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Join us for the…

1st Annual AEE Solar Dealer Conference in February!

We are excited to announce our **1st Annual AEE Solar Dealer Conference, February 6-9, in Mesa, Arizona** – sure to be one the year's top solar events hosted by the fastest-growing distributor in the solar power industry!

The conference will feature:

- **Keynote presentations** by industry leaders John Wiles, Andy Black and David Katz.
- **Product exhibit hall** open all 4 days where our top suppliers will demonstrate their latest products.
- **Dealer training workshops** by manufacturers and AEE Solar, covering everything from product performance, installation and tech tips to marketing, advertising and the use of financing as a selling tool.
- **Special buy programs and incentives,** plus raffles and prizes, a poolside BBQ dinner – also a golf tournament and solar tours the Sunday after the conference!

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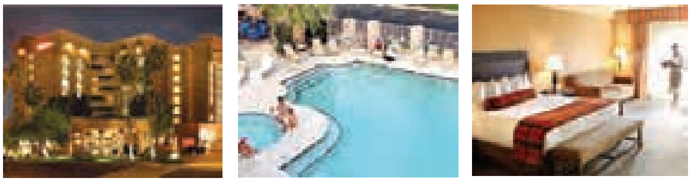
If you are an AEE Solar dealer, please join us in Mesa and get the information and inspiration you need to grow your solar business!

If you are not yet an AEE Solar dealer, it is not too late! Call today, or apply online to become an authorized dealer.

Visit our website for complete information on the conference, including cost, hotel reservations and much more. You can also register online at: **www.aeesolar.com**



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From left to right: 35-W-module (1982), 33-W-module (1979), 35-W-module, (1980), SolarWorld Sunmodule 175-W (2007), 30-W-module (1978), 30-W-module, (1983), 20-W-module (1977), 35-W-module (1980)

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February & March 2008

Clockwise from lower left: Courtesy www.htproducts.com; courtesy Christian Stumpf/TUD; courtesy Gene & Kathy Dolphin; Shawn Schreiner; courtesy www.solarthermal.com; courtesy Kevin A. Schumacher

On the Cover

Solar technologies and resource-efficient materials make Tom and Kathy Carstens' home in Applegate, Oregon, shine. See article on page 58. (Rest assured, resourceful readers: As soon as the shot was taken, we cut the extra lights.)

Photo by Shawn Schreiner

Regulars

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Waiting... for the Sun

At the time of writing, President Bush is poised to sign the 2007 energy bill. The original House version of the legislation, the CLEAN Energy Act of 2007, would have led to a rapid expansion of domestic solar and wind energy generation. But as the bill ground its way through the Senate, the provisions that supported renewable electricity were stripped.

In early December, the House version was passed. That progressive energy legislation that would have:

- Required utilities to source 15% of their electricity from renewables by 2020.
- Provided an 8-year extension of the 30% investment tax credit for commercial/business solar installations.
- Created a 6-year extension of the 30% investment tax credit for residential solar installations, as well as increased the current $2,000 cap to $4,000.
- Revoked $13.5 billion in tax breaks for the five largest oil companies, redirecting this revenue toward tax incentives for RE. (This provision alone would have offset more than half of the cost of the clean-electricity tax incentives in the bill.)

When the House bill reached the Senate, a majority of senators supported it. But in the end, it fell a *single* vote short of achieving the 60 votes required to overcome a Republican filibuster. Democratic Senator Mary Landrieu of Louisiana broke with party ranks and voted against the bill. Republican Senator (and presidential hopeful) John McCain of Arizona was the only senator who chose not to cast a vote.

Regardless, President Bush pledged to veto the bill if it included tax incentives for renewables, imposed requirements on utilities to increase renewable-based generation capacity, or altered current tax breaks for oil companies. According to an Associated Press article, the administration said that "the taxes would lead to higher energy costs and unfairly single out the oil industry for punishment." But a Democrat Party analysis reported that "the $13.5 billion over 10 years amounted to 1.1% of the net profits" projected for the five largest oil companies.

Campaign funding and intense lobbying from global energy companies and utilities impacts which politicians make it into office and how they vote. Without a shift toward publicly funded elections, this game isn't going to change. What is changing is the accelerating capitalization of the renewable energy industry via the private sector. Individual investors, venture capital firms, and technology powerhouses (think Google) are getting serious about investing in renewable energy. "Solar millionaires and billionaires will emerge…" says Travis Bradford in his book, *Solar Revolution*.

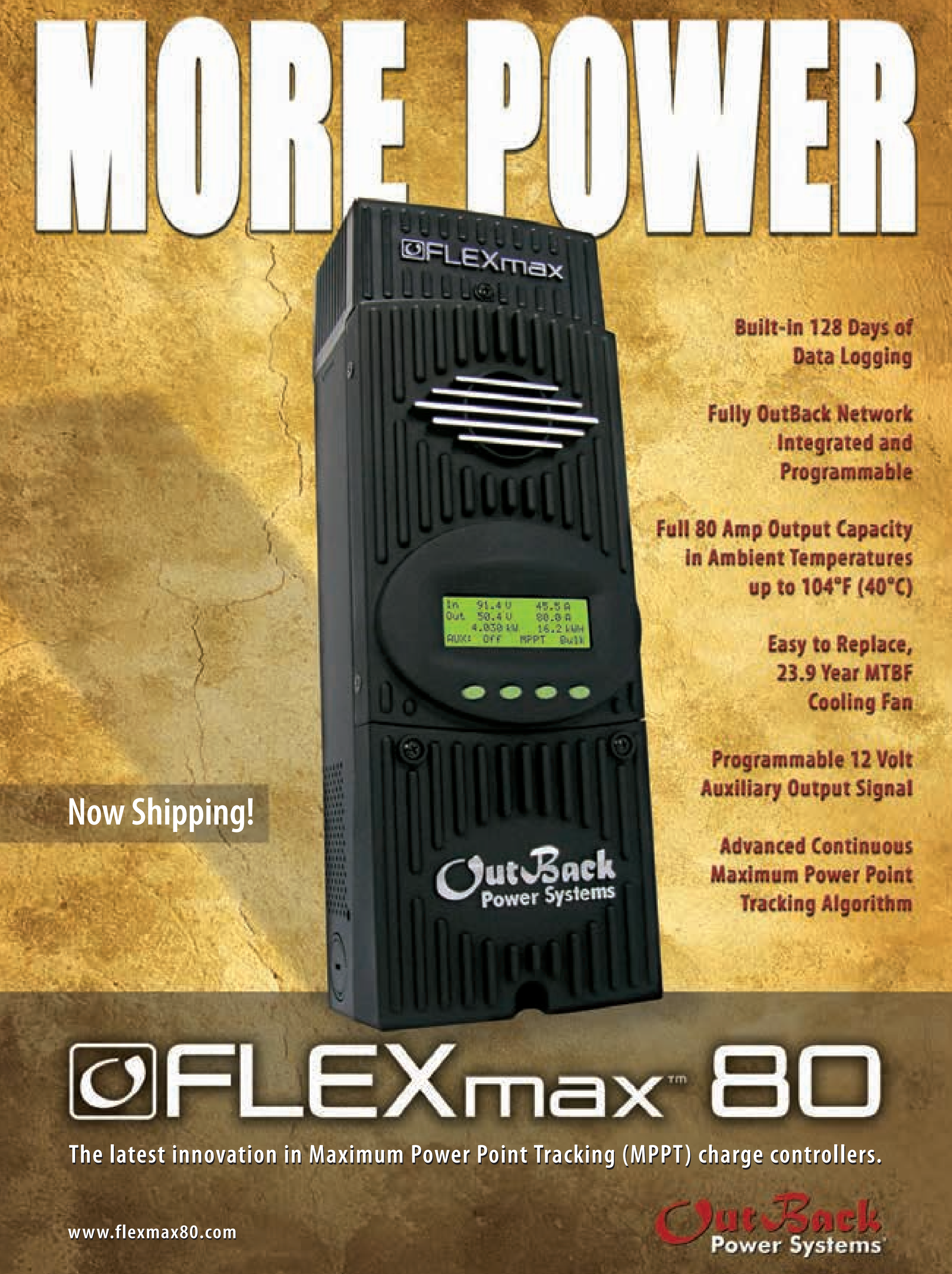
The dismantling of the Senate energy bill's support for renewable electricity was carried out by a minority of congressional representatives, and an administration backed by oil- and energy-company profits. RE technology will ultimately power our future. Resource availability and the evolution of technology will see to that. But if the current boom in RE investment is to continue and rapidly progress, the political relationship between the energy industry and government must be redefined.

—Joe Schwartz for the *Home Power* crew

Think About It...

"Government does not solve problems; it subsidizes them."

—Ronald Reagan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Ask the EXPERTS!

How Much Battery?

One of the strings in my 11-year-old battery bank (twelve L16s) is failing. One of the cells needs water every couple of days, and another in that string is showing similar signs. My system is twelve 75-watt modules (900 watts) and a microhydro turbine that runs spring through fall, with an output between 12 and 15 amps at 24 volts (300 to 375 watts).

I'm paring down the battery bank due to the failures, and wonder whether I should go with eight or twelve batteries when I decide to replace the battery bank. Two of my neighbors use eight batteries in their systems, and one of them said that he felt that I didn't have enough solar capacity to equalize them properly. One local RE installer recommends 165 watts of photovoltaic modules per L16 battery, but I do have a 5 KW engine generator for winter support. I would greatly appreciate your thoughts on battery bank sizing.

Marc Bruvry • Sausalito, California

Replacing your battery bank is expensive, and is heavy, potentially dangerous work. For the greatest longevity, it pays to size the bank properly and monitor battery state of charge.

First, congratulations on maintaining your L16 battery bank so well that it has lasted eleven years. That's impressive! I'd say you've more than gotten your money's worth out of this battery bank.

When we size a battery bank, we first perform a load evaluation to determine the number of watt-hours needed per day, taking into account system component inefficiencies. Then we decide how many days of backup are desired. Typically, we specify three days, but this decision is also based on the weather in the area. Next, we calculate the battery bank capacity required to meet that need, while not discharging the batteries below a desired minimum battery state of charge, usually 50%. (Others prefer a higher minimum, such as 75%.) We also include a derating factor that accounts for the lowest likely battery temperature.

We size the PV array based on the average daily hours of peak solar insolation and daily watt-hours of load, again from the load evaluation that accounts for component inefficiencies. Corrected watt-hours divided by sun-hours equals the watts of PV required to meet daily needs with daily sun. Divide this by the watts each module produces to determine the minimum number of modules needed. We use simple spreadsheets for these calculations. Examples are available from most RE dealers.

Although you can go through the exercise of completing the spreadsheets, it seems that the use and maintenance of your existing battery bank have shown that it's sized well for the longest possible battery life. I'd recommend replacing your existing battery bank with the same number of new batteries. But if you're really set on downsizing to eight L16s, consider the average and deepest depth of discharge (DOD) for your current battery bank based on information from your system's amp-hour meter. If the average DOD is 25% or less (75% of battery capacity remaining), eight L16s might be sufficient.

Battery equalization should not play too heavily into your battery capacity decision. As far as battery equalization goes, if your PV and hydro inputs cannot equalize the battery bank because of heavy appliance loads, you can always equalize with your engine generator.

A final consideration is that most installers prefer no more than two series strings of batteries, with three (like yours) being the absolute maximum. Too many strings can create charging inequalities between the strings. To reduce the number of strings, one needs to use higher-capacity industrial batteries. They are more expensive than most L16s but should last even longer.

Randy Brooks, Brooks Solar Inc. • Chelan, Washington


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Small wind has never been so easy. Announcing the Skystream 3.7™ residential power appliance. It's the first compact, utility-connected, all-inclusive wind generator designed to provide inexpensive, quiet, clean electricity to reduce or eliminate your home's monthly energy bill. Learn if Skystream can work for you at www.skystreamenergy.com.
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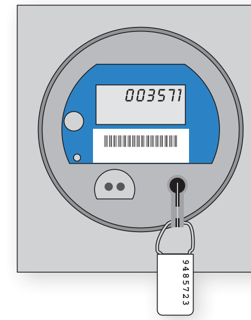
Propane vs. Electricity

I am a full-time solar dealer in California. Prospective solar-electric customers concerned about how to make the best use of energy in their homes often ask me whether they should swap their propane house furnace for an electric one. I have been very reluctant to support this idea, since my understanding was that an electric furnace would use too many kilowatt-hours to make this a better solution financially, and that propane was simply more cost effective. However, I continue to get the calls, and propane continues to get more expensive. Are there any current studies that have compared costs between propane and PV-based electric home heaters?

Rick Burkhard, Alternative Power Solutions Inc. • Sonora, California



This used to be a no-brainer. Historically, in most parts of the country, propane heat has been somewhat cheaper than heat from utility-supplied or PV-generated electricity. Lately, however, the cost of propane has skyrocketed, eliminating its economic edge over electricity for home heating in many places.

Propane contains 91,547 Btu per gallon. A typical furnace will convert about 85% of that to heat, which means that 1 gallon of propane provides about as much heat as 23 kilowatt-hours of electricity.

If propane costs $2.40, then electric resistance heat is cheaper if grid electricity costs 10 cents per KWH or less. An air- or ground-source heat pump could multiply the electrical energy into two to four times as much heat, making electric heat even more competitive. But air-source heat pumps are only recommended for mild climates, and ground-source pumps can be costly to install. To run your own numbers, download this spreadsheet: www.eia.doe.gov/neic/experts/heatcalc.xls.

How about using solar, hydro, or wind power for heat rather than propane? For decades, cheap propane has been the dirty little secret of "independent living," the convenient, flexible fuel that can run a generator, fridge, clothes dryer—you name it. But cheap propane, like cheap oil, is gone and probably not coming back.

Would it ever make sense to use solar electricity rather than solar thermal and passive solar design for heat? Perhaps, if you owned a small, super-insulated house in a moderate climate, although the economics of this are a stretch. But off-gridders who own a large wind or hydro generator could use their surplus this way.

Looking ahead, I expect the price of propane to increase more rapidly than that of electricity. Propane is a by-product of natural gas production. Although 30,000 gas wells were drilled in the United States last year, domestic production has fallen since 2003. The question of how best to heat buildings is destined to be a big topic in decades ahead. Those towering skyscrapers in big cities? The truth is that no one has any idea how they will be heated in 2050.

Randy Udall • Carbondale, Colorado

Selling Back with a Generator

I've always wondered if I could sell electricity back to the utility using my biodiesel-fueled backup engine generator. It sits unused 99% of the time. The solar installers I've asked (thinking they would have the technical know-how) have either said, "No," or "Yes, but it is too expensive." I know large power plants do it cost effectively, but is it possible for a homeowner to do? What does it take and what's the relative cost involved?

Jeff Van Horn • Shoreline, Washington

First, kudos for fueling your generator with biodiesel, rather than petrodiesel. Second, to address your question: Although it is possible to sell generator-made electricity back to the utility, it is usually not practical, cost effective, or even desirable. There are several reasons why:

- Your engine generator will have larger costs per KWH generated compared to other sources of electricity. Compared to utility-scale generators, the size and efficiency of a home generator will most likely make the income earned less than your total expenses for fuel, maintenance, and permits.
- Specialized equipment or a special generator will be required to synchronize your system's output to the grid, and to automatically and quickly disconnect it when problems occur on the grid, like outages or out-of-spec power.
- Net billing laws apply to renewable energy sources, and engine generators do not usually qualify. That means that you would have to establish your generator under a power purchase agreement, which usually pays at an "avoided cost"—about $0.02 to $0.03 per KWH. It also means jumping through lots of regulatory hoops.
- Your engine generator may not meet clean-air regulations, so it should not be used except when absolutely necessary.

Michael Welch • *Home Power*

Low-Wind Turbines

Maybe I've just missed the articles, but you have seemed to avoid talking about some of the less-conventional energy technologies. For instance, why not discuss the benefits and disadvantages of vertical-axis wind generators? People in low-wind areas might well benefit from a wind turbine that can provide usable juice when the wind is too low to even turn a conventional turbine's blades. Also, I've heard that the vertical-axis machines don't seem to kill as many birds and bats, and can handle higher wind speeds more easily.

J. David Neher • San Diego, California

There's so little energy in low-speed winds that it's really not worth designing a machine to capture them.

I would caution you to look very carefully at manufacturers' claims and the supposed "advantages" of their products. Low-speed winds have very little energy in them. The power available in the wind is related to the cube of the wind speed. So if you take a 10 mph wind, you end up with 10 X 10 X 10 = 1,000 units. A 20 mph wind yields 20 X 20 X 20 = 8,000 units. If you have only a 5 mph wind, you get 5 X 5 X 5 = 125 units. In fact, there's so little energy in low-speed winds that it's really not worth designing a machine to capture them.

Though building quality vertical-axis machines is possible, there is no magic in the design that makes them better than state-of-the-art, three-bladed wind generators. The bird-kill issue is wildly exaggerated in general (the number of birds killed by commercial wind turbines is dwarfed by the number killed by habitat destruction, cars, windows, or cats), and verticals have no advantage in that realm anyway. Also, verticals can have problems with both start-up and shutdown. See Robert Preus's article in *HP104* for more perspective on vertical-axis wind turbines.

Ian Woofenden • *Home Power*

Glycol in Drainback

I'm planning to install a combination solar hot water and space heating system that will be ground-mounted. I am hoping to install a drainback system so I can high-limit it, but I need to put the drainback reservoir by the flat-plate collectors in an unconditioned space, so I want to use glycol for freeze protection.

Tom Lane's book, *Solar Hot Water Systems: Lessons Learned 1977 to Today*, says that you can use a 33% glycol solution and that any film left in the collectors will vaporize back into the reservoir. Bob Ramlow's book, *Solar Water Heating,* does not recommend this, and warns that every time the system drains back, a thin film will dry and leave a bit of residue, which will build up and degrade efficiency and the collector. Which is correct?

Steven Parsons • Williamsburg, Massachusetts

They are both right to some degree. The glycol added to the drainback tank will cause some residue to be burned on the inside of the collector riser and header tubes. I've never encountered a system with degraded performance to any degree, but I have seen the fluid turn into a brown, viscous muck over time. I would imagine this is the burned residue mixing with the glycol solution.

You will probably want to change the fluid every few years because the buffers in the glycol that keep it from becoming acidic will be affected by the collector's high temperatures. I have seen many systems like this, and except for the fluid condition, they are still working fine after decades of use. You could probably prolong the life of the solution by using a product called Dowfrost HD, since it contains buffers that don't break down at temperatures below 325°F. Other propylene glycol buffers can break down at about 285°F.

Another thing that helps with glycol-based drainback systems is to slope the collectors toward the inlet as much as possible. It is just common sense to give the header tubes the most slant possible to drain as quickly as possible. Fluid degradation is typically worse in systems that are modestly sloped (less than 1 inch of rise per foot of run). I doubt the riser tubes in any system retain much residue because of the normal tilt of the collectors. If you are concerned about any residue buildup, you can always flush the collectors out every decade or so with trisodium phosphate, an industrial cleaner that is also used as a boiler treatment for calcium buildup.

Chuck Marken • *Home Power*

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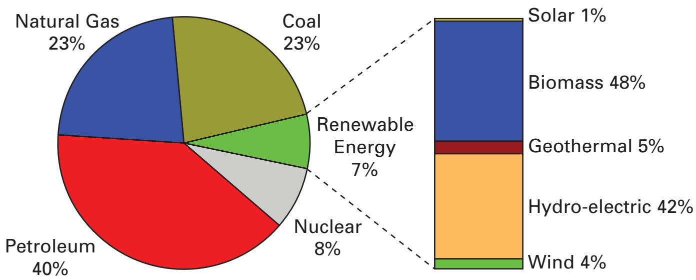
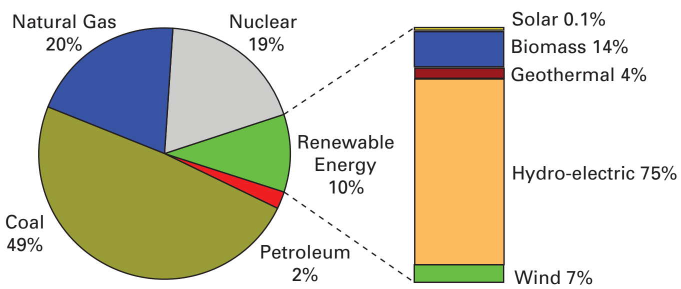


U.S. Energy Consumption by Source



U.S. Electricity Generation by Energy Source

Source: U.S. D.O.E. Energy Information Administration, 2006

Graph Gaffe

I get my copy of *Home Power* in the mail and give it the quick thumb-through before I start the detailed cover-to-cover read. It was during the thumb-through that I was stopped by the chart on page 106 of *HP122.* Could that be correct—40% of the electricity generated in the United States is from petroleum and 23% is from coal? After an Internet search of your source, the Energy Information Administration, and some careful reading, I found the problem: Your chart is correct; it is just labeled wrong. The title should be something like "U.S. Energy Consumption by Source." The chart for "U.S. Electricity Generation by Energy Source" is very different. (At left is 2006 data from the Energy Information Administration.)

It is very interesting to compare petroleum in the charts at left. Petroleum plays a big part in our "energy" consumption, but a small part in our "electricity" generation and consumption. When it comes to electricity generation, think coal, not oil. Thanks for an excellent publication, keep up the good work.

Carl Berger • East Aurora, New York

Thanks to you and a few other readers who wrote in to point this out. The label was correct for what we wanted to portray, but we grabbed the wrong graph to accompany it.

Michael Welch • *Home Power*

The Economic Future of Renewables

People tend to overestimate technological accomplishments ten years in the future but underestimate what will occur in twenty. An economic projection to the year 2030 cannot possibly account for the cumulative innovations and their effects over that time period.

Americans were solo actors in the renewables scene until the 1990s. Today, the number of people at work on various aspects of the problem span the continents. While a lot of this work may appear redundant, one can imagine (for example) that thousands of minor variations in the way semiconductors are fabricated could yield an unusual process insight at any time.

"Business as usual" following the accumulated effects of exponential growth in present manufacturing capacity multiplied by the increasing yield per unit would put the United States at a 100% renewable economy by 2020. The production of RE has to only increase by two orders of magnitude to saturate the American market. The installed base only has to expand one order of magnitude (from 7% to 70%) to account for most of the power production in the United States. At 20% to 30% annual growth rates, an increase of one order of magnitude occurs in five to seven years.

While this is politically incorrect and particularly provocative today, military research is almost invariably interested in how energy is accumulated, stored, and delivered. Vast amounts of the RE work that is known today occurred because the Pentagon needed a longer-lasting satellite, a longer-range rocket, a more sensitive radar, a faster airplane, or a better-aimed bomb. The sustainability mantra of the RE community is echoed in the military's intent to keep troops alive and effective in the middle of deserts, mountains, at sea, and in arctic wastelands.

People tend to overestimate technological accomplishments ten years in the future but underestimate what will occur in twenty.

The semiconductor industry has always been power sensitive, with efforts made continually to reduce heat, increase battery life, and shrink components. The fact that this is green is a side effect. In the bigger picture, consumers choose products and services

based on their overall effects. Transistor radios were bought because they were portable; the fact that they ran on a 9-volt battery was incidental. Laptop computers supplant desktop machines for the same reason. Do people like new jet aircraft because of their energy efficiency or because they make far less noise?

Energy issues get folded into everything else, and the votes that count occur with dollars. Promising voters a "more RE" future is a totally free ride. What politicians are saying will happen is more often than not already accomplished.

Meredith Poor • San Antonio, Texas

There are so many components to building a home that the homeowner must rely heavily on the design and building team.

Qualified Design/Build Team

As much as I promote do-it-yourself projects, there are some things that most people can't figure out in a short amount of time, and that includes building a home. The expert response ("Resource- & Energy-Efficient Building," *Ask the Experts, HP122*) nailed it by advising readers to "assemble a qualified design and building team."

The big question that the public seems to be struggling with is what makes someone "qualified?" As a design and building consultant, I've struggled with this same question—how do I show homeowners, architects, and builders that what I do is of great value and is critical in achieving the goal of a high-performance, sustainable home, and that I am qualified?

What I've found is that third-party certification is the best way to assure homeowners of a specific quality. Leadership in Energy and Environmental Design (LEED) certification for homes and Energy Star certification are two methods that are nationally recognized and endorsed by many.

Some builders and architects will act as the consultants, but a third party is needed to certify the homes, which, I believe, is the key to the validity of how sustainable, green, or high performance a home is. There are self-certifying programs out there, but from my point of view, they don't hold water because they are self-serving to the builder.

I would recommend finding a builder or an architect who is knowledgeable or willing to learn how to build a LEED-certified home. Depending on the components used (and if built well), the home shouldn't cost that much more up front, and will have lower operating and maintenance costs.

Jim Olson • McCall, Idaho

New Jersey RE Policy

I read your article on solar electricity in New Jersey ("Profiting from PV," *HP121*), and enjoyed how thorough and concise it was. I thought you might be interested in knowing about the recent policy changes for solar energy initiatives in the state. New Jersey Governor Jon Corzine recently announced a goal of having 20% of New Jersey's electricity come from renewable resources by 2020. Today, less than 2.5% of the state's electricity comes from renewables.

New Jersey Governor Jon Corzine recently announced a goal of having 20% of New Jersey's electricity come from renewable resources by 2020.

The new state program will scale back the current rebate program, which provides homeowners and businesses grants to cover up to 70% of the cost of a solar-electric system. Instead, the new program will encourage private investors to pick up the cost of installations, and give homeowners and businesses increased financial incentives in the form of renewable energy certificates. Home and business owners will be able to recoup a portion of their investment by selling the certificates to big energy users.

Under the current system, New Jersey homeowners pay an average of about $14 per year to fund the solar rebate program. The new program, slated to be launched in 2009, should initially lessen the financial impact for the typical homeowner to about $5.35 per year. However, the cost is expected to rise to about $33 per year by 2020. Currently, there are no rebates offered for newly installed solar-electric systems in New Jersey, since funds for the existing rebate program have been exhausted. I thought that you and your readers would be interested in knowing about these changes in the New Jersey solar energy situation.

Jaime J. Brownell • via e-mail

We have solarized two homes, both of which... provide all our electrical energy needs, with excess given over as manna to the grid.

Inspired & Solarized

Thank you for a great, helpful, sane, delightful, stimulating, and just plain wonderful magazine. You have inspired us throughout the years as we have solarized two homes, both of which, through energy auditing and conservation, provide all our electrical energy needs, with excess given over as manna to the grid. Indeed, we have also reduced our propane and natural gas usage by three-fourths, by using electricity more for cooking and heating, and solar-heating water.

John & Janet •
San Francisco & Gualala, California

Artesian Hydro

You have a great magazine, and I have learned a great deal from every issue thus far. However, I feel required to correct a misstatement made in *HP122's Ask the Experts* column. An individual was asking about designing a microhydro system to run off a flowing artesian well.

Courtesy Mark Berry

First, the calculations are in error—1 PSI equals 2.31 feet of head, not the other way around. Second, from a "green" standpoint, letting an artesian well run 24/7 is a waste of critical water resources. An aquifer yields water under artesian pressure because it is storing potential energy. That energy was delivered to the aquifer via a recharge area located at a higher elevation than the well. It often takes tens to perhaps hundreds of years for water to flow from recharge to discharge. Using artesian water for electricity generation would contribute to depressurizing the aquifer, which would result in lower yields to the well used and neighboring wells. In extreme cases, depressurization can ruin an aquifer. The result is that further withdrawals constitute mining (withdrawals with no replacement). Once the mineral skeleton compacts and realigns due to depressurization, the aquifer can no longer replace withdrawn water at original rates. This can also lead to subsidence. Not a green scenario!

Jon Kaminsky, licensed hydrogeologist • Lander, Wyoming

Local Incentive

We installed this 5.4 KW system for a client in Port Penn, Delaware, a few weeks ago (see photo at left). The Salem nuclear generating station near Salem, New Jersey, is right across the river from the site—perhaps your readers might enjoy the photo.

Mark Berry, KW Solar Solutions • Newark, Delaware

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write to:

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Bringing SOLAR Home

SMALL CHANGES, BIG RESULTS

by Christina Ammon

In their modest, 600-square-foot home, the Dolphins have brought solar energy to the mainstream.

Big things can happen in small, ordinary spaces. Kathy and Gene Dolphin's tidy bungalow in the storefront-lined Normal Heights neighborhood of San Diego is proof in point. The stucco cottage, hugged by small gardens and fruit trees, effectively challenges the solar stereotype referenced by California's clean-energy advocate Bernadette Del Chiaro, who said, "Solar power has, for a long time, had the stigma of being something for a backwoods hippie or a Malibu millionaire, as opposed to something for Main Street." In their modest, 600-square-foot home, the Dolphins have brought solar energy to the mainstream, setting an inspiring example of clean and efficient energy generation and use for everyday people.


Gene and Kathy Dolphin.

By employing technological fixes, such as solar-electric and solar water heating systems, and adopting new energy-use habits, Gene and Kathy have made their on-grid abode so energy efficient that their utility meter spends more time spinning backward than forward. Effectively, their home produces more electricity than it uses each year. Despite their home's Spartanlike use of electrons, Gene and Kathy live with all the modern conveniences—including a clothes washer, computers, a big-screen LCD TV—even heated towel racks. "Guests who come to our house are amazed beyond belief that we are meeting our energy needs without sacrificing creature comforts," says Kathy.

Seeing the Light

The Dolphins' first introduction to solar power occurred during an annual celebration hosted by their local food cooperative. Kathy and Gene were struck by the solar-powered stage—the sound system and fans all run by the sun. "It really left an impression on us," explains Kathy.

Then, while browsing the bookshelves at the co-op one day, Kathy happened upon a solar cooking book. She bought the book and, using the plans, she and Gene built a simple solar oven made with cardboard boxes and a glass front. Being amateur astronomers, they first used the oven at an informal gathering of telescope makers in Riverside, California. At dinnertime, the Dolphins shared their sun-cooked meal with conference-goers, and the oven was an instant hit.

This experience, along with a belief in conservation and outrage over the rate-tripling California energy crisis in 2000 and 2001, inspired Gene and Kathy to seek ways to shrink their energy footprint. "My first reaction was to pull every plug in the house," says Kathy. Though they had long researched energy efficiency and solar energy—Kathy had even once researched local PV system installers—they were now inspired to put their ideals into action.

Rethinking Energy

Kathy and Gene started with the small, easy stuff. They replaced incandescent bulbs with compact fluorescents, reducing their electric lighting energy requirements, and sought out phantom loads—appliances such as remote-controlled TVs and computers that constantly draw electricity, even when they're turned off. Kathy says that having phantom loads is "like leaving the faucet running all day because you might want to get a drink at some point." To eliminate this unnecessary energy drain, the Dolphins purchased a handful of plug strips to conveniently—and completely—turn off home electronics that were once phantom loads.

As their original appliances began to wear out, Kathy and Gene replaced them with more efficient models. In place of their old refrigerator, they installed an Energy Star model that uses 493 KWH per year—about one-third of the energy required by their old fridge. Their old washing machine, which used 50 gallons of water per load, was replaced by a more efficient Staber machine, which uses only 16 gallons per load, reducing their household's water heating demand. For cooking, they upgraded to a gas range that does not use a continuously burning pilot light.

A solar light tube in the kitchen brings in ample natural light, reducing their need for electric lighting during the day. The tube admits sunlight through a diffuser, which helps distribute daylight within the room while minimizing glare. The solar tube's design does not result in overheating interior spaces during the warm months like skylights often do. At night, the solar tube offers an additional benefit—when the moon is up, it serves as a nightlight.

Thin-film PV modules produce 100% of the Dolphins' electricity. A solar light tube provides daylighting for the home's interior.

San Diego's mild coastal climate offered the opportunity for the Dolphins to forego one of a household's biggest summertime electricity loads—air conditioning. Instead, they actively manage ventilation through the house, opening the windows in the evening when the air is cool, and closing them in the morning to keep out the heat of the day. On the hottest summer days, they also rely on a workshop-type, 350 W fan placed near an exterior door to quickly draw cooler air into the house from the outside.

Upgrading to more efficient appliances was one of the ways that Gene and Kathy reduced their electric bill.

Investing in Solar Energy

Appliance upgrades and simple changes in their daily habits cut the Dolphins' household energy use. Still, they had long been dreaming of using solar energy, so when their old water heater broke, they seized the opportunity to integrate solar water heating into their energy mix. Local installer Mark Naylor installed a 40-gallon solar batch heater on the roof and replaced their old water heater in the garage with a more efficient gas-fired tank heater for backup during cloudy weather. Together, the two tanks provide a total of 90 gallons of hot water storage. The total cost for the upgrade was $2,090.

