend is the U. S. Department of Energy site on energy efficiency and renewable energy (see Access). The site gives some simple and straightforward recommendations without the heavy math.

As a general guideline for flat-plate collectors, if you live in the Sun Belt, you'll want to allow about 40 square feet (3.7 m^2) of collector area to meet the needs of up to two typical hot water users, and 8 square feet (0.7 m^2)

for each additional person. Allow an additional 12 to 14 square feet (1.1–1.3 m^2) per person if you live in the northern United States.

For solar hot water storage, a ratio of about 1.5 gallons (6 l) of storage capacity to 1 square foot (0.09 m^2) of flat-plate collector area is recommended. In very warm, sunny climates, experts suggest that the ratio should be increased to as much as 2 gallons (7.6 l) of storage to 1 square foot of collector area to prevent overheating when hot water usage is low.

My wife and I are "empty nesters"—our two daughters have grown up and moved away. I calculated that we would only need two 4- by 8-foot (1.2 x 2.4 m) collectors to provide between 40 and 90 percent of our hot water needs depending on the season. But I had bigger plans. I wanted to be able to provide some supplemental heat to the house via a radiant floor heating system.

Components

I chose to install six Alternate Energy Technologies (AET), 4- by 8-foot (1.2 x 2.4 m) collectors to give me 192 square feet (18 m^2) of collector area. The Focus on Energy program requires mounting the panels at an angle equal to your location's latitude, plus 10 to 15 degrees. Green Bay is located at approximately 45 degrees latitude. The collectors were mounted on the south-facing roof of our family room at a 60-degree angle.

Based on my calculations, I would need 288 gallons (1,090 l) of storage capacity. I started with two 80-gallon (300 l) Richmond (manufactured by Rheem/Rudd) solar storage tanks with integral heat exchangers. This would give me 160 gallons (600 l) of solar hot water storage. I made this judgment call based on cost containment. I would later find out that the temperatures did rise to excessive levels, so I added a 120-gallon (450 l) storage tank to bring the system up to 280 gallons (1,060 l) of storage.

The system uses a closed loop, filled with propylene glycol antifreeze (Cryotek 100) that is designed for hydronic and solar heating systems. The propylene glycol solution is circulated by a Grundfos 1/6 hp pump, capable of up to 6 gallons (23 l) per minute at a 25-foot (7.6 m) lift. The glycol mixture is pumped to the solar collectors mounted on the south-facing roof and back to the solar storage tanks in the basement.

A Goldline differential temperature control operates the pump with one temperature sensor (10 K-ohm thermistor) installed at the top outlet of the solar collectors and a second sensor installed at the outlet of the heat exchanger collection pipe. I set the controller to start the pump when the collector temperature is 12°F (7°C) higher than the output of the heat exchanger, and to shut off when it reaches a difference of only 4°F (2°C).

For the major system components, I chose to work with Radiantec Inc. They specialize in radiant heating and cooling systems. A separate branch of the company works with solar domestic hot water systems. Their Web site has a wealth of information to assist do-it-yourselfers.

Radiantec sells completely assembled plumbing mechanical packages, including fill and drain valves, expansion tanks, one-way relief valves, isolation valves, and mounting hardware. The package is all assembled and pressure tested at their facility.

The system has two safety components. The first is a mixing valve, which regulates the water temperature supplied to the house to prevent scalding. The second is a high-temperature dump valve and Goldline setpoint control. The setpoint controller automatically opens the dump valve when the water temperature in the top of the solar storage tanks reaches a user-selectable temperature. I set the controller to dump excess hot water at 185°F (85°C) to keep the propylene glycol in the closed loop from breaking down due to extreme temperatures.

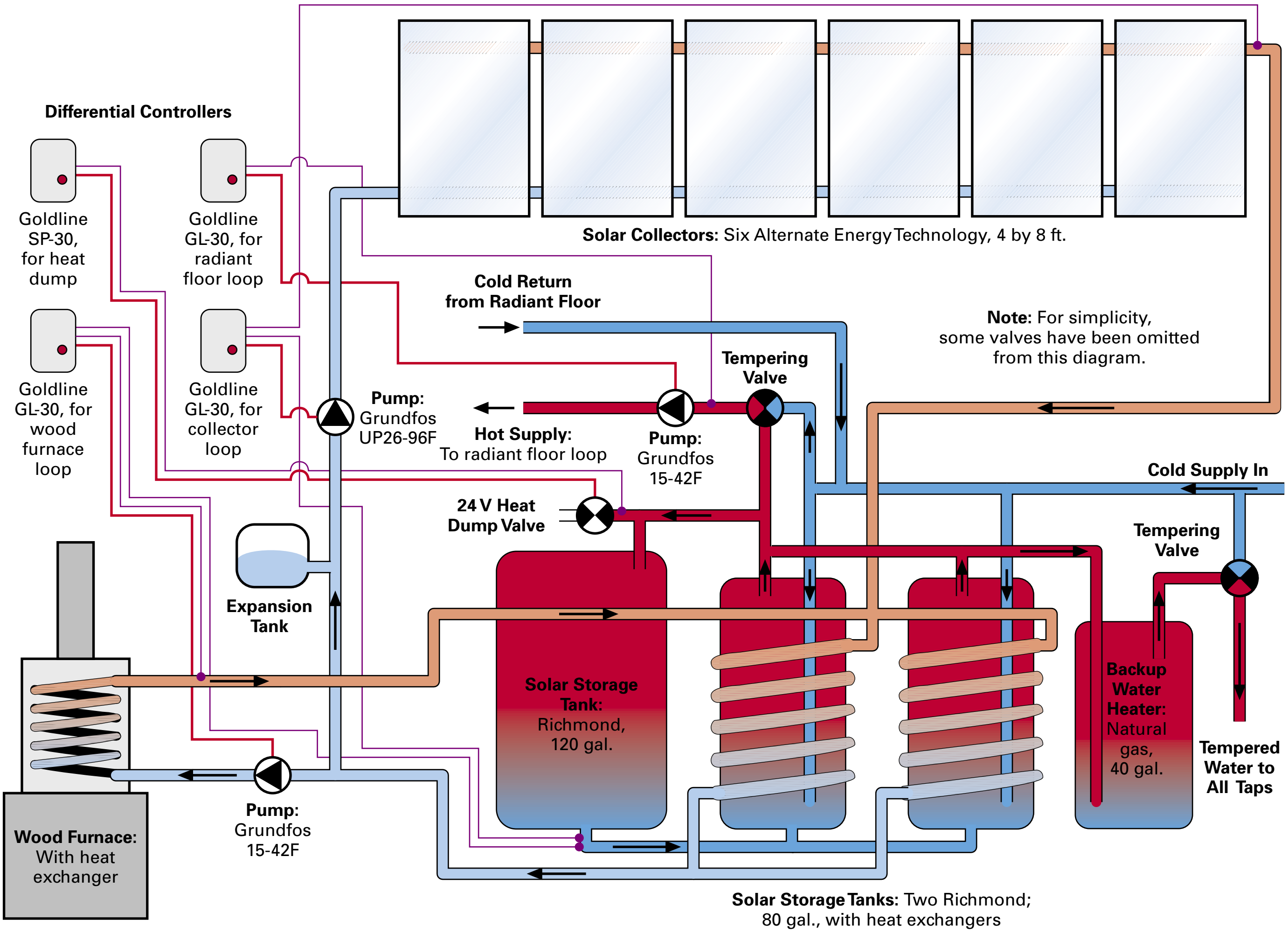
Three Richmond tanks (two with integral heat exchangers) store solar-heated water.

Installation & Inspection

After mounting the collectors and installing the required plumbing (which included many trips to the local plumbing supply store), I was ready to pressure test the system. I had to repair only one leaky fitting in the whole system. Not bad for a nonprofessional! Next I pumped the system full of water (it was summertime), pressurized it to 20 psi, and ran the system for a week. Finally, I pumped in the 15 gallons (57 l) of propylene glycol antifreeze and pressurized the system again.

The next step was to call the Wisconsin Focus on Energy office and request a system inspection and performance test. A week later, I received a call from Bill Hurrle of Bay Area Home Performance. Bill is a solar design engineer who performs

Blaylock Hot Water System



inspections for the Wisconsin Focus on Energy program in northeast Wisconsin.

The inspection took about twenty minutes to complete. The system passed all of the program requirements. Bill told me that it was one of the largest homeowner-installed systems that he had seen since he started working with the program. He showed me how to calculate the average Btu per day that could be captured by the collectors and stored in the storage system. He also recommended that I add the additional solar storage tank, because the system was light on storage capacity.

With the inspection completed, I sent in my application for the rebate and, later, received a check for US$1,800 from Wisconsin Focus on Energy. Phase One was a success.

Upgrades

I had the rebate in hand, but what should I spend it on? I had two improvements to the system that I wanted to complete. The first was the addition of a heat-exchanger coil to my existing wood-burning furnace. The second was the installation of a radiant heating system under the main floor of our home.

Many years ago, I purchased a small wood-burning furnace called a "Little John." It has a single burn chamber with an air jacket that surrounds the fire chamber, and a thermostat that controls a blower, forcing cool air around the firebox and through an 8-inch (20 cm) plenum at the top. Air is drawn through a duct from the basement, circulates around the firebox, returns to the basement, and enters the hot air plenum on the gas forced-air furnace system. It was not the most efficient furnace because of the single burn chamber. After the wood gases left the firebox, the uncaptured heat went right up the chimney.

I built a secondary burn chamber using an old 15-gallon (57 l) water heater tank. I fabricated a 6-inch (15 cm) inlet in the center of the bottom and a 6-inch outlet in the center of the top of the tank. I created a heat exchanger made of two 30-foot (9 m) lengths of 1/2-inch soft copper, wrapped in a coil and supported on a steel frame.

I mounted the tank on the back of the furnace with a 6-inch (15 cm) stovepipe tee and connected the top of the tank to my insulated all-fuel chimney. I plumbed the heat exchanger coil to the closed propylene glycol antifreeze loop. This loop has a separate and smaller Grundfos circulating pump controlled by a Goldline solar differential temperature control.

This addition allows the wood gases to completely burn in the heat exchanger tank and transfers the heat to the circulating antifreeze solution. This heated antifreeze solution is circulated back to the heat-exchanger-equipped solar storage tanks. Burning wood at night and on cloudy days helps preheat our domestic water.

Radiant Heat Loop Installation

At about the same time as I started the installation of the solar collectors, we had ceramic tile flooring installed in the kitchen, dining area, half bath, and main entry hall on the first floor. I knew this could be a cold surface to walk on with stocking feet in the winter.

I had deliberately oversized the solar water heating system to gather more heat than was needed for our domestic hot water needs. I installed an underfloor radiant system to use this excess for space heating. This system is a great complement to a solar hot water system. The radiant heat system releases heat into the basement area and radiates heat up through the floor, keeping the ceramic floor warm to the touch.

This system consists of 500 feet (150 m) of Safelink PEX 1/2-inch tubing that runs to three zones and connects to a set of Safelink PEX manifolds. This set of distribution manifolds comes with circuit-balancing valves with visual flow gauges on the return manifold, isolation valves on the supply manifold, air vent and fill ports, steel mounting brackets, and compression adapters to attach the 1/2- inch PEX to the manifolds without the use of a crimping tool.

The tubing is routed between the floor joists in a serpentine fashion and held next to the subfloor with aluminum heat-transfer plates that are stapled to the subfloor. Warm water is circulated from the solar tanks via a Grundfos circulating pump to the intake manifold. From there, it travels slowly through the PEX tubing, giving up heat as it goes.

The pump is controlled via two thermostats. I installed a Honeywell electric heat thermostat beside the existing forced-air furnace thermostat. I set it at 68°F (20°C) so that it will turn the pump on when heat is needed. I set the forced-air furnace at 62°F (17°C) so that it provides backup heat if the radiant heat is insufficient to meet the house needs. The circulating pump circuit also runs through a normally closed contact on a Goldline setpoint temperature control, which shuts the pump off if the temperature in the solar storage tanks falls below my selected

Tech Specs

Overview

System type: Solar domestic hot water and radiant floor heating; closed loop/antifreeze, with wood and solar heat exchangers

Location: Green Bay, Wisconsin

Solar resource: 4.2 average daily peak sun-hours

Production: 3,225,600 Btu per month average

Climate: Humid Continental; annual temperature range: -15°F to 95°F

Domestic hot water production: 100% for summer, 80% annually

Solar Collector Loop Equipment

Collectors: Six Alternate Energy Technologies, AE-32, 4 x 8 ft. each

Collector installation: Roof-mounted at a 60-degree tilt

Heat transfer fluid: Propylene glycol antifreeze (Cryotek 100)

Heat exchanger: Integral with storage tanks

Circulation pump: Grundfos UP26-96F, 1/6 hp pump, 6 gpm at 25 ft. lift

Pump controller: Goldline GL-30-G

Storage tanks: Two 80-gallon Richmond storage tanks with wraparound heat exchangers; one 120-gallon Richmond solar storage tank

Radiant Floor System

Tubing: PEX, 500 ft. total

Zones: Three, all equal lineal footage

Circulation pump: Grundfos 15-42F

Pump controller: Goldline SP-30 setpoint control

Tempering valve: Watts 70A, set to 130°F

Balance of System

Backup DHW tank: 40-gallon natural gas, tank-type water heater plumbed in series with the storage tanks

Auxiliary heat source: Little John wood furnace with heat exchanger; Grundfos 15-42F circulation pump; Goldline SP-30 pump controller

System performance metering: Azel Technologies Digi-Stat DS-60P digital temperature gauge and Merrill 100 psi pressure gauge

Overtemperature dump valve: 24 VAC solenoid

Dump valve controller: Goldline SP-30 setpoint control temperature of 85°F (29°C). It is not efficient to try to extract heat from the storage tank below this temperature.

I plan to upgrade the radiant floor loop pump in the future because the current pump (Grundfos 15-42F) is cast iron, which could be subject to accelerated corrosion from the water in this open-loop system. I will replace it with a stainless steel or bronze pump.

Performance & Cost Analysis

It is difficult to analyze any specific component of this system on its own because the components all work together. The solar collectors gather heat and store it in the storage tanks. The wood furnace provides heat in two ways, first by directly providing heated air to the house and second by sending heat to the solar storage tanks from the furnace heat exchanger.

On the output side, the system provides preheated water to the domestic water heater, and heat for the house via the radiant heating system. This combination of solar-collected heat and radiant heat distribution has made a significant reduction in the amount of wood necessary to meet my household heating needs. It is particularly noticeable in the spring and fall heating season, when it can meet the house heating requirements with no backup. I do not pay for my wood, so I've based the cost analysis on the reduction in natural gas costs.

The water from the municipal supply is typically about 60°F (16°C). The temperature in the solar storage tanks ranges from 85°F to 125°F (29–52°C) in the winter and up to 180°F (82°C) in the summer. This means that the backup water heater only has to bring it up a little to reach the 130°F (54°C) that we keep it set at. My wife Bonnie has even adapted her habits by postponing her weekend laundry washing until the afternoons, when the solar collectors have had a chance to build up a supply of hot water.

I have tracked our natural gas usage since the beginning of 2002. I charted the number of therms of natural gas consumed from July 2004 to June 2005 to evaluate the performance of my solar and wood heating system for a year, and compared it to the previous year's monthly usage of natural gas. The addition of the solar and wood systems

The Goldline temperature differential and setpoint controls for the solar collector loop, wood heat exchanger loop, and radiant floor system.

Cost Summary

Solar Hot Water System	Cost (US$)
6 AET solar collectors, 4 x 8 ft., with mounts	$2,638.00
2 Solar storage tanks, 80 gal.	1,260.00
Plumbing, valves & insulation	1,158.23
Pumps & controls	761.80
Shipping	543.34
Subtotal (for Focus on Energy rebate)	$6,361.37
Solar storage tank, 120 gal.	$679.00
Gauges & misc.	212.03
Total Solar Hot Water Costs	$7,252.40
Wood Furnace Heat Exchanger	
Pumps & controls	$236.16
Plumbing, valves & insulation	190.98
Total Wood Furnace Costs	$427.14
Radiant Heating System	
PEX tubing & manifolds	$408.13
Pumps & controls	211.05
Plumbing, valves & insulation	126.11
Shipping & taxes	48.64
Total Radiant Heat Costs	$793.93
Complete System Cost	$8,473.47
Less Focus on Energy Cash-Back Reward	-$1,800.00
Less 10% Federal Solar Investment Credit	-$804.00
Grand Total	$5,869.47

reduced natural gas consumption by 62 percent when compared to the prior year. For the months of July, August, and September, I had three months of billings that showed *zero* therms of gas usage—even with lots of hot showers and many loads of laundry.

Financially, I expect the system to have a payback of about 15 years based on current natural gas prices increasing at 10 percent per year. For the period from July 2003 through June 2004, I spent US$441 on natural gas. Compare that to July 2004 through June 2005, when I spent US$251. This represents a savings of US$190 annually. There is one catch with the gas utility. Even for the months that I used only 1 therm of natural gas, which cost me 87 cents, I still had to pay fixed connection charges of almost US$10 per month. So my natural gas bill can never be less than US$120 annually unless I disconnect from the service.

Hot When It's Cold

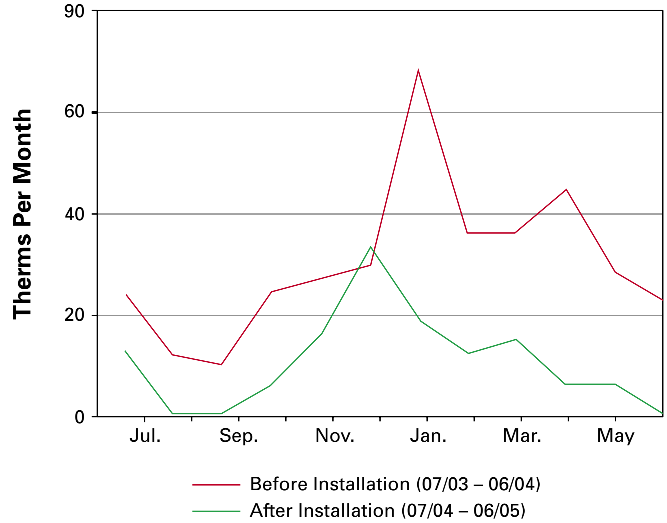
The project was a success on several fronts. I like the independent feeling that I get when I review my natural gas bill and compare it to those of my neighbors. I have always said that I like owning stock in the local utility company because they pay me dividends, but I hate paying them money for monthly utility bills.

With the solar and wood heat, we can afford to keep our house warmer than some of our neighbors' homes. We keep it at approximately 68°F (20°C), and the solar energy helps moderate the temperature swings.