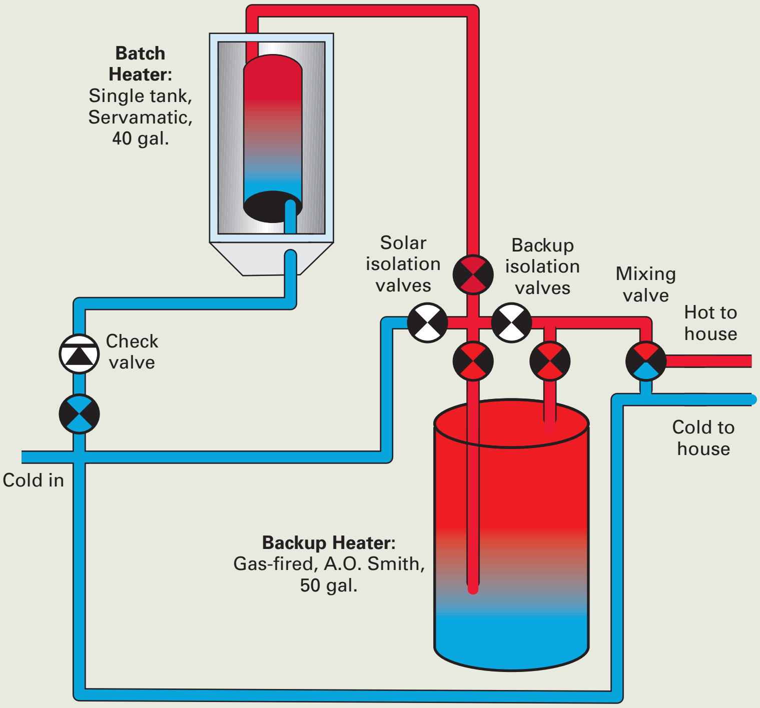
Pleased with the simplicity and success of their solar-heated water system, Kathy and Gene decided to invest in PV. Through a referral from the People's Co-op, they called on Martin Learn, owner of Home Energy Systems. When he arrived and inspected Gene and Kathy's energy bills to size a suitable solar-electric system, he was amazed: The Dolphins had reduced their electricity use by 65% just by switching to compact fluorescent bulbs, using power strips, and replacing their old, inefficient appliances, making their goal of covering all their electricity needs with PV easy to reach. They bought a 2.1 KW PV system, which, after rebates and tax credits, cost about $6,900.

As summer approached, the Dolphins were thrilled as they watched their daily energy generated by the PV system climb from 10.6 KWH in February to surpass 12 KWH by April. That first year, the system generated 3,000 KWH and sent 1,100 KWH of excess energy back to the grid.

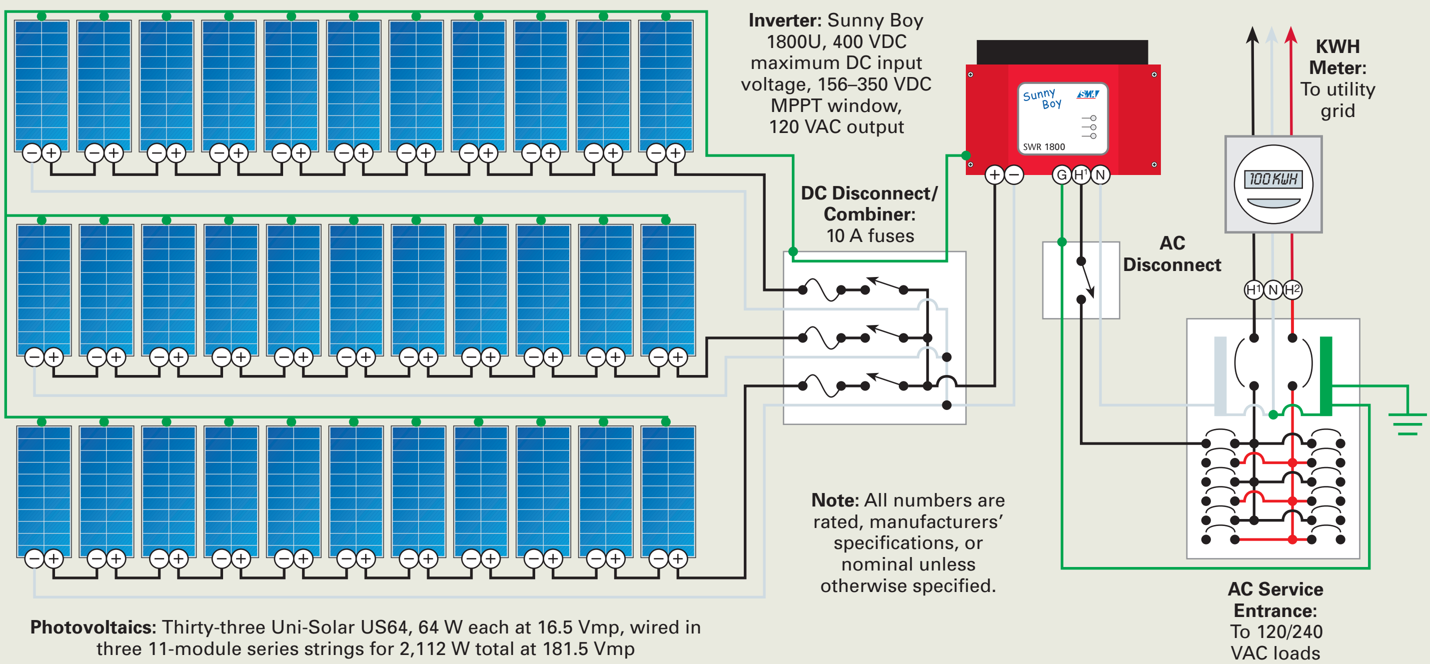
Although Gene says that they were told initially not to expect the system to produce more than 7 KWH per day during the winter, their solar power plant had no problem exceeding that on most days. Gene says that they were so excited to see how well the system actually worked that he

The Dolphins' solar batch heater reduces their water heating costs by half.

Dolphin Solar Hot Water System



Dolphin On-Grid Photovoltaic System



began charting daily measurements from the inverter's digital display and comparing them to the utility meter readings.

"I was particularly interested in seeing if the original energy production estimates were true, and if true, how long it would take to roll back the meter to the January 7 meter reading—when the system was first installed," says Gene. "It took less than a month. We use about 4 to 5 KWH per day, and this system takes care of us very nicely."

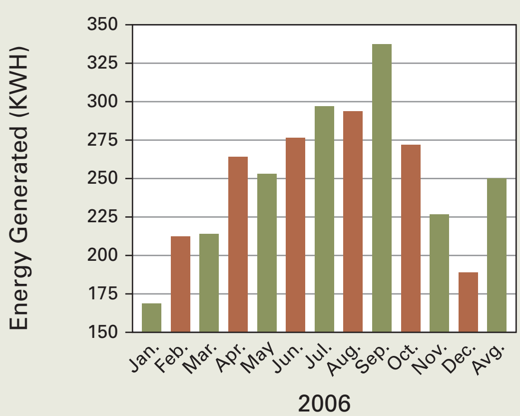
Small Obstacles

Though the journey was mostly a smooth one for the Dolphins, they did encounter a few minor (albeit tall) obstacles—two looming palm trees that cast a shadow on the south side of their house, blocking solar exposure to the PV array. True to form, Kathy and Gene's commitment to conservation kicked in to overcome this hurdle too. They acquired a removal permit and called a relocation service that replanted the trees elsewhere—for the same price it would have cost to just cut them down.

There was also the question of what to do with the excess energy the PV system was generating. California offers annualized net metering and the Dolphins would not get paid by their utility, San Diego Gas & Electric (SDGE), for anything they generated over their annual KWH usage. So, they put

An SMA America Sunny Boy inverter converts the DC electricity produced by the PV array into standard AC household electricity.

PV System Production



PV & SHW Tech Specs

Overview

Location: San Diego, California

Solar resource: 5.7 average daily peak sun-hours

Photovoltaics

Average monthly production: 250 AC KWH

Utility electricity offset annually: More than 100%

Modules: 33 Uni-Solar US64, 64 W STC, 16.5 Vmp

Array: Three 11-module series strings, 2,112 W STC total, 181.5 Vmp

Array installation: Two Home Energy Systems mounts on south-facing roof; one on north-facing roof and one on flat garage roof; all oriented south with a 22-degree tilt

Inverter: Sunny Boy 1800U, 1.8 KW rated output, 400 VDC maximum input, 156–350 VDC MPPT range, 120 VAC output

System performance metering: Inverter display and utility KWH meter

Solar Thermal

System type: Batch (integral passive solar-assisted)

Hot water produced annually: 50%

Collector: Servamatic, rooftop batch heater, 40 gal.

Collector installation: Mounted on south-facing roof at 22-degree tilt

Backup DHW tank: A.O. Smith, gas-fired, FGR 40 242, 50 gal.

their excess electricity to work by installing luxuries that they would otherwise never consider—heated towel racks, an electric fireplace, a fountain that flows all day and night, and a freezer in the garage. They also run electric heaters in the winter, instead of relying on the home's gas-fired floor heaters. Kathy acknowledges that some of these appliances are a little ridiculous, but the thought of the power company profiting from their surplus energy angers her. "It's unjust," she says. Until they come up with more creative uses for the rest of the surplus, they begrudgingly send about 50 KWH per year back to the grid.

Looking at the Bright Side

After seeing their small changes have such a dramatic effect on their energy use with little or no inconvenience, Kathy admits that the general lack of understanding most Americans have of their energy consumption can be frustrating, but says, "What we can do is be an example for people."

And they've done just that through their actions—both at home and in their community. In addition to generating their own electricity and using it more efficiently, the Dolphins streamlined their whole lifestyle. "When you are aware of one kind of waste [energy], it makes you think about how other things are wasted too," Kathy says. Through careful recycling and composting their food scraps, the Dolphins reduced their garbage to one small bag per week. With their compact gardens, they also grow some of their own produce, cutting down on the energy costs of trucked-in, store-bought food. And when SDGE sponsored a compact fluorescent lightbulb exchange program, the Dolphins inspired their church to trade out their incandescent lights.

In a land known for McMansions, Kathy and Gene's old-fashioned stucco house might seem Spartan. But for them, it brings pride and the simple happiness that comes with having just enough: a garden, fruit trees, a comfortable home—and plenty of energy.

Their experience has taught them that the technology is readily available to generate your own electricity, and to do it at home. It's the mind-set that needs to change. As Gene explains, "We have to look at resources as something important, and to think of our needs versus our likes and desires."

Access

Christina Ammon (www.christina-ammon.com) approaches life one word at a time in beautiful Ashland, Oregon. Drawing on her experiences as a vineyard worker, farmer, skier, and adventurer, Chris explores a broad array of topics in her writing. She is a recipient of an Oregon Literary Arts fellowship for literary nonfiction.

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Martin Learn, Home Energy Systems Inc., 6996 Convoy Ct., San Diego, CA 92111 • 858-278-2300 • info@homeenergysystemsinc.com • www.homeenergysystemsinc.com • PV system

System Components:

Servamatic • www.servamaticsolarparts.com • Solar water heater

SMA America • www.sma-america.com • Inverter

Uni-Solar • www.uni-solar.com • PV modules

HIGH DESIGN HIGH PERFORMANCE

Solar Homes in the Spotlight

by Kelly Davidson

Courtesy Christian Stumpf, TUD

This past October, solar energy occupied the spotlight at the nation's capital, when 20 homes, entirely powered by the sun, took up temporary residence just footsteps from the Capitol building. The occasion: The 2007 Solar Decathlon, an international competition sponsored by the U.S. Department of Energy.

Held every other year since 2002 in Washington, D.C.'s National Mall, this progressive competition challenges collegiate teams of budding engineers, designers, and architects to build and operate solar-powered homes that can generate enough energy with solar technology to satisfy a typical household's energy appetite. The team that best blends aesthetics and modern conveniences with maximum solar energy production and optimal efficiency wins.

Here's how it works: Rules restrict the size of the houses to 800 square feet and stipulate that the main energy generation and storage devices, such as PV modules, solar thermal collectors, and batteries, must be located within this footprint. With only a few exceptions, anything goes for architecture and engineering, though the ultimate goal of a market-viable home for 2015 keeps the designs grounded in function and efficiency. One catch is that the structures and their energy systems must be transported to the National Mall, often piece by piece, and reassembled in less than one week.

Almost overnight, a small "solar village" emerged on the lawn between the Capitol building and the Washington Monument. One by one, cranes, flatbed trucks, and moving vans rolled onto the scene. Hard-hat-wearing solar decathletes scrambled, anxiously cracking open cargo containers and crates. Before long, the buzz of power tools filled the air, as crews worked tirelessly to assemble their homes before the competition got underway and the event opened to the public.

Courtesy Kaye Evans-Lutterodt / Solar Decathlon

Above: The University of Maryland's innovative Green Wall—a vertical surface of living plants—helps capture and direct water to a garden.

Opposite: The winning home by T.U. Darmstadt incorporated amorphous PV technology into the louvered shutters for additional electricity generation.

The Main Event

The three overall winners in the Decathlon are determined by points scored in ten contests: architecture, engineering, market viability, communications, comfort zone, appliances, hot water, lighting, energy balance, and getting around. With 200 points, the most in any of the contests, the architecture category was the one to win. A panel of professional architects scrutinized each home for its structural integrity, materials, ingenuity, and overall design strategy. Nearly as critical were the market viability and engineering contests, with a maximum of 150 points each. A jury of engineers examined everything from the insulation to the kitchen plumbing, while experts in building energy simulation crunched the energy stats and evaluated how effectively the teams used simulation tools in the design process.

The heart of the competition is the performance of each house's energy systems during the ten days on the Mall. Each must maintain a steady comfort zone, between 70ºF and 78ºF and 40% to 60% humidity. Using only the electricity produced by the house's solar-electric system and water heated by its solar thermal system, teams must carry out normal energy-consuming activities: cooking meals, washing dishes, doing laundry, taking showers, running a computer, and operating an entertainment system. For the "getting around" part, teams earned points for how many miles they drove an electric vehicle charged by their house's PV system.

Behind the scenes, team engineers strategized ways to maximize energy production and stretch every last watt-hour of energy. An unusually hot and humid week for October put cooling and moisture-control systems to the test, while a stretch of sun and partially overcast days boded well for electricity production and solar water heating.

But in the end, three homes edged out their competitors to earn the best overall scores. With a total of 1,024.85 points, first-time competitor Technische Universitat Darmstadt went into the last, cloudy day with the most energy in their batteries, and secured the top spot with a sleek design that showcases German technologies and materials. Local favorite University of Maryland took second place with a climate-adapted home designed to handle the gamut of weather experienced in the Chesapeake Bay watershed. Santa Clara University captured third place with their California contemporary home that seamlessly integrates high-tech systems with natural materials.

All the teams put their own spin on creative solar design and eco-friendly architecture, pushing the envelope in terms of energy- and resource-efficient building—and giving the public a peek into home construction techniques and RE equipment innovations that may soon hit the mainstream. For a look at what captured the experts' eyes and imaginations this year, check out the winning homes, profiled on the following pages.

Access

Kelly Davidson (kelly.davidson@homepower.com), *Home Power* Associate Editor, was one of more than 100,000 people to attend the 2007 Solar Decathlon.

U.S. Department of Energy Solar Decathlon • www.solardecathlon.org

T.U. Darmstadt • www.solardecathlon.de

University of Maryland • www.solarteam.org

Santa Clara University • www.scusolar.org

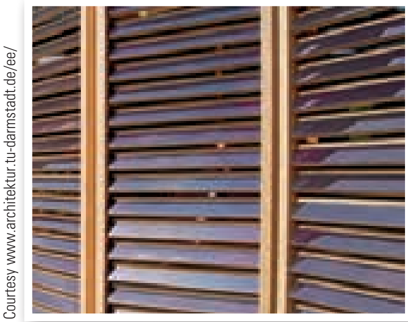
T.U. Darmstadt

With the mantra, "The cheapest KWH is the one which is not needed," as its guiding design principle, T. U. Darmstadt took the Decathlon by storm, winning the architecture and engineering contests, and also earning a perfect score for energy balance.

Although their design strategies—insulating for high efficiency, optimizing solar irradiation and internal energy gains, and eliminating air infiltration—were typical, their design approach was anything but. Each carefully planned layer of the T. U. Darmstadt's house reveals a distinctively European approach to efficient, functional design. The post-and-beam structure supports an outer shell of louvered oak panels, which fold open along the north side to expose the main entry and a wall of quadruple-pane windows with insulated oak frames. To the south, a series of folding, louvered shutters encloses a porch covered by a roof of translucent photovoltaic modules.

A favorite among the jurors and crowd, the motorized solar-electric louvers automatically adjust to a optimal angle for receiving sunlight and complement production from the discretely angled arrays on the roof. The team's goal was to show that a solar roof can be seamless and stylishly integrated into a modern building design.

The real test for this team was designing a building that would perform well in Washington during the competition and in Darmstadt afterward, since the house will be permanently installed on the university's campus for continued research. The team enlisted special software to simulate how different weather conditions and sites affect the house. A touch-panel computer control system allows homeowners to track and adjust lighting, temperature, humidity, and electricity consumption.



Courtesy www.architektur.tu-darmstadt.de/ee/

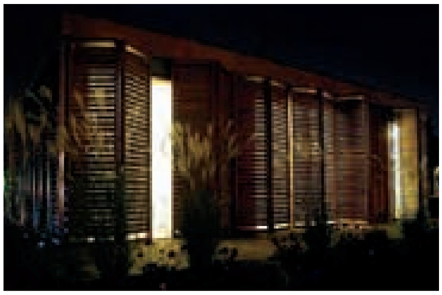
Electricity Generation: Forty SunPower 210 W PV modules on the roof provide the bulk of the home's electricity, along with the PV louvers and translucent Sunways modules that cover the porch roof. The energy generated by the PV arrays is converted to AC using multiple SMA batteryless inverters. These are synchronized with an SMA Sunny Island battery-based inverter that charges a 48-volt, 2,000 amp-hour Hoppecke battery bank.

Courtesy Christian Stumpf, TUD

Powerful Shutters: As the seasons change, the shutters can be opened or closed as necessary to capture or shield passive solar heat gain. The true genius? Equipping the louvers on the east, south, and west facades with Schott amorphous silicon PV cells to maximize electricity production.

The First-Place Winner

Courtesy www.architektur.tu-darmstadt.de/ee/

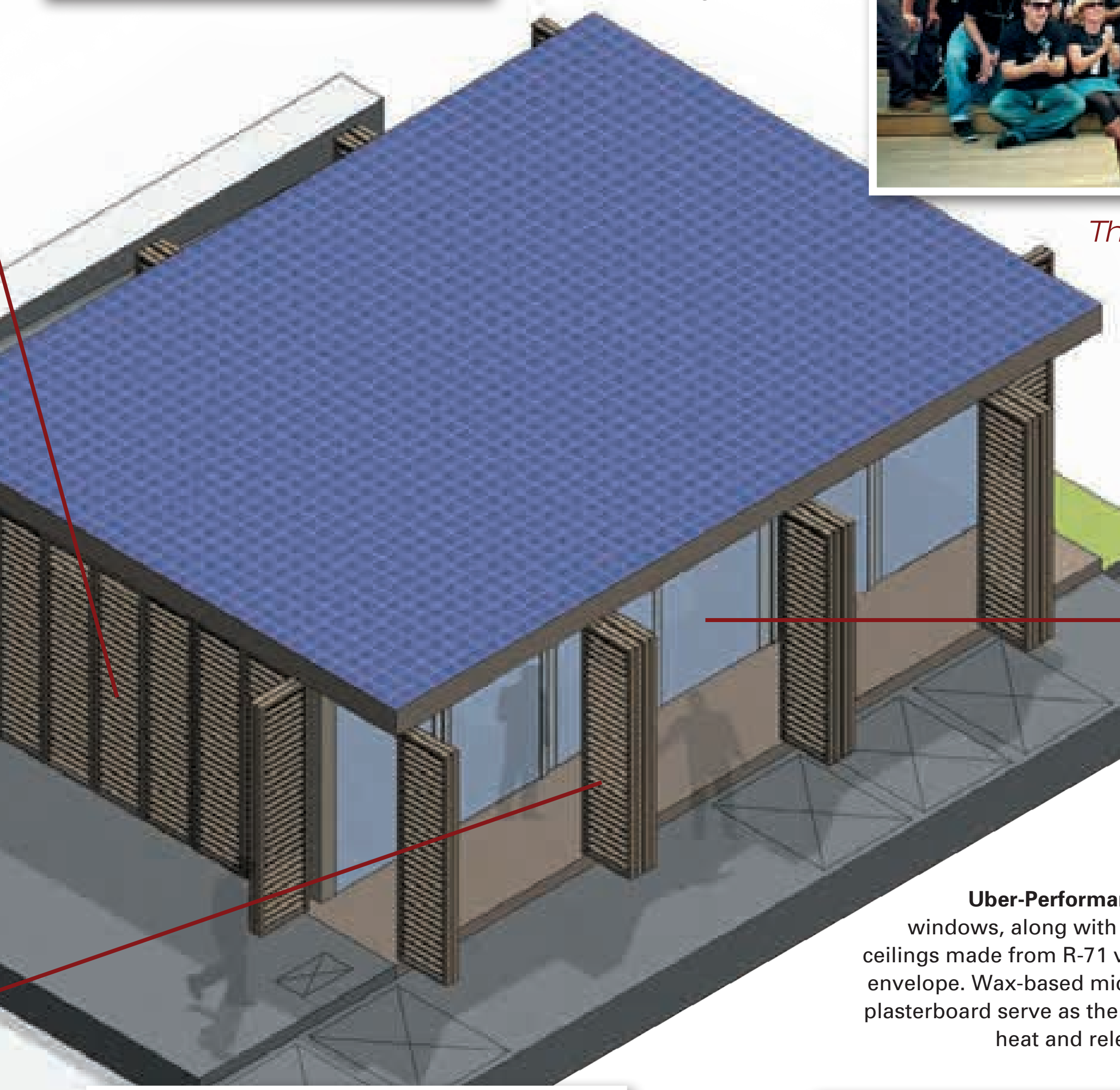


Courtesy Christian Stumpf, TUD

Get Glowing: Inside, the walls of the bathroom form the central core of the floor plan. The walls' white plastic architectural glazing allows daylight to filter through to the bathroom. By night, a mix of interior lighting, including LED lights recessed behind translucent wall shelves, creates a silvered glow.

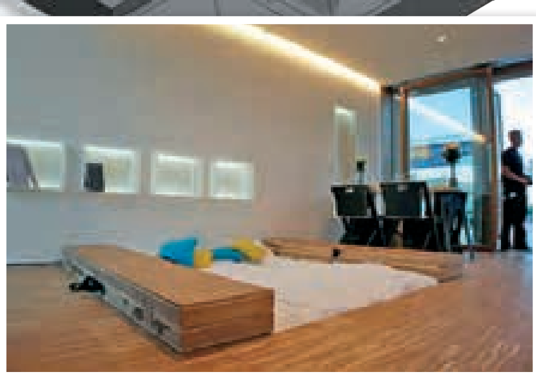
Courtesy www.architektur.tu-darmstadt.de/ee/

The T.U. Darmstadt Team
(some members not pictured)



Courtesy www.architektur.tu-darmstadt.de/ee/

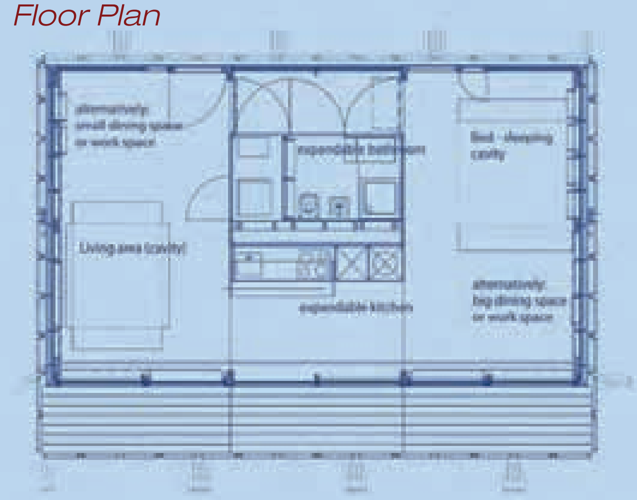
Uber-Performance: Triple-pane sliding doors and windows, along with highly insulated walls, floors, and ceilings made from R-71 vacuum panels, seal the building's envelope. Wax-based microcapsules embedded in gypsum plasterboard serve as thermal mass, passively storing solar heat and releasing it when temperatures drop.



Courtesy Christian Stumpf, TUD

Clever Hideaways: With a built-in bed and couch recessed beneath the floor, the design takes "multifunctional" to a new level. For maximum flexibility within the 542-square-foot space, chairs and two tables fold flat and stow away into a storage drawer in the sublevel couch.

Floor Plan



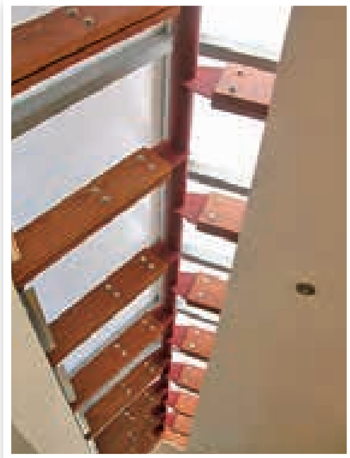
University of Maryland

With its passive solar design and other solar technologies, use of local and natural materials, and heavy reliance on daylighting and water-conservation strategies, University of Maryland's goal was to reconnect human-made shelter with the natural world.

Nature's inherent adaptability is the model for the LEAFHouse's dynamic interior structure. Walls double as built-in cabinets and pullout storage closets, and a queen-size bed folds down to create an instant bedroom. The great room, consisting of a kitchen, sitting area, built-in desk nook, and dining area, opens to the outside deck via a south-facing wall of floor-to-ceiling glass doors, located behind exterior shutters that are specially louvered for optimal shading in the summer and heat gain in the winter.

Well-appointed with innovative technologies, LEAFHouse makes a solid case for integrating smart engineering and strong architectural solutions. A network of sensors inside the house connects to a Web-based control system to monitor and optimize energy use, humidity, lighting, and water consumption. Radiant-floor heating and a high-efficiency ductless system can heat or cool the air using ozone-friendly refrigerant as the heat-transfer fluid. An energy recovery ventilator exchanges stale, interior air with fresh, outdoor air without significant heat loss or gain from the outside. What appears to be an atmospheric waterfall built into the west wall is actually a liquid desiccant system that uses calcium chloride to absorb moisture from the air.

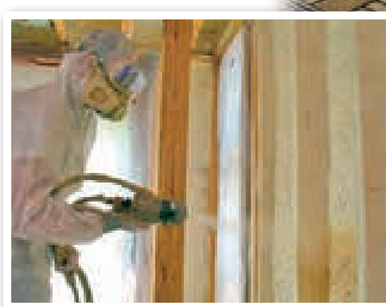
Other nature-based details, like a maple countertop fashioned from a local fallen tree and an exterior wall of plants for filtering rainwater to a greywater garden, wowed the crowd, helping the house win the People's Choice award.



Courtesy Amy Gardner / UMD

Light Tricks: At the ridge, in a gap between rows of PV modules, a 40-foot-long skylight made from translucent, highly insulating Nanogel-filled panes provides daylighting throughout the interior.

Eco-Friendlier Materials. A mix of FSC-certified eastern white pine and corrugated metal finishes the structure. Soy-based spray-on foam (R-5.5 per inch) insulates the walls, floors, and roof, lending to the home's high thermal performance.



Courtesy www.solarteam.org

The Second-Place Winner

www.jimtetro.com

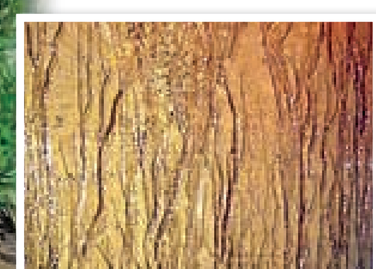
Courtesy Amy Gardner / UMD

Courtesy www.solarteam.org

Solar Solutions: The south-facing roof accommodates 50 evacuated-tube collectors for the radiant heating and solar hot water systems. Thirty-four Sanyo HIT modules (6.97 KW) feed three OutBack MX60 charge controllers. Four OutBack 48-volt inverters provide AC for the house.

Courtesy Kaye Evans-Lutterodt / Solar Decathlon

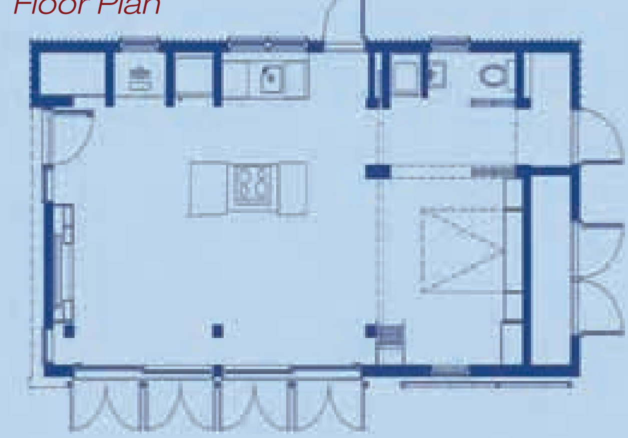
The University of Maryland Team
(some members not pictured)



Courtesy www.solarteam.org

High-Tech Moisture Management: An indoor waterfall charged with liquid desiccant (calcium chloride) removes latent humidity from the home's interior, reducing the air-conditioning load. It also serves as a cool visual design element.

Floor Plan



Changing Spaces: Moveable translucent fiberglass wall panels, complete with a honeycomb core consisting of expanded aluminum and glass cloth, slide open along a track to add space to the great room for entertaining. Similar panels open to the bedroom or close to isolate the bathroom for privacy.

Santa Clara University

Santa Clara University's (SCU) third-place victory was made even sweeter by the fact that this team almost didn't make it to this year's event. As the twenty-first school picked by the selection committee, the team only entered the competition after another team dropped out. But all their hard work almost went for naught when the truck transporting their house broke down in Nebraska. When the truck finally arrived—three days late—the crew worked through the night and still managed to finish construction on time. Despite the transport problems, and having the smallest school of engineering and no school of architecture, SCU earned its place among the top contenders.

The house really shines for its renewable energy systems. SCU scored a perfect 100 points in both the hot water and energy balance contests. For heating, cooling, and hot water, two flat-plate solar thermal collectors mounted on the home's south-facing roof are combined with a prototype absorption chiller. The chiller transfers thermal energy from the solar collectors to a heat sink through an absorbent fluid and a refrigerant, cooling by absorbing and then releasing water vapor into and out of a lithium bromide solution.

The home was designed for off-grid use but features modular PV systems to allow for easy downsizing and grid-connection. The photovoltaic array, for example, can be reduced from 34 modules to 25, and still maintain sufficient energy output for grid-tied use, shaving nearly $8,000 from the system's cost. The electricity generated by the PV system was only needed to power the appliances, lighting, and car. This key difference helped the team score well in the energy balance portion of the event and enter the final days with excess energy stored in their batteries.

Courtesy www.scusolar.org

Structural Sustainability: Innovative bamboo I-joists, developed by Dr. Mark Aschheim and the SCU team, are the first of their kind in the United States. Fabricated out of compressed bamboo, they can support up to 10,390 pounds.

Courtesy Charles Barry / SCU

Thermal Ingenuity: A solar hot water system paired with a prototype high-efficiency absorption chiller uses hot water—instead of electricity—to provide all the heating, cooling, and hot water for the home.

The Third-Place Winner

www.jimtetro.com

Courtesy www.scusolar.org

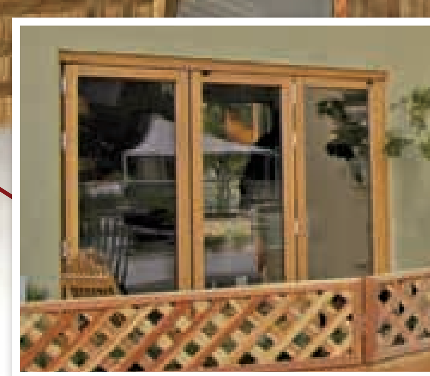
Envelope Efficiency: A highly insulated envelope and passive solar principles maximize the home's energy-saving potential. Layers of recycled denim and cotton fiber batts provide R-24 insulation in the walls, while blown-in cellulose achieves R-37 in the ceiling.

Courtesy www.scusolar.org

PV Performance: Thirty-four SunPower 215 W photovoltaic modules on the roof feed two SMA batteryless inverters in this AC-coupled system. A pair of SMA battery-based inverters charges a 48-volt, 3,346-amp-hour battery bank, sized to provide about five days of backup.

Courtesy www.scusolar.org

The Santa Clara University Team
(some members not pictured)



Courtesy Charles Barry / SCU

Elemental Shelter: Keeping with the team's goal of blurring the boundary between the indoors and outdoors, a south-facing wall of triple-pane, folding glass doors opens the living room to a trellised front porch. This shaded porch shields the interior from heat gain while providing a comfortable outdoor dining area.

Floor Plan

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MNBE-A

2 8D
4 Group 31 end to end
6 Group 32 side by side
Ships knocked down

MNBE-B

8 Golf cart
8 Group 31
Ships knocked down
$575 list

MNBE-C

12 Golf Cart
12 Group 31
12 GVX3050T
Concorde
Ships motor freight

Deciphering Schematics

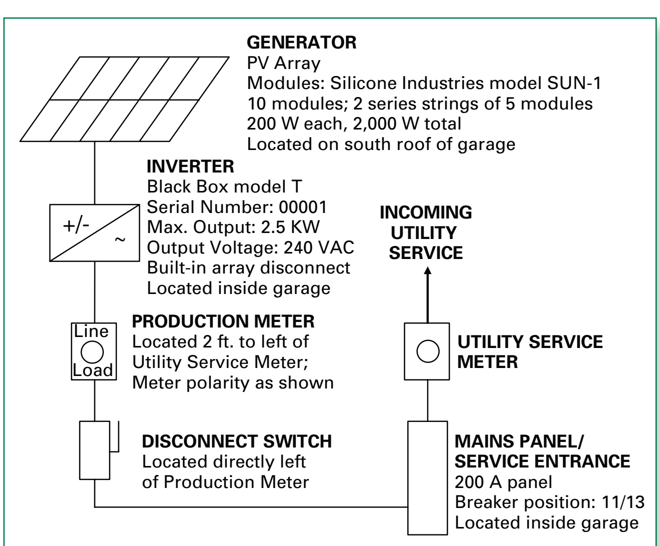
How to Read a *Home Power* Wiring Diagram

by Benjamin Root

Electrical schematics ("skizzes" for short) have been a key element in *Home Power* since its launch more than 20 years ago. These detailed drawings help newcomers understand system concepts, instruct do-it-yourselfers on proper procedures, and document the creative solutions of individual renewable energy (RE) system installers and owners.

Schematics are useful in system planning and design, keeping things straight during installation, proving a system's viability and safety to electrical and utility inspectors, and, later, maintaining or troubleshooting your RE system. (However, if you're just needing to get your system rubber-stamped, most

Typical Single-Line Schematic

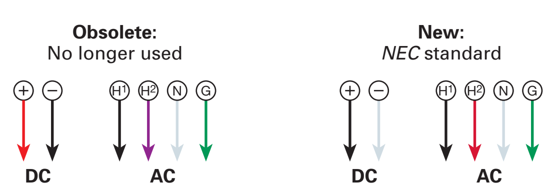


Changes in Color Coding

In the early days of homemade RE, almost everything was powered by direct current (DC) electricity. PV modules make DC, batteries store DC—even alternators rectify to DC. Back then, inverters to convert DC to standard household alternating current (AC) were expensive, inefficient, and unreliable. The solution was to use DC loads like car taillight bulbs for lighting and truck-stop appliances with cigarette lighter plugs. For years, DC wiring in home RE systems reflected the wire-color standards used in automotive systems: Red was hot (positive) and black was chassis (negative). DC conductors in *Home Power's* schematics followed this standard.

However, as RE technologies hit the mainstream and inverter technology came of age, more and more RE homes ran all their electrical loads on standard alternating current. In the world of AC wiring, *black* wires are hot with respect to ground, and white wires are neutral (tied to ground). As a result, RE systems with both DC and AC wiring could have black wires specifying two different things (negative *or* hot).

After years of designating the DC and AC circuits of RE schematics with mixed color-coding standards, we're dropping the automotive red-and-black color-coding and using the *National Electrical Code (NEC)* standard colors of black for DC positive and white (light gray on our white pages) for DC negative. This may make visually separating AC and DC circuits tricky at first, but in the long run, it will better represent the standards in the industry, the *NEC*, and the wire color you should use in your own system.



permitting agencies only require simple line diagrams that show general connections between components—see the example single-line drawing on the previous page.)

Home Power's Approach

Our "full-wire" schematics are designed to educate and demonstrate, so they typically show *all* the electrical conductors and every element in an RE system. While this can seem a bit overwhelming at first, as your knowledge of RE components grows, the details in these schematics will help you understand the relationships between various pieces of equipment and RE systems as a whole.

Home Power schematics combine a classic electronics-style schematic with pictorial representations to help with component recognition. And to help you better visualize the whole system, the parts in the diagram resemble their real-life counterparts.

Where to Start

If you are new to *Home Power*, use the key to familiarize yourself with the typical elements that appear in our schematics. When reading a skiz, first scan the diagram to familiarize yourself with the major components. Next, starting at the energy producers (PV modules, wind or hydro turbines, etc.), follow the wiring through the system: through charge controllers to the batteries (in the case of battery-based systems), then to the inverter, then to the load distribution panel, and finally to household loads and perhaps the grid.

What a Schematic Diagram Won't Tell You

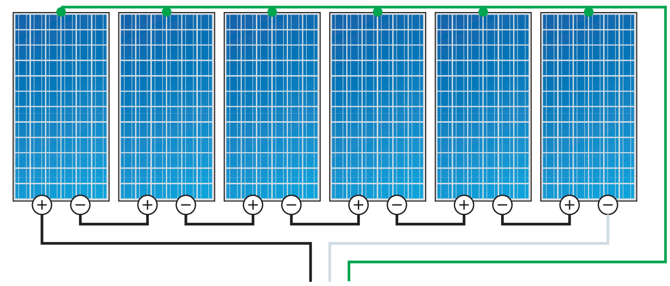
Is there enough information in a *Home Power* schematic to design and install your own RE system? No! Our diagrams focus on system components and the wiring paths that tie them together. Our wiring diagrams *do not* cover these important system design variables:

- System sizing and component choices
- Component placement and physical relationships
- Terminal positions on components
- Electrical boxes and other hardware specs
- Wire types, sizes, and lengths
- Electrical connector types (nuts, split bolts, terminal blocks)
- Conduit types, specs, and use

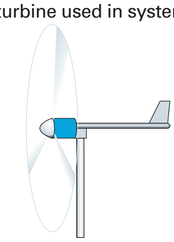
You'll need to get familiar with many other elements before embarking on a system installation. Learn the details of electrical wiring and local electrical codes. Hire a professional if necessary—you might be surprised at what you didn't know you didn't know.

Major System Components

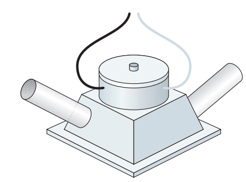
Photovoltaic Array: Drawn to resemble modules used in system (shown wired in series, with frame grounds)



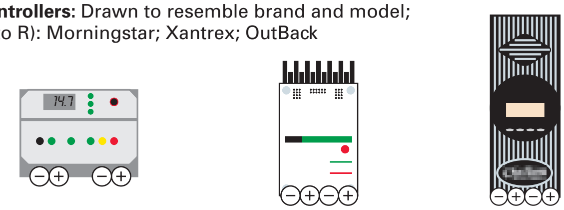
Wind Generator: Drawn to resemble turbine used in system



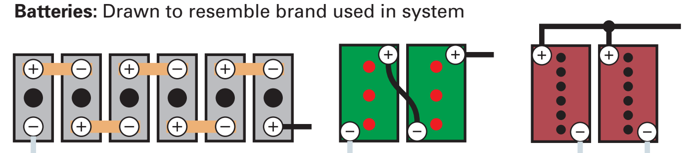
Hydro-Electric Turbine: Drawn to resemble turbine used in system



Charge Controllers: Drawn to resemble brand and model; Shown (L to R): Morningstar; Xantrex; OutBack



Batteries: Drawn to resemble brand used in system

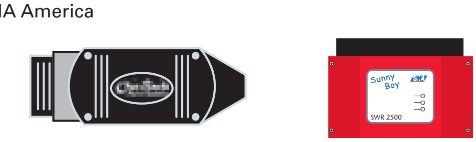


2-volt cells (wired in series)

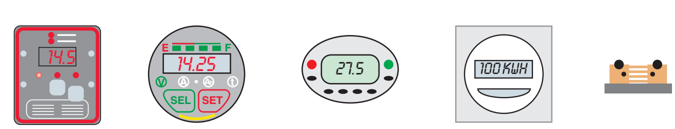
6-volt batteries (wired in series)

12-volt batteries (wired in parallel)

Inverter: Drawn to resemble brand and model; Shown (L to R): OutBack; SMA America



Metering: Drawn to resemble brand and model; Shown (L to R): Bogart Engineering; Xantrex; OutBack; utility KWH; shunt



Backup Engine Generators: Drawn to resemble brand and model; Shown (L to R): Kohler; Winco

Basic Wires, Connections & Parts

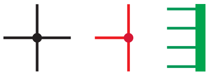
Standard Wires: Current-carrying or equipment ground, common amperage, AC or DC

Large Cables: Current-carrying, high amperage, usually DC from batteries to inverter or battery interconnects

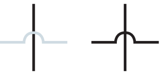
Small Wires: Current-carrying or signal only; meters, sensors, and control equipment

Terminal Blocks: Wire connections to equipment; DC positive, DC negative, AC hot 1, AC hot 2, neutral, ground

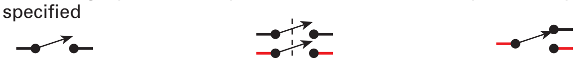
Connected Wires: Electrically & mechanically joined; ground bus bar (green)



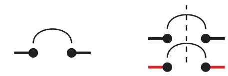
Wires, Not Connected: Wires pass each other without electrical connection



Switches: Single pole, double pole, transfer; mechanical style and amp rating not specified



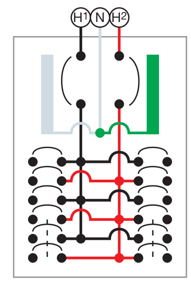
Breakers: Single, ganged; amp rating noted



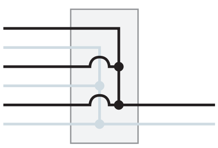
Fuse: Amp rating noted

Ground Rod

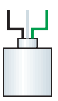
AC Mains Panel / Service Entrance: Neutral & ground bus bars, 120 V breakers, and 240 V ganged breakers



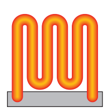
Combiner Boxes & Other Enclosures: Size and specs not shown



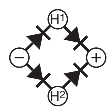
Miscellaneous Components



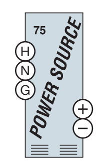
Lightning Arrestor



Diversion Load: Air or water heating element



Diode Bridge Rectifier: AC to DC



Battery Charger: AC to DC

Transformer: AC to AC

As you trace these paths of electricity, notice the minor components as you pass by: parallel connections in combiner boxes, overcurrent protection (fuses or breakers), disconnects and transfer switches, and shunts for metering. Following the path of electricity will help you understand how the system functions.

Access

Benjamin Root has been a graphic designer with *Home Power* for more than 12 years, and has been the art director since Publisher Richard Perez started giving out titles. Ben faces a constant battle in making his 1930s Ashland, Oregon, bungalow energy efficient, and wishes he could wield a hammer as skillfully as he runs a mouse.

2008 Energy Fairs

Spring and summer bring us renewal after a long winter—and what better time to renew your interest in energy? Renewable energy fairs offer the perfect opportunity to get the scoop on the latest gear, take advantage of educational workshops, and tap into local RE expertise in a casual, festive atmosphere. Most events are family-friendly, with activities to kindle young ones' interest in all things solar. Admission prices are friendly as well—for the cost of a night at the movies, you can get your solar start, have a great time with other like-minded folks, and maybe even walk away with sweet deals on renewable energy equipment.

April

▶ Northwest Solar Expo
Portland, Oregon; April 17–20
www.nwsolarexpo.com

▶ North Country Sustainable Energy Fair
Canton, New York; April 25–27
www.ncenergy.org

▶ Saratoga Environmental Expo
Saratoga Springs, New York; April 26–27
www.saratogaexpo.com/event/events.cfm

Courtesy www.the-mrea.org

June

▶ Rhode Island Sustainable Living Festival & Clean Energy Expo
Coventry, Rhode Island; June 7
www.livingfest.org

▶ RE & Sustainable Living Fair (aka MREF)
Custer, Wisconsin; June 20–22
www.the-mrea.org/energy_fair.php

▶ Michigan Energy Fair
Onekama, Michigan; June 27–29
www.glrea.org

July

▶ SolarFest
Tinmouth, Vermont; July 11–13
www.solarfest.org

▶ Shoreline Sustainable Living & RE Fair
Shoreline, Washington; July 18–19
www.shorelinesolar.org

▶ SolWest
John Day, Oregon; July 25–27
www.solwest.org

Courtesy www.solwest.org

August

▶ Illinois RE & Sustainable Lifestyle Fair
Oregon, Illinois; August 9–10
www.illinoisrenew.org

▶ SolFest
Hopland, California; August 16–17
www.solfest.org

▶ Southern Energy & Environment Expo
Fletcher, North Carolina; August 22–24
www.seeexpo.com

Courtesy Judy Pearson-Wright for www.theroundup.org

September

▶ Iowa Renewable Energy Expo
Solon, Iowa; September 13–14
www.irenew.org/expo.html

▶ Rocky Mt. Sustainable Living Fair
Fort Collins, Colorado; September 20–21
www.sustainablelivingfair.org

Courtesy www.jeffcampbell.org for www.theroundup.org

▶ Solar Fiesta
Albuquerque, New Mexico;
September 20–21
www.nmsea.org

▶ Pennsylvania RE & Sustainable Living Festival
Kempton, Pennsylvania;
September 20–21
www.paenergyfest.com

▶ RE Roundup & Green Living Fair
Fredericksburg, Texas;
September 26–28
www.theroundup.org

For the Pros & the Public

RE industry professionals and those who want to launch their RE careers should mark their calendars for two particular industry events: Solar 2008, the official conference of the American Solar Energy Society; and Solar Power 2008, presented by the Solar Energy Industries Association and the Solar Electric Power Association. There will be a variety of training opportunities, workshops, and an array of exhibits.

▶ Solar 2008
San Diego, California
May 3–8
www.solar2008.org

▶ Solar Power 2008
San Diego, California
October 13–16
www.solarpowerconference.com

HOME HEATING BASICS

An Overview of Options

Adapted from the *Consumer Guide to Home Energy Savings*

Dmitry Kutlayev

Space heating is the largest energy expense in most homes, accounting for 35% to 50% of annual energy bills. Upgrading your heating system could reduce your bills significantly. But how do you know what system is right for your home? Here's an introductory look at the options available today.

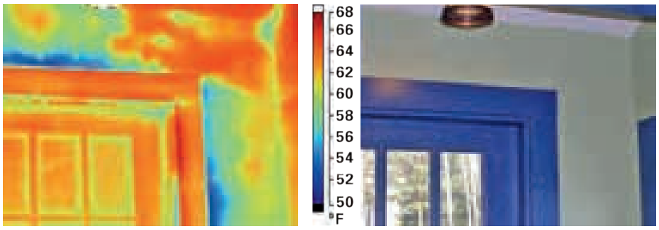
Courtesy www.energyconservatory.com

A blower door test, part of a typical energy audit, can help identify air leaks in your home that reduce the effectiveness of your heating system.

Selecting a System

If you can't seem to stay comfortable or keep your heating bills down, first hire a qualified home performance or heating contractor to help evaluate your home's existing system and determine the best actions to take. It may be that a component of your heating system was improperly installed or needs a tune-up. In many cases, they may find that your heating system isn't the problem, but rather that your home's insulation, windows, weatherproofing, or ducts need help.

Sizing the system. How much heat you need depends on the size of your house and how well it keeps heat in. Never figure out how big a system you need by basing it on the size of the old system. A heat-loss analysis is the only way to properly size a new heating system. (A possible exception exists when replacing steam or hydronic systems: The boiler needs to be sized to the existing radiators you have or plan to add.) A heat-loss analysis should include measurements of wall, ceiling, floor, and window areas and account for insulation levels and weatherization features, including any energy improvements that have been made. Online calculators and free software are available to make this task easier (see Access).



Courtesy www.billcalfee.com

Thermal imaging can help locate areas of heat leakage to address with weather stripping or insulation.

A new heating system should be sized no more than 25% over the peak heating demand. For example, if your home's peak heating demand is calculated to be 60,000 Btu per hour, you should select a heating system with a heating output between 60,000 and 75,000 Btu per hour.

Efficiency recommendations. The efficiency levels you want to look for vary according to the type of system and fuel, as indicated in the "Selecting a Heating System" table on page 54. If you live in a cold climate and your house is well sealed and insulated, it usually makes financial sense to invest in the highest efficiency system available. Your heating contractor will help you determine the financial payback periods of the highest efficiency unit compared to lower efficiency ones.

If your home is still in the design phase, passive solar heating will offer the greatest up-front efficiency and long-term savings. Make sure to orient your home to utilize the energy the sun has to offer and specify appropriate amounts of thermal mass and south-facing glazing, and optimal insulation levels. This design strategy will generally allow you to install a smaller-than-typical backup heating system at a reduced cost and increased lifetime savings.

Common Systems

Forced-air furnace. The majority of North American households depend on a central furnace to provide heat. A furnace works by blowing heated air through ducts that deliver the warm air to rooms throughout the house via air registers. This type of heating system is called a ducted warm-air or forced-air distribution system. The air can be heated by natural gas, propane, fuel oil, electricity, or even biodiesel.

Furnaces and boilers (described below) are rated on their "annual fuel utilization efficiency" (AFUE), which includes start-up, cool-down, and other losses that occur in real operating conditions. The higher the AFUE, the more efficient the furnace or boiler. The AFUE rating for an all-electric furnace or boiler is between 95% and 100%. Units installed outdoors have a lower AFUE because they have greater jacket heat loss. A typical gas- or oil-fired furnace has a hard time keeping valuable heat from escaping up the flue, but "condensing" furnaces are designed to reclaim much of this escaping heat from exhaust gases. High-efficiency oil- and gas-fired systems (85% or greater AFUE) are typically condensing models.

Although it's frequently overlooked, the electricity drawn by a furnace to power its motors and blow air through the house can be considerable—more than 1,200 kilowatt-hours (KWH) per year for some models, adding up to $100 or more to annual electricity costs. This power consumption is not factored into the AFUE ratings, so motor power and efficiency should also be considered when choosing a new furnace.

Boilers are special-purpose water heaters. While furnaces carry heat in warm air, boiler systems distribute the heat in hot water or steam, which gives up heat as it passes through radiators or radiant floor heaters in rooms throughout the house. The cooled water then returns to the boiler to be reheated. In a hot-water system, also called a "hydronic" system, the water is typically heated to about 180°F (or less in a high efficiency system). In steam boilers, which are much less common in modern homes, the water is boiled and steam carries heat through the house, condensing to water in the radiators as it cools. Instead of a fan and duct system, a hot-water boiler uses a pump to circulate hot water through pipes to radiators.

COMMON SYSTEM TYPES

Courtesy www.rheem.com

A forced-air furnace uses natural gas, propane, oil, or electricity to heat air and an electric blower to circulate it throughout your home.

Courtesy www.htproducts.com

A boiler works like a forced-air furnace, but heats and circulates water, instead of air, to radiators or hydronic floor loops.

A heat pump removes heat from the outside air or the ground using phase-change materials. They can work in reverse to provide cooling in hot weather.

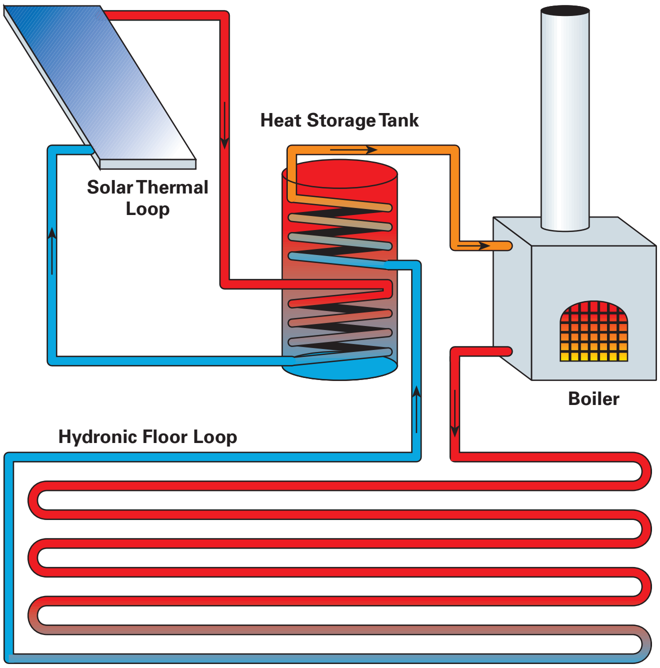

Courtesy www.sunplans.com

Designing new homes or additions using passive solar design strategies can reduce heating costs and increase comfort.

Oil or natural gas is commonly used to heat water in boilers; as with gas- and oil-fired furnaces, boilers can be designed to condense water vapor in the exhaust pipe to reclaim some escaping heat.

Radiant floor heating generally refers to systems that warm the floor, either with electric elements or, more commonly, by circulating warm water in tubing in or under the floor. This warms the room gently, without the noise of blowers and air rushing through ducts. These systems are fairly easy to configure in separate zones, with controls for heating individual rooms. Hydronic (liquid-based) systems are the most popular and cost-effective radiant heating systems for cold climates. For added efficiency, the circulating water can be heated by solar hot water collectors, with the boiler providing a temperature boost, if needed.

HYDRONIC HEATING WITH SOLAR & BOILER



Note: Pumps and other components not shown.

Electric radiant floors typically consist of electric cables built into the floor. Mats of electrically conductive plastic are also available, and are attached to the subfloor, below a floor covering (usually ceramic tile). Because of the relatively high cost of electricity, electric radiant floors are usually only cost effective in small areas like bathrooms, or if they include thermal mass, such as a thick concrete floor, and your electric utility offers time-of-use rates, which allow you to "charge" the concrete floor with heat during less expensive, off-peak hours. If the floor's thermal mass is large enough, and your home is well insulated, the heat stored in the thermal slab will keep the house comfortable for several hours without any further electrical input.

Heat pumps are just two-way air conditioners. During summer, an air conditioner works by moving heat from

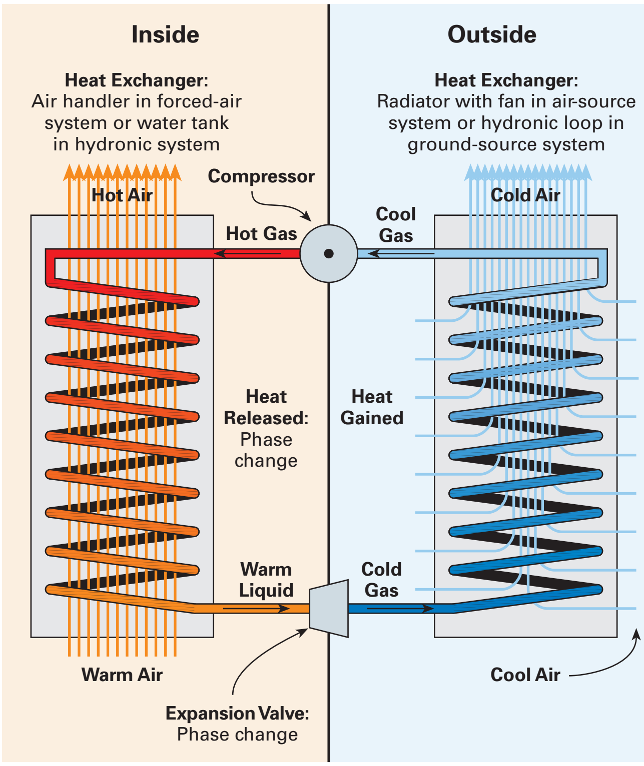

Courtesy www.gimmeshelteronline.com

These hydronic heating loops are awaiting the pour that will embed them in concrete slabs. They can also be installed between floor joists or in specially designed subflooring panels.


Courtesy www.warmlyyours.com

Electric radiant mats can be installed between the subfloor and many types of floor surfaces.

AIR-SOURCE & GROUND- SOURCE HEAT PUMPS



Note: System is reversible to cool house in summer.

the relatively cool indoors to the relatively warm outside. In winter, a heat pump reverses this trick, scavenging heat from the outdoors and discharging that heat inside the house. Almost all heat pumps use forced warm-air delivery systems to move heated air throughout the house.

Air-source heat pumps use the outside air as the heat source in winter and heat sink in summer and are installed much like a central air conditioner. Heat pumps are far more energy efficient than electric furnaces, and they can be used for both heating and air conditioning. But before deciding to replace your present system with a heat pump, you should carefully look into whether it makes sense in your climate. Because air-source heat pumps rely on the outside air as the heat source in the wintertime, the colder that air, the worse the energy performance. Air-source heat pumps make more sense in warmer climates, where summer cooling loads are considerable. Cold-climate air-source heat pumps, which are specially designed for optimal winter use, are currently offered by some manufacturers, and are in field trials by several utilities.

Because underground temperatures are nearly constant year-round—warmer than the outside air during the winter and cooler than the outside air during the summer—a ground-source heat pump (also called geothermal, GeoExchange, or GX) can be much more efficient than an air-source unit and appropriate for both warm and cold climates. These heat pumps require that a pipe loop (typically, polyethylene) be buried in the ground, usually in long, shallow (3- to 6-foot-deep) trenches or in one or more vertical boreholes, from 100 to 400 feet deep. Alternatively, some systems draw in groundwater and pass it through the heat exchanger instead of using a refrigerant. The groundwater is then returned to the aquifer.

According to the U.S. Department of Energy's Energy Efficiency and Renewable Energy Information Center (EERE), even though the installation price of a geothermal system can be several times that of an air-source system of the same heating and cooling capacity, the additional costs are made up in energy savings in five to ten years. Inside components should last at least 25 years and the ground loop, more than 50 years.

Wood and pellet-burning heaters. Wood heating can make economic sense in rural areas if you enjoy stacking wood and stoking the stove or furnace. But for fuel efficiency and cost effectiveness, it is important to properly size the heater to the space, otherwise your heating plans will just go up in smoke—literally. All wood heaters sold today should bear a U.S. Environmental Protection Agency certification sticker, which specifies that they meet emissions standards. Higher-efficiency heaters (typically 63% to 78% efficiency) produce fewer emissions and are often safer, since complete combustion helps to prevent a buildup of flammable chimney deposits.

Pellet stoves, which use small pellets made of sawdust and wood chips for fuel, have lower point-of-use emissions than wood heaters and offer users greater convenience, temperature control, and indoor air quality, along with combustion efficiencies between 78% and 85%. One drawback is that they require electricity to run fans, controls, and pellet feeders. Under normal usage, they consume about 100 KWH of electricity per month.

MASONRY FIREPLACE

Courtesy www.tempcast.com

Quick, hot fires coupled with thermal mass to absorb this heat lend to the efficiency of a masonry heater.

SELECTING A HEATING SYSTEM

Fuel	Current System	Replacement Options	Recommendations
Gas	**Forced air**	Condensing furnace	AFUE ≥ 90 (Energy Star)
			High-efficiency furnace fan
			Sealed-combustion preferable
			May require new flue lining for water heater or new power vent water heater
		Non-condensing furnace	Mild climates (deep South, Pacific NW) only. High-efficiency furnace fan
		Switch to hydronic system	Expense may preclude unless part of large-scale renovation
			Better option where mild summers make central air conditioning unnecessary
	Hydronic	Non-condensing boiler	Mild climates (deep South, Pacific NW) only
		Condensing boiler	AFUE ≥ 85 (Energy Star)
			Sealed-combustion preferable
			Insist on outdoor reset or equivalent controls
			Consider indirect water heater tank
		Switch to forced air	Consider this option if you have a single-pipe steam system and central air conditioning
	Combination space/ water heater		Explore this if you also are looking to replace your water heater
Oil	**Forced air**	Furnace	AFUE ≥ 83 (Energy Star)
	Hydronic	Boiler	AFUE ≥ 85 (Energy Star)
			Sealed-combustion preferable
			Insist on outdoor reset or equivalent controls
			Consider indirect water heater tank
	Switch to gas	(See "Gas" options)	Switching to natural gas may save you money and allow for a more efficient system
Electricity	**Resistance system: furnace or baseboard**	Switch to heat pump	Cheaper option especially if you have forced air and are replacing a central air conditioner
		Switch to gas	Consider if you have a gas line and a central air conditioner in good condition
		Supplemental direct heat	Not recommended as replacement option
			Only use in rooms that are remote from the central system
	Heat pump	High-efficiency air-source heat pump	Energy Star-rated or better; quality installation is important
		Ground-source heat pump	Energy Star-rated or better; quality installation is important
			Specify integrated water heating

Adapted from the *Consumer Guide to Home Energy Savings*, 9th edition

Although gas (and most wood) fireplaces provide a warm glow, they are not an efficient heat source. Fireplace-heated homes generally lose more heat than they provide, because heated air is drawn through the unit and must be replaced by cold outside air. However, if the fireplace has a tight-sealing glass door, its own source of outside air for combustion, and a good chimney damper, it can provide some useful heat.

According to the EERE, masonry heaters produce more heat and less pollution than any other wood- or pellet-burning heater, reaching combustion efficiencies of 90%. Masonry heaters include a firebox, a large masonry mass (such as bricks), and long twisting flue channels that run through the mass. A small, hot fire built once or twice a day releases heated gases into the flue tunnels that, in turn, heat the masonry. This heat slowly radiates outward into the home.

Renewable Fuel?

Burning natural gas, oil, propane, cordwood, or pellets in your home with a high-efficiency furnace or boiler can be a very efficient way to deliver heat to your home. Of these, natural gas has the fewest direct emissions. Some fuel-oil furnaces or boilers can also burn biodiesel—a more sustainable and low-pollution solution. Be sure to check with your system's manufacturer first.

Electric resistance converts electricity directly into heat, which means on-site efficiency for electric heaters is very high and there is no point-of-use pollution emitted. But when the inefficiency of electricity generation by the power company and transmission losses are taken into account, it is actually pretty inefficient to heat with electric resistance. Roughly one-third of the heating value of the fuel burned in a power plant is delivered

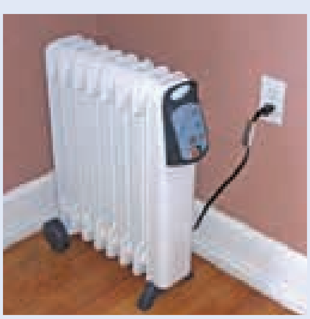
HEATING SMALL SPACES

Small space heaters are typically used when the main heating system is inadequate or when central heating is too costly to install or operate.

Solar air collectors can be installed on a roof or an exterior (south-facing) wall for heating one or more rooms. Factory-built collectors for on-site installation are available, and do-it-yourselfers may choose to build and install their own collector.

Gas-fired space heaters include wall-mounted, freestanding, and floor furnaces, and are most useful for warming a single room or contiguous areas. Better models use "sealed combustion air" systems, with pipes installed through the wall to both provide combustion air and carry off the combustion products. A warning: Ventless gas heaters can expose occupants to combustion by-productss and oxygen depletion, as can stand-alone kerosene, propane, and oil heaters. Because of these hazards, at least five states prohibit vent-free heaters in homes, and many individual cities have banned them as well.

Electric space heaters. Portable (plug-in) electric heaters and electric baseboard units convert electricity directly into heat. Generally, these systems have low or no installation costs. With baseboard heaters, individual room thermostats can be installed so you can turn down the heat in rooms that aren't being used. Operating costs, as for all resistive heaters, are generally very high.



Shawn Schreiner

Solar thermal collectors can efficiently heat your home, and large PV systems can offset some or all of the energy used for electric heating.

as useful heat in your house—the remaining two-thirds are lost to generation and transmission inefficiencies. On the other hand, electricity is used to run heat pumps, which have the benefit of producing more energy than the electricity they consume and can balance out the efficiency losses at the power plant.

In many cases, surplus electricity from an off-grid solar-, wind-, or hydro-electric system can be routed to a heating load, such as an air or water heating element. This can be one effective application of heating with renewably produced electricity. If your home has a large enough grid-tied RE-electric system, the electricity produced may be enough to offset a significant portion of the energy consumed by an electric heating system. If avoiding utility-powered electric heating is not an option, consider purchasing enough "green tags" or green energy credits from your utility to offset your electrical heating energy use.

Of course, the cleanest fuel for heating (and possibly cooling) your home is solar energy, which produces no on-site emissions at all. New homes in cold or moderate climates should be designed to take advantage of passive solar heating. Active solar heating systems can be used in new or existing homes and are compatible with many conventional heating systems. Homeowners can use either solar air heating collectors for preheating of ventilation air or solar water heating collectors to supplement water heating systems. Solar energy can also be used to boost the performance of heat pumps, and an absorption heat pump will allow you to power an air conditioning system with solar energy.