It still is astounding to see how much heat can be captured from the cold outdoors. For instance, at noon on New Year's Day, while returning home from an errand, I passed the high school information sign and observed the temperature of -15°F (-26°C). I checked the temperature gauge when I got home and found 150°F (66°C) water coming from the collectors to the heat exchanger.

Five hundred feet of PEX tubing provide radiant floor heating to three different zones in the house.

Natural Gas Usage—Before & After SDHW System



The solar thermal system means that I have to cut less wood, and the system requires very little maintenance. I just check the pH of the antifreeze annually. In the future, I would like to install some photovoltaic modules to produce enough electricity to cover the small loads of the controls, pumps, and fans of my solar and wood heating system to make it truly an independent system.

Access

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Alternate Energy Technologies LLC • 800-874-2190 or 904-781-8305 • www.aetsolar.com • Solar thermal collectors

Goldline Controls Inc. • 800-294-4225 • www.goldlinecontrols.com • Pump controllers

Grundfos • www.grundfos.com • Pumps

Hercules Chemical Company Inc. • 800-221-9330 or 973-778-5000 • www.herchem.com • Cryotek heat transfer fluid

HouseNeeds Inc. • 802-583-2726 • www.houseneeds.com • Radiant heating supplies

Radiantec Inc. • 800-451-7593 • www.radiantec.com • Solar hot water system supplier

Rheem or Rudd Manufacturing Corp. • 800-621-5622 • www.rheem.com • Richmond solar storage tanks

U.S. Department of Energy, Energy Efficiency and Renewable Energy • www.eere.energy.gov/consumerinfo/heatcool/hc_sizing_water_system.html

Wisconsin Focus on Energy • 800-762-7077 or 608-249-1271 • www.focusonenergy.com

Simple Steps to Save
THROUGH THE SEASONS

Jeremy Truog

Courtesy Johns Manville

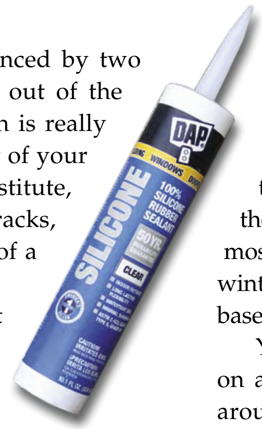
Insulation upgrades, especially in attics and basements, can help you save on home heating and cooling bills through the seasons.

Before you turn up the thermostat to ward off the winter chill that's creeping into your house, take these simple, inexpensive steps to make your home more comfortable and energy efficient.

If you're like most folks, the majority of your energy dollars go toward heating and cooling your home. According to the U.S. Department of Energy (DOE), the average U.S. family spends about US$1,500 per year on home energy, a figure that will probably rise beyond US$2,000 this year due to increasing natural gas and electricity prices. The good news is that because heating and cooling is the biggest chunk of energy usage, is it also the place where you can make the biggest impact. Think of it as an insurance policy against continually rising fuel prices. As prices continue to escalate, your savings become more and more significant.

When addressing home energy use, most people go for the most visible and dramatic improvements, like replacing old furnaces and windows. But investments such as these are often not the most cost-effective places to start. In many cases, the less obvious (and less expensive) fixes like weatherstripping and insulating offer considerable upfront savings—in money and energy.

Stop the Leaks



Heating and cooling costs are largely influenced by two factors—infiltration (air movement into and out of the house) and insulation. Controlling infiltration is really the first step to improve the energy efficiency of your home. According to the Rocky Mountain Institute, the average U.S. home has enough holes, cracks, and crevices in it to make up the equivalent of a 16-square-foot hole in the wall.

Air leakage accounts for 25 to 40 percent (or more) of heating and cooling bills, so you can save big by doing a thorough job of buttoning up your home. Once air leakage is controlled, insulation can help to further reduce your bills.

Air Sealing Priorities. People are often quick to notice minor air leaks in their home, such as those around doors and windows, or through fireplaces and chimneys. But these easy-to-spot leaks are not always the worst offenders in terms of energy efficiency or indoor air quality issues. Air also can enter your home from other, often unheated, parts of the house, such as attics, basements, or crawl spaces. Besides allowing outside air in, these areas can foster moisture development in wall cavities as air travels from cooler to warmer areas.

These less-obvious leaks are driven by the "stack effect"—the tendency for warm air to rise and cool air to fall. Since you only need to stop an air leak at one end, the attic is often the best place to start with your air-sealing activities. Before you add insulation, seal openings around:

- Plumbing vent stacks and pipes
- Electrical, plumbing, and chimney chases
- Open tops of interior wall partitions
- Attic hatches
- Gaps around penetrations for any mechanical equipment (ductwork, air handlers, etc.)
- Recessed lighting. Most recessed lights are designed to be cooled by air movement, so they cannot be sealed or come into contact with insulation without potentially overheating. Replace them with IC-rated (insulation-contact) fixtures. If that is not possible, seal the lights between the fixtures and the ceiling openings.
- Bath fans. These often pump more warm air into the attic than to the outdoors. This can lead to major moisture problems in the attic or ice damming along the eaves, which can force moisture up under the shingles, causing water leaks.

Next, air-seal your basement or crawl space. Seal all heating and cooling duct joints with fiberglass mesh and mastic (a pastelike sealant) or foil tape—but *not* duct tape. While you are at it, insulate these ducts if the basement or crawl space is not conditioned. Look for any holes (for example, around plumbing and electrical penetrations, drainpipes, and chimneys) that might allow air to move from this space into living spaces. Sealing at sill plate and rim joist areas is especially critical.

Only after you have done your work at the top and the bottom of your house should you think about addressing the more obvious air leaks in the middle areas of your home. Here, focus on sealing the larger gaps first. Infiltration into the middle part of your house is generally more obvious, but unless leaks are particularly large, they are also usually less significant than leaks in basements and attics. This is mainly due to the fact that leaks in the middle of your home are usually only a factor when the wind blows. However, the stack effect, which occurs most of the time, causes your home to lose heat even on calm winter days—and you only have to address the home's roof or basement to effectively stop this heat loss.

You can usually find significant leakage areas easily on a windy day with a candle or a stick of incense. Walk around your house, holding the candle or incense stick close (but not too close) to walls, doors, and windows, and watch how the flame or smoke reacts. If the candle flickers or if the smoke from the incense stick swirls away from an area, you probably have a leak. You can also listen for leaks (they whistle), feel a cold stream of air, or look for daylight through cracks.

Insulate, Insulate, Insulate

Once you have effectively air-sealed your home, consider adding insulation. If you're retrofitting your home, begin at the top, go to the bottom, and then, if time and money permit, worry about the middle. New homes should be insulated to U.S. DOE-recommended levels or above. (For recommendations, visit the DOE's Office of Energy Efficiency and Renewable Energy Web site at www.eere.energy.gov.)

Since it is both the most accessible and the most cost-effective area to insulate, the attic should be your first priority. Check with your state energy office for recommended levels of attic insulation.

The Trouble With Basements

Would you ever be satisfied with single-paned windows in your house? Probably not. But did you know that typical foundation walls, even though they may be 8 inches of concrete or concrete block, have about the same insulation value as a single pane of glass? On top of that, concrete is actually surprisingly air permeable.

Nine times out of ten, uninsulated foundation walls are the single largest source of heat loss. Air sealing is a good first step, since it costs a lot less to address than insulating and is easier to mitigate, but that doesn't solve the major heat-loss issue in basements.

There are many different ways to properly insulate a basement. For good construction details on insulating foundations properly, check out the *Builder's Guide* series for various climates by Joe Lstiburek (see Access).

For US$30 to $60, water heater timers offer an easy, automatic way to save.

Don't go by the local code requirements—they just stipulate *minimum* levels.

Once you have insulated the top and bottom of your house, you can think about adding insulation to your home's exterior walls. Options include blowing in insulation through holes drilled in your home's siding, or removing siding completely and adding foil-faced rigid polyurethane foam insulation. Unfortunately, this energy upgrade can be very pricey, so you may want to wait until your home needs new siding or extensive remodeling. Again, check with your state energy office or use the DOE's online insulation calculator (www.ornl.gov/~roofs/zip/ziphome.html) for recommended insulation levels for exterior walls.

In Hot Water

Water heating is typically the second largest consumer of energy in the home, accounting for 20 percent or more of a household's annual energy budget. You might be most familiar with cutting your hot water demand by using low-flow faucets and showerheads, as well as efficient water-using appliances. Here are some other tips that can help you reduce water-heating costs.

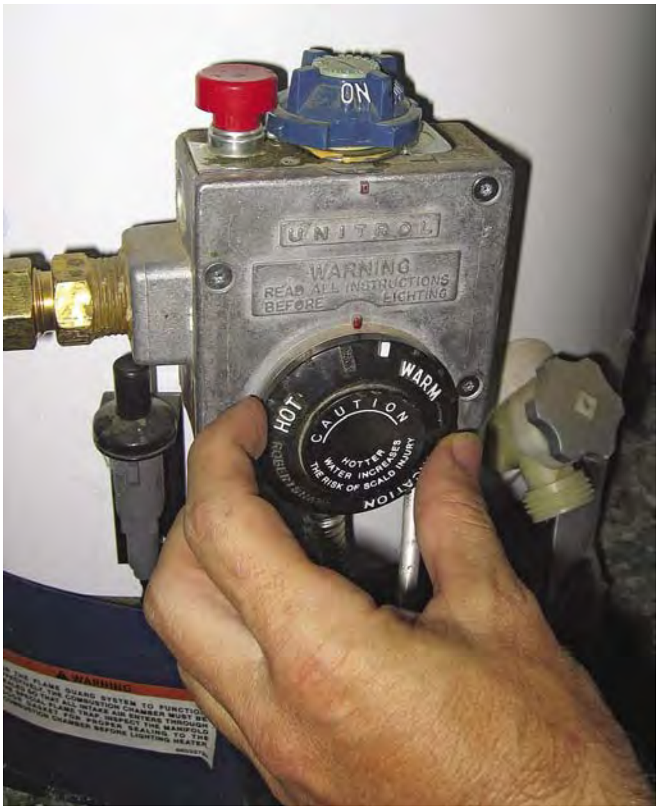
Mix It Right. If you find yourself turning on the cold-water tap along with your hot water to get the right temperature, your water heater temperature is probably set too high, and you're wasting energy and money. Many water heaters are set to 140°F or higher, but for most households a temperature setting of 115°F to 120°F is sufficient. For each 10°F reduction, you can save up to 13 percent on your water heating costs. Check your water heater owner's manual on how to adjust the thermostat on your particular model. Many thermostats do not have numbers on them, or are inaccurate, so you may have to check your water temperature with a thermometer.

Turning down the water heater temperature has additional benefits: Hotter water can cause scalding, and children and seniors are most at risk. Scalding occurs in 2 seconds at 150°F and 15 seconds at 140°F. Also, hot temperatures increase the rate of corrosion on internal fittings and other surfaces in the water heater.

Wrap It Up. A conventional tank-style water heater uses energy to maintain the temperature of the water even when no hot water is being used. This is due to "standby losses"—the heat conducted and radiated through the walls of the tank. These standby losses can represent 10 to 20 percent of a household's annual water heating costs. Adding an insulating layer to keep the heat where it belongs is very cost effective. Installing an R-7 to R-11 insulating jacket can greatly reduce heat loss, saving 4 to 9 percent of your water heating costs. With savings like this, the insulating jacket pays for itself in less than one year. For safety's sake, carefully follow installation instructions and leave the thermostat uncovered. On gas water heaters, isolate the jacket from the flue or the burner.

While you are at it, insulate hot water pipes wherever you can access them. This is especially critical for the first three feet of pipe that exit the water heater. Pipe insulation is a split tube of foam rubber that comes in a variety of diameters. Be sure to choose the right size so you can fully close it around the pipe. Insulating pipes reduces heat loss as hot water flows to faucets, and reduces the time it takes hot water to arrive.

Turning down your water heater's thermostat 10°F can shave up to 13 percent from your water heating costs.



Loops & Timers. Two more simple and cost-effective measures can reduce your water heating costs. If the hot or cold water outlets and inlets run vertically alongside your water heater, convection will cause heat loss. Anticonvection valves and loops work by preventing these losses through the inlet and outlet pipes of the water heater, and installing them can save from 2 to 7 percent on water heating energy use. These simple plumbing devices cost from US$5 to $10. Most new tank-style water heaters come with anticonvection valves or balls—the things you sometimes hear rattling around at the top of the tank. Also, simply having a high spot in the plumbing to the tank will minimize convection.

A programmable thermostat can save 10 percent or more on heating bills.

Consider turning an electric water heater off during certain periods—like during the night when no hot water is being used. You can install a timer for US$30 to $60 that will automatically turn the water heater on and off at preset times. For example, a water heater can be set to go on 30 minutes before you usually take a shower, or wash dishes or laundry, and then be set to go off again soon afterward. Energy savings between 5 and 12 percent per year help pay off this investment quickly.

An Energy-Wise Winter

Every degree Fahrenheit you dial down your home's thermostat shaves about three percent off your heating bill. While this doesn't sound like much, consider this: Adjusting your thermostat just 2°F (from 70°F to 68°F), saves you 6 percent. Combine the overall drop of 2°F with an additional nighttime drop of 5°F or more and you'll cut at least 11 percent from your bill. It's that simple. For about US$30, you can buy a programmable thermostat that will remember to do that for you—easy savings.

Energy efficiency is really a win-win situation. Take these simple steps to bundle up—you'll save energy and increase your home's comfort, while saving your hard-earned dollars and reducing pollution.

Access

Jeremy Truog, Sustainable Environmental Services, 8728 Wilderness Trail, Traverse City, MI 49684 • 231-922-5907 • jtruog@earthlink.net • www.sestc.com

Builder's Guide series by Joseph Lstiburek, US$45 each from Building Science Corp. • www.buildingscience.com

Free Rain

High-Tech, Hands-Off Rainwater Collection

Doug Pushard

Even though our yard is planted with native vegetation adapted to our hot Austin, Texas, climate, it requires watering to keep it healthy and lush. We use a drip irrigation system for watering, which is more efficient than using sprinklers. But this small yard still consumes lots of water during our long, sweltering summers.

Our solution was to tap the clouds, instead of the city pipes, to keep our yard green. Harvested rainwater has zero hardness, contains no chlorides, and has fewer other salts than city water, so it is much better for our plants. Using rainwater instead of city water also reduces our monthly municipal water bill, while reducing the impact on the local watershed.

Water Harvesting Components

Austin receives about 32 inches (81 cm) of rain a year, and at 1,600 square feet (149 m^2), our roof offers plenty of catchment area, so we did not have to worry about rainwater supply or overall system efficiency. On average, we get 2 to 3 inches (5–7.7 cm) of rain each month. The problem is that it comes in buckets—all at once and then nothing for weeks. From our water bills, I estimated our landscape watering needs to be about 1,000 gallons (3,785 l) each month. We had already installed gutters on the house. Now we just needed some way to store and deliver the rainwater to our yard.

Rainwater catchment systems typically consist of three main components: the capture and filtration system (roof, gutters, roof washers, and other filters); the storage system (barrels or tanks); and the delivery system (pipes, pumps, and valves).

Our rainwater capture system uses gutters that are connected to round downspout adaptors. These adaptors connect to underground, 4-inch-diameter (10 cm) PVC pipes, which channel water first to a filtration tank and then to the storage tanks.

I chose two, 2,000-gallon (7,571 l) aboveground fiberglass tanks for rainwater storage. In-ground tanks would have kept the water cooler in our climate, but would have been significantly more expensive. The durable fiberglass tanks are ultraviolet (UV) light-resistant, and can be used for both potable and nonpotable water. I placed the tanks on a concrete pad in a corner of the yard, which keeps them level and out of the mud. The two tanks provide 4,000 gallons

(15,142 l) of storage capacity, which is not enough to meet all of our watering needs year 'round, but a good portion for most months every year.

Rain-gutter screens remove most of the larger debris from the water. A horizontal roof-washer filtration tank from Tank Town (see Access), which is equipped with a sump pump, has a 60-micron filter that screens out the smaller particulates.

When the filter tank fills with water, an auto-on switch on the sump pump activates and pumps the water through a 2-inch-diameter (5 cm) PVC pipe to the top of the first storage tank. A check valve on the pipe prevents water from draining back into the filtration tank when the sump pump goes off. This is one of a few custom details I added to make the system especially user-friendly.

Near the ground, 2-inch-diameter, flexible PVC pipe ties the two tanks together. A three-way motorized valve tapped into the middle of this section connects this line to a primary outlet line. A pressure-sensitive pump delivers the rainwater to the irrigation system. The pump automatically activates when the sprinkler system valves open or a hose spigot is turned on.

In-line PVC unions are installed on both the tanks' inlet and outlet pipes. This, along with the three-way valve, enables each of the tanks and the pumps to be easily disconnected from the system for maintenance or modification. When I expand the system to provide potable water, I'll need to install a UV filtration system before the second pump. The three-way valve and unions will allow me to do this easily and efficiently.

The author next to the rainwater storage tank, pressure pump, pump controller, and roof washer/filtration tank.

Rainwater, stored and then automatically routed through a drip irrigation system, keeps the Pushards' yard lush and green, even through scorching Texas summers.

Because our system is interconnected with a municipal water source, it was required to have a high-hazard, pressure-relief valve (also known as a backflow preventer). This valve ensures that no tank-stored water can enter the city water supply. Regulations vary from city to city, so check with your local water municipality first to see if or what kind of backflow prevention is required. I installed the relief valve near the front of the house, so if I start using rainwater for our household needs I will not have to relocate it.

The sprinkler junction or valve box, in which city water lines join with rainwater system water lines, may also require a permit. I used two standard-sized, in-ground sprinkler boxes. One box holds all the sprinkler valves and the other the system interconnections. A three-way motorized valve made for swimming pools connects the tank and city lines with the outgoing line that feeds the irrigation system. I initially used a sprinkler system valve instead of a pool valve, which was a mistake. Sprinkler valves are low-cost and widely available, but only work one way and when there is pressure in the line.

Two 2,000-gallon (7,571 l) storage tanks hold enough rainwater to meet the yard's irrigation needs.

I also installed a double check-valve in this box to prevent tank water from entering the house. I will remove this valve when I install the UV filtration system for indoor rainwater use. Threaded couplers and manual on/off valves on both sides of these valves enable easy removal.

Automating the System

Although this basic system needs little maintenance beyond cleaning the filter and gutter screens every once in a while, it does require some user involvement, especially during wet-weather events. I wanted to make my system fuss-free, so I would not have to brave a downpour to switch valves manually or worry about the filtration tank overflowing in the middle of a thunderstorm.