Access

Adapted from the *Consumer Guide to Home Energy Savings, 9th ed.*, by Jennifer Thorne Amann & Alex Wilson, with permission from New Society Publishers (www.newsociety.com), and from EERE's *Consumer Guide to Energy Efficiency & Renewable Energy* • www.eere.energy.gov

Online home heat loss calculator • www.builditsolar.com/References/Calculators/HeatLoss/HeatLoss.htm

Info on efficient furnaces, boilers, and heat pumps • www.energystar.gov

List of clean-burning wood heaters & fireplaces • www.epa.gov/woodstoves

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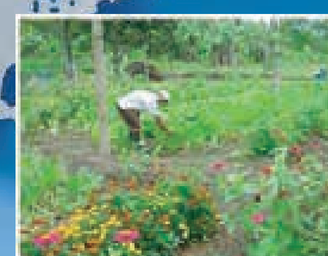

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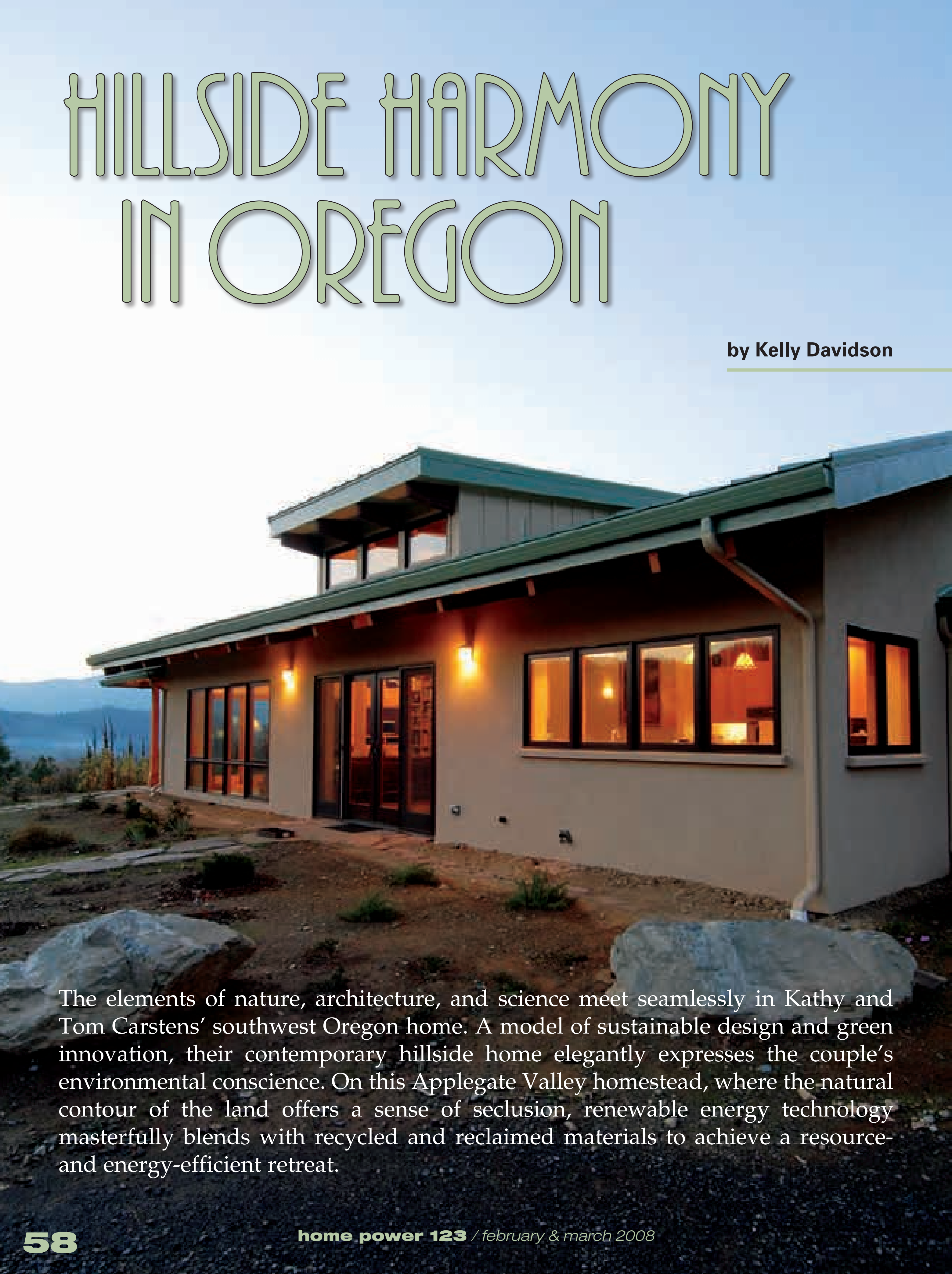


Hillside Harmony in Oregon

by Kelly Davidson

The elements of nature, architecture, and science meet seamlessly in Kathy and Tom Carstens' southwest Oregon home. A model of sustainable design and green innovation, their contemporary hillside home elegantly expresses the couple's environmental conscience. On this Applegate Valley homestead, where the natural contour of the land offers a sense of seclusion, renewable energy technology masterfully blends with recycled and reclaimed materials to achieve a resource- and energy-efficient retreat.

Once you take time to understand that you can save the Earth's resources, save money, and live comfortably doing so, there's no other way to live or build," says Tom Carstens, a 61-year-old former marine pilot who describes himself as a "conservative," putting special emphasis on its root—*conserve.* "It just makes sense."

Above: The Carstens' home sits on a southwest-facing hillside in southern Oregon, a location where seasonal temperature extremes make a well-designed home a necessity.

Left: The open floor plan ties the kitchen, dining, and living areas together.

Below: Kathy's kitchen is a showcase of resource efficiency, including Energy Star appliances and countertops made from recycled plastic, glass, and paper.

Shawn Schreiner (4)

The decision to build a high-performance home was largely inspired by Tom's interest in renewable energy (RE) technology and environmental studies, which blossomed after taking a green-building course at the Southface Energy Institute in Atlanta, Georgia, where he and his wife Kathy resided before retiring to Oregon.

Right from the start, the Carstens knew what they wanted from their home's design—plenty of natural light and an energy-efficient building that would offer thermal comfort with little reliance on mechanical conditioning systems. In shaping their vision, Tom and Kathy drafted a list of design and construction principles that detailed everything from wheelchair accessibility to materials specifications. To help carry out their wishes, Tom found architect Andre DeBar of Portland, Oregon, the recipient of the National Association of Home Builders 2003 Green Custom Home of the Year award.

"I got lucky," Tom admits. "There are a lot of architects who say that they're green but aren't actually green. I went into this cold and, without too much legwork, found an architect with the expertise I needed."

Large, southwest-facing windows admit low-angled sunlight in the winter. Sufficiently large overhangs prevent rooms from overheating in the summer.

Challenges at the Site

Perched on a knoll above a thick stand of pine and madrone, the already-established building pad came with a wide-open, southerly exposure, ideal for solar energy production. But the treeless hillside offered no protection for the house during summers that often see the mercury soaring between 90°F and 110°F. Plus, the best views from the site are to the west. Orienting the main face of the home toward the mountain vistas would have challenged the home's ability to keep cool in the summer and capture the optimal solar gain in the winter. But Kathy and Tom wanted the best of both worlds—an energy-efficient home and gorgeous sunset views.

Preserving the sweeping views while preventing the home from overheating during the summer months was one of Andre's biggest design challenges. Knowing that the steadily declining angle of the sun would make any west-facing windows difficult to shade, Andre devised a solution that would buffer the home from the direct sunlight: an open porch along the west wall of the house covered with an 11-foot-deep overhang. During hotter months, the overhang adequately shades the porch and windows along the wall—limiting the heat gain from this exposure. As a result, the home experiences only one or two hours of direct sunlight from the west during the late evening in summer.

Large windows placed strategically, and clerestory windows above the dining area in the great room and at the peak of the roof above the main entry allow ample natural light into interior spaces, eliminating the need for artificial lighting during the day. When open during the warmer months, the clerestory windows also provide passive ventilation, offering an escape route for warm, rising air.

Deep overhangs on the home's west side shade windows from the summertime sun while still allowing for fantastic views.

Shawn Schreiner (4)

Finding an Eco-Friendly Architect

Point & click. Use the U.S. Green Building Council's online database to generate a list of local LEED-accredited architects who have "demonstrated a thorough understanding of green building practices and principles." www.usgbc.org

Find useful links to American Solar Energy Society (ASES) regional chapters and their member directory that searches by city, state, and expertise (i.e., architecture). www.ases.org

Search Co-op America's "Green Pages" for eco-friendly architects and designers who have been screened and approved by this national nonprofit organization. www.coopamerica.org

Window-shop. Solar home tours—such as the National Solar Tour organized by ASES—are great ways to browse for architects and ideas, and meet with homeowners who have been through the process.

Subscribe. Keep your eye on the business sections and home and garden features in regional newspapers and magazines. An article might turn you on to a rising star or an established pro who suits your needs.

Talk, listen & learn. A good referral trumps traditional advertising any day. Don't be fooled into thinking that the best architects always have the biggest ads. Many talented architects rely on word-of-mouth endorsements from homeowners.

A Unique Sleep

"Given the choice between a traditional bedroom or a tent," says seasoned camper Tom, "we'd choose to be outside under the stars, in the fresh air."

Taking Tom's cue, Andre modeled the master bedroom after a tent. The gable-formed bay—tent-like in its look and feel—extends to the north from the home's main rectangular base. Because the bedroom was physically isolated from the rest of the house, it was also able to be thermally isolated. The common wall between the bedroom and main house was insulated so that the bedroom's windows could be opened throughout the year without affecting temperatures in other interior spaces. During the day, three walls of windows provide ample daylighting. At night, the large window above the built-in bed provides stargazing access. Exposed beams and built-in furnishings made from salvaged Douglas fir complete the connection between this indoor space and the outdoors.

The bedroom is thermally isolated, allowing the Carstens to sleep with windows open without affecting the temperature in the rest of the house.

Maximizing Performance with Materials

With afternoon temperatures known to reach 110°F in July and August, special attention was paid to insulating the structure to avoid using lots of energy for cooling. Insulated concrete forms (ICFs) used for the exterior walls were cost-effective and achieved good efficiency. The home's Durisol wall-forms feature interlocking blocks made from cement-bonded wood shavings and chips—a fire-resistant, vapor-permeable material.

For additional insulation, an insert of mineral wool fiber was added to each block, for a whole-wall R-value of about R-20. Once in place, the cavity of each wall was filled with poured concrete for a strong wall that functions as thermal mass and insulation. The result of the combination is a more continuous R-value throughout the walls, minimal thermal coupling between the inside and outside, and minimal air infiltration.

Structural insulated panels (SIPs)—panels of polystyrene foam sandwiched between two layers of oriented strand board—were used to construct an R-38 roof. The galvanized steel roofing panels are made from 30% recycled steel and painted with a performance finish, which helps mitigate heat by reflecting up to 70% of the sun's light. Gaps between the roof and Durisol wall forms were sealed with urethane spray foam or plugged with recycled denim fiber filler.

For thermal envelope performance, high-efficiency double-pane casement windows complete the seal. A heat recovery ventilation system in the small attic space helps keep fresh air circulating in the house and controls humidity.

Peak Performance

The Carstens' all-electric home relies on several systems to maximize efficiency: a grid-tied solar-electric system, sized

Efficiency in the Details

Tom and Kathy were committed to minimizing the home's environmental footprint every step of the way. As the self-appointed "waste manager" for the construction site, Tom kept busy cleaning up and sorting material for reuse, recycling, or disposal. He even repurposed some of the scraps into makeshift furnishings for the porch and hired a local craftsman to fashion leftover beams into a bench for the entry.

Kathy oversaw the finer points of the interior, which features exposed, rustic beams that were reclaimed from a 100-year-old church in Portland and other natural, local materials, like a river-rock mantle around the wood heater and madrone flooring. Throughout the home, natural linoleum and eco-friendlier countertops made from recycled plastic, glass, and paper make colorful conversation pieces. Energy Star appliances, low-flow fixtures, and dual-flush toilets and urinals in the bathrooms pair up for good energy and water savings in the home. Kathy also tended to the xeriscape landscaping plan, which utilizes drought-resistant native plants to minimize watering.

Getting into Green Building

Though long-time home builder Gary Dorris was a seasoned professional with 20 years in the industry, the Carstens' home was his first venture in resource- and energy-efficient building.

"Working with the new materials and techniques was by far one of the most difficult things I've ever done in construction, but certainly one of the most rewarding," says Gary, who became certified as an Energy Star builder for the project. He also joined Earth Advantage, a nonprofit organization devoted to green building education and training in the Northwest, and supplied each of his workers with Energy Star handbooks on energy-efficient construction techniques.

Construction challenges came with procuring building materials that weren't available locally, as well as becoming familiar with the wall-form system. Subtle inconsistencies in the shape and size of the block made the wall assembly difficult at times, and raising the heavy blocks required a fair amount of coordination and muscle, Gary says. "Running the electric and making changes was not easy with the Durisol," he adds. "For the wiring, you have to run plastic conduit through the blocks' hollow spaces, which are then filled with concrete. That means you have one chance to get the wiring right."

As a newcomer to green building, Gary researched each step thoroughly and approached every task as an opportunity to hone his skills. "It didn't take me long to realize that the process is not all that different from conventional building," he says. "The difference is that green building raises the quality. It's all about building a better home and focusing on the details."

Gary's attention to detail paid off. He won an award from the National Association of Home Builders for his work on the Carstens' home. Thanks largely to referrals from Tom and Kathy, more than 75% of Gary's current business is building new homes or remodeling existing ones using Earth Advantage and Energy Star practices. "Builders do what we're told and follow the plans we're given," Gary says. "So, I can only hope that more and more architects will get on board and give us [builders] more opportunities to build green."

Courtesy Tom Carstens (3)

Shawn Schreiner (2)

Above: 3.3 KW of Isofoton modules provide more than half of the Carstens' yearly electricity needs.

Left: A Xantrex GT3.0 inverter ties photovoltaic power to the utility grid.

to generate up to 4,164 KWH of electricity annually; a solar hot water system that provides 65% of their household hot water needs; and a high-efficiency geothermal, closed-loop heat pump.

The couple received three rebates through the Oregon Department of Energy's residential energy tax credit program and the home earned nearly $12,000 for its RE technologies from Portland-based Energy Trust of Oregon, a nonprofit organization that promotes energy efficiency and renewable resources for customers of Pacific Power, Portland General Electric, and NW Natural.

Lower utility bills will help Tom and Kathy recoup the remaining up-front costs for the RE systems. In one year, from November 2005 to October 2006, the household's electricity bills averaged about $25 per month, with a high of $83.04 in February and a surplus of $15.81 in July. For a 2,544-square-foot, all-electric home in southern Oregon, where cloudy winters mean low solar thermal and solar-electric output, the systems have performed well.

The payback doesn't end there, though. The Carstens received $3,650 in federal tax credits for 2006, as well as a total of $3,600 in state tax credits for 2005 and 2006. Tom couldn't be happier with his investment. "I'm living on a military pension, and I have few monthly expenses for this home. My bills are so low that I barely notice when energy rates go up," says Tom. "The cost of energy is only going to get more and more expensive, but with this home, the rate increases are easier to absorb."

PV & SHW Tech Specs

Overview

Location: Applegate, Oregon

Solar resource: 4.93 average daily peak sun-hours

Photovoltaic System

Average monthly production: 347 AC KWH

Utility electricity offset annually: 53%

Modules: Twenty-two, Isofoton I-150/24, 150 W STC, 34.6 Vmp

Array: Two 11-module series strings, 3,300 W STC total, 380.6 Vmp

Array installation: Power Rail by Direct Power & Water; mounts installed on south-facing garage roof, 20-degree tilt

Inverter: Xantrex GT3.0, 3 KW rated output, 600 VDC maximum input, 195–550 VDC MPPT range, 240 VAC output

Solar Thermal System

System type: Closed-loop, antifreeze

Production: 357 KWH per month (average)

Hot water produced annually: 65%

Collectors: Two, Heliodyne, Gobi 408, 32.3 sq. ft. each (4 x 8 ft.)

Collector installation: Mounted on south-facing roof, 24-degree tilt

Heat transfer fluid: Propylene glycol

Circulation pump: Grundfos UPS 15-58FC

Pump controller: Heliotrope Thermal Delta-T

Tank: Ruud Pacemaker, 80 gal.

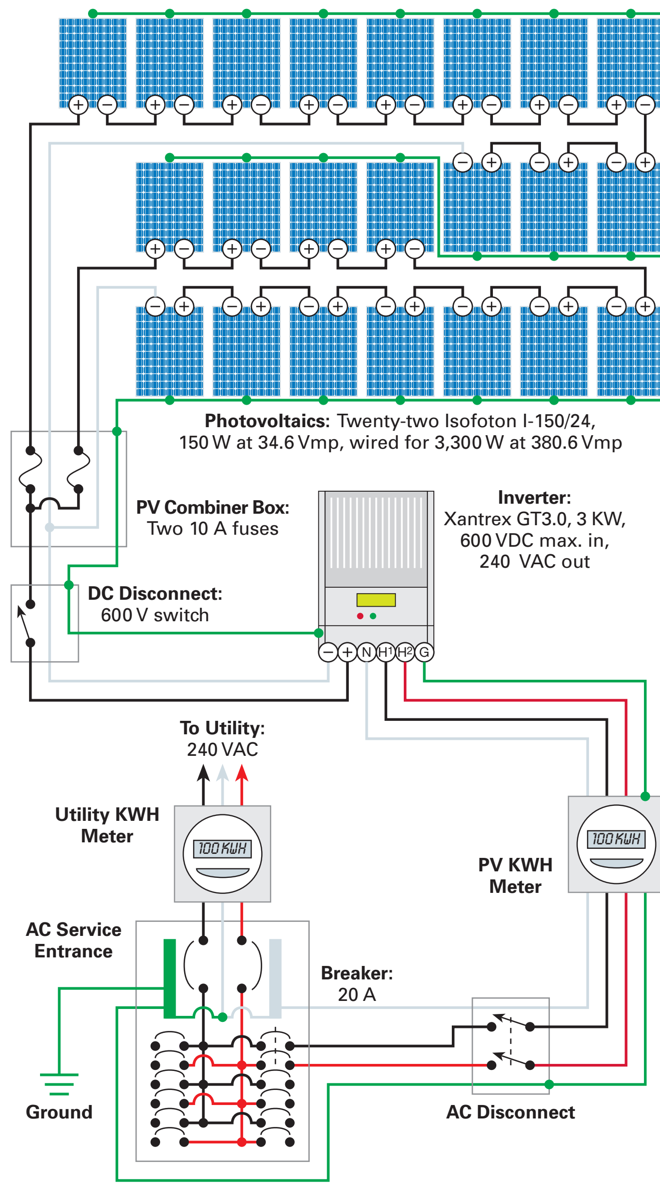
Heat exchanger: Ruud 81V80HE1

Backup DHW: Rheem Marathon, MR50245, 50 gal.

Thermometer: Watts & Weiss Instruments (top of tank)

Flow meter: Pentair

Carstens On-Grid PV System



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

Elegant Efficiency

"The [home] design and RE systems work together to keep the interior temperature comfortable all year," Tom says. "We're proud to tell people that we only turned on the air conditioning three times last summer. We find that, even when the temperatures are in the 80s, we can leave our windows open all day, and the inside of the house stays cool and comfortable."

Originally, Tom thought he might need to supplement the heating system in the winter with a small EPA-certified wood heater. However, the heater is used more for aesthetics and ambiance than warmth. The heat recovery and geothermal heat pump systems effectively circulate heat through R-10-insulated ductwork. As needed, four energy-efficient, reversible ceiling fans help keep air moving and rooms comfortable.

When asked if they'd do anything differently, Kathy agrees enthusiastically with Tom: "It's just perfect. Knowing what we know now, we can't imagine living any other way."

Access

Kelly Davidson, associate editor for *Home Power*, is saving all her pennies to buy land and realize her green dream—a solar-powered, superinsulated, barn-style home built with reclaimed and recycled materials.

Alternative Energy Systems Inc.,1700 Neil Creek Rd., Ashland, OR 97520 • 541-482-1136 • PV system

Andre DeBar, DeBar Architecture, 1035 SE 9th Ave. Ste. 5, Portland, OR 97214 • 503-232-7807 • www.debardesign.com • Architect

Gary Dorris, Dorris Construction, 2209 Old Stage Rd., Central Point, OR 97502 • 541-821-4199 • www.dorrisconstruction.com • General contractor

Pacific Heating and Cooling Inc., 6090 Crater Lake Ave., Central Point, OR 97502 • 541-826-7773 • Heating & cooling system

The Solar Collection Inc., PO Box 295, Talent, OR 97540 • 541-535-5364 • Solar thermal system

Other Resources:

Earth Advantage • www.earthadvantage.com

Energy Star • www.energystar.gov

Energy Trust of Oregon • www.energytrust.org

Southface Energy Institute • www.southface.org

RE System Components:

Climatemaster • www.climatemaster.com • Heat pump

Direct Power & Water • www.power-fab.com • PV module mounts

Heliodyne • www.heliodyne.com • Flat-plate SHW collectors

Isofoton • www.isofoton.com • PV modules

Rheem • www.rheemac.com • Backup DHW

Ruud • www.ruudac.com • SHW tank & heat exchanger

Xantrex • www.xantrex.com • Inverter

Shawn Schreiner

Tom and Kathy Carstens.

Green Building Materials:

Bonded Logic • www.bondedlogic.com • Recycled-cotton insulation

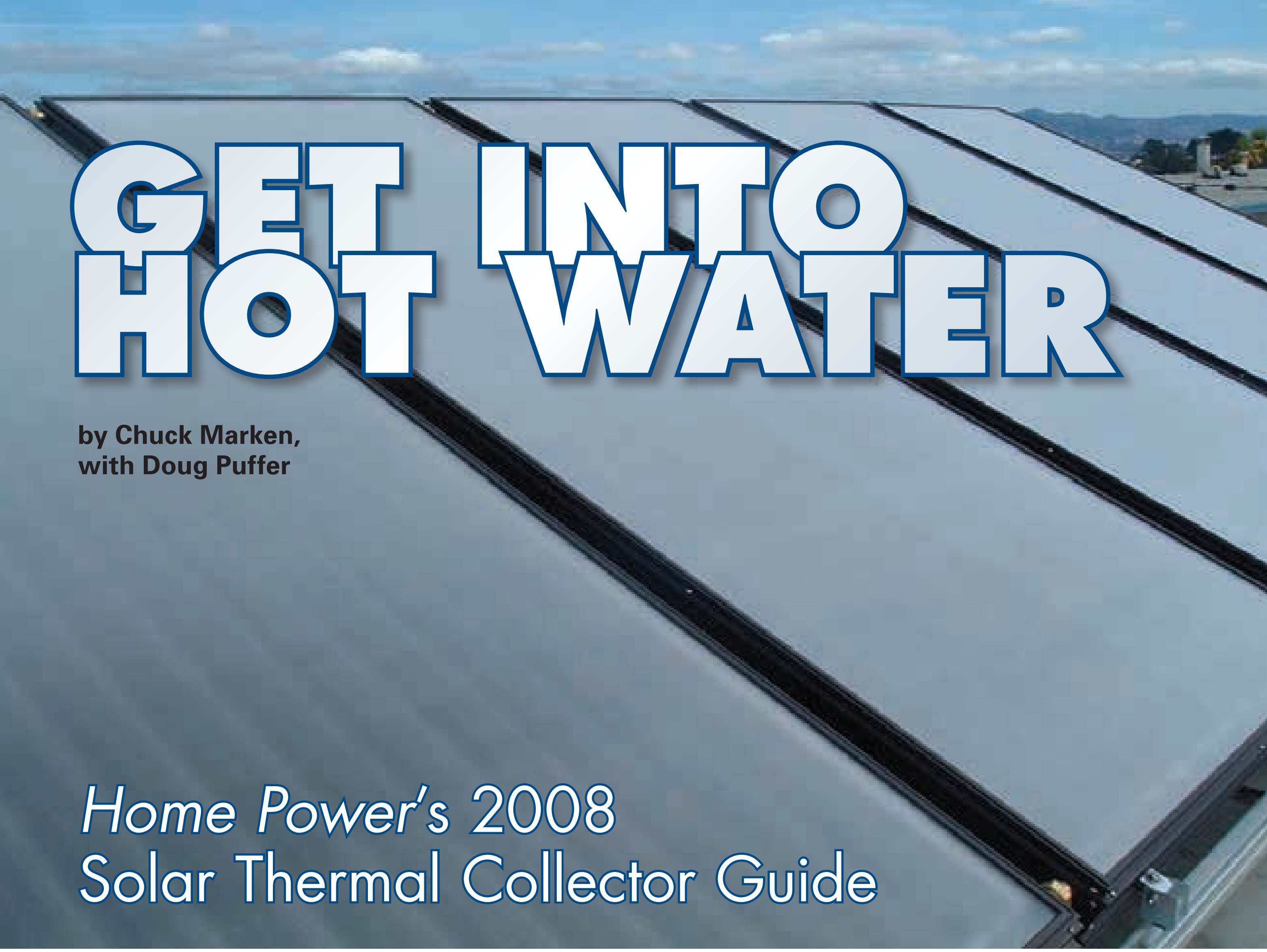
Durisol Building Systems Inc. • www.durisolbuild.com • Block forms

Evergreen Roofing Inc. • www.evergreenroofinginc.com • Steel roof

Green Mountain Woodworks Inc. • www.greenmountainwoodworks.com • Madrone flooring

Loewen • www.loewen.com • Windows

Structures NW • www.structuresnw.com • Structural insulated panels



GET INTO HOT WATER

by Chuck Marken,
with Doug Puffer

Home Power's 2008 Solar Thermal Collector Guide

Courtesy www.heliodyne.com

If you're shopping for a solar hot water system, arm yourself with the information you need to get the best collector performance for your hard-earned dollar. This guide provides a comprehensive listing of solar water heating collectors certified by the Solar Rating and Certification Corporation (SRCC)—the recognized authority for certifying and rating solar thermal equipment in the United States. It's this qualification that you'll need to claim the federal tax credit for installing a solar hot water (SHW) system.

In the late 1970s and early '80s, many claims were made by solar heating collector manufacturers that were difficult to substantiate. To keep the industry honest, a standard testing protocol for performance and durability was agreed upon to ensure an apples-to-apples comparison. Accredited and independent labs perform the testing, and the SRCC compiles the results. Today, you can access the test data online or download the catalog of certified collectors for easy comparison (see Access).

How to Use This Guide

Collectors included in this article's table have been certified under the SRCC's Operating Guideline 100 (OG-100). The collectors listed are from the SRCC rating guide, which is updated on a continuous basis. However, some collectors have been omitted from the table because they are identical (or have only cosmetic differences) to the collectors listed. Individual solar pool-heating collectors are not included in the table since they all perform nearly identically, but a generic example is included for comparison purposes.

Note that many of the collectors listed also are components of *complete* solar water heating systems, which are certified under the SRCC's OG-300 standard. A future SHW system buyer's guide will discuss these complete systems—including integral collector storage (ICS) units.

Design & Performance

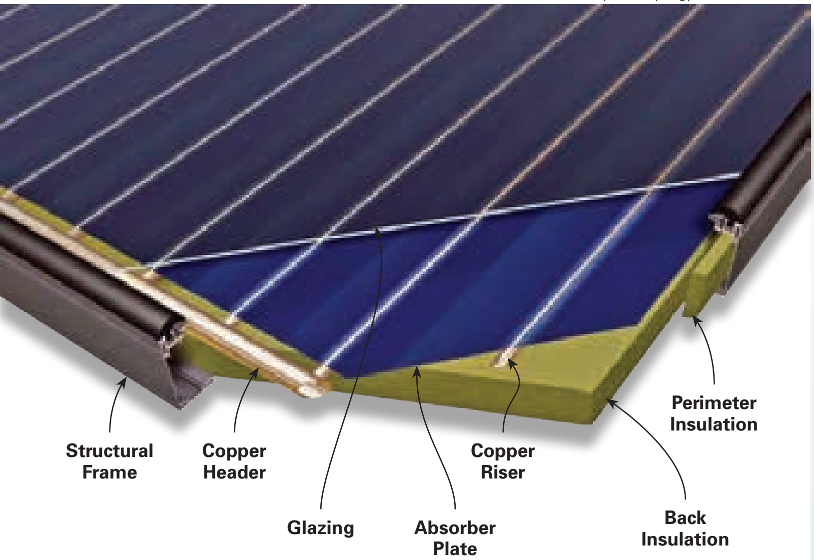
Two general types of SHW collectors are available today: flat-plate collectors and evacuated-tube collectors. The performance of each type depends largely on size, absorber material, absorber coating, outer cover, insulation, and frame. Understanding the role of these factors is the first step in evaluating the collector's performance (see "Specs" sidebar).

Certified *flat-plate collectors* all share similar designs. The real difference is in the materials that make up the frame, insulation, absorber and absorber coating, and transparent glazing. The frame has little to do with performance but a great deal to do with the collector's longevity, as it is the main structural component. Among the flat-plate collectors listed, the insulation is predominantly isocyanurate, a rigid-foam that offers high insulation values per inch and a relatively high service temperature. Some flat-plate collectors are insulated with fiberglass, which has a lower insulation rating per inch of thickness. For glazing, most flat-plate manufacturers have adopted the current standard: one piece of low-iron tempered glass, which passes about 90% of the light to the collector's interior. With few exceptions, the absorber and absorber tubes are made of copper. The absorber coatings for all collectors are either black paint or selective surface (a coating that has high absorption capabilities, similar to black paint, but also has low emissivity, or radiance, to retain the absorbed heat). These specialized coatings help improve the collector's ability to capture solar energy.

Evacuated-tube collectors are available in five different configurations. Four designs use a tube within a tube—a double-glass tube. Between the two layers of glass is the all-important vacuum, which limits heat loss and provides an insulation value that far surpasses that of flat-plate collectors. The twin-glass design works much like a thermos bottle, with the vacuum between two cylinders of glass that are formed together. Many of the evacuated-tube collectors included in the table use a thermos design, a selective-surface absorber, and borosilicate high-transmittance glass. Some collectors use a single glass cylinder with the vacuum filling the entire cylinder, instead of the space between double-glass cylinders. In all cases, the key to high evacuated-tube performance is the vacuum, which provides outstanding insulation.

Flat-Plate Collector Construction

Courtesy www.synergysolar.com



SPECS...

Size: Length, Width, Depth

If south-facing roof space is limited, knowing a collector's physical dimensions will help determine which collector or collectors will be the best fit.

Gross Area (Ft.^{2})

The collector's length times its width. The gross area is the total size of the collector, not just the part gathering heat.

Dry Weight (Lbs.)

This is the collector weight without fluid. Although this is useful information to have for the installation, roof-loading calculations need to include the weight of the fluid as well.

Warranty (Full/Ltd.)

Full- and limited-coverage warranties do have specific conditions, so check the documentation thoroughly to understand what is covered and what is not.

Absorber Material

An absorber material is used to collect the heat from the sun. Copper is the most common material due to its conductive properties.

Absorber Coating

Coatings on the absorber material assist in heat collection. Black coatings are common, as black absorbs heat. Selective surfaces add low emissivity for better heat retention than black paint.

Cover/Glazing

The cover is mainly for protecting the collector from damage but does add some insulating qualities. It should allow as much light as possible through to the absorber while helping slow heat loss.

Frame

The frame is an important structural component of the collector. High-quality materials ensure a longer collector life, which is more critical for coastal environments where salt water may cause certain metals to corrode.

Thousands of Btu

This is the measured energy output of the collector under clear, mildly cloudy, and cloudy conditions. The data in the table is for Category C locations typical of the contiguous United States (see "Operating Categories" sidebar).

Y-Intercept

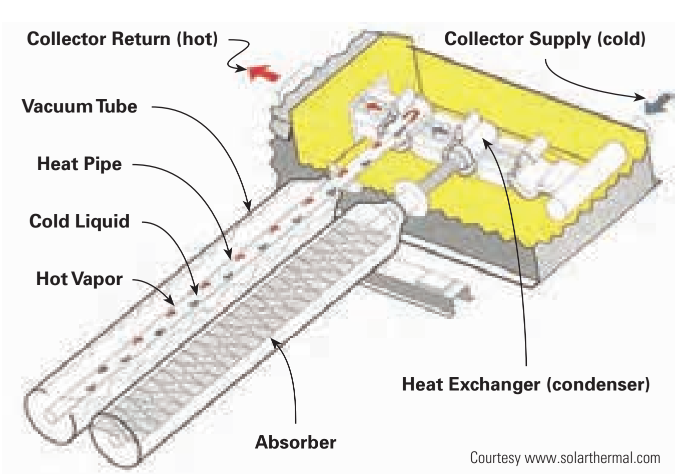
This represents the efficiency of the collector when the circulating fluid entering the collector is the same temperature as the outside air. Used to assess heat-gain performance, it corresponds with the highest point on a collector's efficiency curve.

Slope (Btu/hr./ft.^{2}/°F)

This represents the efficiency of the collector as the temperature difference between the circulating fluid and the outside air increases. Used to assess heat-loss performance, it shows the steepness of a collector's efficiency curve.

Evacuated-tube collectors, like this 30-tube heat-pipe design Thermomax, offer good performance in cold and cloudy climates.

Heat-Pipe Type Evacuated-Tube Collector Construction



A *thermosiphon system* is the simplest of the thermos designs. The collector-loop fluid, usually potable water, fills the entire inner tube. The painted, black absorber takes in the solar energy that hits it after passing through the transparent outer glass. This type of evacuated-tube collector is usually inserted into a special unpressurized tank/manifold that will accept many individual tubes. The water inside the evacuated tubes heats up when the sun is shining, which initiates the thermosiphon effect: Hot water moves into the small holding tank above the collectors, pulling cold water through the inside of the collector to be heated. This is technically an ICS system, which will be addressed in the future guide to complete SHW systems.

Heat-pipe design collectors use a copper pipe, closed at both ends, which contains a solution that vaporizes when heated. The hot vapor rises to a heat exchanger located in a manifold at the top of the tubes, which transfers heat to the solar fluid (water or glycol) to be circulated through the SHW system. Upon giving up the heat, the vapor condenses back to a liquid and falls to the bottom of the tube to repeat the cycle.

A *direct-flow design* circulates the collector-loop fluid through a tube bonded to a metal absorber within the inner glass. The design of a direct-flow tube and absorber is similar to the design of a flat-plate tube and absorber, except it's more efficient with the supreme insulating qualities of a vacuum. Direct-flow can be more efficient than the heat-pipe design because it eliminates the additional step of heat exchange between the heat-pipe fluid and the collector-loop fluid.

Another thermos-type design uses a mirrored surface to reflect sunlight onto a black target tube that collects the solar energy. By concentrating more energy on the target tube, these collectors can produce higher temperatures than other evacuated-tube designs.

A more traditional design for evacuated tubes is a *single glass tube with a vacuum inside*. These are usually designed as direct-flow collectors with a copper heat pipe or water-flow pipe bonded to a metal-plate absorber. They can also be designed as a heat pipe with a heat exchanger. Vacuums are difficult to seal with common gaskets and sealants. Maintaining the seal between the glass and the copper tube that circulates the fluid has been a problem with these collectors. An evacuated tube without a vacuum is kind of like a car with flat tires—it won't set any performance records.

Interpreting Collector Performance

Surface area aside, heat gain and loss influence collector performance most radically. The "Typical Collector Performance Slopes" graph (opposite page) shows collector efficiency as it relates to the difference between the ambient and collector inlet temperatures.

The Y-intercept value for each collector corresponds to a point on the graph where it intersects the Y-axis. This value represents the efficiency of the collector (as a percentage) when the outside temperature is the same as the fluid temperature entering the collector inlet. It's an excellent indicator of the heat gain potential of each type of collector. Higher Y-intercept numbers will result in higher output performance numbers in the SRCC matrix of collector output.

The graph's X-axis (bottom axis) reflects temperature difference: delta T (ΔT), the difference between the ambient temperature and the inlet temperature of the collector loop fluid. As the inlet temperature increases in relation to the ambient temperature, all collectors suffer a loss in efficiency, some more dramatically than others (see "Heat Loss" section).

The steepness of each slope (the diagonal colored lines on the graph) represents how quickly the collector loses heat as ΔT increases. The slope represents heat loss in Btu per hour per square foot per degree Fahrenheit.

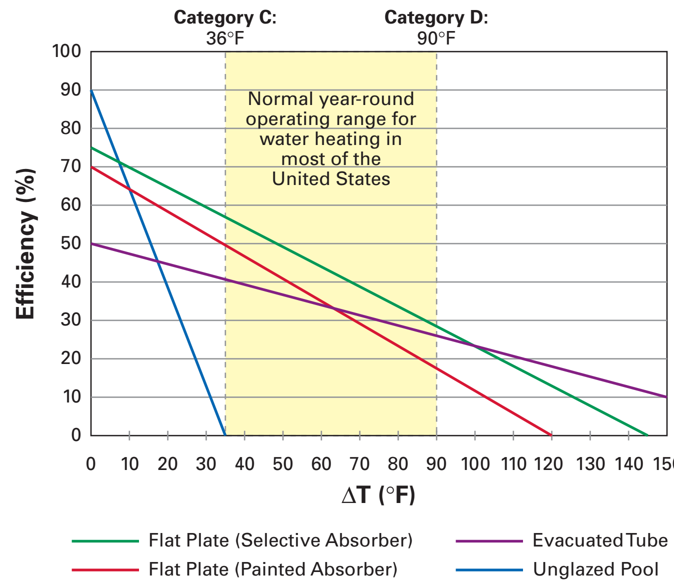
Heat Gain…

For heat gain efficiency, unglazed swimming pool collectors come out on top. Collectors used for swimming pool heating consist of a simple absorber plate without any glazing or insulation, so there's nothing to impede heat gain compared

Why Y?

The Y-intercept values for collectors are from calculations based on the gross area of the collectors, which includes parts of the collector that are not collecting heat (insulation, enclosures, manifolds, etc.). This has been the standard for almost three decades and will likely remain so for years to come, since it best reflects real-world practices in sizing a system to fit a certain space. But what really counts is the output for the buck—Btu produced per dollar invested. This, along with durable construction and a pleasing cosmetic appearance, should be the deciding factors for an informed buyer.

Typical Collector Performance Slopes



to other collector types. When no difference exists between the collector inlet and ambient temperature, unglazed pool collectors have the greatest gain.

Although the single pane of glass cuts the energy received by roughly 10%, for collection efficiency, flat-plate collectors with a selective absorber come in a close second to unglazed pool heaters, at nearly 75% efficiency (75% at the Y-intercept). The collector's selective surface allows for a greater retention of radiation compared to black-painted absorbers. Black paint has high absorption properties but also has high emissivity. Flat-plate collectors with black-painted absorbers have efficiencies of about 70%.

Evacuated-tube collectors lag behind the others in heat absorption, with an average efficiency of about 50%. The double glass in the thermos-type collector designs is responsible for some of this gap on the Y-axis because each layer of glass cuts the light by at least 10%. Other variables, like the absorber coating, integrated heat exchangers, and the bonding of the tube to the absorber plate may also play a role in the lower efficiencies at a ΔT of zero (the Y-intercept).

…Heat Loss

But efficiency at a ΔT of zero doesn't give the whole picture, and collectors perform more or less efficiently depending on their ability to retain heat as the temperature gap widens. Take unglazed pool collectors as the most radical example. Even small temperature changes between the ambient temperature and collector inlet temperature cause a pool collector's efficiency to plummet: A 35°F difference can drop the collector's efficiency to near zero, while this same ΔT can cause only a minor shift in efficiency (about 10%) in an evacuated-tube collector. Collectors with selective surfaces, which have high absorption and low emissivity properties, and those with superior insulation, which also limits heat loss, have a relatively flat slope compared to the steep slope of an unglazed pool collector.

When it comes to limiting heat loss, evacuated-tube collectors come in first. The insulation properties of a vacuum are undeniable, and the performance numbers prove it. Selective surface coatings on the absorber further limit the collector's heat loss by limiting the high radiant heat loss that is common for any black surface.

The best choice of collector type depends on the local climate, as well as your household's hot water temperature and quantity needs.

Courtesy www.synergysolar.com

Thermal Collector

Flat Plate

Manufacturer	Model	Length (In.)	Width (In.)	Depth (In.)	Gross Area ($Ft.^2$)	Dry Weight (Lbs.)	Warranty (Yrs.: Full/Ltd.)
ACR Solar www.solarroofs.com	20-01	72.2	20.0	3.0	10.0	19	0 / 20
	20-01	144.3	20.0	3.0	20.1	38	0 / 10
Alternate Energy Technologies www.aetsolar.com	AE-21	85.2	35.2	3.1	20.8	74	0 / 10
	AE-24	97.2	35.2	3.1	23.8	84	
	AE-26	77.2	47.2	3.1	25.4	90	
	AE-28	85.2	47.2	3.1	28.0	99	
	AE-32	97.2	47.2	3.1	31.9	113	
	AE-40	121.2	47.2	3.1	39.8	153	
	MSC-21	86.0	38.5	3.1	21.5	82	
	MSC-24	98.0	38.5	3.1	24.5	102	
	MSC-26	78.0	50.5	3.1	26.0	102	
	MSC-28	86.0	50.5	3.1	28.7	120	
	MSC-32	98.0	50.5	3.1	32.7	133	
	MSC-40	122.0	50.5	3.1	42.2	159	
Conergy www.conergy.com	F4000	79.1	42.1	3.5	23.2	97	5 / 0
EnerWorks Inc. www.enerworks.com	COL-4X8-NL-SG1-SH10US	46.3	96.3	3.3	30.9	111	0 / 10
	COL-4x8-TL-SG1-SD10US	48.0	96.0	3.0	30.9	111	0 / 10
Genersys www.genersys.com	1000-10	N/A	N/A	N/A	21.9	86	0 / 20
Heliodyne www.heliodyne.com	Gobi 3366	88.6	43.6	4.0	26.8	108	10 / 0
	Gobi 408	97.6	47.6	4.0	32.3	133	
	Gobi 410	121.6	47.6	4.0	40.3	160	
Marathon International www.wallhungboilers.com	Baxi S-SPC 18	76.5	38.6	3.7	20.6	72	0 / 10
R&R Solar Supply 808-842-0011	Sunpro 21	85.1	35.1	4.0	20.5	88	12 / 0
	Sunpro 24	97.1	35.1	4.0	23.4	97	
	Sunpro 32	97.1	47.1	4.0	31.4	123	
	Sunpro 40	121.1	47.1	4.0	39.2	170	
Radco Products www.radcosolar.com	308C-HP	97.1	35.1	3.0	23.7	78	5 / 10
	308P-HP	97.1	35.1	3.0	23.7	75	
	408C-HP	101.6	45.8	3.0	32.3	105	
	408P-HP	101.6	45.8	3.0	32.3	102	
	410C-HP	125.6	45.8	3.0	39.9	129	
	410P-HP	125.6	45.8	3.0	39.9	125	
	412C-HP	152.1	45.8	3.0	48.3	155	
	412P-HP	152.1	45.8	3.0	48.3	150	
Schuco USA www.schuco-usa.com	Premium V, H, LA	84.7	49.3	3.6	29.1	121	0 / 10
	Slimline V, LA	80.3	44.9	2.2	24.9	90	
Sensible Technologies www.jtgmuir.com	STS 410BC	122.3	48.1	3.3	40.9	138	0 / 10
	STS 410BP	122.3	48.1	3.3	40.9	138	
	STS 48BC	98.3	48.0	3.3	32.8	105	
	STS 48BP	98.3	48.0	3.3	32.8	105	
Solahart Industries www.solahart.com.au	Bt	76.6	40.2	3.0	21.4	69	0 / 10
	J	76.6	40.2	3.0	21.4	90	5 Ltd. w/J, 10 Ltd. w/F 5
	Kf	76.6	40.2	3.0	21.4	90	5 Ltd. w/J, 10 Ltd. w/F 5
	L	76.6	40.2	3.0	21.4	69	0 / 10
Solar Development www.solardev.com	SD8-21	N/A	N/A	N/A	20.8	74	N/A
	SD8-26	N/A	N/A	N/A	25.4	90	
	SD8-28	N/A	N/A	N/A	28.0	99	
	SD8-32	N/A	N/A	N/A	31.9	113	
	SD8-40	N/A	N/A	N/A	39.8	153	

1) 2,000 Btu / $Ft.^2$ / Day; 2) 1,500 Btu / $Ft.^2$ / Day; 3) 1,000 Btu / $Ft.^2$ / Day; 4) Btu / Hr. / $Ft.^2$ / °F; 5) Warranty varies with system configuration

Comparison Table

Materials					Thousands of Btu Per Day				
Absorber									
Tube	Plate	Coating	Glazing	Frame	Clear [1]	Mildly Cloudy [2]	Cloudy [3]	Y- Intercept	Slope [4]
Copper	Copper Fin	Selective Surface	Lexan Polycarbonate	Aluminum	8	6	3	0.602	-0.663
					17	11	6	0.604	-0.657
Copper	Copper Fin	Selective Surface	Low-Iron Tempered Glass	Anodized Aluminum	21	14	8	0.706	-0.865
					24	16	9	0.706	-0.865
					25	17	9	0.706	-0.865
					28	19	10	0.706	-0.865
					32	22	12	0.706	-0.865
					40	27	15	0.706	-0.865
					21	15	8	0.706	-0.865
					24	17	9	0.706	-0.865
					26	18	10	0.706	-0.865
					29	20	11	0.706	-0.865
					32	22	12	0.706	-0.865
					42	29	16	0.706	-0.865
Copper	Copper	Selective Surface	Tempered Glass	Aluminum	24	17	10	0.667	-0.629
Copper	Aluminum	Vapor-Deposition Selective	Low-Iron Tempered Glass	Galvanized Steel	37	26	15	0.768	-0.711
					32	22	11	0.726	-0.901
Copper	Aluminum	Metallic Oxide	Low-Iron Tempered Glass	Aluminum	19	13	7	0.591	-0.704
Copper	Copper	Black Chrome	Low-Iron Tempered Glass	Extruded Aluminum	30	21	12	0.734	-0.825
					37	25	14	0.737	-0.805
					46	31	18	0.737	-0.805
Copper	Copper	Selective Surface	Low-Iron Tempered Glass	Extruded Aluminum	20	13	7	0.696	-0.785
Copper	Copper	Mod. Selective Black Paint	Low-Iron Tempered Glass	Anodized Aluminum	20	13	6	0.708	-1.077
					23	15	7	0.708	-1.077
					30	20	10	0.708	-1.077
					38	25	12	0.708	-1.077
Copper	Copper	Black Chrome	Low-Iron Tempered Glass	Aluminum	26	18	10	0.778	-0.875
		Flat-Black Paint			23	15	8	0.764	-1.323
		Black Chrome			36	25	13	0.779	-0.841
		Flat-Black Paint			30	20	9	0.768	-1.276
		Black Chrome			45	30	16	0.779	-0.841
		Flat-Black Paint			38	25	11	0.768	-1.276
		Black Chrome			54	37	20	0.779	-0.841
		Flat-Black Paint			46	29	13	0.768	-1.276
Copper	Copper	Sputtered Cermet	Low-Iron Tempered Glass	Aluminum	31	22	12	0.718	-0.754
					27	19	11	0.715	-0.704
Copper	Copper	Black Chrome	Low-Iron Tempered Glass	Extruded Aluminum	42	29	16	0.714	-0.727
		Mod. Selective Black Paint			40	28	15	0.682	-0.800
		Black Chrome			34	24	13	0.714	-0.727
		Mod. Selective Black Paint			32	22	12	0.682	-0.800
Copper	Copper	Titanium Oxide	Low-Iron Tempered Glass	Aluminum	23	16	8	0.750	-0.858
None	Steel	Polyester Flat-Black Paint			22	14	7	0.772	-1.473
None	Steel	Black Chrome			23	16	9	0.759	-1.045
Copper	Aluminum	Polyester Flat-Black Paint			15	10	4	0.625	-1.316
Copper	Copper Fin	Selective Surface	Low-Iron Tempered Glass	Anodized Aluminum	21	14	8	0.706	-0.865
					25	17	9	0.706	-0.865
					28	19	10	0.706	-0.865
					32	22	12	0.706	-0.865
					40	27	15	0.706	-0.865

Flat Plate (cont.)

Manufacturer	Model	Length (In.)	Width (In.)	Depth (In.)	Gross Area (Ft.^{2})	Dry Weight (Lbs.)	Warranty (Yrs.: Full/Ltd.)
Solar Energy www.solarenergy.com	SE-21	84.0	36.0	2.9	21.9	90	0 / 10–15
	SE-24	96.0	36.0	2.9	24.9	102	
	SE-28	84.0	48.0	2.9	27.0	109	
	SE-32	96.0	48.0	2.9	30.9	124	
	SE-40	120.0	48.0	2.9	38.6	154	
Solene www.solene-usa.com	SLCO-30	74.4	47.4	4.0	24.5	78	10 / Life
	SLCO-32	96.5	47.4	4.0	31.8	106	
	SLCO-40	118.0	47.4	4.0	38.9	132	
	SLCR-30	86.5	50.4	3.6	30.3	110	
	SLCR-32	97.4	47.1	3.6	32.0	108	
	SLCR-40	121.6	47.4	3.6	40.1	152	
Stiebel Eltron www.stiebel-eltron-usa.com	Sol 25 Plus	87.9	48.1	3.1	29.4	108	5 / 0
SunEarth www.sunearthinc.com	Empire EC-21	76.1	40.1	3.3	21.2	71	0 / 10
	Empire EC-24	98.3	36.1	3.3	24.7	81	
	Empire EC-32	98.3	48.1	3.3	32.8	105	
	Empire EC-40	122.3	48.1	3.3	40.9	138	
	Empire EP-21	76.1	40.1	3.3	21.2	71	
	Empire EP-24	98.3	36.1	3.3	24.7	80	
	Empire EP-32	98.3	48.1	3.3	32.8	105	
	Empire EP-40	122.3	48.1	3.3	40.9	138	
Synergy Solar www.synergysolar.com	TC-19.78	78.0	36.0	N/A	19.8	78	12 / 0
	TC-26.52	78.0	48.0	N/A	26.7	108	
Thermo Dynamics www.thermo-dynamics.com	G Series G32-P	97.4	47.4	3.4	32.1	96	10 / 0
Viessmann Manuf. Co. www.viessmann-us.com	Vitosol 100 SV1, SH1	94.0	41.8	3.5	27.2	97	10 / 0

Evacuated Tube

Manufacturer	Model	Length (In.)	Width (In.)	Depth (In.)	Gross Area (Ft.^{2})	Dry Weight (Lbs.)	Warranty (Yrs.: Full/Ltd.)
American Solar Works www.americansolarworks.com	ASW52B	75.0	64.0	5.0	30.8	138	10 / 0
	ASW52B Stretch	75.0	84.0	5.0	42.0	188	
Apricus Solar www.apricus-solar.com	AP-10	77.9	31.3	6.1	14.5	77	0 / 10–15
	AP-20	77.9	58.8	6.1	29.2	125	
	AP-22	77.9	64.4	6.1	32.1	157	
	AP-30	77.9	86.4	6.1	43.6	182	
Beijing Sunda Solar Energy Technology www.sssolar.com	10-10 AS/AB	76.2	36.6	7.4	18.1	88	10 / 0
	10-20 AS/AB	76.2	73.2	7.4	36.5	165	
	1-16	83.7	75.6	6.9	43.0	221	
	1-8	83.7	37.8	6.9	21.5	104	
	2-16	83.7	75.6	5.9	44.1	221	
	2-8	83.7	37.8	5.9	21.9	110	
	5-16 AS/AB	83.7	75.6	6.9	44.1	232	
	5-8 AS/AB	83.7	37.8	6.9	21.8	108	
BTF www.btfsolar.com	Solar Patriot SP-20	77.9	65.3	6.6	33.1	122	5 / 0
Oventrop www.oventrop-na.com	OV 5-16 AS/AB	87.9	76.4	7.4	44.1	232	10 / 0
	OV 5-8 AS/AB	87.9	38.6	7.4	21.8	108	
Solargenix Energy www.solargenix.com	Winston Series CPC WS0503	81.5	41.9	3.4	24.1	107	3 / 10
Thermo Tech./Thermomax www.solarthermal.com	Mazdon TMA-600-20	80.0	59.0	6.3	32.9	135	0 / 5
	Mazdon TMA-600-30	80.0	87.0	6.3	49.3	197	
Viessmann Manuf. Co. www.viessmann-us.com	Vitosol 300 Type SP3, 2 m^2	78.5	55.8	4.8	31.0	127	10 / 0
	Vitosol 300 Type SP3, 3 m^2	78.5	83.8	4.8	46.2	150	

Unglazed Flat Plate

Manufacturer	Model	Length (In.)	Width (In.)	Depth (In.)	Gross Area (Ft.^{2})	Dry Weight (Lbs.)	Warranty (Yrs.: Full/Ltd.)
Typical pool collector	Average model	–	–	–	47.0	25	–

1) 2,000 Btu / Ft.^{2} / Day; 2) 1,500 Btu / Ft.^{2} / Day; 3) 1,000 Btu / Ft.^{2} / Day; 4) Btu / Hr. / Ft.^{2} / °F

Materials					Thousands of Btu Per Day				
Absorber									
Tube	Plate	Coating	Glazing	Frame	Clear [1]	Mildly Cloudy [2]	Cloudy [3]	Y- Intercept	Slope [4]
Copper	Copper Fin	Selective Surface	Low-Iron Tempered Glass	Aluminum	22	15	8	0.704	-0.790
					25	17	9	0.704	-0.790
					28	19	10	0.704	-0.790
					32	22	12	0.704	-0.790
					39	27	15	0.704	-0.790
Copper	Copper Fin	Black Chrome	Low-Iron Tempered Glass	Extruded Aluminum	27	18	10	0.782	-0.811
					35	24	13	0.785	-0.810
					42	29	15	0.787	-0.810
				Aluminum	33	23	14	0.735	-0.945
					35	25	14	0.735	-0.945
					44	31	18	0.735	-0.945
Copper	Copper	Sputtered Titanium Nitride	Low-Iron Tempered Glass	Extruded Aluminum	30	21	12	0.660	-0.755
Copper	Copper	Black Chrome	Low-Iron Tempered Glass	Extruded Aluminum	22	15	9	0.714	-0.727
					26	18	10	0.714	-0.727
					34	24	13	0.714	-0.727
					42	29	16	0.714	-0.727
		Mod. Selective Black Paint			21	14	8	0.682	-0.800
					24	17	9	0.682	-0.800
					32	22	12	0.682	-0.800
					40	28	15	0.682	-0.800
Copper	Copper Fin	Sputtered Aluminum Nitride	Low-Iron Tempered Glass	Aluminum	19	13	7	0.686	-0.809
					26	18	10	0.697	-0.806
Copper	Aluminum	Mod. Selective Black Paint	Low-Iron Tempered Glass	Aluminum	29	19	10	0.700	-0.870
Copper	Copper Fin	Sputtered Cermet	Tempered Glass	Aluminum	30	21	12	0.720	-0.616
Copper	Aluminum	Sputtered Aluminum Nitride	Glass Vacuum Tube	Stainless Steel	22	16	10	0.481	-0.291
					29	21	13	0.481	-0.291
Copper & steel	Glass	Sputtered Aluminum Nitride	Glass Vacuum Tube	Stainless Steel	12	8	5	0.418	-0.206
					23	17	11	0.418	-0.206
					26	19	12	0.418	-0.206
					35	25	16	0.418	-0.206
Copper	Aluminum	Sputtered Aluminum Nitride	Glass Vacuum Tube	Stainless Steel	14	10	6	0.462	-0.276
					28	20	12	0.462	-0.276
					35	26	16	0.529	-0.299
					18	13	8	0.529	-0.299
		Sputtered Selective			48	35	22	0.628	-0.303
					24	17	11	0.628	-0.303
		Sputtered Aluminum Nitride			36	26	16	0.492	-0.339
					18	13	8	0.492	-0.339
Glass	Aluminum	Sputtered Aluminum Nitride	Glass Vacuum Tube	Stainless Steel	23	17	11	0.345	-0.203
Copper	Aluminum	Sputtered Aluminum Nitride	Glass Vacuum Tube	Stainless Steel	36	26	16	0.492	-0.339
					18	13	8	0.492	-0.339
Copper	None	Mod. Selective Black Paint	Low-Iron Tempered Glass	Aluminum	18	12	6	0.600	-1.001
Copper	Copper Fin	Black Chrome	Iron-Free Glass Vacuum Tube	Stainless Steel	26	19	12	0.530	-0.250
					40	29	18	0.530	-0.250
Copper	Copper Fin	Sputtered Cermet	Glass Vacuum Tube	Aluminum	26	19	12	0.509	-0.193
					39	29	18	0.509	-0.193
Polymer	None	None	–	None	23	11	0	0.800	-2.900

Operating Categories

Most locations will not fit precisely into a single SRCC operating category. Collectors will typically operate in the B and C categories in the morning, when cooler ambient temperatures are closer to the inlet temperatures. As a typical day progresses, inlet temperature outpaces the ambient temperature, and the collector operates in the C and D categories.

As a general rule, if you must pick a single category of operation in any location, the C category will be most accurate year-round in all but the very coldest climates in the United States. Many systems will operate closer to the D category in the winter, but will predominately be closer to the C category in the spring, summer, and fall. For collector performance in other operating categories, refer to an individual collector's SRCC data sheet.

An important consideration in examining how the collector types perform is the intersection of the slope lines in the graph. As ΔT increases, all three of the glazed collectors quickly surpass the unglazed collector in terms of performance. As the temperature difference continues to increase, the evacuated-tube collectors pass both types of flat-plate collectors at a ΔT of approximately 100°F. This indicates that the evacuated-tube collectors will perform better than the flat-plate collectors in conditions of extreme cold and/or when an application requires elevated temperatures.

Regional Choices

Because they have high efficiencies at low ΔTs, unglazed collectors are optimal for heating swimming pools only in certain seasons when temperatures are warm and don't fluctuate. In places where the weather is consistently warm—for instance, in parts of Florida or Arizona—this characteristic means solar pool heating can occur almost year-round.

Flat-plate and evacuated-tube collectors can be tougher to evaluate in colder or cloudier locations. For heating domestic water to 130°F, glazed flat-plate collectors can produce more heat than evacuated-tube collectors of similar size, during most of the year, in almost all of the contiguous United States. This is shown in the table as Btu output (sunny, mildly cloudy, and cloudy). It is also reflected by the graph, as the evacuated-tube collectors don't outproduce flat plates until after a temperature difference of about 100°F or so. If you want to make exact comparisons, review the complete SRCC data sheet for each collector you're considering.

In solar water heating applications, evacuated-tube collectors start to outperform their flat-plate cousins in northern latitudes and colder climates like Canada and Alaska. They are less affected by larger temperature differences than flat-plate collectors. Because evacuated tubes can also get fluids hotter, they are well suited for higher temperature, less common applications such as absorption-cycle air conditioning.

Collector Costs

The one thing missing from the specifications table is price. That's because the cost of collectors is difficult to nail down. Prices vary by dealer and whether the cost includes installation. Plus, the cost of key materials—copper, aluminum, and glass—has fluctuated nearly as much as gasoline prices. Btu produced per dollar (output per cost) is the criteria I recommend for the best value. Don't be impressed with gizmos or claims of performance other than the SRCC catalog data. SRCC provides the best source of independent testing data for all certified collectors and, like it or not, the U.S. Congress has made the SRCC the authority by requiring their certification for receiving federal tax credits.

Choosing Your Collector

The bottom line (or X-axis to rocket scientists) is that you can get some real-world performance data from the intercepts and slopes when you factor in the collector size. The specifications table includes three columns of performance data extracted from SRCC data sheets. SRCC's Category C "warm climate" classification, which assumes a temperature difference between ambient and collector inlet of 36°F, is the category used in the table since it best represents the "average climate" in most of the United States. The Sunbelt (southwest United States and Florida) predominantly has sunny conditions. The Midwest and middle coastal areas generally fit into the "mildly cloudy" category, and the northern coastal areas are typically classified as "cloudy."

A collector's output is an important consideration in collector selection, but it isn't everything. Also factor in a manufacturer's reputation and track record, as well as the materials used in collector construction. With few exceptions (i.e., pool collectors), all the hot water collectors in this guide are made with durable metals, glass, and high-temperature insulation—materials with proven track records.

Access

Contributing editor **Chuck Marken** (chuck.marken@homepower.com) is a New Mexico-licensed plumber, electrician, and heating and air conditioning contractor. He has been installing and servicing solar thermal systems since 1979. Chuck is a part-time instructor for Solar Energy International and the University of New Mexico.

SRCC • www.solar-rating.org

Resurrecting a *Classic* Wind Generator

Courtesy Kevin A. Schumacher

A restored, 1950s-era Jacobs wind generator flies again.

by Willi Hampel

Several decades ago, before modern small-scale wind turbines hit the market, one of the most sought-after wind generators was the pre-Rural Electrification Administration direct-drive machine made by Jacobs Wind Electric. It's rugged, powerful, and reliable when maintained well. When I was growing up, my father and I flew five different homebuilt wind turbines, and I had always dreamed of someday flying a "Jake." I kept my eyes peeled in my travels around the Midwest, hoping for a find.

In September 2003, I spotted an old Jake sitting idly on a tower only a few miles from my family's home in Merton, Wisconsin, and immediately thought to myself, "I need to get this machine running again." I also had the feeling that, decades ago, I had once read about this particular machine.

Searching through some of my old periodicals, I found an article from nearly three decades earlier describing the history of the machine that I had spotted. In 1976, then-U.S. Representative Henry S. Reuss installed the 32 VDC, 1,800 W, direct-drive Jacobs Wind Electric generator at his summer home in North Lake, Wisconsin. The wind generator was connected to the utility grid through a Gemini synchronous inverter.

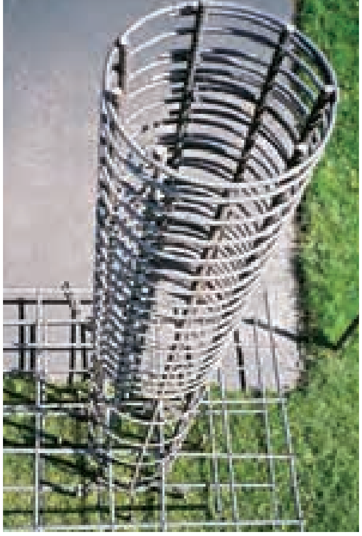
After striking a deal with the current owner of the wind generator, I began assembling the necessary equipment to remove the machine from the tower. I devised a ladder arrangement to access the tower safely. Some friends and I constructed a 12-foot-long gin pole, made of 3-inch seamless steel tubing, to remove the wind turbine. Removing a 400-pound wind generator from atop a 72-foot tower can be challenging, but we did it and lived to tell the tale. The next step was to rebuild the generator and put it back into action.

We Can Rebuild It!

Although the machine was in poor shape from years of neglect, that didn't deter me. From the circa-1976 photos, I could see that the original flyball-type governor had been changed to a blade-activated governor. Both types use the centrifugal force of the rotating machine to actuate. With the flyball governor, higher rpm cause spring-loaded weights to move outward, decreasing the rotor speed by increasing the pitch of the blades through gears. With blade-activated governors, the blades are spring-loaded, and the blade pitch is increased as they move out on their shafts.

After gently heating up the governor casting with a propane torch, I removed the housing from the tapered generator shaft with a three-pronged gear puller. Liberally applied solvent helped remove the gummed-up grease on the blade shafts and spider casting, and a lot of wire-brushing removed the rust. My friend Jim machined new ball joints to replace the badly worn originals. After several coats of corrosion-inhibiting paint, the blade-activated governor was ready for many more years of service.

The Model 45 Jacobs generator (rated at 45 A, 40 VDC) had to be completely disassembled. We steam-cleaned the armature to remove dirt, debris, and other potentially conductive contaminants, and then oven-baked the windings to remove all moisture before varnishing. The insulation resistance (conductor-to-ground) tested "good," as did



Prepping and pouring the footings for the tower. Far left: The excavated holes, with rebar cages in place. Center: Detail of rebar cages. Right: Tubular concrete forms are filled to form the upper 8 feet of the tower foundation.

the commutator. The commutator bars were polished and undercut, and the windings coated with insulating paint. The armature bearings were replaced with sealed bearings. The stator was wire-brushed to remove the rust and painted with several coats of antirust paint.

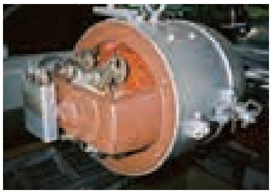
Having rotten tips, the Jake's wooden blades required major refurbishing. Also, the tail vane had broken, causing the tail to overshoot its parked position. This allowed one of the blades to smash into the tail, putting a cut in its leading edge.