This is where I could find no information in the rainwater harvesting guides I read. A simple job such as switching between city and tank water led to some very strange recommendations. Fortunately, I had some experience with automation and was not going to be put off simply because the experts said automation couldn't be done.

A good precaution for systems here in Austin, where we often have torrential downpours, is an emergency switch in case the filtration tank is close to overflowing. I installed an electronic bobber float switch high on the inside wall of the filtration tank. This switch triggers a 24-volt overflow ball valve to open, emptying the filtration tank through an outlet drain. The valve closes when the bobber switch goes off. This switch is a simple on/off relay that attaches to my Stargate home controller (see sidebar). The ball valve is also connected and controlled by my home automation system.

Before entering the storage tanks, rainwater is routed through a 60-micron filter in the roof washer. The sump pump is located in the upper right corner of the washer.

Automated Watering

Stargate interactive automation systems give users one-touch control of a home's lighting, heating and cooling, security, and irrigation systems. I now use mine to monitor my rainwater storage and drip irrigation system. When the rainwater tanks approach empty, the system automatically switches to irrigate with city water.

An increase or decrease in the amount of water in the tank causes a pressure change, which is measured by a transducer. As the water level changes in the tanks, the transducer sends new voltage readings to the controller. Based on these readings, valves in the system are opened or closed. These transducers can also be used to remotely indicate the fill level of tanks even in non-Stargate systems. Sample values are given in the Tank Fill-Level Conversion table (opposite page).

The psi value, where 1 psi equals 2.31 feet (70 cm) of water, represents the depth of water in the tank. By using a few equations, the psi value can be converted to feet of water. Converting this value to gallons depends on the size and dimensions of the tank. In cylindrical tanks, this amount can be calculated using the following formula:

$$V = \pi \times R^2 \times H \times 7.48$$

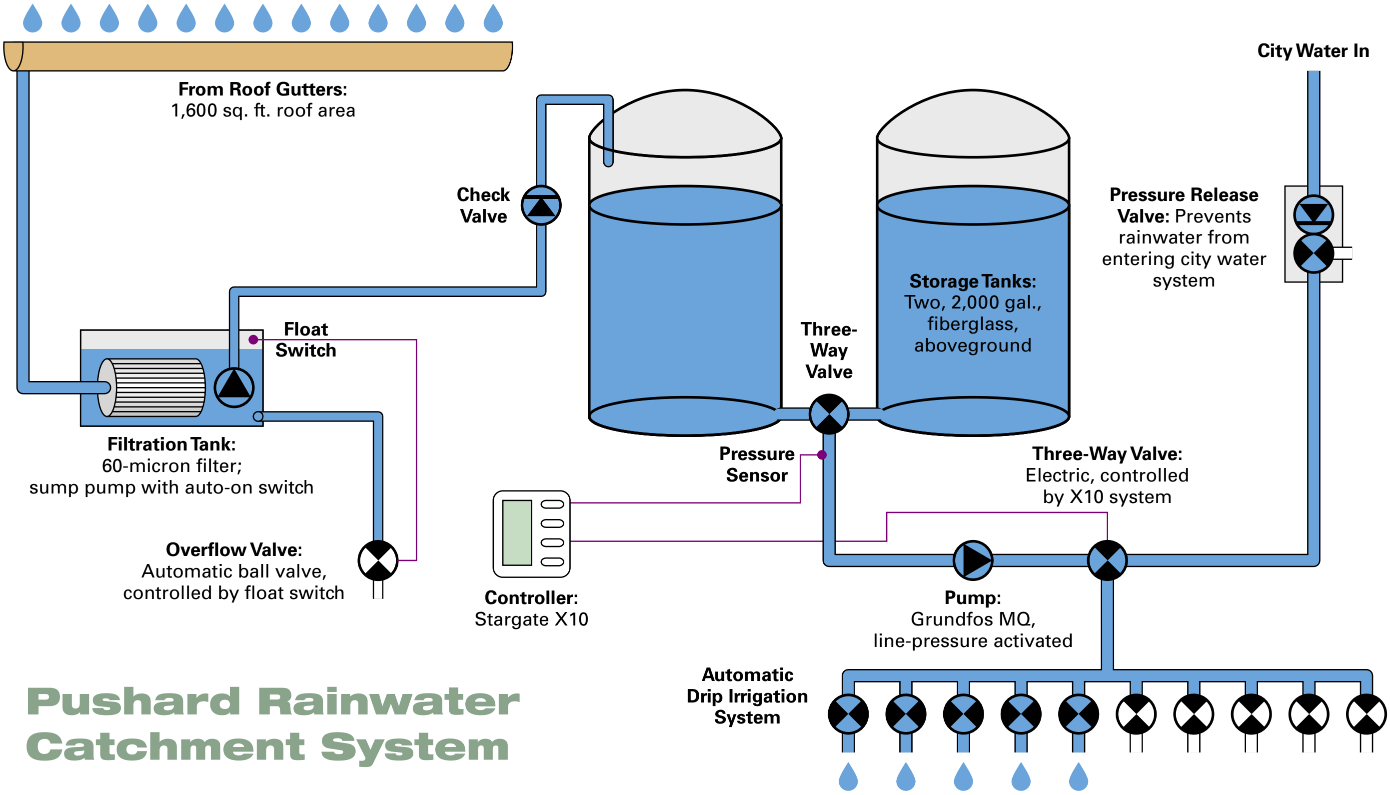
Where V is volume of water in gallons, R is the radius of the tank in feet, and H is the height of the tank in feet. 7.48 is the number of gallons per cubic foot of water.

My 6- by 9.5-foot tank has a 3-foot radius; using the above formula, the tank's capacity is:

$(3.14 \times 3\ \text{ft.}^2 \times 9.5\ \text{ft.}) \times 7.48\ \text{gal./ft.}^3 = 2{,}008\ \text{gal.}$

Each foot in rise equals about 211 gallons (2,008 ÷ 9.5 = 211); each inch equals approximately 17.6 gallons (2,008 ÷ 114 = 17.6). So putting it all together, a measurement of 1 psi (2.31 ft.) equates to 478 gallons in each tank:

[(2 ft. x 211 gal. per ft.) + (12 in. per ft. x 0.31 ft.) x 17.6 gal. per in.]



Pushard Rainwater Catchment System

An AC current sensor, attached to an X10 Powerflash module, monitors power to the sump pump. X10 is a widely used and inexpensive home automation protocol that sends commands via standard house wiring—no new wires are required. With the X10, lights can be dimmed or turned off, indoor temperature can be adjusted, and curtains can be opened or closed with a simple command issued from a computer or even a telephone. In my system, when the sump pump turns on, the X10 module sends an "X10 ON" command over the wires to my controller. I send this to my message log on my computer so I can monitor the status of the system.

To determine how much water is stored in the tanks at any one time, I installed an LM31 pressure sensor (transducer) in the PVC line from the tanks, immediately after the three-way valve. This sensor is a simple threaded device that fits into a 2-inch, male-to-female reducer in the PVC pipe. As water fills or drains from the tank, pressure is registered on the transducer. The sensor is attached to my home controller as an analog input and sends voltage output, from 0 to 5 volts, which is converted to gallons based on code I have written (see sidebar). If the tanks are less than 10 percent full, the system automatically switches to irrigate with city water.

A high-hazard pressure-relief valve (or backflow preventer) prevents back-siphoning of tank water into the city system.

The valve box contains a three-way motorized valve that automatically switches between the rainwater storage tanks and city-supplied water.

Tank Fill-Level Conversion

Tank Head Pressure (PSI)	Transducer Output to Stargate (V)	Stargate Digitized Value	Calculated Water Depth (Ft.)	Capacity (Percent)	Calculated Water Level (Gal.)
0.0	0.0	0.0	0.0	0%	0
1.0	1.0	51	2.4	25%	502
2.0	2.0	128	4.8	50%	1,004
4.1	4.1	255	9.5	100%	2,008

The LCD keypad inside the house displays the status of the rainwater storage system, including how full the tanks are.

A small LCD panel at the tanks also monitors how full the tanks are and whether the system is using city or tank water. This panel is directly connected to my home controller, which updates the LCD whenever there is a pressure change. With one quick read, the panel provides me with a convenient way of knowing how the system is functioning.

The computer code that operates the whole system is available on my Web site (see Access). Those who are uncomfortable programming a home automation controller might consider joining the JDS Users message board, where they can find folks who are willing to program and maintain a system remotely.

Another approach to automating most of the system is to use a dedicated controller from Munro Companies. Their SmartBOX module requires no code. It will open and close valves, and connects to almost any sprinkler timer. It will not give all of the functionally I achieved with individual components, but will probably perform 60 to 70 percent of it.

System Costs

With water costs in Austin projected to rise about 10 percent a year, the system will pay for itself in about fifteen to twenty years. The upfront costs of our system were higher than I had originally estimated, with the tanks being the major expense. Beyond economics, though, I feel that the system is a great investment in our ecological future.

The automation of the system was relatively inexpensive, especially since I already owned a home automation controller. (Costs for a similar Stargate controller range from US$800 to $1,300.) My challenge was figuring out how to make the parts work together seamlessly. With the automated system in place, operating and maintaining the rainwater system is simple. I clean the gutters and the filter in the filtration tank about once a year. The system runs itself, and at any time and from any location, I can monitor its performance.

Rain Catchment System Costs

Items	Cost (US$)
Tanks, filtration box & pressure-sensitive pump	$5,600
Pressure-relief valve, high-hazard	600
Installation of underground pipes & cement pad	500
Two three-way valves with 24 VDC actuators	392
PVC pipe & connectors, wire, concrete & electrical box	350
Ball valve, 24 VDC motorized	270
LCD panel with mounting kit	112
Float switch, X10 Powerhouse Powerflash & AC current sensor	104
LM31 transducer	99
Junction box for sprinkler valve	33
Total	$8,060

Access

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Aquatic Eco-Systems Inc. • 877-347-4788 or 407-886-3939 • www.aquaticeco.com • Motorized ball valve, #MV112T

Jandy Pool & Valve Co. • 707-776-8200 • www.jandy.com • Three-way pool valves & actuators

JDS Technologies • 800-983-5537 or 858-486-8787 • www.jdstechnologies.com • Stargate systems & associated peripherals

JDS Users Group • www.jdsusers.com • Tips, sample code & advice on coding Stargate X10 control systems

Measurement Specialties Inc. • 800-745-8008 or 757-766-1500 • www.msiusa.com/schaevitz • LM Series, low-cost pressure sensor

Munro Companies • 800-933-1290 or 970-242-6810 • www.munropump.com • SmartBOX controller

Scott Edwards Electronics • 520-459-4802 • www.seetron.com • SGX-120L LCD panel

Smarthome • 800-762-7846 or 949-221-9200 • www.smarthome.com • Float switch, X10 Powerhouse Powerflash & AC current sensor

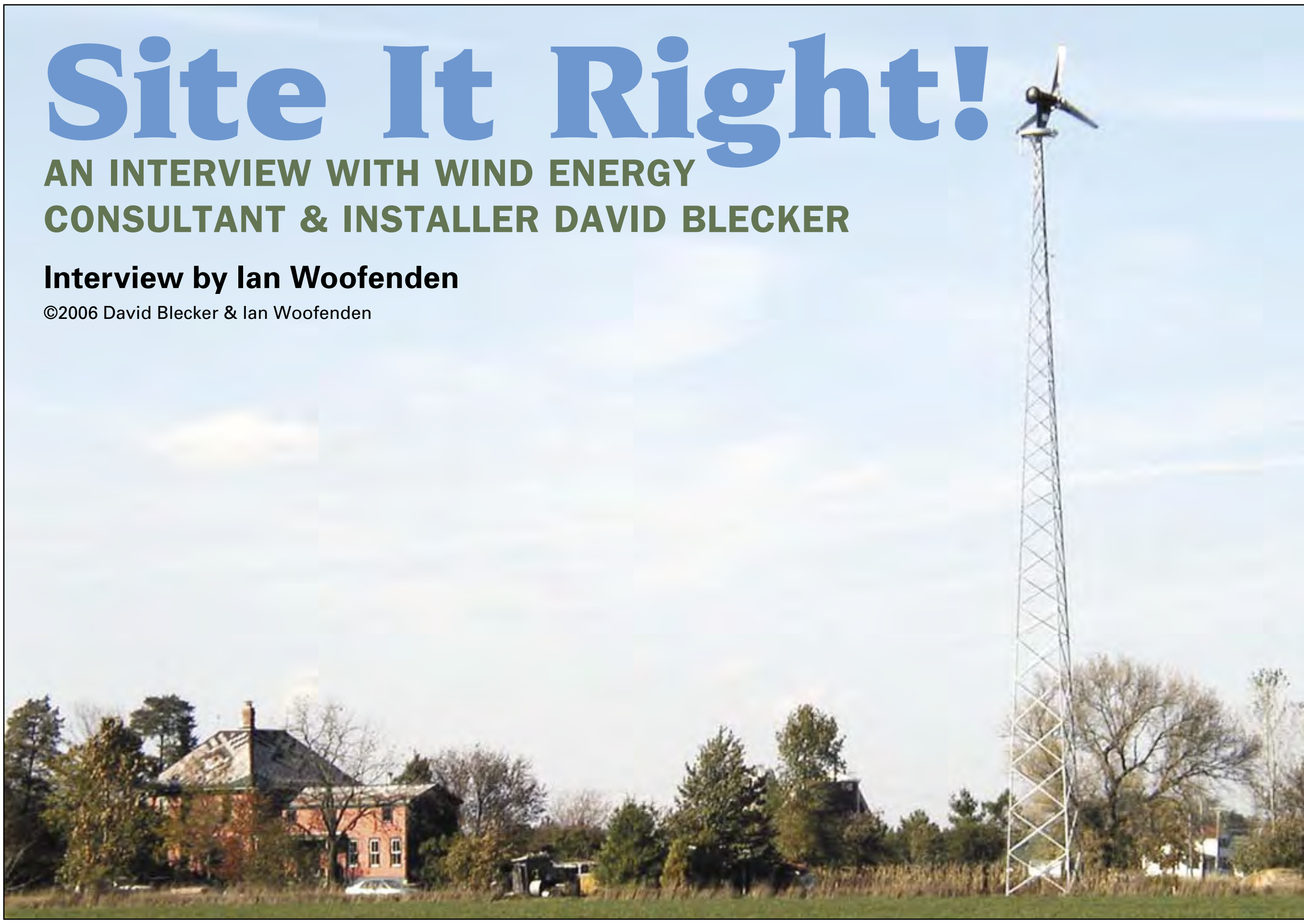
Tank Town • 512-894-0861 • www.rainwatercollection.com • Water storage tanks, pumps & filtration systems

Rainwater Collection For the Mechanically Challenged by Suzy Banks & Richard Heinichen, Paperback, 108 pages, ISBN 0966417062, US$19.95 from Tank Town (see Access info above)

Site It Right!

AN INTERVIEW WITH WIND ENERGY CONSULTANT & INSTALLER DAVID BLECKER

Interview by Ian Woofenden



Determining the height of your wind generator tower and where to locate it are important factors when designing a wind-energy system.

David Blecker is an electrical engineer by training and a wind geek by passion. He started working on renewable energy (RE) policy in 1990, which indirectly led to putting up his first "met" (meteorological) tower in Alaska seven years later. Since then, he's started a renewable energy business that has installed hundreds of kilowatts (KW) of wind and solar capacity, including the first Proven WT6000 wind turbine in the United States, and remanufactured 65 KW and 90 KW Vestas turbines.

David teaches wind system installation workshops for the Midwest Renewable Energy Association and has been on their board of directors since 1996. He's a member of the North American Board of Certified Energy Practitioners' small-wind installer certification committee and is also heavily involved in the world of RE policy. I asked David to share his insights into wind-electric system siting with *Home Power* readers, and he kindly obliged.

David inspects a 15-meter-diameter (49 ft.) Vestas turbine.

What do you say when a customer first contacts you about using wind energy?

I take the person through an informal interview process on the phone. I do this for two reasons. One is to begin winnowing the range of available wind system options. Customers are often overwhelmed by turbine, tower, and balance of system (BOS) options. With a few critical pieces of information, I can narrow the design choices to an understandable few, and begin to specify a system budget for the customer. The questions help me understand how much energy the customers use, when they use it, how much it costs them, who the local utility is, and what the site is like.

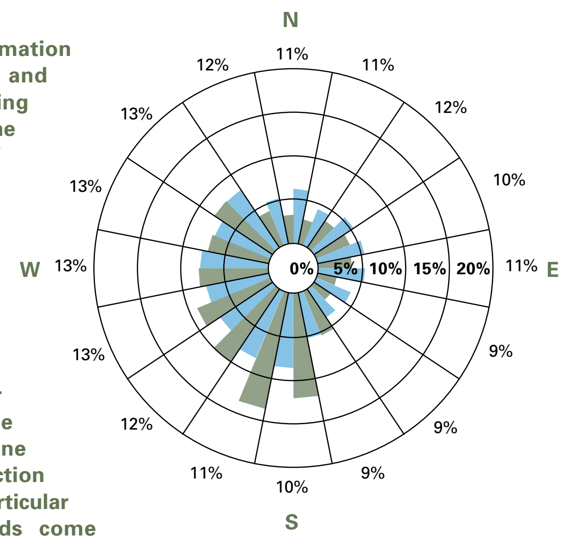
The second reason for the interview is to gently align the customer's expectations with the laws of physics. Many people, understandably, come to me with little knowledge of wind turbines and energy. The phone call serves as a quick seminar on KW versus KWH, the costs of different wind turbines, and an explanation of how much energy they can produce. Even if they don't buy a system, my goal is to help people understand wind energy a little bit better.

What are the various methods of evaluating a site for home-scale wind energy?

From the office, I first look at state wind and topographic maps. If the site

Interpreting a Wind Rose

A wind rose gives information about the wind speed and frequency of wind blowing from various directions. The length of each "spoke" around the circle is related to the frequency of time that the wind blows from a particular direction. Each concentric circle represents a different frequency, from zero at the center to increasing frequencies at the outer circles. You can analyze a wind rose to determine the prevailing wind direction and frequency. In this particular example, prevailing winds come from the south-southwest.



Survey Dates: 12/4/2003 – 12/4/2005 (10-minute intervals)
Location: Elkhorn, Wisconsin
Elevation: 1,027 ft.
Height: 164 ft.
Outer percentages represent average time intervals when wind speed exceeds 10 mph

Percent of Total Wind Energy
Percent of Total Time

This tree's branches show the phenomenon of flagging—growth deformities caused by strong winds.

is near a long-term wind-speed monitoring site or an airport, I'll look at that data too. If the site looks promising and if the conversation from the interview is positive, I'll make a site visit. It's still always surprising how different a site looks and feels when my boots are on the ground.