The blades were sanded down to the bare wood and any rotten wood replaced. Next, epoxy resin was spread onto every wooden surface and forced into the wood grain with a heat gun. After sanding, a fiberglass mesh, soaked in more resin, was applied to each blade. After three additional resin coats, with sanding between, each blade was given a final hand-sanding. Two coats of marine-grade epoxy paint were applied with a spray gun. Finally, the rotor was assembled with the governor and static-balanced.

Some miscellaneous parts needed attention too. The turbine tail vane and a generator bearing housing were cracked and required welding. A new tapered roller bearing was installed—it supports the entire weight of the wind generator on the tower. Various other Jacobs components had to be purchased to complete the restoration—blade-actuated governor springs, a tail vane spring, a yaw slip ring and brushes, and generator brushes.

Left: The original Gemini synchronous inverter in its new home.

Below: The restored Model 45 Jacobs generator— as good as new!



The Gemini synchronous inverter was not part of a standard Jacobs wind-electric system. When interposed between a variable-voltage DC power source (such as a wind generator) and an AC grid, it converts DC electricity to AC and interties it—similar to modern grid-tie inverters.

The Gemini was caked with sawdust, so I completely disassembled it and cleaned it with acetone, alcohol, and flux remover. Some friends and I determined that several components needed to be replaced. One rectifier was bad, the voltmeter didn't work, and the generator-field-excitation circuit board was shot. (We guessed that the damage was caused by a lightning strike.) We ordered parts from various suppliers and eventually got it running again.

Tower Installation

To minimize the view of the tower by the immediate neighbors, I decided to place it among several trees on the property. A pier and pad footing was chosen for the 120-foot-tall Radian SSV self-supported tower. Three 6- by 6- by 10-foot-deep holes held rebar cages. Tubular cardboard concrete forms were centered on each protruding rebar cage for the upper 8 feet of the foundation. Anchor bolt assemblies were positioned and leveled inside the tubes, and the tubes filled with more than 11 cubic yards of concrete. A backhoe filled and compressed the dirt around the footings. Leveling nuts to support the tower were screwed onto the anchor bolts.

If you loved playing with erector sets as a kid, putting together a self-supported tower is about as much fun—just bigger—and you get to play with a crane to boot. The crane operator visited the site to discuss logistics, such as where to bring in the crane, the crane's location during the lift, the lifting capacity needed, and where to assemble the tower on the ground. Preparation was key to a successful tower lift as

Assembling the top tower section.

The crane lifts the 3,200-pound, 100-foot-tall tower section.

well as keeping the costs down: At $150 an hour for crane rental fees, I wanted to minimize lift-day delays.

Friends helped me assemble the tower in two sections—the top 100-feet and the bottom 20-feet—to allow use of a smaller crane. The tower legs were laid out and leveled on concrete blocks. Starting from the top and working down, we put together most of the top section in one day. Without jacks, a scaffold, or an A-frame, putting the tower together on the ground is definitely a three-person job. Once the top section was bolted together, we mounted 2-inch conduit along the length of the section and pulled the electric cables.

The Jacobs generator saddle, slip ring, and brush assembly were then attached to the top of the tower. Finally, the wiring was attached to the slip rings, which allow the wind turbine to yaw, or move into the wind, while transmitting energy to the wiring running the length of the tower.

Assembling the bottom 20-foot-tall tower section onto the footings without a crane required a lot more people power, since each of the three vertical legs weighs 180 pounds. Six people tilted each leg to a vertical position while three other people held ropes attached to the top of the legs, making sure the section didn't tip over. The cross-braces were mounted, and everything fit perfectly!

Once the crane was set up, the boom was extended toward the top of the horizontal 100-foot-tall tower section. Three slings were rigged to the three tower legs, approximately 20 feet down from the top of the tower. Then, the lifting began.

Once the tower was vertical, the crane operator lifted the upper section over some fruit trees and positioned it directly above the bottom section. Three of us harnessed ourselves onto the legs of the bottom section and guided the top legs into place. They lined up perfectly—we just dropped in the bolts and torqued the nuts. I then climbed up the tower to detach the lifting slings, and waited to mount the wind generator atop the newly placed tower.

Hampel Wind System Costs

Description	Cost
Tower	$10,600
Legal fees	3,640
Cement, paint, steel, aluminum, etc.	2,220
Wind turbine	2,120
Miscellaneous	1,860
Equipment rental	1,360
Balance of system	1,250
Labor	870
Grid-tie equipment & inverter repair	460
Total	$24,380
Less Wisconsin Focus on Energy rebate	-$5,940
Final System Cost	$18,440

Regulatory Hurdles

With the wind generator and inverter refurbished, I had to work on getting approval for installing the system. First, an expert from Wisconsin Focus on Energy, which works with residents and businesses to install cost-effective energy efficiency and renewable energy projects, performed a site assessment. Focus on Energy requires that the entire wind turbine rotor should sit at least 30 feet above any obstruction within a 500-foot radius of the tower. Remembering that trees grow and towers don't, I estimated tree heights for the next 20 to 30 years to determine the tower's height. My 1.3 acres has a 70-foot-tall tree to the west, and to the east is a 40-acre white pine forest with trees that will probably reach 75 feet. The site assessor recommended a minimum tower height of 112 feet, and I rounded up to 120 feet.

Unfortunately, my proposed tower location didn't meet property-line setback requirements, so I had to request a variance through the Merton Zoning Board. In September 2005, I had to attend a public hearing before the Merton Zoning Board of Adjustment (BOA). After I described the project and answered questions from the board members, the meeting was opened to the public. The concerns were declining property values, audible noise, and visual impact to the neighborhood. Our suburban neighborhood homes are about 30 years old and sit on 1- to 3-acre partially wooded lots.

My request for a variance was denied—but after all the elbow grease and sweat I'd put into bringing the Jake back to life, I was determined to see it fly. With the help of an attorney who is recognized as an expert in small wind-turbine legal issues, I appealed the decision.

After numerous discussions between my attorney and the town attorney, and four more public hearings, the BOA granted my variance—but with fifteen conditions attached (including a 70-decibel noise limit at the closest property line, and a requirement that a structural engineer verify that the tower was installed according to the manufacturer's specifications). After almost six months of effort, I finally received a building permit to erect the wind turbine.

Mounting the rotor assembly to the generator. Temporary coverings protect the blades from damage.

The crane lifts the Jake skyward to its new perch.

Back In the Saddle Again

Then came the moment I'd been dreaming about—getting the wind generator into the air. The crew on the ground attached the generator to the crane, and the 14-foot-diameter blade rotor was attached to the generator. The governor springs were fastened and tensioned, and the crane hoisted the whole assembly to the top of the 120-foot tower.

The challenge was that a Jake generator with its rotor assembly attached doesn't hang perfectly level from the lifting eyebolt—the weight of the rotor assembly causes the generator to tilt downward at the rotor end. At 120 feet in the air, I had to exert a lot of ergs of energy to get the three mounting bolts to align. Luckily, we had tied a 150-foot rope to the generator before lifting it to the top of the tower. That way, my helpers on the ground were able to pull the rope to help me get the assembly level, so I could attach the generator to the saddle.

With the generator and rotor assembly secure, the final lift was the tail vane. The trick was to properly tie a rope to hold the vane horizontal during mounting, yet still allow the rope to be easily untied from atop the tower once the vane was in place.

Once this was completed, I felt an overwhelming sense of relief. As I stood, harnessed at 120 feet, with the very machine

I had read about all those years ago, I thought that perhaps it would have also made the late Representative Reuss proud to see his old Jake ready for action again.

Ironically, from my 120-foot perch, I was able to see several famous landmarks in the region and also the very spot from which I had recovered the Jake. The fact that it was now in place on my property and ready for my family brought back pleasant childhood memories of time spent with my father working on wind turbines. I hope that this experience also will instill a sense of environmental responsibility in my son.

Final Touches

Getting the Jake up on the tower wasn't the end—we still needed to wire the system. Because this system was eligible for net metering, an interconnect agreement and site inspection was required by the local electric utility, and a sign-off was needed from the local electrical inspector. They gave their approval—almost three years to the day after I first set eyes on the old Jake!

An average wind speed of 11.8 mph should generate about 400 kilowatt-hours per month, providing roughly two-thirds of our electrical needs. Presently, five loads (see "Household Loads" table below) account for about 90% of our home's electricity use.

With the Jake running, we're more motivated to see how we can minimize our energy usage by implementing conservation measures and upgrading to more efficient appliances. I am also pleased that since our Jake was erected, it has generated many positive responses from people in the area. In fact, more than one neighbor has expressed interest in installing a wind turbine.

Courtesy Roger W. Hoge

The restored Model 45 Jacobs wind-electric generator, rebuilt and reinstalled at the author's property.

Household Loads

Item	KWH / Month	% of Total
2 Refrigerators	225	37.8%
Dehumidifier	90	15.1%
Air conditioning	82	13.8%
Lighting	75	12.6%
Gas furnace blower	63	10.6%
Clothes washer	10	1.7%
Gas clothes dryer (spin motor)	10	1.7%
Computer	10	1.7%
Television	9	1.5%
Well pump	8	1.3%
Microwave oven	5	0.8%
DVD recorder	4	0.7%
Toaster	2	0.3%
Vacuum cleaner	2	0.3%
Total	595	

Getting an arguably famous Jacobs Wind Electric system back up and running again was a dream come true. If you see a turbine standing idle in the wind, stop to imagine the possibilities of generating your own electricity and helping to make a cleaner world for our children. Then put your dream into action!

Access

Willi Hampel (willi.hampel@gmail.com) is a Wisconsin-based professional engineer with more than 20 years of experience designing medical diagnostic imaging equipment. He has more than 30 years of experience installing and maintaining residential wind turbines.

Curtis A. Eggert • 218-829-4394 • Jacobs parts

Mid-State Electronics • 920-787-7383 • Inverter repair

Pantec Studio • 262-692-6157 • pantec2@msn.com • Blade repair

Radian Communications Services Corp. • 309-697-4400 • www.radiancorp.com • Tower

Sagrillo Power & Light • 920-837-7523 • msagrillo@itol.com • Expert advice

Schober, Schober & Mitchell S.C. • 262-785-1820 • www.schoberlaw.com • Legal advice

Do-It-Yourself

TIPS FOR SOLAR HOT WATER SUCCESS

by Bob Inouye

photos by Nile Woods Photography

One homeowner shares the challenges and rewards of installing a solar hot water system at his home near Naches, Washington.

Thirty-five years ago, when my wife and I were college students living on a budget, the house we called home was a dirt-floored log cabin in northwestern Montana. We had no modern conveniences—just a cookstove for warmth, an underground pit for keeping food cool, an artesian spring for filling the old cast-iron bathtub, and an outhouse built from a leftover Steinway piano crate. Ah, the good life.

It's easy to wax nostalgic over those bygone days of the 1970s, when oil shortages pushed the then-novel idea of renewable energy (RE) into the limelight. When it came to RE solutions for the home, most people experimented, with one eye to basic science and another to the spare parts bin. We were no different. Back then, our solar hot water system was nothing more than a black metal barrel in a wooden box with an old window mounted to the front, facing south.

These days, as I seek to improve the energy efficiency of our modern home in Yakima County, Washington, I am continually amazed by how much the times have changed. Information is abundant, and prefab parts are plentiful—to the point of being overwhelming for greenhorns on the DIY RE scene. When I started researching a solar hot water (SHW) system for our three-bedroom home, I had no delusions about the project's complexity. I knew that installing and maintaining a modern system would be a tad more involved than our previous "black barrel" method. For one thing, this time, my basic plumbing and electrical skills were up against two existing electric water heaters and 13-year-old plumbing in hard-to-reach places.

All I can say is thank goodness for the ever-evolving home improvement genre. Taking notes in the margins of back issues of *Home Power* and studying online resources armed me with more information—and much-needed confidence—to tackle the task. First up: determining which system would work best for our home, budget, and site.

Picking & Choosing

In our sometimes-snowy region where winter temperatures drop below 0°F, the logical choice was a closed-loop system. Unlike open-loop systems that pump potable water through the collectors and piping, closed-loop systems circulate a solution (usually propylene glycol antifreeze) through an isolated loop between the collectors and storage tank. A heat exchanger transfers the solar-generated heat to the domestic water system.

Although I'd considered high-tech evacuated-tube collectors, the cost-effectiveness of flat-plate collectors won me over, and I already knew what I wanted: low-iron tempered glass for good sunlight transmission and longevity, a selective coating for more efficient heat gain, sturdy frame construction for durability, and polyisocyanurate insulation on the collector's sides and back to minimize heat loss. A number of manufacturers make flat-plate solar collectors that fit my criteria, so my decision became more about the manufacturers and their retailers than the collector itself. I evaluated each on pricing, customer service, Web sites, and shipping costs. Then, I considered the feedback from

Top: Backfilling the support posts.

Middle: Drilling holes for bolts that will secure the crossbeams and add rigidity to the posts.

Bottom: The floor is stoutly framed to support the solar hot water storage tank.

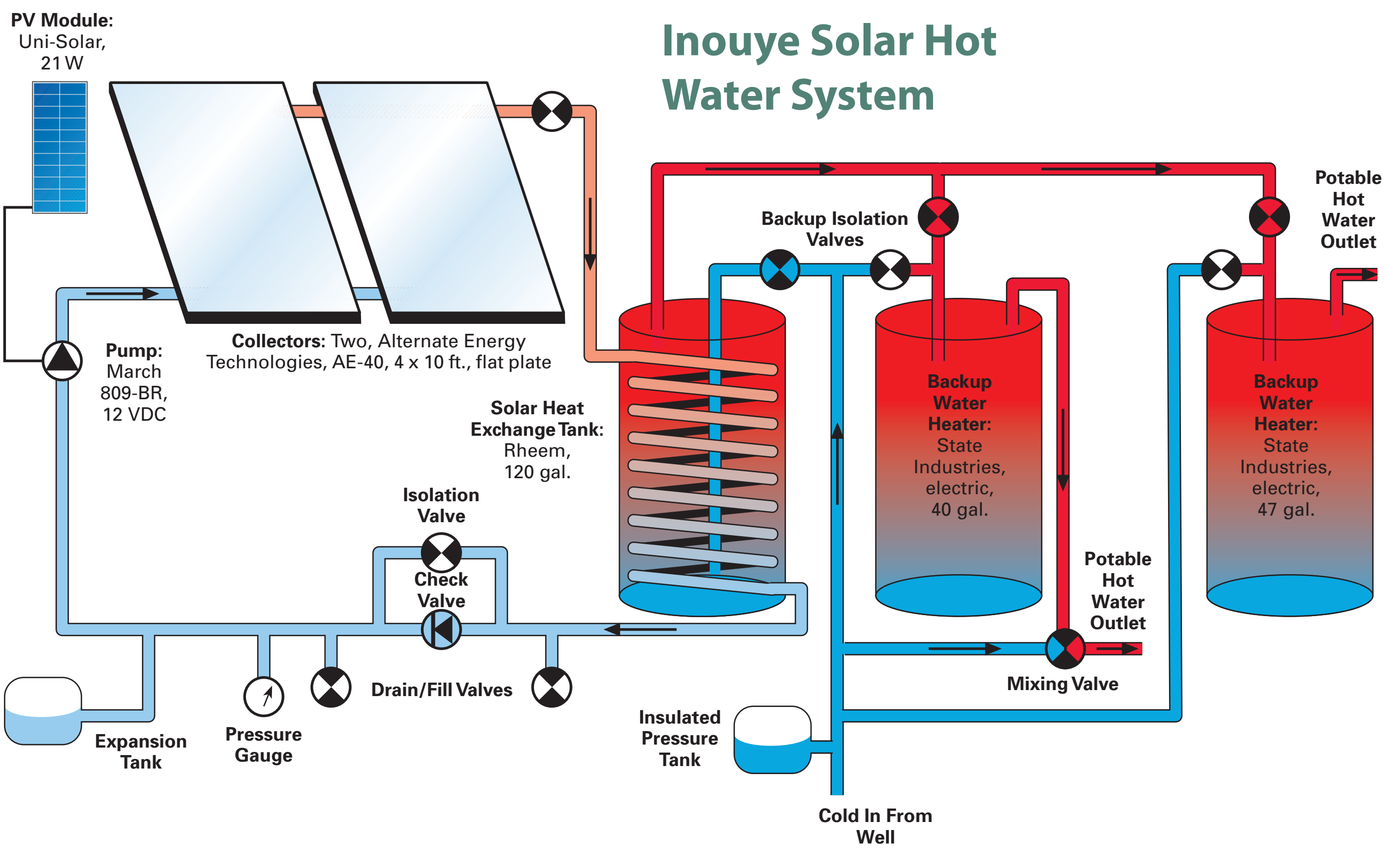
The framework—
ready for insulation and a roof.

articles in *Home Power* and performance data collected by the Solar Rating and Certification Corporation.

Collectors and storage tanks come in many sizes, and the most appropriate ones for your application will depend on your household hot water usage and the amount of solar radiation at your site. The average American uses about 20 gallons of hot water per day, so it seemed reasonable to assume that 40 square feet of collectors and 80 gallons of hot-water storage would be ample for a two-person household in the Pacific Northwest. But because our country lifestyle entails heaps of dirty work clothes, bathing muddy dogs and horses, and hot baths after a long day of chores, I decided to supersize the system rather than rely on our existing electric hot water tanks to make up for production shortfalls. I settled on 80 square feet of flat-plate collectors and selected a 120-gallon storage tank for extra storage capacity, to tide us over during cloudy spells, winter months, and high-use periods.

After specifying the collectors and storage tank, I needed to choose a circulation pump for moving the antifreeze solution through the system (see "Pick the Right Pump" in *HP121*). Without circulation, temperatures in the collectors can climb as high as 400°F and overheat the antifreeze solution—causing the glycol to break down. As a result, the system loses its antifreeze protection, and the solution must be drained and replaced.

Inouye Solar Hot Water System



The less expensive option is a standard 120-volt AC pump, switched by a controller that receives input from two or three temperature sensors, one at the collectors and one or two at the storage tank. The more expensive option up-front is a 12-volt pump driven by a solar-electric module that powers the pump when the sun shines. Though both of these pumping strategies reportedly work well, I put my faith in the sun and a 21-watt PV module. In our remote location, where utility outages can be counted on, the sun is a more reliable power source.

Solar Siting

Once I'd specified the components, deciding where to mount the collectors was tricky. A variety of factors came into play, including limiting shading of the collectors, roof strength, insulation, and aesthetics. In our area, getting a local building permit to add weight to an existing roof is either difficult or impossible. With retrofitting out of the question, and to preserve views and avoid disturbing some nearby landscaping, I decided to mount the collectors on the roof of a purpose-built shed just south of our home.

The almost-complete closed-loop plumbing. The original spring-type check valve was replaced.

The completed plumbing, wrapped with high-temperature insulation and equipped with a swing-type check valve.

The well-insulated shed was sized just large enough to accommodate the tank and mechanicals.

The shed's insulated interior accommodates the storage tank and other mechanicals. This saved space inside the house and simplified the plumbing between the collectors and storage tank, making it shorter and limiting heat loss. As an unexpected benefit, the collectors' position on the shed allows the early morning sun to hit the exposed backside of the collectors, which causes a slight temperature rise in the closed loop even before the sun hits the glazing.

Lessons Learned

Although no two DIY installations are ever identical, systems do share some similarities. The first mantra for a successful installation is that good planning goes a long way. Here are some valuable lessons I learned from my installation.

Map out your plumbing route. Put some thought into how your new feed line will run from the SHW storage tank to your pre-existing hot water tank. Look for a route that will provide short-term benefits (ease of installation) and long-term dividends (shorter lines for less heat loss).

While connecting the two existing tanks and the new tank in the shed, I spent a lot of time getting cozy with tight crawl spaces while soldering pipes, pressure-testing connections, adding support for and insulating the pipes, and then installing temperature sensors. If possible, use an above-floor route that is more installation-friendly than mine.

Prepare for high heat. The hot closed-loop exchange pipes between the collectors and the solar storage tank call for special insulation that can withstand high temperatures. Ordinary foam insulation sleeves are not designed to hold up

The flat-plate collectors in place, but not yet plumbed. The collectors were canted slightly to the right to facilitate drainage and thermosiphoning.

against the higher temperatures produced by solar collectors. UV-resistant rubber pipe insulation rated up to 220ºF works well but can be difficult to find locally. The piping coming out of the storage tanks is not subjected to the high temperatures present in the closed loop, and ordinary pipe insulation works well.

Keep the heat. Insulating your existing hot water tank will keep heat loss to a minimum. I added fiberglass insulation blankets to both storage tanks.

Consider your source. The warmer your source of domestic cold water, the hotter your output from a solar hot water system. Our home is fed by a 98-foot well with 50°F water. Originally, our well's pressure tank had no insulation. As a result, the cold-water temperatures would drop significantly in winter. When replacing our leaking pressure tank, I wrapped the new tank with 6-inch-thick fiberglass insulation, added several inches of solid foam-board insulation on top, and enclosed the tank in a draft-free wooden box. Now, in the winter, I get 45ºF water feeding the house and the solar storage tank, and no longer have to heat the pressure tank with a 120-volt heat lamp to keep it from freezing.

Pay Now, Save Later

As is true of most RE systems, the financial rewards for solar-powered hot water trickle in slowly over the system's

Fundamental SHW Lessons

Check the valves. The package I purchased came with a spring-controlled check valve, which has the advantage of working either vertically or horizontally. However, this particular one required more opening pressure than the circulation pump could provide. After diagnosing the problem, I cut the pipes, redesigned some of the routing, and switched to a swing-type check valve. Though swing valves won't work vertically, they open with less pressure and are more reliable over time. Spending the extra $6 for this check valve at the start could have saved me both time and money.

Avoid overheating. During low- or no-use periods, the glycol solution in closed-loop systems can overheat if hot water in the storage tank is not being drawn out for household use. Our oversized system will sit idle occasionally when we are gone on vacation. To avoid overheating, I added a manually operated "vacation bypass" on the closed loop. In vacation mode, this ball valve routes the antifreeze mix around the check valve. This allows heat from the storage tank to thermosiphon upward and radiate through the collectors at night, cooling the water in the tank so it won't overheat the next day.

Check your thermostat. Before installing our SHW system, we had to keep our electric tank-type heaters' thermostats set relatively high (145°F) to produce enough hot water to fill the bathtub. Now that the electric tank is fed from the SHW storage tank, we found that its thermostat could be turned down to 120°F.

Temper your hot water. Domestic water from SHW systems can reach temperatures of 160°F or more, which is dangerously hot for human use. A tempering valve mixes enough cold water into the hot water line to prevent scalding water. Make sure to place one where the hot water exits your final hot water tank, and that will cover all the taps in the household.

Let the air out. Air bubbles in the closed loop can hamper the flow of the antifreeze solution. Though I was careful about filling the closed loop, some air bubbles lingered in the system. A manual ball valve (to preclude leaks) topped with a Schrader valve (to purge trapped air) allows you to manually release trapped air without losing antifreeze. Place the two valves at the highest point in your closed-loop system, where the antifreeze solution exits the collector and air bubbles will collect. You'll only need to use the valve once or twice after filling the closed loop.

Calculate your optimum mix. The percentage of glycol in your heat-transfer fluid depends on your local temperatures. Too much glycol makes the mix more expensive and less efficient; too little glycol leaves your system vulnerable to freezing and breakage. For our local temperatures, the ideal mix is a 40% glycol solution, which I determined based on recommendations in Bob Ramlow's book, *Solar Water Heating*.

lifetime—which can range from 20 to 30 years. All said and done, this project, including shed construction and mechanical installation, took three months of spare evening and weekend hours, and cost almost $7,000.

Since the system only came online in September 2007, it's too early to accurately predict our monthly savings, but I can say that it has required little backup so far. By staying attuned to the weather and running the big laundry loads on sunny days, we minimize the number of kilowatt-hours we consume from the grid to heat our water.

Compared to our monthly electric bills for the past six years, the first three months of operation with the new system show that our average usage has dropped by 547 KWH per month. At our current rates ($0.07 per KWH), that reduction amounts to a savings of $38.29 per month.

After accounting for the $2,000 federal income tax credit and lower monthly bills, I suspect that we'll likely have recouped the expense of installing the solar hot water system in eleven years—although it could be longer, depending on future repairs. That payback time is more than reasonable when you take into account that electricity rates have gone up 19% in the last two years and will continue to climb, and considering that I liberally sized my SHW system. Plus, the new system nixed my plan to spend at least $1,000 on a new front-loading clothes washer, which would have used less hot water.

But the ultimate reward is a good sun-heated bath for my aching joints after a long day of work—and knowing that we are doing our small part to reduce demand on non-renewable resources.

Access

Bob Inouye (email@inouye.us) lives with his wife Carol in the foothills of the Cascade Mountains in Washington. The couple happily shares 180 forested acres with horses, mule deer, elk, turkeys, beaver, salmon, and steelhead. Solar hot air collectors are next on their RE drawing board.

System Components:

Aero • www.aeroflexusa.com • Pipe insulation

Alternate Energy Technologies • www.aetsolar.com • Collectors, circulator pump

The Alternate Energy Store • www.altenergystore.com • SHW storage tank, thermometers, propylene glycol

Uni-Solar • www.uni-solar.com • PV module

Solar Water Heating, A Comprehensive Guide to Solar Water and Space Heating Systems, by Bob Ramlow with Benjamin Nusz • www.arthaonline.com/bookpage.html


The TriMetric
Model 2020
BATTERY SYSTEM MONITOR
Displays vital battery system data to help users provide better battery care, increase conservation awareness and aid system maintenance.
• Volts • Amps • Amp-hours • Min/Max volts
• Days since charged • Battery % full
• Remote locatable • About $169
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Bogart Engineering PentaMetric

Battery Monitor

by Ian Woofenden

Application: The PentaMetric is a three-channel DC monitor that can record energy produced and used in DC systems, as well as battery state of charge (SOC).

System: We installed a PentaMetric in my family's complex, off-grid renewable energy system, to independently monitor the production from three wind generators.

Operating a renewable energy system without metering is like driving a car without instrumentation. Can you imagine not knowing how fast you're going, what your fuel level is, that your alternator is not functioning, or that your oil pressure or engine coolant temperature is at a dangerous level?

Good metering is also important in a renewable energy system. In one common configuration, Bogart Engineering's PentaMetric DC monitor provides in-depth information on the SOC of your battery pack, and also independently monitors two additional RE inputs, such as a PV array and a wind turbine.

The Importance of Good Metering

An off-grid RE energy system can have a variety of needs for metering, including:

- Battery SOC
- PV, wind, hydro, or engine generator charge amperage, wattage, and watt-hours produced
- Load amperage and wattage

Battery SOC metering is essential in battery-based systems. It shows you how much energy you can use, and when you need to conserve energy or start the backup generator. General SOC information is usually displayed as a percentage of "fuel" remaining in the battery bank. In addition, some battery monitors track historical data, like the last time the battery bank was fully recharged or how many days it has been since you've equalized the pack. Good information is an important tool for maximizing the life span of your battery pack.

While most off-grid systems use a battery monitor to track battery SOC, separate production metering is useful for verifying that your generating sources are working as expected and within specifications. Without it, you may not even know if your whiz-bang wind generator is barely producing, or that you are not getting full output from your PV array, which could indicate a bad connection in your wiring.

Load metering is also a good tool, helping you know how much energy your appliances are consuming. While most or all of the appliances used in off-grid homes these days are AC, if you are running DC appliances like a freezer or pump, the PentaMetric can track their energy use independently. It can give you a clear picture of whole-house or specific appliance energy use. And you can monitor the benefits of energy-efficiency upgrades to your home. The PentaMetric is only capable of DC load monitoring and/or whole-system monitoring of the DC output to a battery-based inverter—it will not monitor AC circuits.

Company & Products

Bogart Engineering is a small family business in northern California that has been making electronic equipment for the RE industry for almost 15 years. Owner Ralph Hiesey has a

Tech Specs

List Price: $418 for input and display; $100 additional for computer interface

Warranty: 1 year

Features

Compatible with 12 to 48 V nominal battery banks

Total draw of both units is 1.5 W, maximum

Input and display units are each $4\frac{1}{4}$ x $6\frac{1}{2}$ x $1\frac{3}{4}$ inches

Computer interface is 4 x 2 x 1 inches

Measurement Options Include:

Voltage—two battery banks

Amperage—three channels

Amp-hours—three channels

Cumulative battery amp-hours—two channels

Watts—two channels

Watt-hours—two channels

Battery SOC—two channels

Days since charged—two channels

Days since equalized—two channels

Temperature—max. and min.

Auxiliary relay

Audible and visual alarms

High Points:

Comprehensive datalogging

Three-channel capability

Many features

PC interface

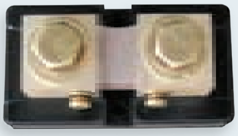
Audible low-voltage alarm

Low Points:

Many features—complex

Less than user-friendly interface and documentation

What's a Shunt?



A shunt is an electrical device that has a precisely measured resistance. It is normally wired into the negative lead of a renewable energy system between the battery and its charging sources and loads. The large lugs on the shunt provide a means to wire it in series with the circuit to be measured. The small screws (Kelvin terminals) receive the sensor wires that go to the meter.

Measuring voltage drop across the shunt's precisely calibrated resistance allows a meter to calculate the amperage through the shunt, using Ohm's law (Amps = Volts ÷ Ohms). So a meter can become a "bean counter," using internal programming to calculate the charges (amp-hours) and therefore energy (watt-hours) moving in the system.

background in math and electrical engineering, and has lived off grid with a PV system since 1985. Early on, he realized the importance of understanding his system and decided to design a meter to help him do this. In 1993, he introduced the TriMetric battery monitor, which has been widely used in RE systems over the years. It monitors voltage, amperage, and amp-hours, along with a range of additional data, via a single shunt (see "What's a Shunt?" sidebar, above right).

About two years ago, Bogart released the PentaMetric, which can monitor information from three individual shunts. Many off-grid renewable energy systems are hybrids, with more than one energy source, and the PentaMetric makes it convenient to concurrently monitor, for example, battery SOC, solar-electric input, and wind-electric input.

Installation

Physical installation and wiring of the PentaMetric was straightforward. The meter includes an "input unit" to collect and process the data obtained with its nine-pin wiring connector and the display unit. Shunts and sensor cabling were not included with the meter. We flush-mounted the display unit in a large, metal enclosure that houses additional metering for our system, and we surface-mounted the input unit inside the same box.

We already have a TriMetric functioning as a battery SOC meter. Since we wanted to monitor three wind generators, we didn't use the battery SOC function on the PentaMetric. We installed three 100-millivolt/100-amp shunts in the negative runs between the wind generator DC outputs and the battery pack. The sensor wiring took some delicate work, but the diagram in Bogart's detailed manual clearly showed us what to hook up where.

Programming

Setting up the PentaMetric's programming was less straightforward. This unit, as the extensive manual admits, is "complex." I would say that it's too complex for most RE system owners, techno geeks aside. Its many features are undoubtedly useful, but for me, understanding and programming all of them seems like a complicated chore. We initially had trouble getting the meter to function properly but eventually figured out that we needed to switch an obscure setting to get all three channels to read production accurately.

PentaMetric designer Hiesey says that one explanation of the "Penta" in the product name is that there are five main buttons across the display unit. (It also has five input channels—two for voltage and three for amperage.) These buttons allow you to display five categories of data, including volts, amps, amp-hours, watt-hours, SOC, and number of days since charged. These fields are user programmable, and the display has handy plastic pouches for labels—your own or the ones provided with the meter.

We set up our meter to measure voltage, amps, and amp-hours, the appropriate categories for monitoring our three wind turbines. I was initially excited to read that the PentaMetric would display charging data in both watts and watt-hours, but this feature is limited to only two of the three meter channels. I hope that in future versions, we'll see watts and watt-hours on all three channels, since these are the measurements most people are used to working with. After all, we buy and sell electricity in kilowatt-hours, and measure the rate of energy use and generation in watts.

One great feature we did not use is the optional computer interface, which allows you to program the meter and log data via a Windows-based computer. Since we're a Mac household, I haven't tried this, but I gather it makes the programming and information analysis much easier. The computer interface can store months of data, depending on the frequency and number of measurements taken.

Techie Meter

Don't expect this meter to be plug and play, or completely intuitive. It is indeed complex, and the documentation, while complete, is not easily comprehended. Hiesey is the first to admit that this meter is not for everyone. Bogart's TriMetric battery monitor will serve the needs of most off-grid RE system owners, who primarily need to keep track of battery SOC. For more complex systems, and for system owners who want to quantify the energy produced and used in their systems, the PentaMetric can do the job. Check out the product instructions on the Bogart Engineering Web site to see if it's appropriate for your system. We've found it to be a useful device for comparing wind generator outputs, both instantaneous and cumulative. The PentaMetric is a good addition to our stable of meters, and the company gives great support when needed.