Many folks think the purpose of the site inspection is to figure out how a wind system can work at the customer's location. I take the opposite view. I want to know the reasons it *won't* work. The highest value I offer to prospective customers and the wind industry is to keep good turbines from being installed in bad locations.

An anemometer (right) and a wind vane (left) measure wind speed and direction.

The size range of residential-scale wind turbines—a microturbine (in hand) next to a 31-foot-diameter turbine suitable for a large home or ranch.

How do you decide whether it's worth the expense and time of installing a recording anemometer or datalogger to determine the wind resource at a given site?

For small wind systems (100 KW and smaller), there is no good reason to do site-specific monitoring. Even a short (30 m; 98 ft.) met tower installation can cost more than US$7,000. I'd much rather see a customer put that money into a taller tower or a datalogging system to evaluate their installed system's performance. The only reason to monitor a site pre-installation is to predict turbine production costs down to the fraction of a penny. But 99.9 percent of all residential wind projects are built because the owner *wants* to harvest energy from the wind. If a homeowner's motivation is pure economic return, I give them a copy of the *Wall Street Journal* and wish them well.

Do you recommend using vegetation as an indicator of a site's wind resource? What other nontechnical indicators do you use?

Absolutely! If the trees on a site show flagging—deforming of their branches from wind—there's no question that a viable wind resource exists. However, the absence of flagging does not mean an absence of wind! Flagging only occurs when winds blow consistently from one direction. Even Class 5 high-wind sites will not show flagging if the wind direction changes a lot.

I also try to talk to hunters, crop duster pilots, and farmers. Folks who spend a lot of time outside know if it's windy and where.

What about print and Web resources for wind data? Are they useful and accurate for individual sites?

At this point, just about every state with a reasonable wind resource has been "mapped." The U.S. Department of Energy's Wind Powering America Web site is a great place to start (see Access). Your state energy office or public service commission may have wind maps as well. I caution people to view the maps critically. First off, wind is really site specific. A wind map may show an area as having a great resource, but a particular site might be sheltered by a ridge, located in a valley, or deep within a stand of 100-foot-tall evergreens. Many of the older wind maps don't have fine enough resolution to capture this kind of detail.

You also have to understand that all wind maps are computer-generated models based on a limited set of information, and as such they are inherently limited. On the other hand, my sense is that the newest supercomputer wind resource models being developed (by WindLogics and AWS Truewind, for example) are reasonably accurate even at the micro level.

What do the average wind-speed numbers really mean? Is knowing the average wind speed at the local airport useful?

Good questions! Average wind-speed data can be really useful if it is from a valid source. By that I mean a nearby site with similar exposure to the prevailing winds, with similar topography and similar vegetation. To be valid, the average should also be calculated from at least hourly recordings.

Your local Federal Aviation Administration office can be a real help in finding out how the averages were determined. If you know the average wind speed, you can make a reasonable estimate of a turbine's annual energy production based on a manufacturer's published performance data. To be safe, I usually derate the estimate by 20 percent to avoid creating false expectations.

How do you decide the proper height of the tower? What's the difference in a wind generator's output at "X feet" and "X + 40 feet"?

Because the power in the wind is proportional to the cube of the wind speed, small changes in average wind speed mean big increases in available wind power. Ground clutter (trees and other vegetation, buildings, etc.) all reduce wind speed and cause more turbulence. This robs a turbine of its "fuel."

We also know that wind speed increases with elevation. Tall towers let us "reach" up to higher wind speeds and less turbulence. A turbine mounted on a 120-foot tower will produce about 30 percent more energy per year than one on an 80-foot tower! More important, turbulence really pounds the snot out of blades and bearings. Your turbine will last a lot longer and you'll have lower maintenance costs if it's installed on a taller tower. In summary, use the tallest tower you can, use the tallest tower you can, and use the tallest tower you can.

Do you have any general advice about turbine selection and sizing?

I've met a lot of people who want to install the biggest turbine they can afford and then pay for their kids' college fund by selling excess electricity to the local utility. Sadly, we still have to work within the constraints of a skewed economic system, where the true cost of grid energy is not reflected in our utility bills. The typical rates paid by utilities for excess wind energy will not send anyone out for a grande espresso, let alone college. So, my advice is to pick the turbine that will most closely produce as much electricity as you use in a year. This provides the highest value by offsetting retail-rate grid purchases while minimizing excess energy sell-back.

How do you decide whether it's "worth it " to install a wind turbine?

Wow. Tough question. Most folks who decide to own a turbine do so because of the perceived value of clean energy, self-reliance, protection against utility rate hikes, and because they *like* wind energy. For me, the biggest question is, will I still feel good about selling a turbine to this customer ten years from now? The answer depends on the customer's expectations, the site, and the turbine.

What do you predict for the future of home-scale wind energy?

I'm excited and optimistic about the future. Looking at the technology, we're seeing new turbines coming to the market from Southwest Windpower and Abundant Renewable Energy, to name two. These machines are based on state-of-the-art designs for performance, reliability, and construction, and I hope they will enjoy great success in the field.

On the policy front, we're seeing more utilities and co-ops adopt progressive tariffs that support customer-owned renewables. Recently in Wisconsin, We Energies, our largest utility, changed its wind net-metering tariff to increase the allowed wind generator size from 20 KW to 100 KW!

Finally, none of this happens in a bubble. The cost of fossil fuel is going up, which means higher electric rates for all consumers. Not to sound callous—I know higher energy costs are hurting people and businesses—but every utility rate hike reinforces people's awareness about the opportunities for wind and solar energy to make a real difference for our environment and our pocketbooks.

Any closing sage advice for folks contemplating their first wind-electric system?

Their *first* wind system? Well, if the system is designed, installed, and maintained properly, it should be their *only* wind system! I guess it comes down to this: There are a thousand reasons *not* to generate your own electricity from the wind, including significant economic, utility, and zoning barriers. But at the end of the day, we face certain truths: Fossil fuels are a limited energy resource, our current electric generation methods are compromising the rights of our children to inherit a healthy planet, and the cost of grid electricity will continue to go up.

Renewable energy gives us the ability to change this balance of power. We can make and use clean energy in our neighborhoods, on our farms, and at our businesses. We know that when all the costs are factored in, renewables *are* more economical than burning coal or splitting atoms, and we can feel good about it.

If you're considering wind energy, I say bully! Wind energy is both remarkably simple and amazingly complex. So do your homework. Talk to people who live with turbines, take a workshop, and go to an energy fair. Understand what wind energy can do and what it can't. An educated consumer is the wind dealer's best friend. And when your system is up and running, take the time to sit back and enjoy watching it spin!

Access

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

"Apples & Oranges 2002: Choosing a Home-Sized Wind Generator," Mick Sagrillo, *HP90*

"Wind-Electric Systems Simplified," Ian Woofenden, *HP110*

"Wind Generator Tower Basics," Ian Woofenden, *HP105*

NRG Systems wind measurement systems • www.nrgsystems.com

RENEW Wisconsin's Small Wind Toolbox • www.renewwisconsin.org/wind/windtoolbox.html

Wind Data:

Wind Powering America • www.eere.energy.gov/windandhydro/windpoweringamerica/wind_maps.asp

National Wind Coordinating Committee • www.nationalwind.org/resources/state.htm

National Oceanic & Atmospheric Association • www.ncdc.noaa.gov/oa/climate/online/ccd/wndspd.txt

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Creating *Affordable* Solar Apartments

Lisa Stefanik, Focus on Energy

Though the building is a recent addition to the neighborhood, Yahara River View Apartments in Madison, Wisconsin, complements the older buildings around it, with a modern nod to renewable energy. Ten solar hot water collectors rise above its entrance, creating a feeling that this isn't your conventional apartment complex. And it most certainly is not.

Renewable energy technologies paired with other energy-saving measures create affordable apartments for tenants.

Tapping Into Efficiency

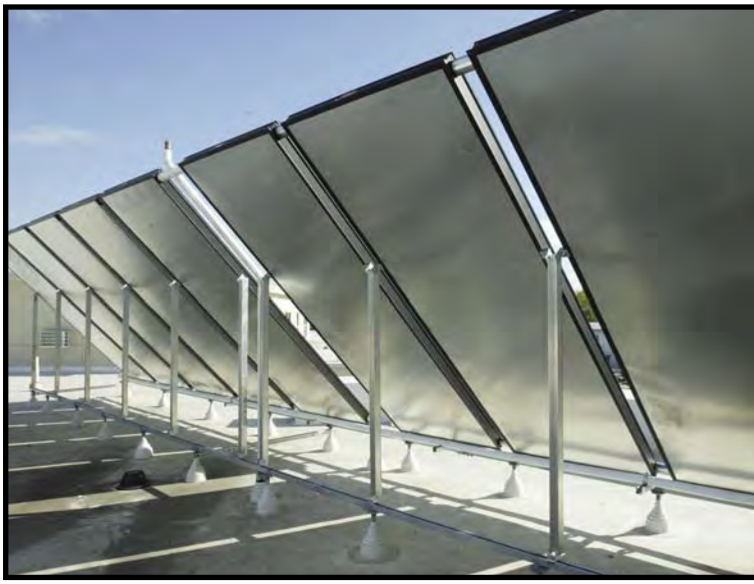
Common Wealth Development (CWD), a Madison-based nonprofit that focuses on neighborhood economic development, affordable housing, and community development, designed this apartment complex with a firm goal in mind—build 60 new, affordable housing units that would remain affordable by using renewable energy and energy efficiency measures.

In coordination with Focus on Energy, Wisconsin's energy efficiency and renewable energy initiative, as well as the local utility company, Madison Gas & Electric (MG&E), CWD designed and built these apartments with the knowledge that energy costs in Madison, and across the country, are steadily rising.

"Our goal was to make the building as energy efficient as possible so it would be as affordable as possible for the residents," said Paul Jasenski, project manager for CWD.

Many energy efficient systems are integrated into the apartment complex. These systems include high efficiency boilers, in-floor radiant heating, R-19 wall insulation, compact fluorescent lighting, and solar-powered outdoor lighting. Apartments are outfitted with Energy Star-qualified windows and appliances. Of course, the most noticeable addition—proudly displayed on the roof—is the solar hot water system, which provides heated water for domestic use and space heating.

This system supplies about 27 percent of the building's hot water requirements. Ten 4-by-10-foot Heliodyne flat-plate collectors capture solar heat. Nontoxic, freeze-proof propylene glycol solution is pumped through the collectors and routed through a heat exchanger that preheats a 500-gallon (1,893 l) solar storage tank, where the sun's heat is transferred to a potable water system. Natural gas-fueled, high-efficiency condensing boilers provide backup water heating when the building's demand for hot water surpasses the solar energy available. "The boilers are smart, only firing when the situation demands it," says Jasenski.



The solar hot water collector mounting system.

Planning Makes Perfect

Yahara architect Jim Glueck helped Burke O'Neal of Full Spectrum Solar work with the HVAC and plumbing contractors to ensure the hot water collectors, piping, and ancillaries fit into the existing plans. Specifically, O'Neal worked with the HVAC contractor to make sure that the leg supports for the collectors would not interfere with the location of exhaust vents. Plumbing contractor staff helped define where the solar hot water system ended and the potable water plumbing began.

The blueprints called for placing the solar collectors as close to the roof's edge as allowable so they would be easily visible from the main entrance. However, the collectors had to be properly placed to ensure their installation did not void the roof warranty. O'Neal was able to use the roofing system manufacturer's "boots" to seal the roof membrane to the mounting posts, while still preserving the roof manufacturer's warranty.

The location of the solar collectors had other implications as well. Planning for these large collectors required reevaluating the roof loads, since the propylene-glycol-filled solar collectors would tip the scales at 1,650 pounds (748 kg) total. The collectors also had to be positioned to shed snow, while still providing clearance for roof vents and air intakes. They also needed to be positioned away from combustion vents, which can emit corrosive fumes.

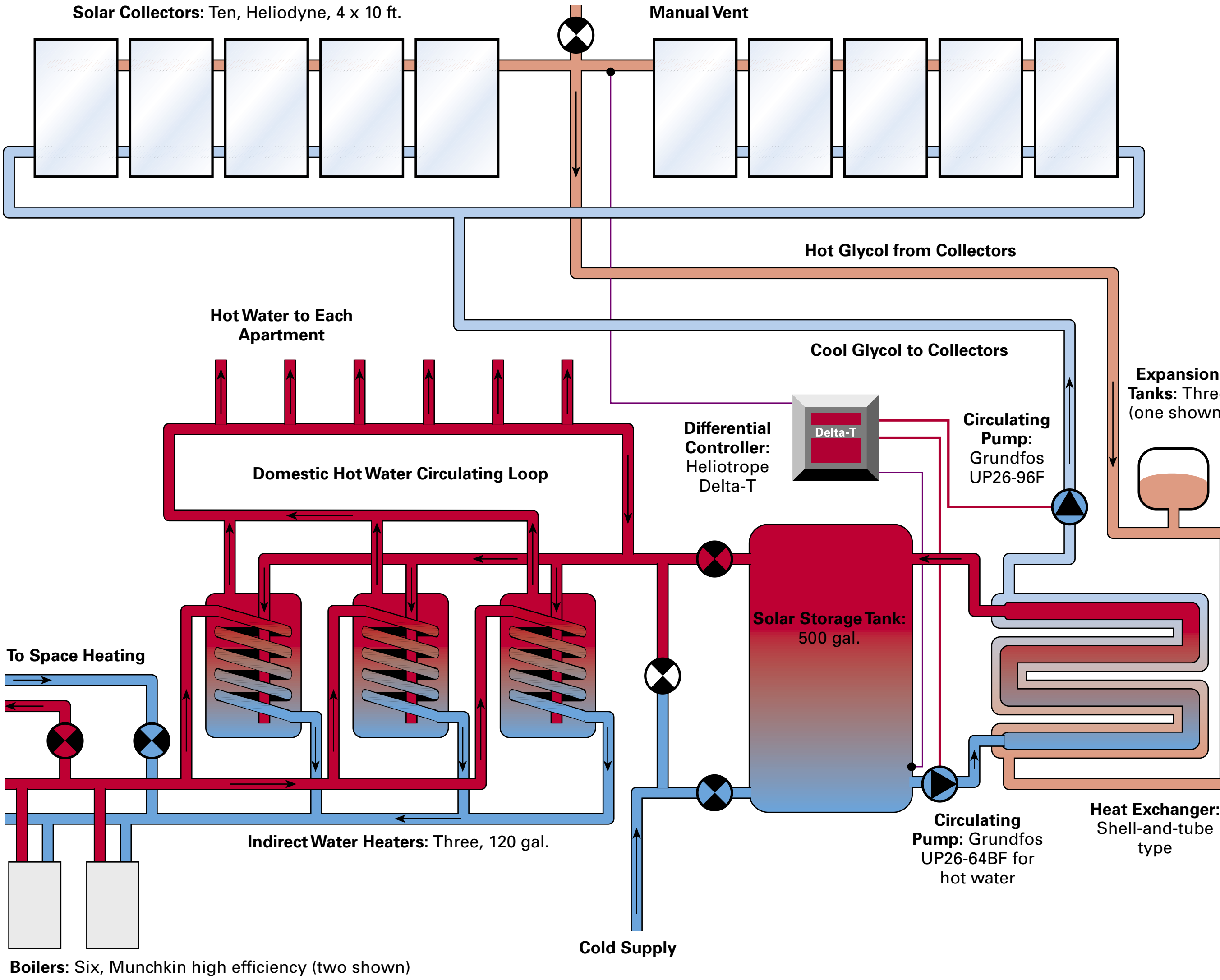
The general contractor followed carefully sequenced steps during the installation process. O'Neal needed to work around the construction of the walls to install and pressure-test each section of the plumbing before it was fully enclosed. It was also vitally important to allow plenty of space in the mechanical room where the solar hot water workings—piping, heat exchanger, pump, and storage tank—were located.

Superefficient washing machines reduce demands on the building's water heating systems.

Measuring Energy Savings

While the apartment's systems inherently create energy savings, each tenant actively shares the responsibility. A system of submetering devices monitors the use of the building's radiant floor heating system. Each of the 60 apartments is outfitted with a monitor that reads the amount of heat being used, and periodically sends the information electronically to a bill-generating center. Tenants

Yahara River View Apartments System



High-efficiency condensing boilers provide backup water heating when the building's demand for hot water exceeds the solar energy available.

A 500-gallon tank stores solar-heated water.

Tech Specs

Overview

System type: Closed-loop antifreeze with two pumps—one in the collector loop and one in the water-side loop

Location: Madison, Wisconsin

Solar resource: 4.5 average daily peak sun-hours

Production: 9.5 million Btu (95 therms; equivalent to 2,784 KWH per month, average)

Percentage of hot water produced annually: 27 percent (estimated)

Equipment

Collectors: Ten, 4-by-10-foot Heliodyne Gobi collectors

Collector installation: Roof mount (on pedestals, flashed into the flat rubber-membrane roof), oriented south, 45-degree tilt angle

Heat transfer fluid: Heliodyne Dyn-O-Flo high-temperature propylene glycol

Circulation pumps: Collector loop: Grundfos UP26-96F; water-side loop: Grundfos UP26-64BF (bronze)

Pump controller: Heliotrope Delta-T

Storage

Tank: One 500-gallon ASME insulated storage tank

Heat exchanger: Heliodyne HP 152, shell-and-tube, counterflow heat exchanger

System performance metering

Thermometer: Four Pasco J40-702 temperature gauges

Pressure gauge: One Ametek U.S. Gauge P570K-100CBM

receive a monthly heating bill, which helps them get a handle on their heating costs. "Giving residents control over their apartment's comfort, and responsibility for the costs, provides a financial incentive to save energy," says Jasenski.

But the bottom line can't be measured completely in dollars and cents. Even the most visible component, the solar thermal system, does more than provide hot water to the apartments. "It instills pride in the residents and reminds them that they are getting some energy for free," says Jasenski. "It also insulates both us and the tenants from spikes in energy prices."