Access

Ian Woofenden (ian.woofenden@homepower.com) lives off grid in Washington's San Juan Islands, and spends a bit too much time watching the meters on his solar-electric, wind-electric, and solar hot water systems.

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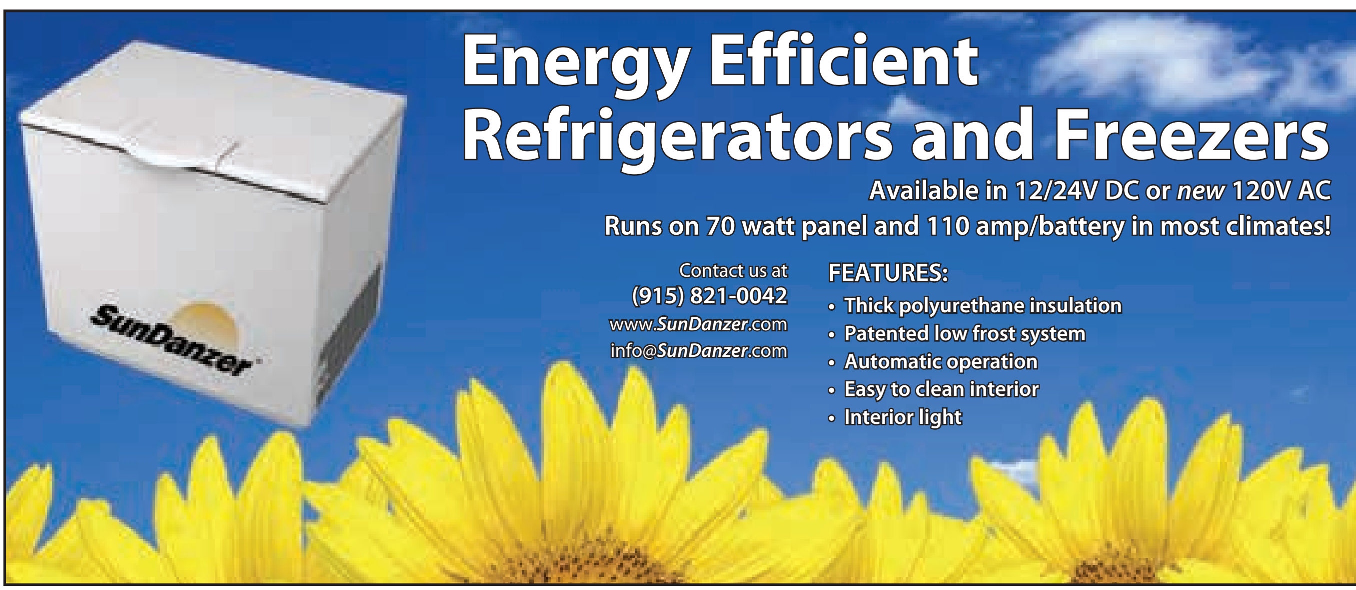
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RE Independence in Nicaragua

by Andreas D. Karelas

Several remote communities along Nicaragua's Caribbean coast now enjoy the benefits of clean energy produced by PV and wind-electric systems.

On the hills along Nicaragua's Caribbean coast, hand-built wind turbines spin with the seaside winds, providing remote villages with clean electricity for lights, CB radios, and small appliances. In these communities, where indigenous Mestizo and Creole people live in thatch-roofed huts, even a small amount of clean electricity can have a huge impact on their quality of life.

With nearly half the world's inhabitants and only a fraction of the world's wealth, developing countries such as Nicaragua are more susceptible than developed nations to the crippling financial effects of rising fuel prices. Unlike the coal-based United States, Nicaragua is particularly vulnerable, since nearly 80% of its electricity is fueled by imported oil. Along the country's Caribbean coast, where approximately one-tenth of the country's population lives, the situation is particularly grim. More than 70% of the region does not have electricity, according to Nicaragua's Ministry of Energy and Mines (MEM).

As the poorest region in the country and the second poorest in the Western Hemisphere, Nicaragua's Caribbean coast suffers from high unemployment, illiteracy, and primitive health care. A thick jungle to the west and inadequate infrastructure—a lack of roads and bridges within the region and connecting to inland points—isolates the coastal communities from fruitful commerce, contributing to massive migration to the country's bigger cities.

But one nonprofit organization—blueEnergy—is making a difference in this region by providing affordable and sustainable energy solutions that empower these small communities and the people in them. Because blueEnergy manufactures wind turbines and other key components locally, they can keep energy costs low and improve equipment serviceability, while boosting employment where it is desperately needed. And, with this less expensive energy, they can also help foster sustainable economic growth. Fourteen local men and women are employed at blueEnergy's locations throughout Nicaragua, receiving on-the-job training, RE know-how, and computer skills.

A Shift to Sustainability

"With diesel fuel more than $5 a gallon and difficult to transport, and no hydro power nor geothermal resources, wind is a natural and preferred choice for Nicaragua's Caribbean coast," says Mathias Craig, the executive director and cofounder of blueEnergy.

The organization got its start in 2002 as a class project at the Massachusetts Institute of Technology before being incorporated in 2003 and opening offices in France, Nicaragua, and the United States. Its mission is to develop a model of low-cost, sustainable electrification of remote, off-grid communities that can be replicated around the world.

For now, the organization focuses its efforts exclusively on project development in Nicaragua, where the MEM expressed interest in using blueEnergy wind turbines countrywide for unmet energy needs. BlueEnergy maintains offices in Managua and Bluefields, and the organization has built and installed eight energy systems along the Caribbean coast.

In the Meskito community of Kakabila, a new system—200 watts of solar-electric modules and a 1-kilowatt wind turbine mounted on an 80-foot tilt-up tower—provides electricity for two schools and a community center. Further north, strong and smooth coastal winds propel a new 1 KW turbine on a 40-foot tilt-up tower, which provides primary power for a school in the small fishing community of Set Net.

"The solar resource on the Caribbean coast of Nicaragua isn't stellar, but it's good," Craig says. "We use small amounts of solar electricity to supplement energy production during low-wind months. This allows us to size our wind system optimally and use smaller battery banks for energy storage, thereby reducing life-cycle cost."

Wind at Work

BlueEnergy's systems are assembled locally at a wind-powered shop on a campus of the National Technical Institute, a government-sponsored secondary school for aspiring engineers, mechanics, and technicians. In June, the crew completed its third and largest energy system installation at the Bluefields location—a 12-foot-diameter, 1 KW turbine mounted on a 100-foot lattice tower.

In the shop, equipped with two welding machines, an air compressor, an acetylene torch, and other modern shop tools, a crew of local employees and international volunteers work year-round, fabricating hybrid wind/solar systems. Wind turbines are based on wind guru Hugh Piggott's design, which uses locally available metal and parts. Other equipment is purchased from nongovernmental organizations and RE distributors in Managua (see "Sustainable Energy at Monkey Point" sidebar).

A blueEnergy volunteer carries a PV module down a narrow jungle path to the installation site.

In addition to electrifying schools and community centers, blueEnergy's systems serve as community battery-charging stations. With a loan of approximately $400 through a local microfinance agency, community members can purchase battery kits, which include a 12-volt, deep-cycle, 105-amp-hour battery and a battery box. These batteries can power lights, radios, and small appliances at homes or businesses. Users pay a small fee to charge their batteries, with the cost determined jointly by the community and blueEnergy. Revenue earned goes into a community energy fund, which is used to operate and maintain the renewable energy systems.

Community Collaboration

BlueEnergy relies heavily on word of mouth and community meetings to attract new projects. In most cases, the villages seek out blueEnergy after seeing a system in a neighboring village.

The process begins with an assessment to determine if an RE system would be appropriate for the community. Based on established criteria, blueEnergy evaluates the local electrification need, site-specific wind and solar potential, and most critically, how the community organizes itself and handles community responsibilities.

BlueEnergy systems are custom designed for every application, with costs typically ranging from $10,000 to $20,000 for an installed system. This cost is expected to go down as blueEnergy expands its operations. Through grants and private donations, the nonprofit currently bears all the monetary costs associated with manufacturing and installing the systems. Instead of cash, the community contributes a fair amount of equity in labor, food, lodging, transportation, and, occasionally, materials for sheds or storage buildings to house components.

"It is absolutely critical that the community understands that they have to give something up to get the system," Craig says. "We give them the ideas, but they have to be willing to work for it and take ownership of the system."

(continued on page 98)

Sustainable Energy at Monkey Point

Mathias Craig remembers the night last summer when the lights came on in Monkey Point, Nicaragua. “I was in awe,” the 29-year-old blueEnergy cofounder says, recalling the laughter and excited chatter that rang throughout the crowded school building after the community’s hybrid wind- and solar-electric system was up and running.

For the 300 residents of Monkey Point, a remote village roughly 30 miles south of Bluefields on Nicaragua’s south-central Caribbean coast, the moment marked the first step toward freedom from generators and lanterns fueled by expensive, imported diesel fuel. The hybrid wind–PV system, the community’s first renewable power source, provides about 150 kilowatt-hours (KWH) of electricity per month—enough to power lights for the school and a community radio, and to charge batteries for the health clinic and eight homes.

Preparing to lower the tower.

Configuring Components

A blueEnergy team member flew to Managua to purchase the PV modules, batteries, and other electrical components. This equipment arrived days later after first traveling by bus and, then, by supply boat on the Río Escondido. Meanwhile, back in Bluefields, the crew got to work constructing the wind turbine and tower. Here’s a look inside their process:

Electrical. The electrical assembly is key to transforming the wind into electricity. The wind generator’s stator, a metal plate embedded with twelve copper coils and sealed with resin, is precisely positioned between two metal plates (“magnet rotors”) embedded with powerful neodymium magnets. As the blades of the turbine spin, the magnetic flux created between the magnet rotors cuts through the copper coils, inducing the flow of electricity. The wild alternating current (AC) produced by the turbine has variable voltage and variable frequency, which is rectified into direct current (DC). In the power shed, the DC goes through a charge controller to a battery bank that stores the wind-generated electricity. An inverter converts the DC into AC needed for common appliances.

Village children help carry conduit from the boat.

BlueEnergy’s Nicaragua director Guillaume Craig (center) works with community members to attach blades to the turbine.


In the shop, blueEnergy team members test the stator (left) and set rotor magnets in resin (right).

Children proudly gather around a wind turbine that provides pollution-free electricity for their community center.

Mechanical. The turbine's three blades start out as thick, rectangular blocks of locally harvested caoba hardwood. Over three days, woodworkers use a mix of saws, drawknives, planes, chisels, and sandpaper to shape the each block into a sleek airfoil—6 feet in length to match the size and power of the alternator. To protect the wood from the elements, the blades are then painted with multiple coats of fiberglass resin. The blades, magnet rotors, and stator are bolted to a metal frame that workers fashion from welded angle iron. Layers of plywood, fiberglass, and resin form the tail vane that is attached to the back of the turbine body on an angled hinge. Together, the tail and hinge make a passive furling system that turns the turbine out of high winds to protect itself.

Tower. BlueEnergy's metal workers assemble the tilt-up tower from domestically available 20-foot sections of steel tubing, about 4 inches in diameter. At the shop, the 5/16-inch steel cables used to anchor the tower at the site are cut and then painted to protect the cables from corrosion.

At the Site

Monkey Point is only accessible by a five-hour boat ride across often-rough waters, and crew and equipment were transported in traditional open-top wooden boats. Torrential rains and wicked winds plagued several of the voyages, leaving blueEnergy's crew members scrambling for refuge beneath garbage-bagged gear and any covered nook or cranny in the boat's well.

After hours of bailing water from the bottom of the boat, crews arrived to face the greatest challenge of the installation: carrying 30 bags of cement, an 80-foot tower, hundreds of feet of cable, and all the other components and tools up the muddy, steep path to the top of the hill.

Several of blueEnergy's most industrious members had helped the locals prepare the site weeks before the equipment and rest of the crew arrived. For six days straight, this team worked through unforgiving heat and humidity, digging five holes—about 6 feet deep, 6 feet long, and 3 feet wide—for the anchors and the tower's foundation.

Four anchors for the guy cables were fashioned out of 10-foot lengths of 3/4-inch rebar, which were bent at the workshop to form a hook at one end. The hooked end was connected to a rebar grate at the bottom of each hole and surrounded by about 100 pounds of concrete. After the holes were backfilled with dirt, only the top piece of each anchor protruded from the ground. Pre-drilled, triangular-shaped metal pieces were welded to the rebar to serve as the connection point for the guy wires that support the tower.

A few weeks after the anchors had been placed, the full blueEnergy crew, about 12 people, arrived back at the site. Over several days, the system was assembled on the hilltop, which offered another challenge: stringing the power transmission cable safely through 150 feet of thick jungle. The method of choice: tying a rock to one end of a string and launching it through Y-shaped branches along the path, then pulling the wire with the string. Four machete-wielding volunteers braved spiders and lizards to clear the way for the wire, while launching lines through the forest canopy.

Since the villagers had already constructed a storage shed for the balance of system components, mounting the PV modules on the roof and making the final connections was fairly straightforward. The highlight of the installation came on the last day in one glorious moment, when more than 20 volunteers and community members secured the guy wires to their respective anchors, and raised the tower and wind gennie into the air.

Powerful Potential

With some wind, a little sunshine, and the flick of a switch, life in Monkey Point is changing. A school building that once sat vacant after sundown now serves as a community center for meetings, celebrations, and late-night church services. Families that once relied on jars of diesel fuel with burning rags for light now read by electric fluorescent lights or listen to worldwide events on the community radio. "We are living in an historical time," says Pearl Watson, a resident and nurse in the community. "Having electricity in Monkey Point is truly something great for our development."

To this end, blueEnergy asks the community to form an energy commission, made of six to eight members who are elected by the populous. This group serves as a tool through which the community manages the system.

It is the community's responsibility to maintain the system once it has been installed. Regular preventive maintenance involves lubrication, stripping off corrosion from the turbine housing, sanding down any defects in the blades, and repainting the body of the turbine. The blueEnergy team provides an extensive training program that prepares community members for these tasks, and commits to helping local operators work through problems and repairs.

"By the time we leave, the communities understand how to fix and care for the system, but whether they choose to follow through in the long term and adopt renewable energy as a way of life, only time will tell," Craig says. "So far, the people have taken good care of their RE systems."

Effecting Real Change

By providing power to schools and community centers, blueEnergy hopes that RE-generated electricity will improve the standard of living and empower people to work together to coordinate future clean energy systems. With electricity comes hope that these communities can open night schools, where those who must work in the fields during the day can learn to read and write—under lamps lit with renewably generated electricity. Someday, additional turbines in these communities may also support refrigeration for freezing fish and systems for purifying contaminated well water. And in time, blueEnergy's systems may help promote cottage industries, and allow the region's primitive health clinics to improve with new technology and top professionals.

As one of its first moves after winning the elections in 2006, the Sandinista government prioritized energy as a key national issue. With the deteriorating condition of old petroleum-based power plants worsening an already significant energy-production deficit, the MEM is actively searching for ways to meet energy needs with new investments in renewable generation. Craig says that the MEM has invited blueEnergy to the discussion table, and that they are in the process of discussing how blueEnergy's electrification model could be replicated throughout the coastal region.

"I feel tremendous satisfaction when I see that—four years after our humble beginning—people are starting to believe in our vision, and are starting to think about the future and the importance of sustainability," Craig says. "The attitude is infectious, and we can see it spreading in all facets of the lives of our employees and the community members we serve."

Access

Andreas Karelas (andreas@resource-solutions.org) has a dual master's degree in International Affairs, and Natural Resources and Sustainable Development. He lives in San Francisco and works for the Center for Resource Solutions with the Green-e Energy program.

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Ground-Fault Protection is Expanding

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

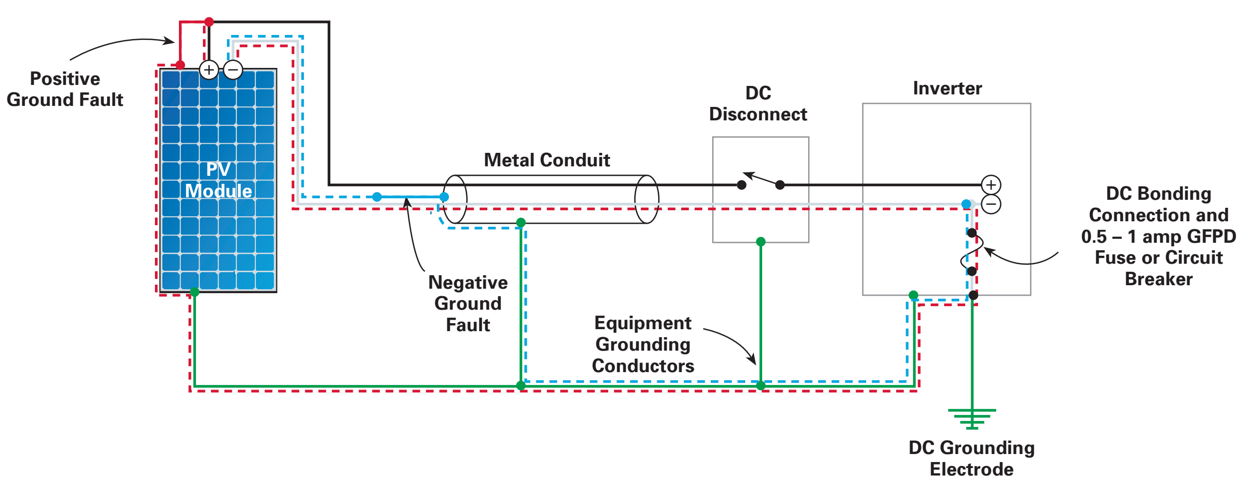
In 1984, engineers at the National Fire Protection Association (NFPA) directed the PV industry to propose Section 690.5 for the *1987 National Electrical Code (NEC),* which would require a ground-fault protection device (GFPD) on PV systems installed on dwellings. This requirement resulted from a presentation by engineers from a national laboratory that showed a PV module that had been subject to a ground fault and had subsequently caught fire and melted down. The engineers failed to mention that this was a prototype, unlisted PV module, the module was on a concrete pad, and that ground faults in PV systems were somewhat rare. So it's not surprising that these firefighters concluded that PV ground faults lead to fires, and directed the engineers to submit the proposal. However, when the requirement was established, no GFPDs existed for PV systems.

In 1989, I joined the PV industry as a full-time employee at the Southwest Technology Development Institute. One of my first projects was to develop prototype hardware that could be used to meet the new Section 690.5 requirement. In the *1987 Code,* the requirements for this fire-reduction device were to:

1. Detect ground faults in PV arrays mounted on the roofs of dwellings
2. Interrupt the fault current
3. Indicate that a ground fault had occurred
4. Disconnect the faulted part of the PV array
5. "Crowbar" (short-circuit) the PV array

The original GFPD prototype was developed in two versions that were similar except for voltage rating. The basic concept was to insert a 0.5- or 1-amp circuit breaker in the DC system-bonding conductor. This device connected the grounded circuit conductor (usually the negative) to the grounding system (the point where equipment-grounding conductors and the grounding-electrode conductor are connected together). Any ground-fault currents must flow through this bond on their way from the ground-fault point back to the driving source—the PV module or array (see illustration). When the current in this bond exceeds the rated 0.5 or 1 amp, the circuit breaker trips to the open position. This action interrupts the fault current, even when the fault is

Ground-Fault Current Paths



Example positive conductor faulted to PV module frame. Path of positive ground-fault currents—return to source.
Example negative conductor faulted to metal conduit. Path of negative ground-fault currents—parallel negative current paths.

Note: All ground-fault currents must flow through the DC bonding connection.
Any time positive or negative ground-fault currents exceed ground-fault fuse/breaker rating, that device opens and ground-fault currents are interrupted.

Clockwise from upper left: One-pole, ground-fault protective device for a 48-volt PV system.

Two-pole, ground-fault protective device for a 48-volt PV system.

Four-pole, ground-fault protective device for a 48-volt PV system.

many feet away—on the roof of the building, for instance—and indicates that a ground fault has occurred. These actions satisfy requirements 1, 2, and 3.

This small circuit breaker is mechanically linked to between one and four large, 100-amp circuit breakers that open when the smaller, fault circuit breaker opens. These added breakers are connected in series with each of the incoming ungrounded conductors from the PV array and they disconnect the PV array from the rest of the system, thereby meeting requirement 4.

Requirement 5 was added to reduce the PV array voltage to zero by shorting the positive and negative conductors together to minimize a potential shock hazard. In the original GFPD design, this was accomplished by using either a motor-driven circuit breaker on 48-volt systems or by using a solenoid-driven (closed) shunt-trip breaker on higher-voltage systems. This fifth shorting requirement was later removed from the *NEC* when it was determined that it might be possible to damage a "new technology" PV module by short-circuiting it. Although that module never materialized, the crowbar requirement was not reintroduced—even though the PV wiring can handle the worst-case short-circuit currents, being oversized by a factor of 125%. It is an impressive demonstration (with a bright flash and a loud bang due to the DC arc) when circuit breakers rated at 750 volts close and short-circuit a 100-amp PV array that has an open-circuit voltage of 600 volts.

Modern Ground-Fault Protection Devices

Early GFPD prototypes were released to the PV industry in 1991. In 1997, a GFPD was manufactured for 48-volt (and below) PV systems. Other ground-fault devices for low-voltage systems soon followed, as off-grid, PV systems became more common and were inspected more frequently.

As higher-voltage, utility-interactive PV inverters became available in the late 1990s, using a 0.5- or 1.0-amp fuse as the sensing element and the inverter's control electronics to monitor the fuse was more cost effective. The inverter's fault lamp or display indicated that a ground fault had occurred and the inverter shut down, effectively disconnecting the equipment.

Coming in 2008

The *2008 NEC* will require GFPDs on nearly all PV systems, including those mounted on commercial buildings (nondwellings) and on ground or pole mounts. This requirement was added to the *NEC* because an uninterrupted ground fault on PV arrays can continue as long as the sun is shining and may not be detected until significant damage has been done. The possible arc from the ground fault and the overloaded equipment-grounding conductors each pose serious hazards.

Sizing equipment-grounding conductors using *NEC* Section 250.122 for PV systems with fuses does not always result in a conductor size that can withstand continuous ground-fault currents. The conductor and overcurrent sizing requirements for PV source and output circuit and the current-limited nature of PV module outputs do not ensure that overcurrent devices will open properly in a very short time as they do on AC circuits. Therefore, a requirement was added to interrupt the ground-fault currents on all PV systems when they exceed the 0.5- or 1-amp trip value.

The overcurrent trip value for larger systems (greater than 10 KW) will be higher than for smaller systems and is still under study. Before May 2007, inverters larger than about 10 KW had only partial GFPD functionality. They detected the ground faults, indicated that the fault had occurred, and shut down. However, they did not *interrupt* the fault currents.

Ground-fault fuse location on a high-voltage inverter.

Now, with a change in UL Standard 1741 for PV inverters and the *2008 NEC*, all utility-interactive inverters will have full functionality for ground faults and will act in a manner similar to the smaller residential devices. Off-grid PV systems with batteries operating at 48 V nominal or less need to have a charge controller with GFPD built in, or an external device will have to be added.

Small (two series strings or less) off-grid systems that have no DC wiring inside or on a building will be exempt from the GFPD requirement. A water-pumping system with all circuits located away from a building is one example of such a system. A few nonresidential installations, where the equipment-grounding conductors are oversized by a factor of about two above the circuit conductors, may be exempt as well.

The AC Ground-Fault Issue

Common AC ground-fault circuit interrupters (GFCI) are not designed to be backfed. The output of a utility-interactive inverter connected to the load terminals and backfeeding a receptacle or breaker GFCI, a 30-milliamp equipment-protection, ground-fault breaker, or even a 600- to 1,200-amp main breaker with ground-fault elements may damage that device with no external indication of a problem. Any time a utility-interactive PV system is installed, the entire AC premises wiring system—from the PV inverter output to the service entrance—should be examined to ensure that there are no ground-fault devices in a circuit that may be subject to backfeeding. Some of the newest ground-fault breakers in the 1,000 amp and larger sizes are listed as suitable for backfeeding, but be sure to confirm that by reading the product literature. Usually in a residence, the PV currents do not flow *backwards* (load to line) through any ground-fault circuit interrupters and there would be no problems. However, many commercial buildings have main breakers that are ground-fault breakers, and a PV system on such a building could subject the breaker to backfeeding and possible damage.

Arc-Fault Circuit Interrupters

In some ways, arc-fault circuit interrupters (AFCI) are similar to GFCIs and should not be backfed by PV inverters unless listed and identified for backfeeding. The AFCI detects an arcing line-to-line fault in a house's AC wiring, in some cases even in an extension cord, and shuts off power to that circuit. The *2008 NEC* requires their installation throughout the house to increase the safety of electrical systems. DC arc-fault circuit interrupters are not currently available.

However, a line-to-line fault in the DC wiring of a PV array can pose danger. The PV industry and Underwriters Laboratories are studying the issue to determine the characteristics of a typical DC arc originating from a PV system and how, if possible, to detect, control, and extinguish that arc. This is not an easy task because the electrical sources (the PV modules) in any system are widely dispersed and numerous.

Finding Faults, Improving System Safety

In the United States, the number of PV installations continues to increase year by year. Nearly all PV systems will soon be required to have a GFPD. Efforts are continuing to enhance the safety of PV systems for the general public through revisions and additions to the *NEC* and UL Standards. The goal is to have safe, reliable, and cost-effective PV systems. The future of renewable energy must be a safe one.

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 contact me. See the SWTDI Web site (below) for more detailed articles. The U.S. Department of Energy sponsors my activities as a PV industry support function under Contract DE-FC 36-05-G015149.

Access

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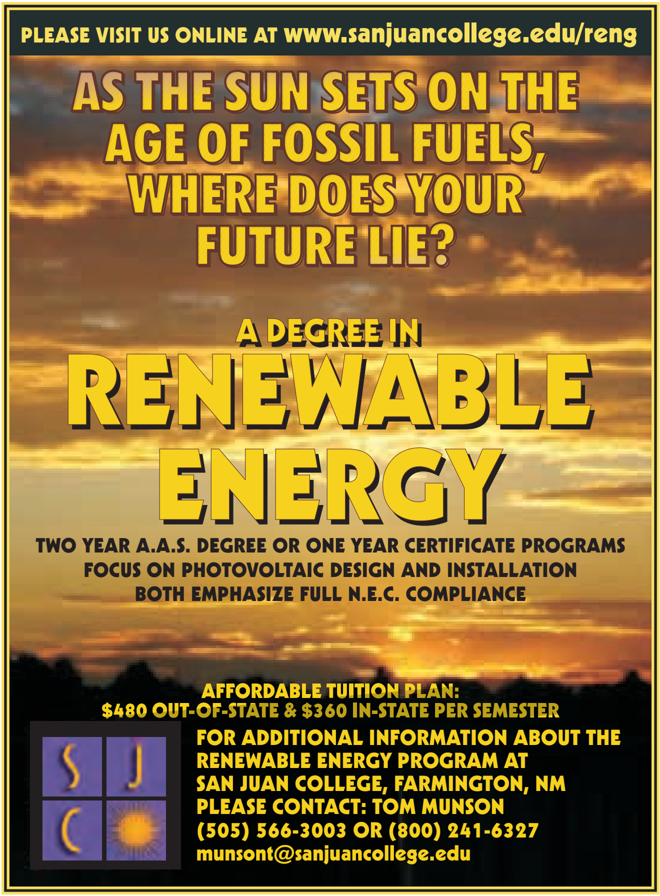
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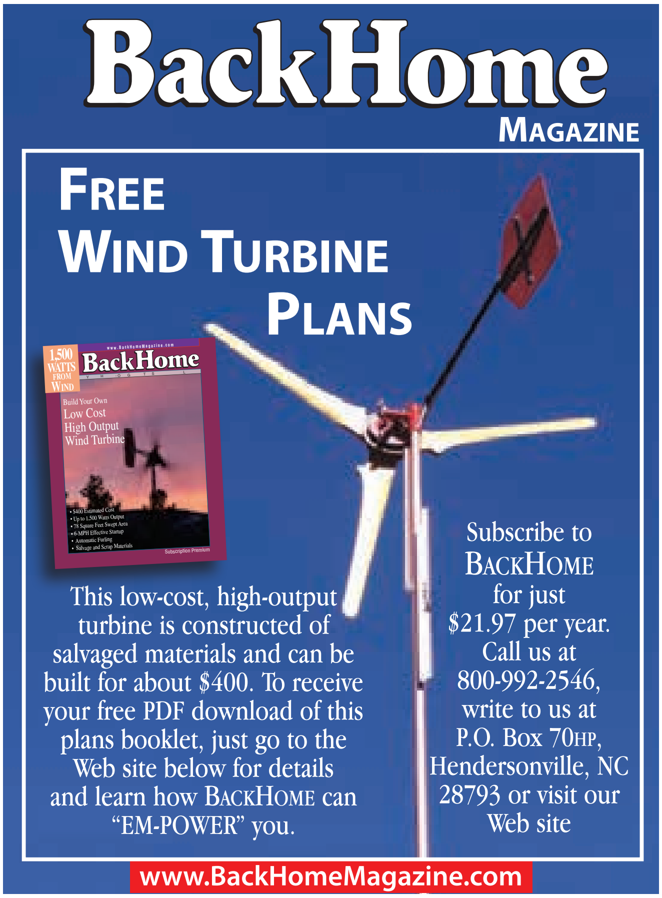
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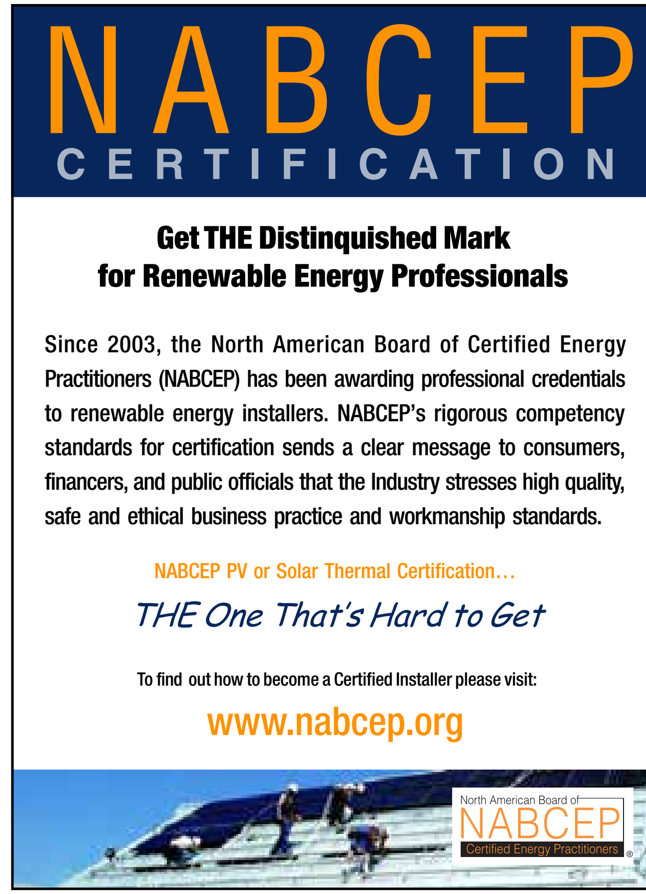
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Presidential Energy

by Michael Welch

Walk into any bookstore, stop by any newsstand, or turn on the television, and it's undeniable. Finally, everyone's talking about the energy crisis—and just in the nick of time for campaign season. All the buzz is fueling the ongoing conversation about U.S. energy policy and forcing the candidates to go beyond the normal lip service. But even with the green spotlight shining brightly these days, getting the politicians on track to a renewable energy future—one with climate change arrested and reversed before it is too late—may not be easy. One of the best ways to help is to get out there and exercise your vote.

When it comes time to select the next President, the majority of Americans will choose between a Republican and a Democrat. Why? Tradition, allegiance, ignorance, or perhaps to make sure the lesser of two evils ends up in the White House, sculpting our next of most critical steps in achieving energy independence and reversing climate change.

Party Power

At the end of August, the Democrats will choose their nominee for President at their convention in Denver. Days later, in Minneapolis-St. Paul, the Republicans will appoint their nominee. The party platforms adopted by the delegates at the national conventions are the official statements of each party's position on a variety of issues. Not surprisingly, the individual policy positions of the candidates often echo the philosophies of the party from which they need support to win the nomination. Only after the candidate earns the party nomination does he or she have more power to set the party agenda. Understanding these philosophies and platforms is key to understanding the candidates and how this election will play out.