Access

Focus on Energy • 800-762-7077 • www.focusonenergy.com

Common Wealth Development • www.cwd.org

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Product Manufacturers:

Ametek/U.S. Gauge • 215-355-6900 • www.ametekusg.com • Pressure gauge

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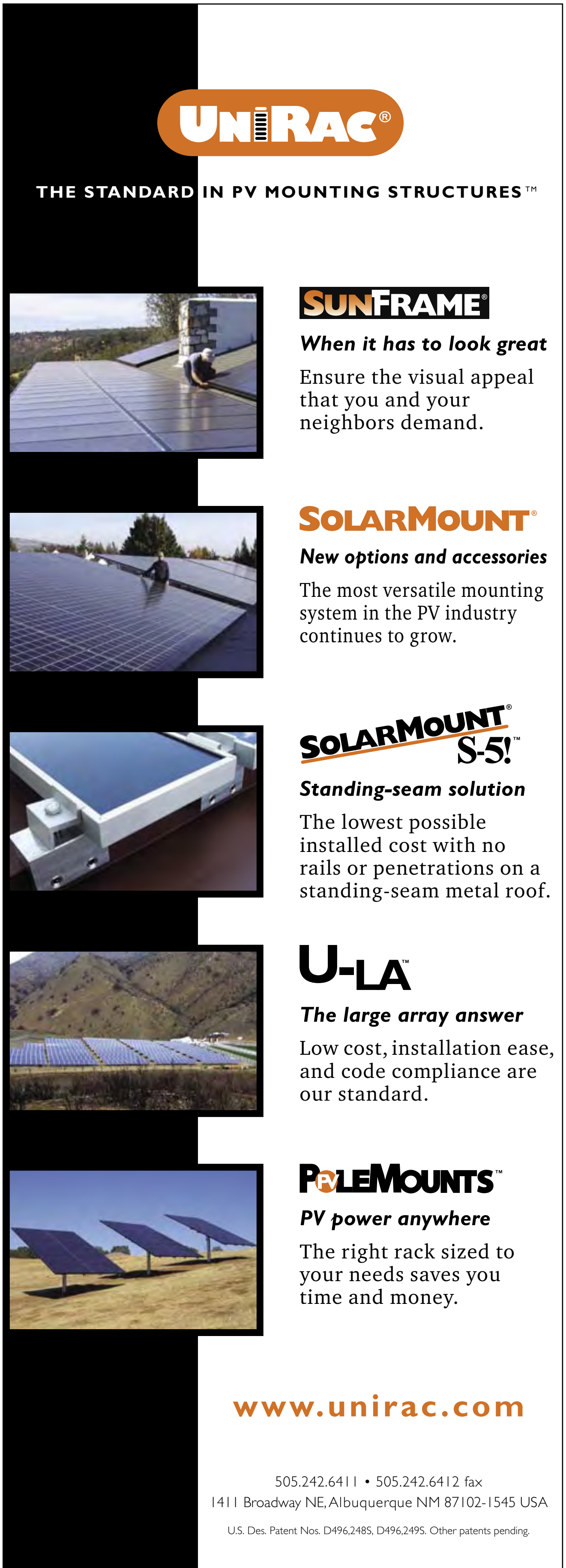
Heliodyne & Heliotrope Thermal Inc. • 510-237-9614 • www.heliodyne.com & www.heliotrope.com • Solar hot water collectors, pumps, controller & heat exchanger

Pasco • 800-772-8700 or 916-786-3800 • www.pasco.com • Temperature gauges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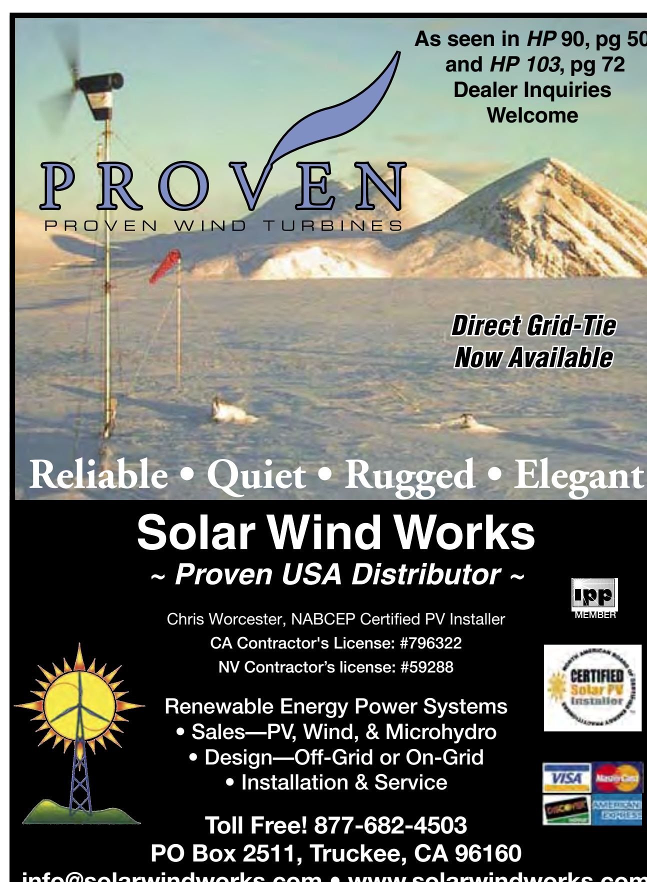
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Big HeaT
FROM A SMALL STOVE

Ianto Evans & Leslie Jackson

Flemming Abrahamsson's office in Denmark gets its heat from a rocket mass heater.

Courtesy Catherine Wanek (2)

This "coffee rocket" can boil a liter of water in less than five minutes.

Rocket mass heaters are inexpensive, efficient wood-fired heaters you can build for yourself in a weekend. For the do-it-yourselfer, these homemade stoves offer real comfort and fuel efficiency.

Although these heaters can be adapted to many uses—cooking and water heating, for instance—they are primarily used for space heating, delivering warmth right where you need it, to a bench below your fanny or a bed to curl up on. They can be constructed out of readily available (and even salvaged) materials for as little as US$100.

One Solution for Woodstove Woes

Rocket mass heaters are an application of the "rocket principles"—the result of a team of folks searching for a more efficient way to heat with wood. Numerous researchers focusing on the problems of fuelwood shortages and local air pollution have arrived at similar designs.

Woodstoves rely on air, either pulled or blown through or around the fuel, for burning. A stovepipe serves this purpose, pulling air through the combustion chamber via convection. Ironically, for most woodstoves to burn fuel cleanly, a lot of heat is pumped up the pipe—and out of your house. Rocket mass heaters rely on a quick-burning, intensely hot fire, positioning the chimney *inside* the stove and dispersing just enough oxygen through the smoke gases to achieve high temperatures.

Rocket Science

The rocket mass heater earned its name from the sound it makes when air rushing over the fuel creates a hot, fast-burning fire. Because you can't see the fire, this sound becomes an indicator of how well the fuel is burning and whether the fire needs stoking.

The core of the rocket is a J-shaped tube with square corners and abrupt right-angle turns. Thin lengths of wood are stood on end in the feed tube—the short leg of the J. Most burning occurs in the horizontal section known as the burn tunnel, with the flame path extending up the J's long leg, the heat riser.

As the hot gases released from the fire rise up the long leg of the J, cooler air is drawn into the short leg and through the fuel. The revolutionary part of rocket mass heaters is its chimney (the heat riser), which is located inside the stove. By enclosing the heat riser, exhaust gases are captured and

Rocket Mass Heater Anatomy

Heat Riser Barrel: Contains the hot gases coming from the burn tunnel. The top can be used as a cooking or food-drying surface.

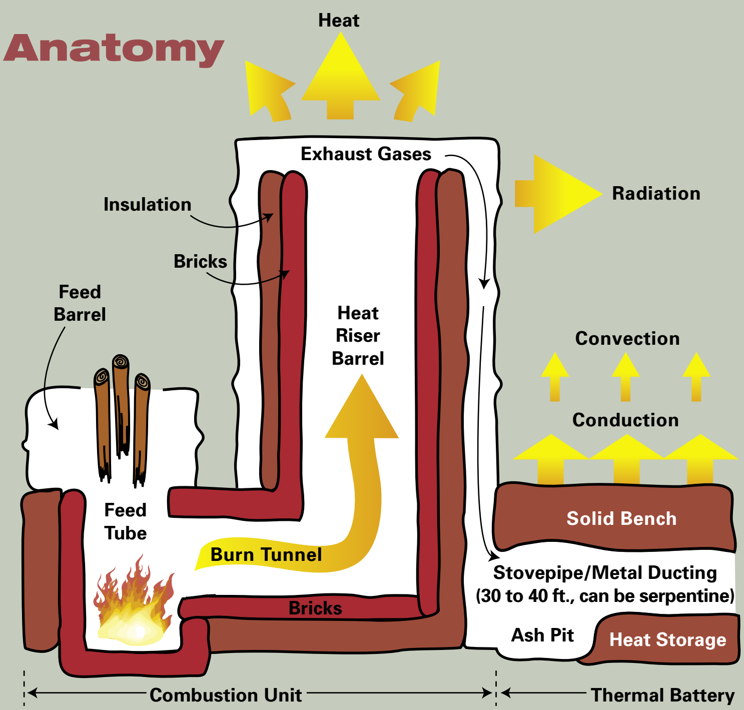
Feed Barrel: Helps contain and direct the burning fuel. Its lid helps regulate airflow to the fire.

Bricks: Contain the combustion gases. These bricks should be capable of withstanding high temperatures.

Stovepipe/Metal Ducting: Form the tunnels through the thermal mass.

Insulation (such as lightweight pumice, vermiculite, or perlite mixed with clay slip): Reduces heat loss from the combustion unit.

Clay Soil, Sand & Straw: Used in cob mix to sculpt around the combustion unit (the stove itself) and to build the thermal storage structures, such as benches, walls, and beds.



encouraged to cool *before* leaving the area. Temperatures inside a 3-foot-long internal chimney have been measured between 1,200°F and 1,800°F. But by the time the gases leave the stove, the metal barrel that surrounds the chimney releases enough heat to lower the temperature to about 700°F.

A home in Cottage Grove, Oregon, marries the rocket mass heater's capacity for cleaner burning to the heat-storage properties of cob—a mineral–fiber composite made by mixing together damp clay, sand, and straw. Cob-and-stone constructed benches and walls act as thermal mass, storing the heat released as the rocket heater's flue gases wind their way through a long network of pipe embedded in the walls, floors, and benches. By the time combustion gases finally exit the building, they've given up most of their heat to the mass, and their temperature has dropped to about 200°F. Massive materials like rock and concrete also store heat well, but cob has the distinct advantage of being sculptable. Sitting or lying on a heated seat warms your body wherever it makes contact, and you can bask in the warmth rising from the seat.

! WARNING !

Rocket mass heaters are not commercially available at this time. Because they involve fire and can reach temperatures that could combust materials in the home or natural environment, it is up to the experimenter to take appropriate cautions to ensure the safety of individuals and property in the vicinity of the stove.

Check with your local building code official before starting your project. Many locales have specific regulations governing wood-burning appliances.

Applications

While rocket mass heaters are ideal for earthen buildings with thermally massive walls, floors, and built-in furniture, they can be built into almost any kind of structure—from cargo containers to yurts—and are suitable for many climates. The model of rocket mass heater described in the book, *Rocket Mass Heaters*, suits maritime climates quite well, but is not limited to them. Once you understand the principles of these stoves, you'll be able to modify them to suit your own heating needs.

Rocket mass heaters need fairly regular attention and stoking, and are better suited for houses where someone is normally at home. They don't give the quick blast of radiant heat that you get from an all-metal woodstove, but they reduce the amount of fuel burned by turning almost all the wood into heat. Plus, they store most of the heat generated, for optimal comfort when you need it.

Access

Ianto Evans, c/o Cob Cottage Co., PO Box 123, Cottage Grove, OR 97424 • 541-942-2005 • 541-396-1825 • www.cobcottage.com

Leslie Jackson • www.rocketstoves.com

Rocket Mass Heaters: Superefficient Woodstoves You Can Build (and Snuggle Up To) by Ianto Evans & Leslie Jackson, 2006, Paperback, 100 pages, ISBN 0966373839, US$18 from Cob Cottage Co. and online at www.rocketstoves.com • Detailed instructions on how to build a rocket mass heater and thermal storage structures

Small Steps into Renewable Energy

Stephen M. Dodd

The author with his power system in heavily wooded, sun-scarce coastal Oregon.

I desperately needed electricity for my timber management shop and cabin on my off-grid property on the coast of Oregon. I wanted it simple, but I wanted a normal household, with hot water and basic appliances. I also wanted support for a full range of power tools.

I bought my property in Oregon in the mid-1960s with the thought of preserving a bit of the forests where I grew up. The parcel is deep in a timber reserve, overlooking the Pacific Ocean among steep coastal ridges. I had a great love for this place, where old men told of coming in on the train in 1910 and buying a hundred acres, a barn, and a cow for US$100. Whenever they needed cash, they'd sell off a tree. At that time, several small houses could be built from a single tree. Others would tell of going tuna fishing for a couple of months in the summer and buying a house with the income. We were timber and fishing people, after all.

After growing up on the Oregon Coast, I went away to college to eventually become a research scientist and then a semiretired real estate investor. After 35 years of longing, I returned home to my timber lot. My goal for this property was to create a place where I could get away from the business world and my cell phone, read trashy novels, and watch my trees grow.

Building

Many of us up here in the great Pacific Northwest subscribe to the KISS method—keep it simple, stupid. If you don't require a thing, why support and repair it? For some of us who grew up in the trades, it is hard to see a difference between the charging systems of a large ocean-going tug or fishing boat and what you might design for electricity at an off-grid home. After years of employment in century-old paper mills and plywood plants, it didn't seem much to ask to create and manage my own electricity.

I was advised by my local code office that due to the early purchase date of my property, it was grandfathered in for a structure of some kind. I chose to build an agricultural building, putting off thoughts of a dwelling for later. I decided to build a steel shop that could double as a support location for management of the trees and a shelter for sleeping bags and such. I selected a 50- by 32-foot (15 x 10 m), two-story design. Since I had no intention of using this building as a long-term dwelling, it is configured as a huge garage with a loft. I included a septic system to support waste management on the property.

Generator

The site is a long way from the grid, and I planned for some time to include a solar-electric system of some sort. But I have a big, well-tooled shop that requires a lot of electricity, and I realized that no matter what sort of system I might design, I would always need a generator here on the rainy Oregon Coast. I bought an 8 KW diesel engine generator from Wrico International of Eugene, Oregon.

The generator consumes about $^{1}/_{4}$ gallon (1 l) of diesel an hour at idle and about $^{9}/_{10}$ gallon (3.4 l) at high output. I use jerry cans for fuel storage, and a single 5-gallon (19 l) can often lasts for weeks. I rarely run the generator more than half an hour each day. I use off-road diesel, which is not taxed for highways in Oregon. This saves some cash. I have not even spent US$50 on diesel this year.

I chose a 240 V generator because I have some equipment that uses 240. I have a 120-volt inverter that is connected to my battery bank and to one 120-volt leg of the 240 VAC generator output. So while the generator is running, I have 240-volt electricity from the generator to power shop tools, and 120-volt electricity to charge the battery bank via the inverter.

I quickly found that a short stint of generator charging while doing carpentry work keeps the system fully charged. As you gain experience charging various battery systems, it becomes clear that the charge rate a battery bank will accept drops rapidly as the bank reaches full charge. I usually turn off the generator as the charge rate falls below about one-third its highest rate. This leaves the topping off for the sun or wind. It also restores silence for the birds, bees, and bears. And it quiets those who insist my place is really a beached diesel submarine.

Power Center

After careful study and listening to good advice, I decided to make a standard AC household. It is clearly possible to design a fully DC system, but DC appliances are more expensive and offer a very minimal product line compared to their AC counterparts. I remain very pleased that I chose standard 120 VAC service for the output side of my battery system. Everything on the "living" side is "normal." I chose 48 volts DC as my nominal charging and battery bank voltage. This allows for longer distances between the batteries and RE charging sources, smaller gauge and less expensive wires, and fewer parallel wiring connections.

The power wall nears completion.

I was quite lucky to purchase eight discontinued Xantrex (formerly Trace) 12-volt, 200-amp-hour (2.5 KWH) sealed, absorbed glass mat batteries at a significant discount. This yields a total of 400 amp-hours of battery capacity at 48 volts (20 KWH; 10 KWH at 50 percent depth of discharge).

I purchased a reconditioned Xantrex 5548 inverter. This inverter produces reliable AC electricity, manages battery charging while the generator is on, and allows for remote or automated generator start-up and shutdown.

I played with all the automated functions for several days. I even set up the system to start the generator whenever I drag the system down with a lot of use of my 13-amp, worm-drive skill saw. But now I never use the automated functions. I do use the menus to remotely start the generator for either charging or 240-volt electricity, but see no need for further automated complication. I don't really want the generator starting up while I am away.

Eight Xantrex 1200-200 sealed, absorbed glass mat batteries—400 amp-hours (20 KWH) at 48 volts DC.

Tech Specs

Overview

System type: Off-grid, battery-based, PV and wind

Location: Hauser, Oregon

Solar resource: 4 average daily peak sun-hours

Production: 50 AC KWH per month

Photovoltaics

Modules: Two Sharp NE-165U1, 165 W STC, 34.6 Vmp, 24 VDC nominal, and two Sharp NT-185U1, 185 W STC, 36.2 Vmp, 24 VDC nominal

Array: Two, two-module series strings, 700 W STC total, 69.2 Vmp, 48 VDC nominal

Array installation: Homemade mounts installed on south-facing roof, 40-degree tilt

Wind Turbine & Tower

Turbine: Air-X Marine

Rotor diameter: 46 inches (1.15 m)

Rated energy output: 38 DC KWH per month at 12 mph (5.4 m/s)

Rated peak power output: 400 W at 28 mph (12.5 m/s)

Tower: 30-foot homebuilt mast of 2-inch schedule 40 galvanized pipe

Energy Storage

Batteries: Eight Xantrex 1200-200, 12 VDC nominal, 200 AH at 20-hour rate, AGM

Battery bank: 48 VDC nominal, 400 AH total

Balance of System

PV charge controllers: Two Xantrex C40, 40 A, PWM

Inverter: Xantrex SW5548, 48 VDC nominal input, 120 VAC output

System performance metering: Bogart Engineering TriMetric

A large DC disconnect and Class-T fuse are between the batteries and the inverter. This switch was provided by an industrial electrical contractor friend. A battery bank of this size at 48 volts can produce significant arcing. The cutoff switch has to be capable of instantly switching such loads without worrying about arcing.

A Bogart TriMetric 2020 battery system meter allows me to accurately monitor the charge level of the batteries. This unit tracks amp-hours generated and consumed through the daily cycle. The TriMetric allows me to track every amp-hour. Experience over time reveals that this metering device is both very accurate and relevant.

Solar Input

I shopped around on the Internet and bought a pair of 165 W, 24 V Sharp Solar modules for my initial solar contribution. Later I added a pair of 185 W, 24 V Sharp modules. In strong sun, I see 9 to 12 A at 48 V. These modules were wired to a Xantrex C40 charge controller and to appropriate overcurrent protection devices, and then to the batteries.

I find that my system does just fine with four modules totaling 700 rated watts. At about US$600 per module, there is a limit to how many I really need. It is obviously a tremendous advantage to be able to supplement charging at low cost with a generator.

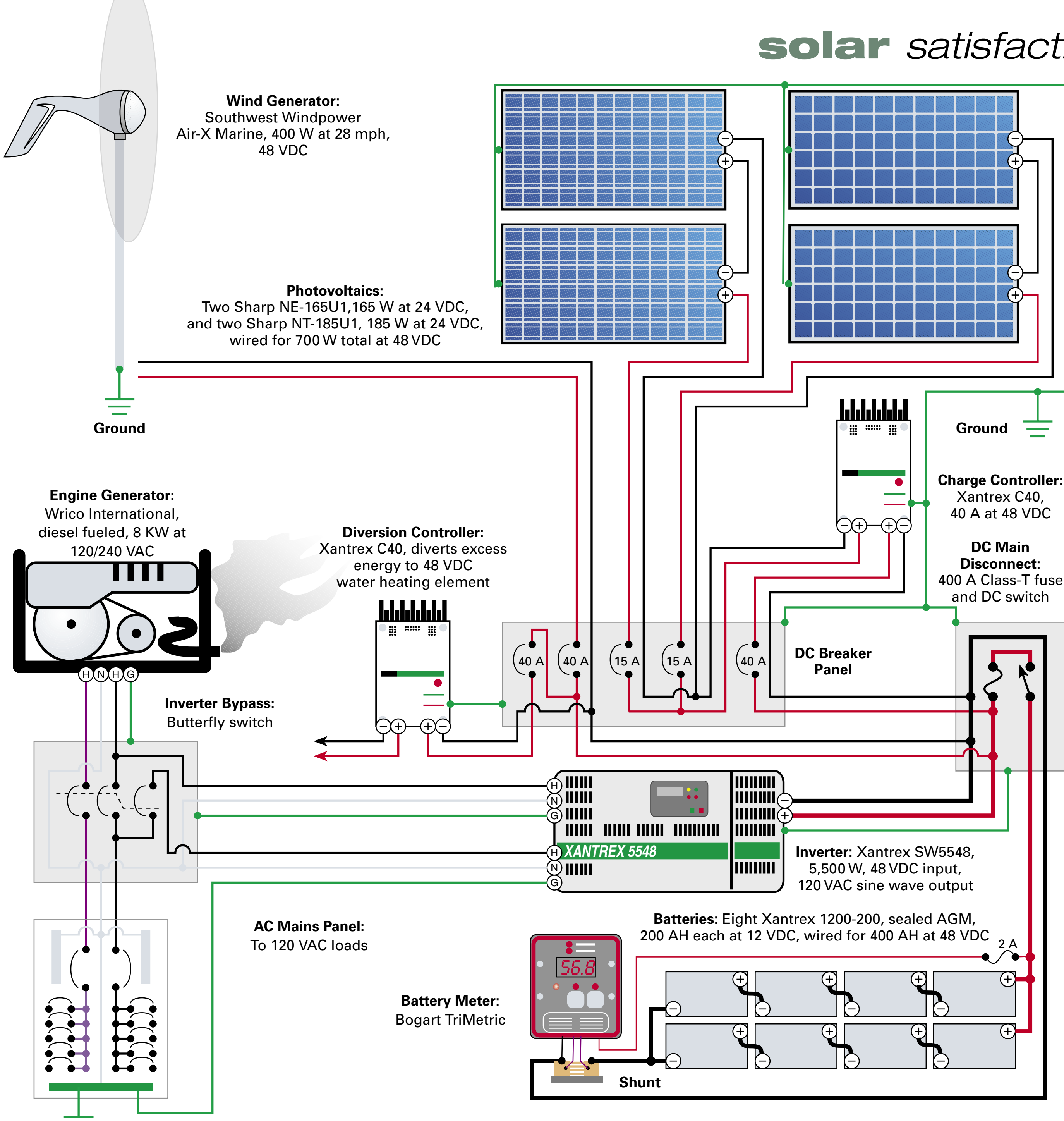
Solar exposure here is poor. In winter, my place has significant morning shade. Nonetheless, I have found that my battery bank stays charged up pretty easily with the 700-watt array. While we usually have 90 to 120 cloudy days here in winter, we can also have a lot of sun. Some winters, I have probably averaged 20 minutes a day of generator charging. Last year, we had long stretches of full sun during the winter, so I hardly used the generator at all.

Wind

The Oregon Coast can get a lot of wind. While some areas of my property are exposed to wind, the location of my agricultural building is sheltered. I have experimented with both Hornet and Air-X Marine wind generators. I could not get the Hornet in strong enough wind to produce high enough voltages to charge my 48-volt system.

PV & Wind System Costs

Item	Cost (US$)
Wrico International engine generator	$6,169
4 Sharp PV modules, 2 ea. 165 & 185 W	2,300
Xantrex SW5548 inverter	1,850
8 Xantrex 1200-200 AGM Batteries	1,120
Air-X Marine wind generator	450
Generator utility trailer	350
2 Xantrex C40 controllers	250
Conduit	200
Wire	150
Handmade roof mounts	150
Generator cable	120
Wind generator tower pipe	100
Electrical boxes	75
Battery cables	60
Total	$13,344



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

The Air-X Marine produces a little better in my environment. I doubt that it produces one percent of my electricity, but it tends to produce exactly when all other systems are not producing anything at all, so I value its small contribution. While it is cloudy, wet, and windy when I am away from the property, the Air-X Marine may be steadily keeping up with the batteries' self-discharge and my standing loads (1 to 2 amps).

Up to the Task

Timing has a lot to do with keeping my system well charged. I don't have a lot of people around making random energy demands, although I do have plenty of energy in case that occurs. But I can generally choose when I use electricity. I tend to do most of the power tool usage early in the morning when the batteries are at their lowest level. With the generator running while I'm working, the batteries get charged, and the sawing and drilling get done.

I have a refrigerator, but I only plug it in when I am going to be around a lot. It is in a cooler part of the building. By midmorning, the sun is on the array and I can use the computer or watch TV with the surplus energy. Often these demands are offset by incoming solar energy.

Many cloudy days around here are punctuated with bright sun for an hour or so in the midafternoon. That is great timing in my opinion. As evening comes and lights go on, my other electricity use trails off. Most of the time, my batteries are quickly recharged the following day.

Solar Water-Pumping

Water is an important consideration for any property. I secured water rights to artesian springs on my property, but they are below the building. I placed an 1,100-gallon (4,160 l) tank on a ridge above the building. Next, I built a weir with drilled plastic pipe for the input. From there, the water flows slightly downhill to a 5-foot-diameter (1.5 m) concrete well tile, dug into the ground and floored with concrete to serve as a reservoir.

The springs' flow rate varies from 1 or 2 gpm (4–8 l) in summer to 25 gpm (95 l) in winter. The reservoir has a 4-inch overflow pipe near its center that returns excess water to the ground stream. From this reservoir, I pump up to the storage tank on the ridge. I use the same 1 1/2-inch line up from the pump as an intake for the building. The overall head is about 90 feet (27 m).

The available pressure at the building is about 26 psi. A booster pump and expansion tank raise the pressure to about 50 psi before the water enters the plumbing distribution system. This booster pump operates intermittently, for a duration of two minutes per cycle.

I use a Conergy (formerly Dankoff) Slowpump attached to a Conergy controller and a single, 24-volt solar-electric module to pump the water. The pump is rated at 3 gpm (11 lpm) at a 400-foot (122 m) head. It produces about 2 gpm (8 lpm) under average conditions at my site. I use a float switch in the reservoir to shut down the pump as the water level falls, since it is not good to run the pump dry.

The reservoir holds about 325 gallons (1,230 l). But it can be easily pumped down on a strong solar day. I have a control switch in the building that triggers the pump upon my demand. I simply watch my water level and pump up the storage tank when needed.

Often I clean the concrete reservoir and charge its contents with chlorine before pumping. A cup of bleach works fine. A microbiologist friend of mine assures me that contained clean water stays clean indefinitely. I don't drink this water, but tests lead me to believe that I could.

Access

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Bogart Engineering • 831-338-0616 • www.bogartengineering.com • TriMetric battery monitor

Conergy (formerly Dankoff Solar Products Inc.) • 888-396-6611 or 505-473-3800 • www.conergy.us • Pump

Sharp Electronics • 800-SOLAR06 or 714-903-4600 • www.sharp-usa.com/solar • PVs

Southwest Windpower • 866-807-9463 or 928-779-9463 • www.windenergy.com • Wind generator

Wrico International • 541-744-4333 • www.wricointernational.com • Diesel engine generator

Xantrex Technology Inc. • 800-670-0707 or 360-435-8826 • www.xantrex.com • Inverter, charge controllers, batteries


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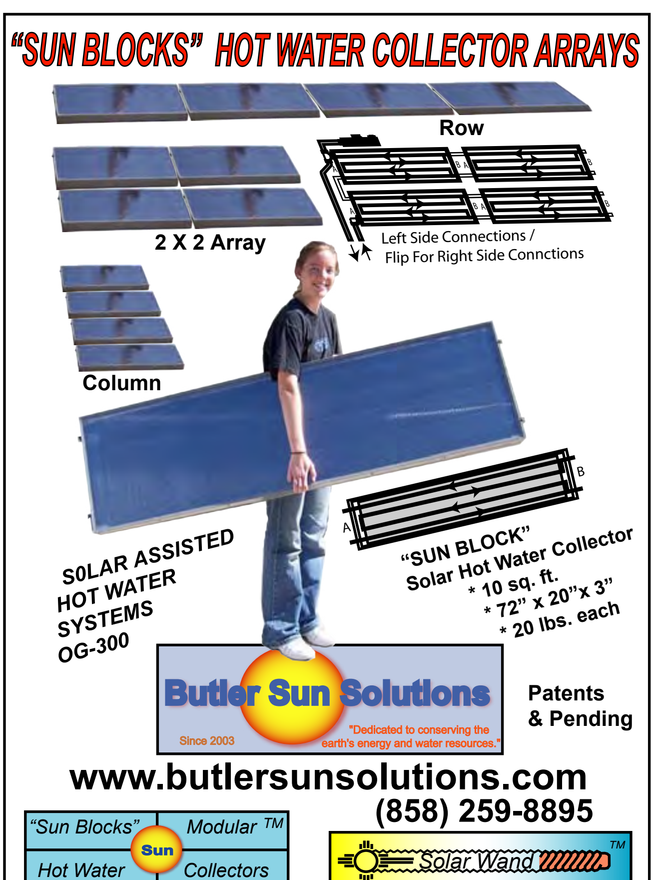
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Considerations

for PV Site Surveys

John Wiles
Sponsored by the U.S. Department of Energy

The requirements of the local and national electrical and building codes determine how a solar-electric (photovoltaic; PV) system is installed. A site survey is an excellent time to integrate these requirements into the actual constraints established by the building, its location and orientation, the preferences of the owner, and any other site-specific restrictions.

Face South & Prevent Shading

For maximum energy production, PV modules need access to full sun, and should not be shaded. An unshaded roof with a "true south" orientation is often one of the premier sites for a solar-electric system, but, as in many situations, compromises are frequently necessary. In the continental United States, true south may differ from magnetic south, as obtained with a compass, by up to 18 degrees.

Examine potential array mounting locations (often on some portion of the roof) to determine if these sites will be shaded between 9 a.m. and 3 p.m. Shading wastes the sun's free renewable energy by limiting PV production. Although this loss has fewer consequences in a utility-interactive (grid-tied) system compared to an off-grid system, arrays should be located in shade-free locations to maximize their effectiveness. In a utility-interactive system, the utility grid will provide any needed energy that the PV system does not provide. In an off-grid system, if solar energy is not collected, then the electrical loads may not be supported without installing additional PVs or using some sort of backup system, such as an engine generator.

An example of too much shading on a PV array.

Assessing the solar window is especially important for shorter winter days, when the sun is low in the sky and even short objects far away may shade the PV array. If the site visit doesn't occur on one of these winter days, you can use other means to estimate the sun angles and shading. Sun-angle charts can be downloaded from the Web (see Access) and, with the use of a little trigonometry, can be used to estimate the potential shading at the selected location. Using other manual and semiautomatic devices is the most accurate way to determine shading at different times of the year (see Access). Keep in mind that trees and other vegetation may grow a foot or more per year, and consider this when you're siting a system.

Roof-Mounted Arrays

The weight of PV modules and mounting racks may add extra loads to the roof beyond its design load limits. Added loads are particularly important for some of the heavier glass-on-glass modules, and on roofs that already have several layers of shingles. Consult the *North American Board of Certified Energy Practitioners (NABCEP) Study Guide* for specifications on roof loading and attachments, which also lists resources for additional information (see Access).

Examine the attic of the house, if it has one, to determine the spacing of the trusses and to see if any extra materials will be needed to attach the array mounting rack to the roof. Pro installers should inspect the attic and document any existing roof leaks to the owner. The owner should have any leaks repaired and the roof put in good condition by a roofing contractor prior to the start of any PV installation. This can go far in preventing disagreements at a later date, should leaks occur.

Don't forget to measure the angle of the roof for both wind-loading estimates and to determine if an elevated mounting rack will be needed.

Measure the angle of the roof before installing the array and mounts.

Conductor Routing & Inverter Location

The location of the inverter in relation to the PV array and the AC load center will affect the conductor lengths between these components. The lengths of the conductors between the PV array and the inverter, and between the inverter and the AC load center will determine the voltage drops and energy losses in these parts of the system. Select a location for the inverter that shelters it from direct sun (to avoid solar heating, which will reduce output and efficiency). But, where possible, place it adjacent to the AC load center to minimize the number of AC disconnects required. If the AC load center and service disconnect are on the outside of the house, then the inverter should be placed in that location.

Inspect the wall where the inverter is to be mounted, noting construction type and the possibility of any internal objects, such as pipes or electrical conductors. Larger inverters are quite heavy, and must be carefully and firmly attached to the wall. New building and energy codes are allowing much lighter structural walls than have been required in the past. In some cases, the wall structure will need to be reinforced to carry the weight of the inverter.

PV Source & Output Conductors

Routing the conductors from the roof requires some planning, and may depend on what edition of the *National Electrical Code (NEC)* is in force in the locality. Prior to the 2005 edition, the *NEC* required that PV source and output conductors remain *outside* of the building, until they were routed to the readily accessible main DC PV disconnect (usually at ground level). This disconnect could be located inside or outside the house (local jurisdiction preference), at the location where the conductors penetrate the building's skin. Always-energized PV conductors had to be treated like AC service entrance conductors—which must remain outside of the building until reaching the AC service disconnect. Plan the routing of the conduit carrying these conductors to minimize the circuit length and to keep them as unobtrusive as possible.

The *2005 NEC* allows these circuits to penetrate the roof at the array and be routed inside the house to a readily accessible disconnect only if they are installed in a metallic raceway. Due to the difficulty of installing metallic raceways like electrical metallic conduit in existing walls, this technique is generally limited to new construction. Flexible, metal-clad cable (type MC) is not allowed because it is not considered a metallic raceway, but flexible metal conduit (type FMC) is, so the adventurer could possibly route those PV conductors out of sight in a retrofit situation.

The Utility-Required Disconnect

For those areas in which the utility requires a lockable disconnect, locate the disconnect in the vicinity of the utility kilowatt-hour (KWH) meter. The location of this disconnect with respect to the inverter and the AC load center will dictate the number of additional AC and DC PV disconnects that may be required and the routing of the various circuits.

A minimalist installation would be one in which the local jurisdiction requires the house AC service disconnect and AC load center to be located on the outside of the building near the AC KWH meter. If this location is not in direct sun, or the inverter can be shaded, the inverter and a single DC PV disconnect (as well as the utility-required disconnect) could all be located in the same area. This type of installation requires minimum conductor lengths and no additional switchgear. If the load center is mounted in an outside location, and, for some reason, the inverter must be mounted inside the house, an additional DC PV disconnect and an additional AC disconnect, both located at the inverter, could be required.

It is important during the survey to examine the exterior wall where cable and conduit penetrations will be made and where switchgear will be mounted. The wall surfaces and construction materials will dictate what mounting systems must be used.

Off-Grid & Battery Backup Systems

Any device, such as batteries, that might give off explosive gases (such as hydrogen) and corrosive fumes (sulfuric acid) should be located in a well-vented area. A moderate temperature environment is recommended, since batteries enjoy their best life and maximum efficiency between 77°F and 80°F (25°C and 27°C). Batteries should *not* be installed in living areas, due to the potential for cracked batteries to leak acid and the possible liberation of hydrogen gas. An insulated exterior location or a garage is best.

Currents between the batteries and inverters are typically high because these systems operate at low voltages and high power levels, so the cables must be kept short. If a wall separates the batteries and the inverter, code usually dictates that a disconnect and overcurrent protection be placed in both locations.

Other Questions or Comments?

If you have questions about the *NEC* or the implementation of PV systems that follow the requirements of the *NEC*, feel free to call, fax, e-mail, or write me at the location below. See the STDI Web site (below) for more detailed articles on these subjects. The U.S. Department of Energy sponsors my activities in this area as a support function to the PV industry under Contract DE-FC 36-05-G015149.

Access

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

The 2005 *National Electrical Code* and the *NEC Handbook* are available from the NFPA • 800-344-3555 or 508-895-8300 • www.nfpa.org

Photovoltaic Power Systems & the 2005 National Electrical Code: Suggested Practices • www.nmsu.edu/Research/tdi/public_html/Photovoltaics/Codes-Stds/PVnecSugPract.html

2008 *NEC* Proposals PDF • www.nmsu.edu/~tdi/pdf-resources/2008NECproposals2.pdf

Sun charts • http://solardat.uoregon.edu/SunChartProgram.html

NABCEP Study Guide • www.nabcep.org/resources.cfm

Solar Site Assessment Tools:

Solar Pathfinder • 317-501-2529 • www.solarpathfinder.com

Solmetric SunEye • 877-263-5026 • www.solmetric.com

Wiley Electronics Acme Solar Site Evaluation Tool • 845-247-2875 • www.we-llc.com/ASSET.html

Growth & Challenge

for Smaller Installers

Don Loweburg

Now more than a year old, the silicon shortage continues to inflate the costs and reduce the availability of solar-electric (photovoltaic; PV) modules. As a consequence of the limited module supply, a spot market has evolved, where modules can be purchased—but only at a premium.

The situation boils down to capital availability—installation companies with sufficient capital generally experience no shortage of modules, while smaller companies struggle to get their hands on PV products. Of course, this is not an unexpected development. Numerous consolidations at the manufacturing and distribution levels of the PV business have occurred during the last few years. And, as the market for PV installations has grown in the United States, particularly in states with incentive programs like California, New Jersey, New York, and Arizona, some installing companies are growing rapidly. Several companies are developing a national presence, with multiple sales offices in those states that show lots of PV promise.