Republican Party. Known for its open allegiance to business interests, the party leans toward the capitalist principle that problems are better fixed by the hands of business than by government involvement. The current party platform from 2004, entitled, "A Safer World and a More Hopeful America," focuses largely on winning the war on terror. Only a few paragraphs pay respect to the environment. In the quest for "affordable, reliable, more independent energy supply," the platform pushes for oil drilling in the Arctic National Wildlife Refuge (ANWR), and encourages the construction of nuclear power plants as an affordable, emissions-free means for addressing climate change. In the alternative energy arena, the party promotes research and investment, "to realize the enormous benefits of a hydrogen economy and put the United States on the cutting edge of energy technology."

Democratic Party. Although the Democrat's allegiance to business is strong, it is tempered somewhat by an underlying belief that government can make a positive difference in peoples' lives. The party platform from 2004, "Strong at Home, Respected in the World," presents strategies for defeating terrorism and promoting democracy before shifting to a discussion of energy independence. The platform touts the need for RE and more energy-efficient vehicles, including hydrogen and hybrid cars. The party line for global warming seems to be "cap and trade," which limits greenhouse gas (GHG) emission totals, and allows companies to bid for the right to pollute. The environmental talk concludes with a promise to "protect Nevada from the high-level nuclear waste dump at Yucca Mountain, which has not been proven to be safe by sound science."

The Candidates

Barack Obama • www.barackobama.com. A media favorite and one of the top "energy" candidates, Obama is calling for GHG emissions to be cut 80% below 1990 levels by 2050 through cap-and-trade auctions, rather than giving away pollution credits for free to coal and oil companies. His energy plan details everything from phasing out incandescent bulbs to reducing U.S. oil consumption. According to his Web site, he will invest $150 billion over ten years to advance fuel technology, commercialize plug-in hybrids, develop commercial-scale renewable energy, and control pollution from power plants. He believes in the continued use of nuclear energy, but he tempers that position by toeing the party line against the disposal of nuclear waste at Yucca Mountain.

Bill Richardson • www.richardsonforpresident.com. This candidate put it on the line, saying, "I am calling for a New American Revolution—an energy and climate revolution." While other Democrats are holding at 80%, Richardson is calling for a 90% reduction in GHGs by 2050—20% by 2020, 80% by 2040. Like most of his counterparts, he suggests a cap-and-trade system to create incentives for the electrical and industrial sectors. Though he voted in favor of the 1987 measure that designated Yucca Mountain as a nuclear waste dump, he now says he opposes the project but supports nuclear power as an energy option. As governor of New Mexico, he enacted landmark legislation that requires utility companies to generate 10% of their energy from renewable sources by 2011.

Chris Dodd • www.chrisdodd.com. This fifth-term senator from Connecticut puts climate change on equal footing with energy independence. He is among the crowd pushing to reduce GHGs by 80% before 2050. True to his word, he cosponsored the Global Warming Pollution Reduction

Act, a climate bill that would establish a strict cap-and-trade system for GHGs. His 14-point energy plan funds research and development of RE and energy efficiency (EE) with a corporate carbon tax—a bold position taken by few. He opposes coal-to-liquid technologies and nuclear power, and instead, advocates "historic" investments in biofuels and other clean energy technologies. Like several other candidates, he suggests that the government lead by example by using hybrid and plug-in vehicles that run on clean energy, and equipping all government buildings with "the greenest technologies." He voted "no" to drilling in the Arctic National Wildlife Refuge and consistently votes for the environment.

Dennis Kucinich • www.dennis4president.com. As a five-time re-elected Ohio congressman, Kucinich calls for a new energy initiative as ambitious as President Kennedy's effort to send a man to the moon. He proposes a "Works Green Administration" similar to the Great Depression's Works Progress Administration, to put people to work at green-energy jobs. He would rejoin and implement the provisions of the Kyoto GHG treaty, an international protocol for climate change ratified by every participating country except the United States. He talks openly about "sustainability" as the key to human survival on Earth. He calls nuclear energy "unsafe, unreliable, and unsustainable," and has spoken out against the plan to transport nuclear waste from nuclear sites to Yucca Mountain, exposing millions of people to the hazards and risks. He votes for any bill that promotes RE and energy efficiency, like the recent Clean Energy Act of 2007, and consistently votes against drilling in ANWR.

Duncan Hunter • www.gohunter08.com. Though this Southern California congressman hails from the land of sun and surf, energy and environment are apparently not a priority. He says he'd like to achieve energy independence, yet his track record says otherwise. On energy issues, he generally votes the party line or not all. Not only did he neglect to vote on three of the last four energy-related bills, but he voted *against* the Clean Energy Act of 2007. A disbeliever in the science of human-caused climate change, he says, "Few people in global warming can tell you exactly what's happening." He voted for an Energy Bill amendment to raise auto fuel economy standards, and he voted against an amendment that would prevent drilling for oil in ANWR.

Fred Thompson • www.fred08.com. This lawyer-turned-actor-turned-Senator from Tennessee talks about reducing GHGs, but his record doesn't suggest a strong environmental and energy conscience. Among the nonbelievers in the science of climate change, he told talk-show host Paul Harvey, "Some people think that our planet is suffering from a fever. Now scientists are telling us that Mars is experiencing its own planetary warming." A supporter of nuclear waste disposal at Yucca Mountain, Thompson also voted in favor of drilling in ANWR, and defunding solar and renewables. In a December speech promoting drilling in ANWR, he also called for more "coal and nuclear power."

Hillary Clinton • www.hillaryclinton.com. This New York Senator and former first lady says we need to take "sensible first steps," such as "clean coal," biofuels, renewable technologies, and improved auto fuel efficiency, to slow down climate change. Her plan to reduce GHGs and oil imports relies on a 100% auction of pollution credits through a cap-and-trade system. She'd jump-start clean energy development to the tune of $50 billion with a strategic energy fund partially supported by taxes on oil companies and fees for drilling on public lands. Also, a new loan program would help low- and middle-income families buy and build more energy-efficient homes. Against moving nuclear waste to Yucca Mountain, she has voted for and/or cosponsored some positive Senate bills like the Global Warming Pollution Reduction Act of 2007.

John Edwards • www.johnedwards.com. Senator Edwards is serious about building a new energy economy and recognizes global warming as an immediate crisis. By 2020, his plan aims to produce 65 billion gallons of ethanol and biofuels per year, generate 25% of electricity from renewable energy sources, and reduce carbon dioxide emissions by 15%. His plan phases out coal-fired power plants, and imposes taxes and fees on pollution to generate a $13-billion-a-year fund to be spent on renewable energy and other incentives. A step farther than most, he calls for mitigation of agricultural greenhouse gases, more powerful pollutants than carbon dioxide. He voted for big increases in car mileage and against drilling in ANWR. Though he voted in favor of Yucca Mountain in 2002, he soon after changed his position and is now in opposition to opening the repository.

Joe Biden • www.joebiden.com. "We must act!" says this Pennsylvania senator. He absolutely wants to fix climate change and goes beyond many other progressive candidates by calling for a return of the United States to global climate change negotiations. His plan supports RE on all levels, including a 20% RE portfolio standard for utilities. He does favor biofuels, and wants 25% of all gasoline filling stations to provide alternative fuel pumps by 2017. He'd raise fuel mileage standards for new cars to an average of 40 mpg, and he's very big on energy efficiency for both the public sector and the government, targeting a 30% decrease in energy use in federal buildings. In the Senate, he cosponsored a bill to reduce GHGs to 80% below 1990 levels by 2050, via an emissions cap-and-trade system.

John McCain • www.johnmccain.com. Breaking party ranks, this Arizona senator acknowledges that human-caused climate change is a real threat. He cosponsored the well-known McCain–Lieberman Climate Stewardship Act of 2003, which ended up with little support from environmentalists because there were stronger bills in the Senate. Plus, he included his favorite global warming response—new nuclear power plants. McCain feels that fixes to climate change should come through market forces. His votes and bill sponsorships in the Senate generally reflect his concern about GHGs. But he also has voted against an energy bill amendment that would have increased vehicle fuel economy, while voting for other legislation that would increase mileage.

Mike Gravel • www.gravel2008.us. A former senator from Alaska, Gravel would "act swiftly to reduce America's carbon footprint by initiating legislation to tax carbon at the source and cap carbon emissions." On his Web site, Gravel states that "global climate change is a matter of national security and survivability of the planet." He'd also "initiate a massive scientific front" to end dependence on oil. His platform calls for working with other major polluting nations, like China and India, so that fighting climate change will be a global effort. He doesn't have a recent voting record, since he left the Senate in 1981, but his most famous energy-related victory was the building of the Alaska oil pipeline—whoops.

Mike Huckabee • www.mikehuckabee.com. This former governor of Arkansas does not necessarily believe in human-caused climate change but did state that we could use technologies that do not produce GHGs. As for the existence of global climate change, he says, "Whether there is or there isn't, it doesn't release us from the responsibility to be good stewards of the environment." He's in favor of energy independence (who isn't?), but lumps nuclear in with solar and wind, and likes the idea of something like the Manhattan Project for "alternative energy sources" to move toward energy independence. On the kind-of plus side, as Arkansas's governor, he signed the state's Renewable Energy Development Act of 2001, which includes a net metering law, and supported the National Governors Association climate change policy position.

Mitt Romney • www.mittromney.com. A former Massachusetts governor, this candidate has an interesting mix of energy positions. He's not sure how much global warming is human-caused, and wants to err on the side of "no regrets"—but not unless all the other countries implement GHG reductions, fearing unfair business advantages. He wants energy independence and less reliance on oil, but would accomplish this by drilling in ANWR, building up liquefied coal as a fuel, and fast-tracking nuke plants. As governor, he proposed the Climate Protection Plan of 2004, which would have extended the previous governor's participation in limiting the state's GHGs. On the other hand, he backed out of the Regional Greenhouse Gas Initiative pact with other northeastern states, because it might increase energy costs.

Ron Paul • www.ronpaul2008.com. With "free-market" as his mantra, Paul says that "the environment is always better taken care of with strict property rights. Under property rights, you are never allowed to pollute." He wants no federal tax money to go toward efforts to address RE, energy efficiency, or climate change, but also none for oil, gas, war, and nukes. In the House, he voted against the moratorium on drilling in ANWR and against raising auto fuel standards. In fact, he votes against or doesn't vote at all for nearly every energy spending bill that comes up, regardless of the party in power—probably because that would mean spending tax dollars, and he is against such subsidies.

Rudy Giuliani • www.joinrudy2008.com. Though energy and environment are not among the twelve issues that form his campaign base, Giuliani hosts a Web page devoted to energy independence that provides an overview of any and every kind of energy option. Apparently, energy diversity is his theme, but his law firm has a history of working and lobbying for huge energy companies, including coal-fired power plants. He calls for easing and hastening permits for more nuclear power plants, liquified natural gas ports, and oil refineries. His company's recent lobby actions speak volumes. Large energy firms like Southern Co. and American Electric Power Co. have hired his firm and other lobbyists to defeat a provision in the 2007 Energy Bill that would require them to use 15% renewable energy.

Tom Tancredo • www.teamtancredo.org. This representative from Colorado blames immigration for human-caused climate change (and other stuff), and has no developed energy policy. As for fixing global warming, he says, "Look, it really doesn't matter. The thing we must do is reduce our reliance on potentially violent countries." However, he wants you to know that on any issue, "Tom stands for America." Flag-waving aside, in the House he votes the party line, including against higher mileage standards and for drilling in ANWR. He most recently voted against the Clean Energy Act of 2007. The only energy spending bills he has voted for are those that came out of Congress when it was controlled by his party.

The Future is Ours

There's a vast difference between the candidates, though party affiliation typically carries through to individuals' proposed energy policies and past practices. We could easily end up with candidates who are so beholden to energy companies that not much would be different from the current administration. Or, we could end up with candidates who would try to make energy and climate change the national priority.

Can any presidential candidate make the differences we need? With the kind of control that big business has over our government, who knows. But without a president who supports a progressive energy policy, our hope for protecting our environment and humanity itself is not as great.

So vote your conscience in this primary, but just moderate it by a strong dose of reality: Consider which candidates you feel could actually win the presidential election if nominated. Just be sure to vote, that is the best way your voice will be counted. And if you have the time, get in there and roll up your sleeves (and maybe put on your waders) to work for and help get out the vote for your preferred candidate.

Access

Michael Welch (michael.welch@homepower.com) has not missed voting in an election since he came of age. He's been working for a clean, safe, and just energy future since 1978 as a volunteer for Redwood Alliance and with *Home Power* magazine since 1990.

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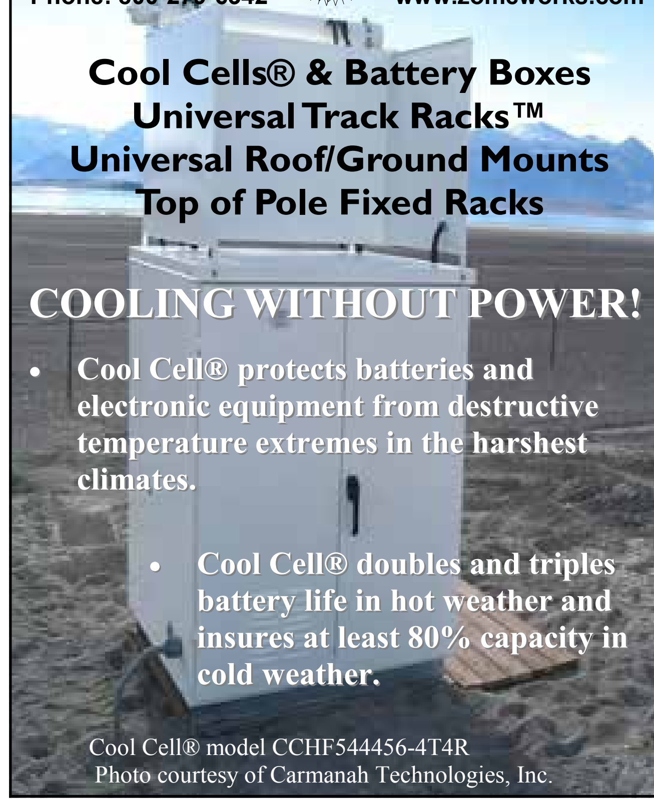

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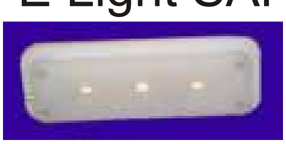

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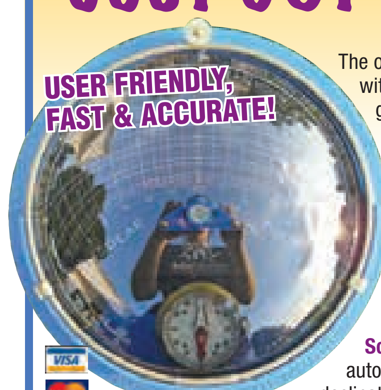

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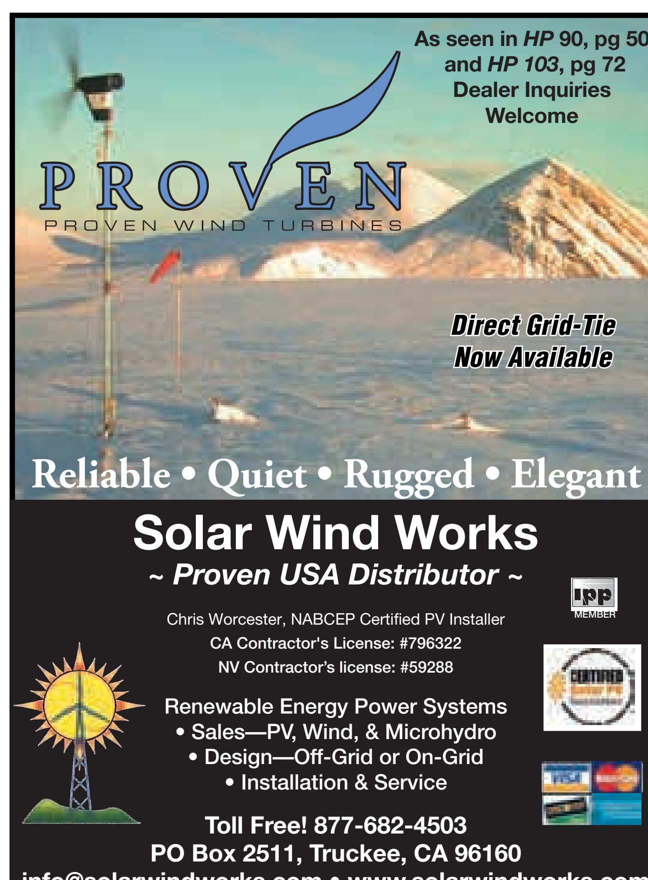
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Whither Weather & Water

by Kathleen Jarschke-Schultze

We know the oceans and the Earth are warming. Polar ice caps are melting. Climate change is inevitable. Even I've been seeing a change in the weather, here in Siskiyou County, California, where I've lived for 22 years. My husband Bob-O, who has lived here for 35 years, says he has witnessed a pronounced change.

The Snow Goes

We live in a mountainous area. Around us is the southern end of the Cascade Range, the Marble Mountains, the Trinity Alps, and the jewel in our crown, Mt. Shasta, at 14,179 feet. Mt. Shasta used to be covered in snow at least a third of the way down from the summit all year long. Now, every summer for the last eight years or so, the black volcanic bones of the mountain are laid bare—less snow left every year, more mountainsides exposed. This doesn't look right; it doesn't look like our mountain.

You can see Thompson Glacier in the Marbles from the Salmon River. And, although the glacier has been a perennial sight since recorded history in the county, it is just about gone now. Next summer's heat will take it out. In the late '80s, when we lived on the Salmon River, we would take the pass through Callahan Summit to get to town. The snow would be 4 to 6 feet deep. The county kept the road plowed as well as they could, so it was mostly passable. I did not grow up around snow, so I liked it. Bob-O can remember when the snow on the pass was so high that the passage was through what seemed like a tunnel cut in the 15- to 20-foot drifts. No more.

On our way through the drifted pass we would see one of my favorite things. When a tree branch drops a blob of snow on a snowy, steep mountainside below, it will sometimes roll downslope, gathering more snow as it goes. This wheel of snow gets larger as it travels, and then will catch and stop at the bottom of the drift. At the very center of the snow wheel is the most amazing turquoise color of the bluest tropical ocean. It has been 15 years since I've seen a snow wheel.

These anecdotal observations are backed up by official measurements recorded by the government. Tests done by the Klamath National Forest in May 2007 showed the snow depth to be 46% to 0% of average at several locations.

The River Flows

"Whiskey's for drinkin', water's for fightin'." Mark Twain said that. He was in California at the time. That was in the mid-1800s, and the situation has not improved. The lakes and rivers around here are lower and slower. No one recalls ever seeing the water level in Lake Shasta sink to the depths that it did in 2007.

Water use from the Klamath River, a major river in southern Oregon and northern California, has gained national attention in the past few years, with the contenders being farmers, who want the water for agricultural use, and the environmentalists, fishermen, and Native American tribes, who want the water to remain in the Klamath and its feeder streams for salmon and wildlife habitat.

There also are seven hydro-electric dams owned by PacifiCorp. on the Klamath River. Four of those dams are up for relicensing. It has been a bitter battle. The dams produce enough electricity for 70,000 homes. The dams also block 300 miles of habitat needed to revive failing salmon populations. A toxic algae bloom has appeared in Iron Gate Reservoir, which is the last dam on the river. Below Iron Gate, the Klamath runs free to the sea. At this point, it looks like the salmon are going to win, but it will take at least ten years to remove the dams responsibly. This means taking care to deal with the silt buildup and other concerns.

Since we drive around the reservoir to get to our home, this will mean changes for us. We're not sure how we will be affected. We are in a bird migration path here, and the reservoir is a popular stopover for many species. In the spring, I look forward to seeing the American white pelicans feeding around the edges of the water on my morning drives. There is one particular boat dock I pass where I always look for the "tai chi" heron. He is usually there, at the end of the dock, the mist of the morning lake rising around him. He stands on one leg and contemplates his world. I will miss him for sure.

The Rain Slows

All the small municipalities in Siskiyou County were on short water supplies this year. Post office bulletin boards sported public announcements threatening water rationing if people could not conserve water on their own. The water table here has dropped alarmingly over the last 20 years. Wells are going dry. People are worried, and rightly so.

We have two digital rain gauges here at Chateau Schultze. One reads a little more exuberantly than the other. We call one the Republican and the other the Democrat. I won't say which is which. We keep track of our annual rainfall from

October 1 to September 30 of the next year by averaging the individual totals from the gauges and calling it good. Our rainfall last year was 18.5 inches, which is about average for us now. The year before that we got 24 inches, which for us was phenomenal. In the '80s, 20 to 24 inches was typical.

The Creek Grows

Our creek is seasonal. It regularly dries up in the summer heat. When the trees start to turn colors in the fall and stop drawing creek water up their roots, pools begin to form along the creek bed. Even if it doesn't rain, the pools get bigger and deeper. Then we will hear a soft tumble of water over the rocks. This is when we call our neighbor Stan, who lives down creek. "The creek is at our house," we say, like it is a living entity arriving for a long visit. Three days later, Stan will call back: "The creek is here now." Stan lives a half mile away.

This year, the trees turned and the pools began forming. This is the time of year when we are pretty power-skinny: Cloudy days with little sun, the daily downslope, down-canyon winds have stopped, and the creek not running yet. Without solar-, wind-, and microhydro-electricity, we put 6 gallons of gas through our Genny DC generator to charge our batteries over the space of two weeks.

One evening the sky was very dark and rain was predicted, and I told Bob-O the creek would come back "tonight." He thought maybe, but not enough to turn the hydro on. "No," I insisted, "The creek *is* coming back." It rained 2 inches in 24 hours. We woke up to a roaring, brown creek. All the fallen leaves were sluiced downstream. Within a day, the water was running clear and we had hydro power again. O, happy day. We've never seen that happen before.

Who Knows?

What does it all mean? Shoot, I don't know. These are the things I see in my world. I'm lucky enough to live in the country and observe these changes. I'll adjust to the changes; I'll adapt to my environment. But I have the feeling that we're all going have to tighten our water belts and treat this resource with the respect it deserves. Our oceans cover three-quarters of the Earth and water gives life to every living thing. As the freshwater disappears, so will we. Hey, after all, aren't we mostly water ourselves?

Access

Kathleen Jarschke-Schultze (kathleen.jarschke-schultze@homepower.com) is assembling and prepping her drip irrigation system for spring at her off-grid home in northernmost California.


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CALIFORNIA

Feb. 25–27, '08; Santa Monica, CA. PV System Design. Producing PV design documents; for engineers & designers. Info: www.sunengineer.com/workshops.htm

May 7-8, '08. San Diego, CA. National solar business training event for installation companies, start-ups, and their employees. Business-specific training featuring premier manufacturers and business specialists. Sponsored by ASES and Conergy Inc. • www.ases.org/solar2008/

Oct. 13–16, '08. San Diego, CA. Solar Power 2008. Conference & expo. Info: 202-296-1688 • mglunt@solarelectricpower.org • www.solarpowerconference.com

Arcata, CA. Workshops & presentations on RE & sustainable living. Campus Center for Appropriate Technology, Humboldt State Univ. • 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

Jun. & Jul., '08. Crawford, CO. Solar Energy for Do-It-Yourselfers. Solar ovens, dryers, batch water heaters, hot air collectors, clotheslines, greenhouses & intro to PV. Info: Our Sun Solar • 970-921-5529 • www.solarenergyclasses.com

Carbondale, CO. Workshops & online courses on PV, water pumping, wind, RE businesses, microhydro, solar domestic hot water, space heating, alternative fuels, straw bale building, green building, women's PV courses & more. Solar Energy Intl. (SEI) • 970-963-8855 • sei@solarenergy.org • www.solarenergy.org

FLORIDA

Feb. 21–22, '08. Orlando, FL. Efficiency & Renewable Energy Summit. For industry & utilities. Info: www.acius.net

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

IOWA

Feb. 20–22, '08. Des Moines, IA. Forum on Energy Efficiency in Agriculture. Info: ACEEE • 202-429-8873 • agforum@aceee.org • www.aceee.org

Iowa City, IA. Iowa RE Assoc. meetings. Info: 319-341-4372 • irenew@irenew.org • www.irenew.org

MASSACHUSETTS

Mar. 11–13, '08. Boston, MA. BuildingEnergy08. Conference & trade show. Info: NESEA • jnokes@nesea.org • www.buildingenergy.nesea.org

Auburn, MA. Seminars: Solar Basics, PV, Hot Water, Wind, RE & more. Info: CNE Solar Store • 508-832-4344 • peter@cnesolarstore.com • www.cnesolarstore.com

Hudson, MA. Workshops: Intro to PV; Advanced PV; RE Basics; Solar Hot Water & more. Info: The Alternative Energy Store • 877-878-4060 • support@altenergystore.com • http://workshops.altenergystore.com

MICHIGAN

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

MISSOURI

New Bloomfield, MO. Workshops, monthly energy fairs & other events. Missouri Renewable Energy • 800-228-5284 • info@moreenergy.org • www.moreenergy.org

MONTANA

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

NEW HAMPSHIRE

Rumney, NH. Green building workshops. Info: D Acres • 603-786-2366 • info@dacres.org • www.dacres.org

NEW MEXICO

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

NORTH CAROLINA

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

OREGON

Mar. 28–30, '08. Portland, OR. Better Living Show. Sustainable lifestyle event incl. wind, solar, hydrogen & geothermal. Info: www.betterlivingshow.org

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

PENNSYLVANIA
Philadelphia Solar Energy Assoc. meetings. Info: 610-667-0412 • rose-bryant@verizon.net • www.phillysolar.org/psea.htm

TENNESSEE
Summertown, TN. Workshops on PV, alternative fuels, green building & more. The Farm • 931-964-4474 • 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, D.C.
Mar. 4–6, '08. Washington Intl. RE Conference (WIREC 2008). Trade show & business conference. Info: ACORE • 202-393-0001 ext. 7582 • weirich@acore.org • www.americanrenewables.org

WISCONSIN
Amherst, WI. Feb. 21, '08 (again Mar. 5, '08): Intro to Solar Water & Space Heating System. Feb. 22–24, '08 (again Mar. 26–28, '08): Installing a Solar Water Heating System (hands-on). Info: Artha Sustainable Living Center LLC • 715-824-3463 • chamomile@arthaonline.com • www.arthaonline.com

Custer, WI. MREA '08 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

AUSTRALIA
Feb. 17–21, '08. Adelaide, S. Australia. Intl. Solar Cities Congress. Support cities in UN energy & climate policies by stimulating interest in RE & energy efficiencies. Info: Plevin & Associates • 61-8-8379-8222 • events@plevin.com.au • www.solarcitiescongress.com.au

AUSTRIA
Mar. 5–7, '08. Wels. World Sustainable Energy Days. 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

Apr. 6–10, '08. Vienna. Energex. Congress & exhibition. Energy for human development & the protection of the environment: policy, economy & technology. Info: Aims Intl. GmbH • Mariannengasse 32 A-1090, Vienna • 43-1-402-77-55-0 • energex2008@aims-international.com • www.energex2008.com

BRAZIL
Mar. 23–25, '08. São Paulo. EcoBuilding trade show & conf. Intl. meeting for architecture & technologies for sustainable construction. Info: www.anabbrasil.org/ecobuilding2008

COSTA RICA
Feb. 2–10, '08. Durika. Solar Electricity for the Developing World. Hands-on workshop. Info: See SEI in Colorado listing. Local coordinator: Ian Woofenden • 360-293-5863 • ian.woofenden@homepower.com • www.durika.org

CUBA
Mar. 24-27, '08. Cayo Coco, Ciego de Ávila province. CUBASOLAR 2008. Intl. energy, environment & sustainable development. Info: CUBATUR • 205-99-49 • gavilan@cubaenergia.cu • www.cubaenergia.cu

GERMANY
Mar. 7–9, '08. Stuttgart. Clean Energy Power 2008. Intl. conf. & expo on passive homes, bioenergy, geothermal & solar. Info: See Reeco in Hungary listing.

Jun. 12–14, '08. Munich. Intersolar 2008. Solar developments exhibition & forum. Info: www.intersolar.de

HUNGARY
Apr. 24–26, '08. Budapest. REnexpo. Industry conference on RE & EE for central & southeast Europe. Info: Reeco GmbH • 49-0-7121-3016-0 • duong@energie-server.de • www.energy-server.com

ITALY
Nov. 7–9, '08. Milan. Casa Energia Expo. Exhibition on residential buildings that produce & save energy. Info: Artenergy • Via Antonio Gramsci • 39-026-630-6866 • press@zeroemission.eu • www.zeroemission.eu

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Standard Solar Inc., serving Montgomery and Frederick Counties, Maryland, Northern Virginia, and Washington, DC. since 2004. Specializing in residential solar electric installations. Visit our Website: www.standardsolar. 202 Perry Parkway #7, Gaithersburg, Maryland, 20877. Tel. 301-944-1200; email: metrodc@standardsolar.com

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New Mexico

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Wisconsin

Photovoltaic Systems LLC.

Photovoltaic Systems LLC, since 1980 we have been designing, installing and servicing solar electric systems statewide in WI. NABCEP Certified Installer, Xantrex certified dealer & authorized service cntr.; MREA instructor teaching basic thru advanced PV systems workshops. James Kerbel 7910 hwy 54 Amherst Wi. 54406 715-824-2069 PVSOLAR@wi-net.com

Wyoming

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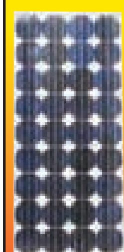

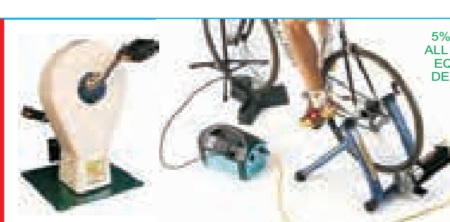

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RE People

Who: Michael Parfit & Suzanne Chisholm

Where: Near Victoria, British Columbia, Canada

When: 2003 to present

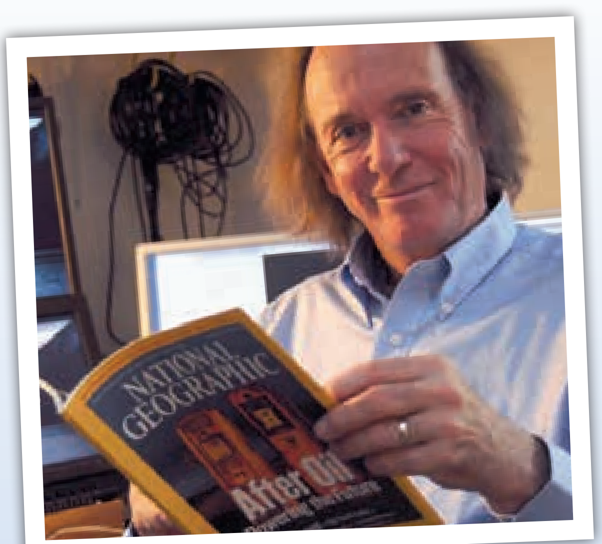
What: Solar-electric system

Why: Necessity & environmental consciousness

Michael Parfit and Suzanne Chisholm are communicators. They write, edit, and produce articles, books, and documentary films about nature and other topics with their company, Mountainside Films. Suzanne was trained as a development economist, and now is a videographer and still photographer who travels the world. Michael is a journalist who in 2005 penned the cover story for *National Geographic*. The article explored the world's energy plight and considered various solutions. Michael wrote about the big picture, and also included his personal experience.

Just before starting to work on the "Future Power" article, Michael and Suzanne moved to an off-grid island near Victoria, British Columbia, Canada. Needing electricity for their home and film production office, they installed a 1,500-watt solar-electric system with gasoline generator backup. So they know firsthand the problems that the *world* island faces—how to power our needs with the resources available, without fouling our nest or sacrificing convenience and functionality.

While necessity has pushed Michael and Suzanne toward renewable energy (RE), there's an underlying fascination with the technology for environmental reasons as well. Michael does not see "how civilization, in the idealistic meaning of the word, can survive on oil for much longer without a descent even further into chaos than we are in now." The promise of home-scale renewable energy is exciting to him—he expects it to be "as significant a factor in human lives as the personal computer in a matter of a few decades."



As is too often the case with new RE system owners, Michael and Suzanne expected the initial system to power more than it was capable of. The upside is that RE—and especially PV systems—are very modular, so they will soon add more solar capacity, or perhaps a wind generator.

The high point of their renewable energy experience so far, says Michael, was the day their PV system came online. "The feeling of independence, as fragile and incomplete as it was, was dramatic," Michael said. "We felt that we were cutting one of the ties to the long umbilical cord that links every one of us to ugly politics, ugly treatment of people, and unsustainable, nasty habits. You can talk about the benefits of renewable energy until the words are all used up, but there's nothing like actually seeing energy move into the system."

—Ian Woofenden