Adrian Matthiassen

While solar investment is booming and creating a supply of capital, well-heeled companies are having an ever-growing influence on the business of installing solar-electric systems, possibly to the detriment of smaller businesses, which tend to be module-poor.

International Influence

Just as the PV module shortage is shaping the domestic installation business, so is it dramatically shaping the international scene. Recent developments by two German companies will also certainly offer both opportunities and challenges for PV installers in the United States.

Conergy AG, headquartered in Hamburg, Germany, has been buying small and midsized renewable energy companies all over the world and has more than 1,200 employees. Although Conergy acts as a conventional distributor, serving a network of installing companies, their most recent unveiling was SunTechnics, an installation subsidiary in Sacramento, California, that has put them into a primo position to compete for West Coast PV installations. Conergy's SunTechnics has two offices in the United States, and ten others worldwide.

Just this year, SolarWorld AG, based in Bonn, Germany, surprised many in the PV industry when it purchased Shell Solar's entire monocrystalline operations. As a vertically integrated company, SolarWorld manufactures and sells silicon wafers, silicon cells, modules, and complete PV systems—and also provides installation services—making profit from every level of the PV business chain. Like Conergy, this well-financed company has a global perspective, with about 1,000 employees worldwide. SolarWorld's CEO Frank Asbeck says that with the Shell Solar buyout, SolarWorld AG is poised to become "the biggest producer of solar power technology in the United States."

These changes and other marketing strategies, such as the sale of PV systems through national chains like The Home Depot, represent a growing trend towards corporate involvement in all phases of the PV business, including the marketing and installation of PV systems.

The Shortage & Small-Scale Success

Although some experts predict that the silicon shortage will ease next year, others note that given the global growth of PV, the supply may still fall short of demand. Major new incentive programs are being implemented in Italy and Spain. Forecasts also show strong growth in the U.S., German, and Japanese markets.

Given the increasing demand for PV, ample possibility exists that the module shortage, as experienced by independent PV system installers, may persist indefinitely. Which begs the question: Can smaller companies prosper in this module-constrained market?

To compete with the corporations, smaller companies need to purchase modules in large quantities. To do so, some are expanding their operations by acquiring financial capital. But this is prohibitive and unrealistic for most small businesses. There is, however, another kind of capital wholly within the means of smaller companies.

That's *human* capital. Building superior customer service, seeking special training, and obtaining professional certification are all examples of investments in human capital. Small companies can also excel by offering personalized service. In fact, many customers say they prefer to work with companies in which the owner is actively engaged with them and intimately knowledgeable about their project.

So, smaller solar business should take heart—the global solar and renewable energy boom is bound to offer challenges and opportunities for companies of all sizes. Larger companies will be hiring, both in the manufacturing and service areas. And smaller companies can diversify by offering specialized services, such as load audits, energy efficiency advice, and energy management, in addition to installing systems.

As the old saying goes, "A rising tide raises all boats." Thankfully, where solar technology is concerned, there's room on the sea for both large ships and small.

Access

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Energy & Environmental Justice

Michael Welch

Racial and poverty issues are closely associated with the politics of energy. Environmental racism is the act of siting hazardous disposal sites and polluting industries near impoverished communities and neighborhoods, commonly populated by people of color. This happens mainly because the residents do not have enough political clout to keep these industries at bay. While historically these injustices have hit African American, American Indian, and Latino communities the hardest, when it comes to making a buck, exploitive industries are becoming color-blind. Environmental Justice (EJ) is the name of the movement that wishes to correct the environmental problems that certain minority groups and the poor are forced to put up with.

Jacob Holdt

Dumping Grounds

Perhaps the best-known example of environmental injustice is the use of traditional native lands to further U.S. nuclear weapons programs and for the potential siting of a nuclear waste dump in the Nevada desert. Industry and the government would have us believe the Nevada Test Site is a barren wasteland with no redeeming value, and a good dumping ground for nuclear waste. But according to a Western Shoshone elder, the American Indians that had inhabited the area for generations consider the area to be sacred, including Yucca Mountain—the site of a proposed U.S. nuclear waste repository.

The original nuclear testing site was foisted upon Nevada in an era of secrecy and official denial of problems with nuclear radiation, with its few native inhabitants forced to forever stay away. On the surface, this appears to be an issue without modern-day ramifications. But to the voiceless few who still live downwind and downstream from the site, and for those who will never be able to visit their sacred lands, it is an ever-present problem.

The siting of the nation's nuclear waste storage facility under the Test Site's Yucca Mountain is an environmental justice issue, on a large scale. Even though more suitable sites in other states had been identified, the dump site still ended up in Nevada. It is clear that Nevada was chosen because it has the least political clout of any state—they could not muster the Congressional support to prevent it.

In the Southwest, another example of environmental racism is taking place. Well before the invasion of non-native people, Navajo and Hopi Indians have lived side by side. Their reservations are now stretched over 27,000 square miles, mostly in northeastern Arizona, and extending into Utah and New Mexico. These native peoples have traditionally lived off the land, growing maize and other crops, and hunting and raising animals for meat. Since the U.S. government stepped in, though, the amount of available land and their rights to determine what happens to that land have gradually been eroded.

Today, the powerful Peabody Coal Company, with some mines already in place, wants access to the coal—worth an estimated US$10 billion—that lies under these lands. Strip mines would devastate this area by skimming the earth off the top of the land to expose the coal veins underneath. But the biggest problem for these inhabitants may be access to water. The mined coal is mixed with water to make slurry, and pumped more than 200 miles to an electric power plant. At 3.3 million gallons per day, this is drawing down the water table, drying up springs and making it difficult for already sparse plant life to reach water with their roots. It is also making living on the land almost impossible, as residents need to dig deeper and deeper to obtain water, yet cannot afford the tools to do so. As has been government policy with American Indians for centuries, relocation and payment are the government's preferred mitigation.

Pollution to the People

A more common example of environmental injustice involves the siting of heavy industry and power plants in low-income and minority neighborhoods in cities. Almost all city industries, including power plants, are placed in poverty-stricken areas, even though larger homes in more affluent neighborhoods use more energy. This is due not only to the amount of influence the inhabitants might have, but also occurs because poorer neighborhoods have lower property values, making them more attractive to industry. Developers will not normally build high-end buildings in poor neighborhoods, unless they can get incentives, such as redevelopment funding.

A good example of this is an older power plant located in a former industrial area of uptown New York City. Surrounding property was developed, including the addition of the United Nations building, other expensive office buildings, and high-rise apartments. Con Ed, the utility that owned the plant, sold the property for US$680 million. Now the power plant is to be shut down, and the site is slated for luxury high-rises, hotels, and upscale chain stores. But NYC still "needs" that energy, and more, so Con Ed made plans to install more steam and turbine facilities at their plant on the Lower East Side, an area of city housing projects and renovated tenements.

Not all environmental justice issues come from a lack of clout. It is common for industries and the government to promise jobs and robust economies to communities that are willing to risk environmental problems. A great example of this is another nuclear waste dump slated for the lands of the Skull Valley band of the Goshutes Indian tribe, south of Salt Lake in Utah (see *Power Politics* in *HP46 & 94*). The nuke dump is intended to be a temporary facility, until its waste can be moved to Yucca Mountain. The U.S. Department of Energy offered the tribe millions of dollars at first to consider, and then later to site the dump there. This handout, and the promise of future jobs and other support for the community, pitted the traditionalists in the tribe against a handful of leaders who pushed for the facility without adequate support of their community. The U.S. government's Bureau of Indian Affairs has final power over Indian elections, and is supporting the faction that wants the dump, despite an election that opponents say removed power from that faction. Now the dump is moving closer to being built, though recently the State of Utah has entered the fracas against its construction.

Worldwide Effects

Global warming also plays a part in environmental injustice. As the effects of climate change increase, the poorest world citizens will suffer the most and the earliest. It will be hardest for them to leave the low-lying areas that will be flooded from rising sea levels, or flee the previously arable lands that become desert from increased heat and drought.

Native Inuits of the far north are already experiencing life-changing consequences from global warming. Their lifestyles rely on snow, ice, and permafrost, all of which are disappearing at an alarming rate, along with the animals that also live and breed there. In a warmed world, where can they go and what can they do? For them, it may mean the end of their culture and way of living.

Righting Wrongs

The U.S. government publicly recognizes the need for environmental justice. According to the U.S. Environmental Protection Agency (EPA) Web site:

Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

EPA has this goal for all communities and persons across this Nation. It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

Unfortunately, the government's right hand does not always act upon the goals of the left hand. Even if it did, that hand is tied by a lack of funding. Minority and indigenous environmental rights and needs are commonly ignored when government and industry stand to profit. Scientific studies are needed to empirically prove what everybody already knows—that poorer regions of the nation, mainly inhabited by minorities, suffer the most from pollution and benefit the least from clean-up funding. But environmental injustice is difficult to prove, especially when the government won't fund the testing and science needed. Again, not enough clout.

Fortunately, environmental justice activists are rising up in Washington, DC, as well as in state capitols. People are starting to use EJ as a tool for environmental protection, forming alliances with groups from affected neighborhoods and communities. For example, the Hunter's Point community of San Francisco has rallied to shut down a power plant that was responsible for gross levels of air pollution in the area. An estimated 40 percent of the children growing up in this area suffer from asthma. As part of a settlement in Hunter's Point, the utility, PG&E, funded the installation of about thirty rooftop solar-electric systems in the neighborhood.

Whether it's working at the grassroots level to organize and protest environmental injustices in our communities, or using less energy in our own homes and making sure that the energy we do use comes from renewable sources, we can all play a vital role in making sure all of our communities are healthy, safe places for everyone to live, work, and play.

Access

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Environmental justice resources • www.ejnet.org/ej

Wind Generator Rated Power

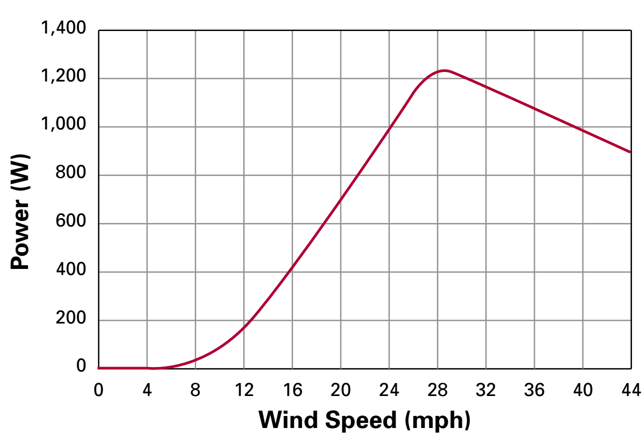
A Marketing Point

Ian Woofenden

Derivation: "Rated" is from Latin rata, *fixed or settled, from Latin* reri, *to consider or reckon.*

When people ask me, "What size is that wind turbine?" I tell them the diameter of the rotor—which defines the turbine's swept area or collector size. This frustrates some people, because they are used to talking about the size of wind turbines based on their rated power—600 watts, 1.5 KW, or 10 KW, for example. But, for several reasons, the rated power of a wind generator is little more than a marketing point.

Wind Generator Power Curve

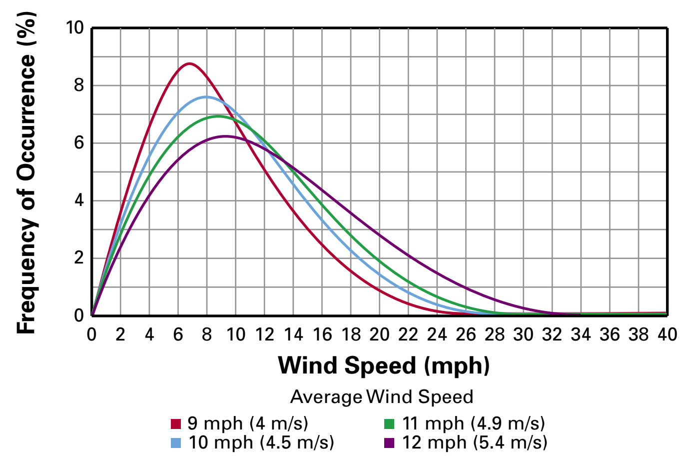


A power curve shows the output of a wind generator over its normal operating range. Look at the curve above, and notice where your eye goes. Right to the top, doesn't it? Now look at the wind speed needed to generate that peak power. For most turbines, it's in the 25 to 30 mph (11–13 m/s) range.

Now look at the wind distribution curve. This shows the percentage of time that a typical wind site experiences each wind speed. Notice where this curve peaks, and more important, the range in which most wind occurs. How often is your wind turbine going to experience 25 to 30 mph? A very small percentage of the time. Most of its energy-generating life will be spent in the 10 to 20 mph range.

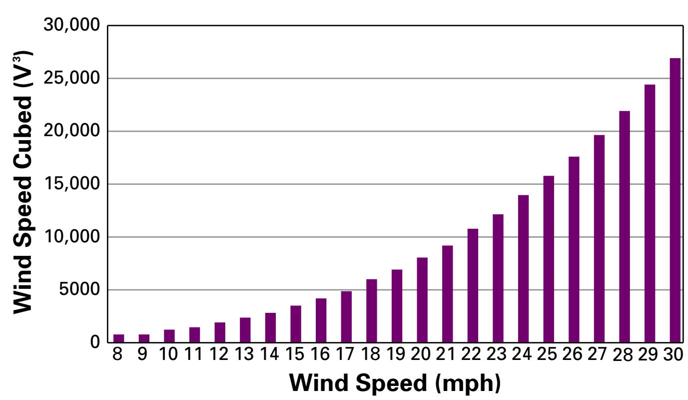
That's one reason why talking about wind generators by using the rated or peak power is misleading. It's kind of like talking about cars by their top speed instead of their range or their fuel economy at typical driving speeds.

Wind Distribution Curve



Because the power available in the wind increases in proportion to the cube of the wind speed (V^3), small variations in wind speed can mean very large changes in the available power. For example, the power difference between 10 and 12 mph, or 25 and 30 mph is a factor of almost two to one (10 x 10 x 10 = 1,000; 12 x 12 x 12 = 1,728; 25 x 25 x 25 = 15,625; 30 x 30 x 30 = 27,000). So not only is rated power a distracting point to focus on, it's an inconsistent one, since there is no standard

V^3 with Increasing Wind Speeds



rated wind speed used by all manufacturers (some rate at the peak output, and others at an arbitrary point).

In the real world, wind turbines with similar rated or peak power can produce widely different amounts of energy. I lived for several years with both a “900-watt” turbine and a “1,000-watt” turbine in similar wind conditions. The turbine with the *lower* rated output produced more kilowatt-hours by a factor of about 2.3—it had a larger collector area, even though it didn’t have high peak power.

Rated power depends on the rated wind speed, the efficiency of the complete turbine, and the design philosophy behind the machine. Some designers (my favorites) don’t focus on high peak power, since they know that performance in moderate winds is the crucial factor. Also, trying to effectively capture the energy in high winds adds greatly to the weight and material cost of the wind generator, for relatively little return.

Because the wind is variable, and the power available depends on the cube of the wind speed, power curves and rated power have little if any value to consumers trying to understand how much energy they will get from a given turbine. Energy estimates from real-world testing would be best, but short of that, using rotor diameter as a quick way to identify turbines will help you think more intelligently about wind turbine capacity.

So what size is that turbine? Mine are 8, 9, and 12 feet in diameter…

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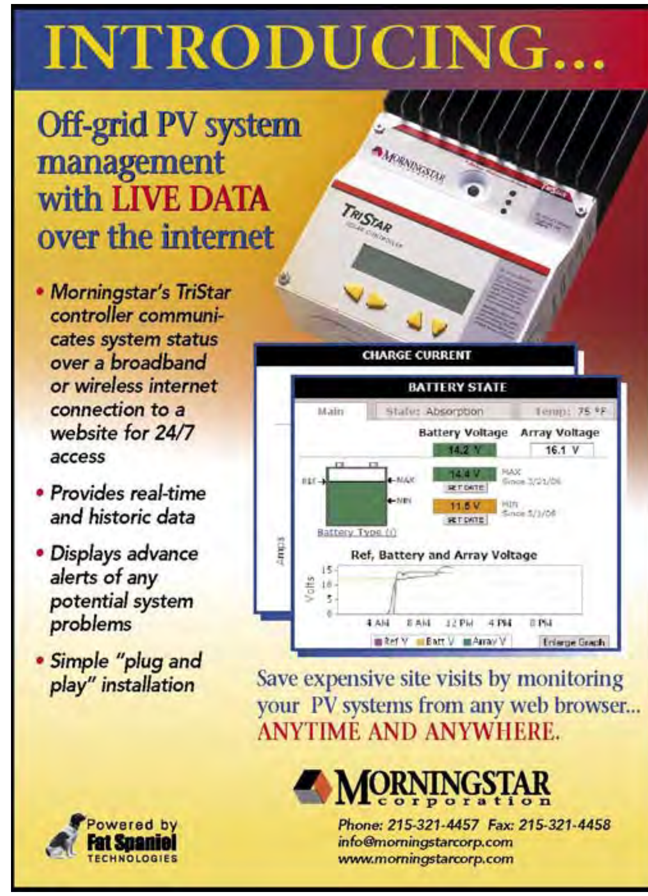
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Words to the Wise

Kathleen Jarschke-Schultze

"A word to the wise is sufficient." I heard or read this phrase recently and it got me pondering. Is a word sufficient? And, when we get advice, can we tell right away that is it good advice? Or must it pass the test of time?

Wiser

Well, I thought to myself, I don't have to repeat another's mistake if I'm told it won't work or there is a better way to do something. That was an arrogant thought. And then I immediately remembered the time I had an idea of making a shade structure for my chicken yard using some hog wire, black poly pipe, and old tent ribs from our boneyard, and covering it with a tarp.

One weekend morning over breakfast I told my husband Bob-O my plan. "That won't work," he said flatly. "The hog wire isn't stiff enough."

I then spent most of that morning and afternoon proving him right. In my head it worked great. And I had to try for myself. Sometimes, even if someone tells me my idea won't work, I need to see that for myself.

Advice & Content

In June, I attended the Midwest Renewable Energy & Sustainable Living Fair in Custer, Wisconsin, where I asked many of our old friends and quite a few of the hard-core solar and wind bozos two questions: 1) What's the best advice you've ever been given about life? and 2) What's the best advice you've ever been given about renewable energy?

For me, the best life advice came from my older brother, Michael. When I got my first paying job (not babysitting), he told me this, "To be an invaluable employee, just do the job you were hired for." His point? Many people don't do the job they were hired for, and stand out. I have been on both sides of this equation, employee and employer, and his advice has generally been proven right.

Bob-O had the life advice as soon as I asked. "Be here now," he said. Several people echoed this sentiment, either with the same phrase or "Live in the moment."

Life, As We Know It

I got several tidbits passed down from people's grandfathers. "Don't be what you isn't, just be what you is, because if you is what you isn't, then you isn't what you is." That came from a fan from Alberta. "You can't push a rope." And the classic, "This too shall pass."

RE consultant Dennis Pottratz says, "Advice is appropriate under two conditions: when it is asked for, and when the situation is life threatening." His RE advice was, "Don't feel guilty, because there is no defense against a direct hit of lightning."

"Happiness is a choice." "Keep smiling." "Think carefully before you speak." "Don't forget to breathe." "Between a rock and the water, the water always wins." "Work the problem, don't get caught up in side issues." "There isn't a problem without a solution." University of Wisconsin professor Lynn Sagrillo says, "Don't quit, make them kick you out." "Better to be busy than bored." "Trust your instincts." Someone quoted songwriter Jesse Winchester: "If you're skating on thin ice, you might as well dance."

Many gave advice on this theme: "Do what you enjoy; do it well." "Whatever you are going to be in life, be the best you can be." When this guy's father would say this, his brothers would say, "So if we become bums, we will be the best bums we can, Dad." "Do what you love; love what you do."

"Life—don't take it too seriously." "Chew your food." "Cast off fear." "To thine own self be true." "Nothing like taking a risk." "Get out of your own way." "Go lie by your own dish." "All we are is stewards."

Wind guru Mick Sagrillo likes the old Chinese proverb, "Give a man a fish and he'll eat for a day, teach a man to fish and he'll eat for life." "You can do anything you set your mind to." "Adversity builds character." "Compassion is the only thing to take seriously." "Try to be generous." "Don't be afraid to try." "Be kind and it will all work out."

MREA director Tehri Parker's life advice comes from her mother-in-law. "Marriage is like yoga—you need to be flexible and breathe deeply." Her mother-in-law is a yoga teacher.

"Live smart, learn as much as you can, keep learning." "All we have to do is 'be' together and it will all happen." "Do someone a favor and it will become your job." "Keep your corner of the world clean." "If you don't want to be used, be useless." "Let go." And finally, "I'm not willing to exchange the thrill of living for the security of existence."

RE in a Nutshell

The best RE advice I've gotten is to read your meters, but don't read them like a fuel gauge—your system meter can give you a lot of information beyond the fullness of your batteries.

Bob-O's RE advice is, "A watt saved is a watt earned." This too was frequently echoed. "Efficiency, efficiency, efficiency." "Start with conservation." "Wherever you live, live like you're off grid." "Keep the heat in, before you invest in RE." And finally, "Turn off the damn lights!"

This advice was countered by, "Keep it really simple. Don't make yourself crazy by trying to get the last bit of efficiency."

Since I was in the Midwest, where wind power is big, I got wind advice. "There are three things to remember about wind power: 1) taller tower; 2) taller tower; and 3) taller tower." "Don't put up wind (or hydro) on a marginal site." "If you have a wind generator, put it on a tall tower."

MREA director Tehri's RE advice? "There's no such thing as an average house."

Some advice was two-fold. "Don't sweat the petty stuff, pet the sweaty stuff." On the Midwest Fair: "RE—Come for the RE, stay for the beer. Life—Come for the beer, stay for the RE."

"Systems grow." "There's no substitute for quality." That's from long-time solar advocate and author Bob Ramlow. It could be for life or RE.

Solar and computer nerd Darren Emmons, whose nickname is DC, says, "You can never have too much PV." "Cover the very basics first and work up from there." "Don't flog old batteries, get good batteries."

"RE—just do it!" "Remember, renewables are not the answer to everything." "If you are looking for land, listen. You might hear water or wind." Midnite Solar's boB G. came up with "Talk nerdy to me."

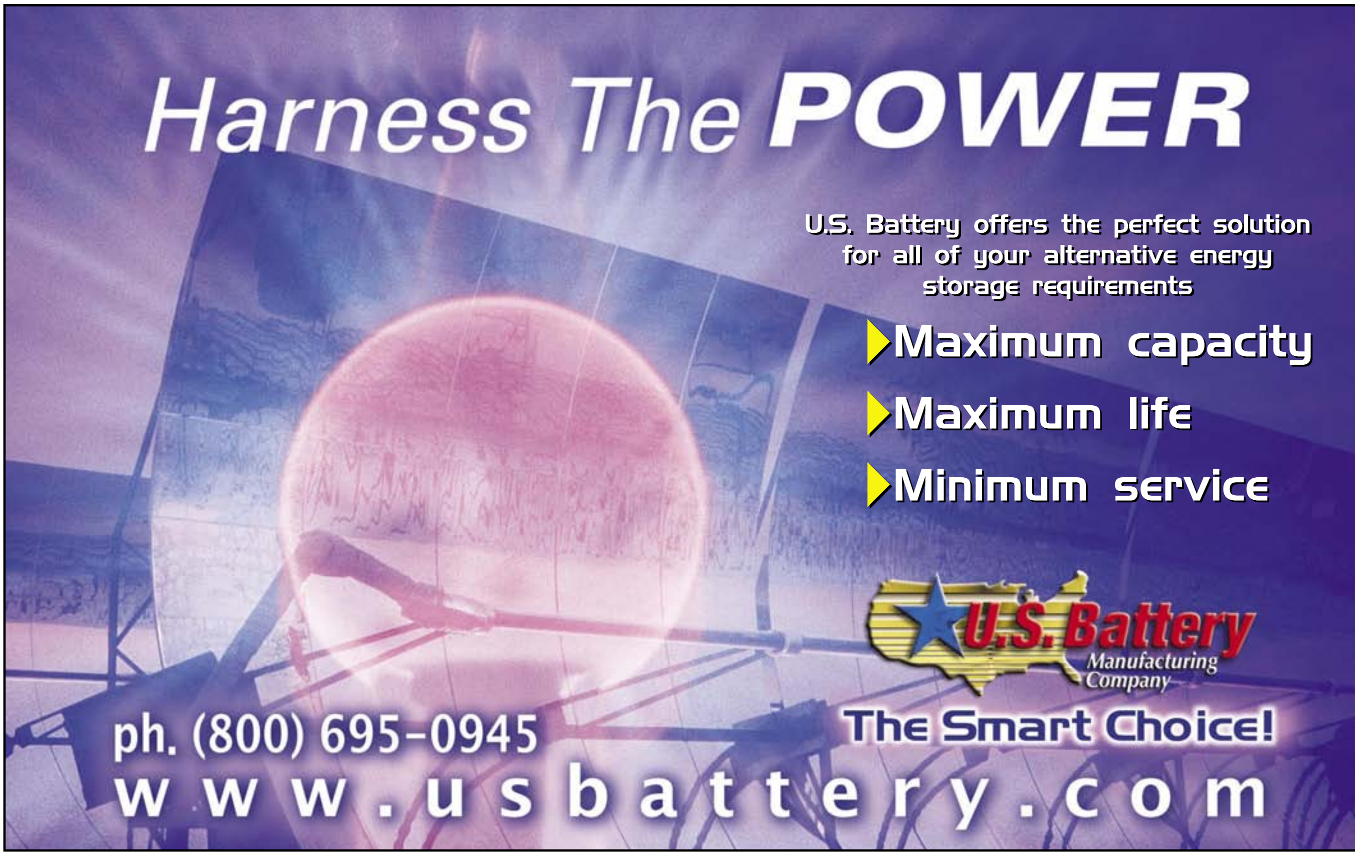
RE instructor and installer Chris LaForge always tells the students in his classes to "test it three times before you turn it on. Once forwards, once backwards, and once forwards again."

Kathleen in a Nutshell

I have to admit asking these questions was just plain fun. Some people had advice at the ready, while others thought about it and told me when I saw them next. I heard stories about family members who had given the advice. I scored some good gardening advice. Organic gardener, artist, and solar installer Amy Wilson told me to plant my perennials in the middle of the garden, rather than on the edge. Then you don't have to constantly battle the bunchgrass in the asparagus. I feel enlightened. Of course, that reminds me of a Buddhist saying, "Before enlightenment—haul water, chop wood. After enlightenment—haul water, chop wood."

Access

Kathleen Jarschke-Schultze is stacking her winter firewood at her home in northernmost California. c/o *Home Power*, PO Box 520, Ashland, OR 97520 • 800-707-6585 • kathleen.jarschke-schultze@homepower.com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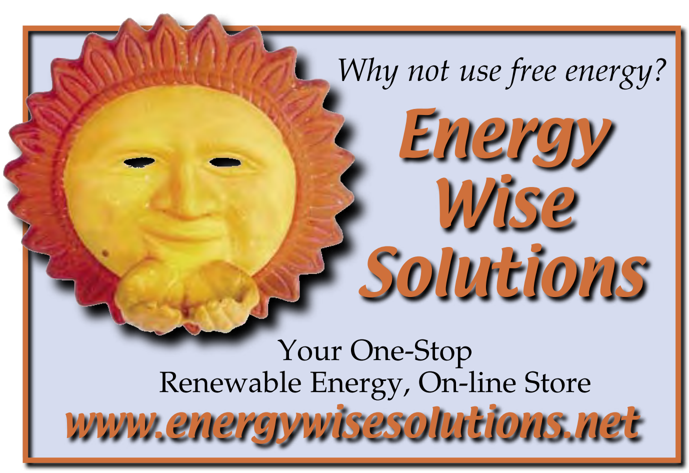
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RE happenings

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Oct. 7, '06. Everywhere, U.S.A. National Tour of Solar Homes. Info: Local chapters of the American Solar Energy Society • www.ases.org/tour/2006_tour/listings.htm

Info on state & federal RE incentives. NC Solar Center • www.dsireusa.org

Ask an Energy Expert. Online or phone questions to specialists. Energy Efficiency & RE Info Center • 800-363-3732 • www.eere.energy.gov/informationcenter

Sandia National Laboratories PV systems Web site. Design practices, PV safety, technical briefs, battery & inverter testing • www.sandia.gov/pv

CALIFORNIA

Oct. 16–19, '06. San Jose, CA. Solar Power 2006. Industry conf. & exhibit on solar applications. Info: SEIA • 202-682-0556 • mbrownstein@seia.org • www.solarpowerconference.com

Arcata, CA. Campus Center for Appropriate Technology (CCAT), Humboldt State Univ. Workshops & presentations on RE & sustainable living • 707-826-3551 • ccat@humboldt.edu • www.humboldt.edu/~ccat

Hopland, CA. Workshops on PV, wind, hydro, alternative fuels, green building & more. Solar Living Institute • 707-744-2017 • sli@solarliving.org • www.solarliving.org

COLORADO

Carbondale, Paonia & Denver, CO. Workshops & online courses on PV, solar water pumping, wind power, RE businesses, microhydro, solar hot water, radiant heating, alternative fuels, and green building. Also: women's PV courses. Solar Energy Intl. (SEI) • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

FLORIDA

Melbourne, FL. Green Campus Group meets monthly at Florida Tech to discuss sustainable living, recycling & RE. Info & meeting times: fleslie@fit.edu • http://my.fit.edu/~fleslie/GreenCampus/greencampus.htm

IOWA

Iowa City, IA. Iowa RE Assoc. meetings. Call for times. I-Renew • 319-341-4372 • irenew@irenew.org • www.irenew.org

KENTUCKY

Oct. 14–15, '06. Lexington, KY. Bluegrass Energy Expo. Trade show, workshops, exhibits & demos, film festival, kids' activities, energy consultations & more. Appalachia—Science in the Public Interest • 859-523-4773 • benperry@a-spi.org • www.bluegrassenergyexpo.org

MICHIGAN

Dimondale, MI. GLREA 2006 RE workshops. Oct. 2–6: PV Apprentice Training; Nov. 4 & Nov. 18: Introductory RE; Dec. 9: Introductory Solar Heating. Info: Great Lakes RE Assoc. • 517-646-6269 • jennifer.malinowski@glrea.org • www.glrea.org

West Branch, MI. Intro to Solar, Wind & Hydro. 1st Fri. each month. System design & layout for homes or cabins. Info: 989-685-3527 • gotter@m33access.com • www.loghavenbbb.com

MONTANA

Whitehall, MT. Seminars, workshops & tours. Straw bale, cordwood, PV & more. Sage Mountain Center • 406-494-9875 • www.sagemountain.org

NEW MEXICO

Oct.–Nov. & Feb.–Mar. each year. Deming, NM. Intro to Homemade Electricity course. Mimbres Valley Learning Center • 505-546-6556 ext. 103 • www.mvlc.us/MVLC-DABCC.htm

Six NMSEA regional chapters meet monthly, with speakers. NM Solar Energy Assoc. • 505-246-0400 • info@nmsea.org • www.nmsea.org

NORTH CAROLINA

Oct. 21–22, '06. Beech Mt., NC. Small-Scale Wind Energy workshop. Info: NC Small Wind Initiative, Appalachian State Univ. • 828-262-7333 • wind@appstate.edu • www.wind.appstate.edu

Saxapahaw, NC. Get Your Solar-Powered Home. Solar Village Institute • 336-376-9530 • info@solarvillage.com • www.solarvillage.com

OHIO

Sep. 30–Oct. 1, '06. Athens, OH. Athens Area Sustainability Festival. Workshops on alternative building, RE & sustainable living. Arts & crafts, music & kids' program • 740-674-4300 • fun@susfest.org • www.susfest.org

OREGON

Cottage Grove, OR. Adv. Studies in Appropriate Tech., 10-week internships. Aprovecho Research Center • 541-942-8198 • apro@efn.org • www.aprovecho.net

Philadelphia, PA. Philadephia Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@verizon.com

TENNESSEE

Oct. 19–22, '06. Summertown, TN. Personal oil independence course. Grow your own fuels; put PV on your roof. Info: The Farm • ecovillage@thefarm.org • www.thefarm.org

TEXAS

El Paso Solar Energy Assoc. Meets 1st Thurs. each month. EPSEA • 915-772-7657 • epsea@txses.org • www.epsea.org

Houston RE Group quarterly meetings. HREG • hreg@txses.org • www.txses.org/hreg

WASHINGTON

Oct. 7, '06. Guemes Island, WA. Intro to RE workshop. Solar-, wind- & hydroelectricity, solar cooking & solar hot water. Classroom & tours. Info: See listing below.

Oct. 9–14, '06. Guemes Island, WA. Solar-Electric Design & Installation workshop. Comprehensive classroom and hands-on training on photovoltaics. Info: See listing below.

Oct. 16–21, '06. Guemes Island, WA. Solar Home Design & Natural Home Building workshop. Learn to design healthy, energy-smart homes. Classroom, labs, tours. Info: See listing below.

Apr. 25–27, '07. Guemes Island, WA. Solar Hot Water workshop. Classroom, tours & installation. Info: See listing below.

Apr. 30–May 5, '07. Guemes Island, WA. Wind-Electric Systems workshop. Design, system sizing, site analysis, safety issues, hardware specs & a hands-on installation. Info: See listing below.

May. 7–12, '07. Guemes Island, WA. Homebuilt Wind Generators workshop. Learn to build wind generators from scratch, incl. carving blades, winding alternators, assembly & testing. Info: see SEI in Colorado listings. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com

WASHINGTON, DC

Oct. 14–15, '06. DC Green Festival. A party, including exhibits, speakers, etc. Info: Co-op America • 202-872-5339 • www.greenfestivals.org

WISCONSIN

Custer, WI. MREA '06 workshops: Basic, Int. & Adv. RE; PV Site Auditor Certification Test; Veg. Oil & Biodiesel; Solar Water & Space Heating; Masonry Heaters; Wind Site Assessor Training & more. MREA • 715-592-6595 • info@the-mrea.org • www.the-mrea.org

INTERNATIONAL

Internet courses: PV, green building & intl. development. Solar On-Line (SóL) • 720-489-3798 • info@solenergy.org • www.solenergy.org

Internet courses: PV Design & Solar Home Design. Solar Energy International online. Info: See SEI in Colorado listings.

AUSTRIA

Feb. 28–Mar. 2, '07. Wels. World Sustainable Energy Days. Includes conferences on energy efficiency, green electricity, renewable HVAC & more. Info: O.Ö. Energiesparverband • 43-732-772-014-380 • office@esv.or.at • www.esv.or.at

CANADA

Nov. 1–5, '06. Ottawa, ON. CanSIA Solar Conf. Industry updates, gov't. activities, attracting investors, workshops & sessions. Info: Canadian Solar Industries Assoc. • 866-522-6742 • info@cansia.ca • www.cansia.ca/conference2006.asp

British Columbia. BC Sustainable Energy Assoc. meetings at chapters throughout province • www.bcsea.org/chapters

Calgary, AB. Alberta Sustainable Home/Office. Open last Sat. of every month, 1–4 PM, private tours available. Cold climate, conservation, RE, efficiency, etc. • 403-239-1882 • jdo@ecobuildings.net • www.ecobuildings.net

CHINA

Oct. 24–27, '06. Beijing. Great Wall World RE Exhibition. Bringing together power executives, regulators, RE experts, suppliers & investors. Info: Skizttly Zhu • 86-10-62-180-145 • registrar@gwref.org • www.gwref.org

Apr. 10–12, '07. Shanghai Intern. Wind Energy Exhibit & Conf. Info: Ms. Shirly Sun, 86-01-30-42-113-676 • chinapower2007@yahoo.com.cn • www.cwee.com.cn

COSTA RICA

Jan. 22–28, '07. Rancho Mastatal. RE for the Developing World—Hands-On. Overview of solar electricity, hot water & cooking; biogas & other RE technologies. Info: see last listing for WA state.

Feb. 2–10, '07. Durika. PV for the Developing World. Comprehensive workshop on PV. Info: see last listing for WA state.

GERMANY

Oct. 23–24, '06. Bremerhaven. Ocean Energy Conference. For R&D, industries, project developers, utilities, policy makers, etc. Info: OTTI e.V. • 49-941-29-688-37 • britta.haseneder@otti.de • www.otti.de/kolleg.htm

INDIA

Nov. 6–8, '06. New Delhi. World Wind Energy Conf. Info: World Wind Energy Assoc. • 49-228-369-40-80 • secretariat@wwindea.org • www.wwindea.org

ITALY

Oct. 26–29, '06. Milan. PV Tech Expo. Conf. & exhibit for the PV manufacturing industry. Info: ArtEnergy Publishing • 39-02-66-306-866 • info@pvtech.it • www.pvtech.it

NICARAGUA

Jan. 8–19, '07. Managua. Solar Cultural Course. Lectures, field experience & ecotourism. Richard Komp • 207-497-2204 • sunwatt@juno.com • www.grupofenix.org

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